# SpaceDOC-2

# Active Base Tasks and Delivery Orders

# <u>Transition to SpaceDOC-3 Anticipated</u>

BT-1: Fluids and Combustion Facility (FCF) Project Sustaining Engineering (SE)
BT-2: Acceleration Measurement Project (AMP) Operations and Development
BT-6: Fluids and Combustion Facility (FCF) Project: Facility Integration and Operations (FIO)
BT-7: Cognitive Communications (Cog-Com)
DO-213: Exploration Medical Capability (ExMC)
DO-222: Zero Boil-Off Tank-2 Project (ZBOT-2)
DO-230: Packed Bed Reactor Experiment (PBRE) - MI&O
DO-234: Flow Boiling and Condensation Experiment (FBCE)- Mission Integration and Operations (MIO)
DO-242: SCAN Next Generation Relay Capability (SCAN-NGC)
DO-248: Space Communication Architecture Emulation Tool (SCAET)
DO-250: Exploration Medical Integrated Product Team Technology Development Efforts for ISS Technology Demonstration
DO-252: Zero Boil-Off Tank – Non-Condensable Gas (ZBOT-NC) – Mission Integration And Operations (MIO)
DO-255: Solid Fluid Ignition & Extinction – Mission Integration and Operations (SOFIE-MIO)
DO-256: Spacecraft Fire Safety Demonstration (SFS DEMO) Blue Origin Project
DO-257: Spacecraft Fire Safety Demonstration (SFS DEMO) - Commercial Lunar Payload Services (CLPS) Project
DO-265: Advanced Next System Development (ADVNEXT)

**Base Task #1 Fluids and Combustion Facility (FCF) Project**
**Sustaining Engineering (SE) & Operations**
**Contract Period 1/1/2014 to 3/31/2023**
**For the Performance Period 10/1/2021 to 11/30/2023**

## 1. Introduction

The Fluids and Combustion Facility (FCF) Project consists of the Combustion Integrated Rack (CIR) and the Fluids Integrated Rack (FIR). The CIR also includes its payload inserts, and the Multi-user Droplet Combustion Apparatus (MDCA), the Advanced Combustion via Microgravity Experiments (ACME) and the planned and Solid Fluid Ignition & Extinction (SoFIE). The FIR also includes the Light Microscopy Module (LMM) and Flow Boiling Condensation Experiment (FBCE). FCF will be reconfigured on ISS into the SoFIE and FBCE configuration near the beginning of this POP (October-December 2021).

The CIR and FIR are in the operations phase that includes the flight unit operations for physical science utilization of the ISS, along with sustaining engineering of the flight and ground infrastructure. The flight units on the ISS, as well as the units on the ground (Ground Integration Units and the Trainers at NASA JSC) need to be operated and maintained.

This statement of work will be for the sustaining engineering of the FCF racks on orbit and on the ground, resolution of any anomalies, evaluation of trends, software sustaining engineering and upgrades, hardware obsolescence mitigation, hardware sparing, new upgraded hardware development, manifested hardware verification. Also, as new payloads are developed for the FCF, analytical modeling and engineering analysis of the interface will be required, along with integrated analysis and documentation for the ISS Program.

Responsibility for FCF payload planning and operations, the Mission Integration Process (MIP), and operation and sustaining engineering for the Tele-science Supports Center were transferred to BT6 as of Oct 2017.

This on-going Task is sponsored and funded by (NASA) Johnson Space Flight Center (JSC) code OB. Status is provided weekly (OB-Tag-up meeting) and major issues/concerns are elevated to the OB Vehicle Integration Panel (VIP).

## 2. Background

The Fluids and Combustion Facility (FCF) and its initial inserts, the Light Microscopy Module (LMM) and the Multi-user Droplet Combustion Apparatus (MDCA) have been launched and the flight units were installed and operating in the USLab of the ISS. The CIR Flight Unit, along with MDCA, was delivered to the ISS by STS-126 (November 2008). The FIR Flight Unit, along with the LMM, was delivered to the ISS by STS-128 (August 2009). Key spares (or spare kits) were developed as part of the CIR and FIR development but various spares have required completion since the deployment of the flight units (FCF-PLN-4090, FCF Maintenance Plan). NASA maintains bonded storage of the completed spares in Building 333, along with numerous residual parts from the FIR and CIR development. An assessment of maintaining the FIR and CIR till 2028 has been completed (FCF-MEM-4143, FCF Service Life Extension). The assessment identified various risks that will require on-going assessment of spare quantities, future calibration of key pressurized components in CIR, and recertification of the key CIR fuel and oxygen components. Also, various upgrades are planned over the next few years to increase the data management capability and support newer camera interfaces (LMM and CIR Cameras, Image Processing and Storage Units, FIR Laser). New payloads are also planned for the FIR and CIR per the current traffic model consisting of Advance Combustion via Microgravity Experiments (ACME), Flow Boiling and Condensation Experiment (FBCE), Confocal Microscopy for LMM, and Solid Fuel Ignition and Extinction (SoFIE). Figure 2-1 shows the CIR Payload Utilization Schedule and Figure 2-2 shows the FIR Payload Utilization Schedule. Fig. 2-3 shows the MSG Payload Utilization schedule (for GRC payloads) and Fig 2-4 shows the MWA Payload Utilization schedule.

The MIP activities include all GRC, FCF, EXPRESS, Maintenance Work Area (MWA) and the Microgravity Science Glovebox (MSG) payloads on the ISS that require assistance in interfacing and coordinating with the ISS Program. All MIP activities have been transferred to BT6 as of Oct 2017.

The GRC Telescience Support Center (TSC) provides various services to the users to support payload mission operations. All TSC activities have been transferred to BT6 as of Oct 2017.

This CCR adds content to launch a replacement SoFIE Air Flow Sensor removed from the CIR Ground Interface Unit (GIU) and build a new flight spare and replacement for the GIU.

This CCR adds an assessment of sensors, valves, seals, and other limited lifetime parts to extend the service life of FCF on the ISS to 2030.

This CCR adds a replacement SoFIE sample holder built to the current revision that resolves the actuator arm movement anomaly observed on ISS. Incorporates these modifications in sample holders thar are returned from ISS.

Refer to the current Utilization Schedule at the time of the CCR. Updates occur monthly after the Utilization Scheduling Meeting the second Wednesday of the month.

## 3. Applicable Documents

The contractor shall perform this task in accordance with all applicable contract documents with the additional of the following documents for performing specific FCF activities (note: the contractor shall update any plans to conform to approved changes in procedures/processes implemented):

FCF General SAR Plan, FCF-PO-PLAN-0020
CIR ICD with ISS, SSP-57217C-ICD
FIR ICD with ISS, SSP-57218B-ICD
FCF Utilization Process, FCF-PLN-0875
FCF Maintenance Plan, FCF-PLN-4090
FCF Training and Certification Plan, FCF-PLN-0788
FCF Software Sustaining Engineering Plan, FCF-PLN-2171
CIR Phase III Flight Safety Data Package, CIR-DOC-3850
FIR Phase III Flight Safety Data Package, FIR-DOC-1712
CIR Payload Accommodations Handbook, CIR-DOC-4064
FIR Payload Accommodations Handbook, FIR-DOC-1863
FIR Payload Interface Definition Document, FCF-FIR-IDD
CIR Payload Interface Definition Document, FCF-CIR-IDD
(IPSU-CL) Engineering Requirements Document FCF-REQ-4371
Stowage Provisioning and Shipping Procedure for Flight Hardware, SPACE-DOC-001
GRC Telescience Support Center Requirements Document, TSC-DOC-002
GRC Telescience Support Center Implementation Plan, TSC-DOC-004
GRC Telescience Support Center Description Document, TSC-DOC-009
GRC Telescience Support Center Training and Certification Plan, TSC-DOC-015

## 4. Performance Work Statements

In the performance of these performance work statements, the contractor shall maintain and control all applicable records, data, and documents. The contractor and NASA shall co-chair a configuration control board to manage and maintain the flight hardware and software configurations. The five main areas for accomplishing the required work are: FCF Integration, FCF Operations, FCF Sustaining Engineering, Mission Integration and Planning, and Telescience Support Center.

## 4.1. FCF Integration

The FCF to ISS integration responsibilities remain in BT1, however Payload to FCF integration, have been transferred to BT6 as of October 2017.

### 4.1.1 FCF to ISS Integration (Carried forward)

The Contractor shall integrate all relevant inputs from the FCF payloads and maintain and update all required FCF documents and data deliverables for the ISS program on a manifest and increment basis. Deliverables to ISS will be negotiated through the Payload Integration Manager (PIM) at JSC and agreed to through the PIM schedule. The Contractor shall maintain and update the FCF Payload Integration Agreement (PIA) Main Volume, and the Data Sets for all payload information along with FCF information. For each ISS Increment, the contractor shall be responsible for consolidating this data into a single electronic submittal to the ISS Payload Data Library (PDL) and the User Requirements Collection (URC) for each FCF rack and integrated Payload. The URC data inputs, also made on an increment and flight-specific basis, define the investigation operations, which include the procedures, power, thermal and data resource requirements and investigation timeline information for flight planning purposes.

The Contractor shall maintain and update, if necessary the CIR and FIR Interface Control Documents (ICDs) with the ISS (SSP57217C-ICD, SSP57218B-ICD). The Contractor shall be responsible for providing engineering products required by ISS including payload information in accordance with the integration schedule developed and negotiated with ISS.

The Contractor shall be responsible for all compatibility, interface and verification tests between FCF and payload hardware and software. The Contractor shall be responsible for scheduling, installation, checkout and verification of the payload hardware and software through ground simulators and the Ground Integration Unit (GIU) which is located in NASA GRC's Building 333 (high-bay, clean room). The Contractor shall provide the necessary support for proper integration of the payload hardware into the ground units and the performance of integrated verification and validation tests based on the payload unique Verification Plan that may include system testing, mission simulations, and ground/flight end-to-end testing.

The Contractor shall develop and maintain ground support and test equipment for both early development testing and final test and verification of the flight hardware. The Contractor shall provide payload development teams with sufficient access to FCF hardware and software during the payload hardware/software development cycle, to ensure successful operation of the final integrated system. The Contractor shall provide payload teams with sufficient personnel support, training, and training materials on the use of FCF hardware. Note: The payload development team is responsible for environmentally testing (vibration, EMI, thermal, etc.) and certifying their hardware prior to doing integrated testing with the FCF.

The contractor is responsible for providing the proper verification documentation to the ISS Program for FCF manifested hardware to the ISS. The contractor shall obtain concurrence from NASA on the all verification reports, along with the verification submittals provided to the ISS Program.

The contractor shall assume:

a) Integrated verifications are required for each of the payloads defined in the FIR and CIR Utilization Schedule. CIR: CFI, Flame Design, and SoFIE experiments; FIR: ACE-T1 and Fluid Boiling and Condensation Experiments (FBCE)
b) The contractor shall use the launch working dates as defined by the Flight Planning Integration Panel launch schedule.

The contractor shall perform the required manifesting and coordination activities to support the launching of any CIR and FIR manifested hardware on the Progress, Ariane Transfer Vehicle (ATV), JAXA H-2 Transfer Vehicle (HTV) and commercial opportunities (Space-X, Orbital, CTS etc.). Status of the manifested hardware in preparation for the assigned launch should be reviewed with NASA at the weekly status meetings. The contractor shall coordinate with NASA and hold a Pre-Ship Review (PSR) for approval to final preparations and shipment of the hardware following verification of flight readiness and closure of open work. New hardware builds (i.e., not re-flights or series hardware) shall be in accordance with the overall contract requirements for a Pre-Ship Review. FCF hardware that is re-flight or series hardware will only require a Pre-Ship Engineering Review Board in accordance with FCF-PO-PLAN-0020, FCF General System Acceptance Review Plan. Also, the contractor is responsible for meeting the IPLAT/HFIT requirements for the hardware prior to ship to the launch vehicle integration site. Each hardware item will be processed prior to shipment from GRC according to the Stowage Provisioning and Shipping Procedure for Flight Hardware. The contractor will provide the hardware to NASA for final quality approval and shipment of the hardware to the proper location.

The contractor shall work with the ISS Program to review storage and packing drawings for FCF hardware being launched to ISS. Also, the contractor shall provide to the ISS Program the export control information, technical data sheets, and Proforma information necessary to be manifested.

The contractor shall be responsible for the post-mission operations/logistics of the FCF returned hardware. The contractor shall be responsible for hardware returned to GRC, and for sample removal and delivery to the PI or payload developer team. If applicable, the contractor shall be responsible post mission testing of the returned hardware to for engineering analysis and possible readiness for refurbishment and/or anomaly assessments.

The contractor shall assume:
Four (4-6) FCF manifests per year to support CIR and FIR resupply.
The contractor shall use the launch working dates as defined by the Flight Planning Integration Panel launch schedule.
No delivery support for shipped items is required at the delivery site or launch site (ship and shoot approach).
Return of FCF resupply hardware (such as, bottles, fuel reservoirs, etc.) occurs on Space-X return missions (or other return vehicle as defined by the ISS common transport guidance).
Retrieval of time-critical samples at the launch site or earliest access area will be the responsibility of the payload developer team.

The contractor shall support discussions and activities required for the return of LMM and ACME from ISS.

Late stow/hand delivery of small items may occur for time critical events.

### 4.1.2 Safety Assessments (Carried forward)

The Contractor shall perform FCF safety hazard analysis to identify hazards and mitigation methods to assure that the proposed design does not violate any safety requirements that will endanger human life or mission success. The Contractor shall prepare and present Flight and Ground Safety Hazard Reports and Phase 0/I and Phase II Safety Compliance Data Packages to appropriate Safety Panels for the FCF hardware (only a support function for the payloads being integrated into FCF).

The Contractor shall identify safety critical structures through analysis and appropriately document the analysis. The Contractor shall maintain and update FCF Flight and Ground Safety Packages in accordance with the JSC Payload and KSC Ground Safety Review Panels' procedures, including collection of safety package inputs for the payload experiments and ground hardware, checking for completeness, developing a safety package, and assisting the payload team in presenting to the ISS

Safety Panel and other Safety Panels as required.

The Contractor shall provide assurance that the integrated FCF experiment system (FCF and Payload) meets all FCF and ISS safety and safety verification requirements (flight hazard reports). The Contractor shall perform an integrated safety analysis and test of the flight hardware that shows that all hazards are controlled or that waivers have been approved detailing acceptable risk level. These analyses and verification tests shall be documented in Flight and Ground Safety Hazard Reports and a Phase III Safety Compliance Data Package. The Contractor shall assure that all hazards that must be controlled by operational means are properly implemented in crew procedures, flight rules, and/or training. The Contractor shall participate and present the Phase III Safety Review to the appropriate Flight and Ground Safety Panels.

The contractor should assume:

a) An annual CIR safety certification is required based on the FOMA re-calibration.
b) A launch safety package is required for each FCF manifest (approximately 4 per year).
c) Participation in each of the payload development’s safety reviews identified in the CIR and FIR utilization schedule is required.
d) New hardware developments will require a Phase 0/I/II Review and a Phase III review package.

## 4.2. <u>FCF Sustaining Engineering (Carried forward)</u>

The Contractor shall provide comprehensive sustaining engineering for long duration FCF mission operations (extended to 2028) and associated ground infrastructure. The sustaining engineering activities consist of logistics support, ground infrastructure support, hardware and software maintenance, and facility upgrades.

In the implementation of the various sustaining engineering activities, new hardware, refurbished hardware, and re-flight hardware will be developed and delivered to NASA. The contractor shall provide an Acceptance Data Packages (ADP) per DID-V-05 for the delivered hardware or an updated ADP for modified hardware.

### 4.2.1. <u>Logistics and Maintenance (Carried forward)</u>

The contractor shall implement a logistics and maintenance program to support the Fluids and Combustion Facility and its associated inserts (SoFIE and FBCE) to maintain availability of the flight units in accordance with the FCF Maintenance Plan. The ISS Program has a goal of 90% availability of the facility class racks on the ISS. The contractor is responsible for performing the engineering analysis of the FCF hardware to assure long-term operations till 2028. This includes collecting the on-orbit performance data, assessing the data, developing quarterly status reports, and utilizing the collected operational trend data to establish a maintenance schedule for the CIR and FIR on-orbit racks.

The contractor shall track the FCF limited life items to assure they meet the safety and/or mission assurance for continued FCF operations. The contractor shall evaluate and prioritize maintenance operations to restore or maintain the flight units in an operational condition. The contractor shall also develop and/or maintain maintenance procedures to support maintenance operations.

The contractor shall perform mission specific spares analysis and provide NASA with a list of prioritized spare items required to support on-orbit FCF operations based on actual on-orbit run times and risk areas. Spares that are lacking on-orbit or not available on the ground, shall be identified as priority candidates for future development planning. The contractor shall annually provide a recommended list of spares to NASA for approval for completion. The contractor shall also track FCF on-orbit hardware and return reusable hardware to an operational condition to support adequate sparing and resupply resources.

The contractor shall develop the maintenance reports identified in the FCF Maintenance Plan that consists of Sparing Health and Status Report, Camera and Science, Health and Status Report, Telemetry Health and Status Report, Safety Health and Status Report, Hard Drive Health and Status Report.

The contractor shall assume:

a) The SoFIE development will include adequate spares to support the SoFIE mission life.
b) Status reports are updates to the previous report with new operational data and based on the frequency defined in the FCF Maintenance Plan.
c) Spares recommended for consideration to NASA will be provided annually. NASA will provide the approved list to the contractor within 10 days to determine the go-forward development plans within the budget constraints.

#### 4.2.2. Ground Support (Carried forward)

The Contractor shall be responsible for the on-going maintenance support of all ground support hardware and associated software, to include: the CIR, FIR and Ground Integration Units (GIUs); ground support equipment used in flight hardware development, testing, and verification; package simulators (such as, UML Simulator, IOP Simulator, etc.) and, any FCF specific hardware required in the TSC that support on-orbit payload operations. The contractor shall also maintain proper calibration of the ground support equipment that is used in the testing and maintenance of the GIUs.

##### 4.2.2.1 Ground Integration Units (GIUs) (Carried forward)

The contractor shall operate the GIUs when needed to perform anomaly resolution, new payload configuration verifications (such as SoFIE), spare hardware verifications, software testing, and software certification for the flight unit. The contractor shall maintain the configuration of the GIUs to assure that the current flight configuration can be reproduced if needed and the proper configuration for future configurations necessary to support the missions. All new hardware to interface with the GIUs shall be assessed and verified that it will not damage the GIU.

The contractor shall safely operate the Payload Rack Checkout Unit at GRC (Building 333) as part of operating the CIR and FIR GIUs. The personnel operating the PRCU shall be trained and certified for PRCU operations. The contractor shall provide between six and twelve certified operators. Also, the contractor shall assist in the testing of the PRCU water per ISS water quality specification (SSP30573) and perform regular change-out of PRCU ISS-quality water per a pre-approved schedule. The contractor shall implement the maintenance of the PRCU safety permit for the operation of the PRCU and associated support equipment at NASA.

The contractor shall assume:

a) The SoFIE development will include an SoFIE GIU that can be utilized in the CIR GIU for testing.
b) The NASA GRC's PRCU is calibrated and serviced annually under a separate contract for PRCU maintenance. The contractor will perform the water quality tests. The contractor will coordinate with the PRCU contractor for the PRCU calibration, training, and any PRCU sustaining engineering activities to assure minimal impact to the on-going operations.

##### 4.2.2.2 Gas Mixture and Parts Cleaning (Carried forward)

The contractor shall operate and maintain government furnished payload processing facilities on Glenn Research Center, including the gas mixture lab in building 332; and the parts cleaning lab and sample filling station in building 110. The facilities will be used to clean flight hardware, fill flight samples and fill flight gas bottles.

The contractor will use the facility to perform a Non-Volatile Residue (NVR) contamination test, as a secondary priority to FCF sustainment, in support of the Orion testing at the Thermal Vacuum Facility at Plumbrook Station. This testing will use samples and solvents provided by the government.

The contractor will use the gas mix facility to perform gas analysis in support of the ELP Xenon recovery program.

#### 4.2.2.3 ISS Ground Hardware (Carried forward)

The contractor shall support preparation of the FIR Engineering Model (EM) International Standard Payload Rack (ISPR) for return to the ISS program office. This effort will include removal of all non-ISS provided equipment from the ISPR and support for handling and installation of the ISPR into an ISS provided shipping container. (This activity is on hold)

#### 4.2.2.4 LMM Breadboard Microscope (Carried forward )

Provided training for operation of the LMM Breadboard Simulator.

#### 4.2.2.4 Ground Support Equipment Test Stand (Carried forward)

The contractor shall implement and maintain the GSE Test Stand configuration to allow full functional operations of LMM GIU microscope including command and telemetry interface to the TSC through the end of the LMM flight test program. The contractor shall provide hardware to implement this configuration such as a CCU simulator.

## 4.3 Sustaining Engineering

### 4.3.1 Software Sustaining Engineering (Carried forward)

The Contractor shall be responsible for providing software configuration management for the development or modification of ground and flight software, which may be developed or modified to correct software faults, work around hardware failures, or nominal upgrades to provide additional system capabilities. Software maintenance shall include keeping commercial software licenses current that are required for software maintenance and development.

The contractor shall provide Software Sustaining Engineering support in accordance with the FCF Software Sustaining Engineering Plan that includes a review of all CIR and FIR anomalies, and proposed solutions, along with software required for new upgrades. The contractor shall co-chair a SW Configuration Control Board (CCB) with NASA that approves proposals for SW modifications and release of new flight software. Software sustaining engineering will be provided for FCF developed flight and ground code and scripts including script development specific to payload requirements as outlined in their respective Integration Agreements.

The contractor shall work with NASA to prioritize the Redmine tracked software issues for resolution based on operational anomalies. The priorities shall be reviewed as part of the Non-Conformance Report Board activities. The contractor shall implement in-scope FCF software enhancements based on recommendations of the contractor and approved by NASA through the Software CCB without.

The contractor shall assume:

a) The Software SE team is Level of Effort activities (5000 man-hours per year).
b) The SE team will provide software updates (including user displays) for FIR & CIR Facility hardware, LMM hardware and SoFIE hardware as approved through the SW CCB
c) FIR Operational software updates (including scripts, TREK, and TADS) for FBCE, LMM-BIO and ACE-T Series will be implemented as approved through the SW CCB
d) CIR Operational software updates (including scripts, TREK, and TADS) for ACME and SoFIE will be implemented as approved through the SW CCB

#### 4.3.2 Hardware Sustaining Engineering (Carried forward)

The contractor shall produce upgrades and spares to FCF subsystem hardware (IOP, Image Processing and Storage Units, Electrical Power Control Unit, Diagnostics, etc.) according to design specifications to assure continued long-term support of future payloads. The contractor shall meet all design and development requirements, as well as all integration documentation.

Deliverables may include standard design review materials, flight unit hardware and software, ground units to be included in the FCF Ground Integration Unit and other FCF simulators, appropriate flight spares, integration and verification plans. As part of the integration of new FCF hardware the contractor shall update all appropriate FCF documentation including flight drawings, the Payload Accommodations Handbooks, the Interface Control Documents, all FCF Configuration Documents, etc.

The contractor shall provide an annual recommendation of spares based on the logistics and maintenance data that includes an overall cost and schedule for development/build. NASA will provide an approved listing of the spares to be developed within 10 days of the recommendation. The contractor shall procure, manufacture and/or acquire from bonded storage the necessary hardware to assemble the spare units. The spare units shall have functional and environmental testing performed and placed in bonded storage, manifested (per NASA direction) or for use on the GIU.

The contractor shall assume:

a) NASA facilities are used for all thermal and EMI environmental testing at no cost to the contractor. The contractor may recommend using other NASA facilities (Vibration, Off-Gas, Acoustic) for approval.
b) An annual calibration (performed by NASA Cal Lab) and manifesting the FOMA Cal Unit is required. However, the contractor that also perform analysis of the measurement uncertainty for possible longer calibration intervals. Not a deliverable since the FOMA Calibration Units are GRC property.

The following Spare hardware deliverables are required.

Table 4.3.3-1 Sustaining Engineering Deliverables

| Hardware/Task | P/N | Qty | Delivery Date (FHA) |
|---|---|---|---|
| ACME Data Camera | S1101MFA2000 | 1 | November 2021 (Carried forward) (due to COVID19 was 9, 6,1/2021, 12/2020) COMPLETE |
| GC Helium Bottle | 67212MFAM70400 | 1 | November 2021 (Carried forward)(was 9/2021) COMPLETE |
| GC Check Gas Bottle | 67212MFAM70600 | 4 | November 2021 (Carried forward)(was 9/2021) COMPLETE |
| FCF Hard Drives SSD (Set #1) | 67212MFAB32050 | 1 | November 2021 (Carried Forward)(was 9/2021) COMPLETE |
| FCF Hard Drives SSD (Set #2) | 67212MFAB32050 | 3 (was 6) | November 2021 (3 carried Forward/3 Deleted)(was 9/2021) COMPLETE |
| FCF 8T Hard Drives (Set #3) | 67212MFAB33050 | 3 | November 2021 (was 9/2021) COMPLETE |
| ~~FCF Magnetic Drive (Flight)~~ | ~~NA~~ | ~~6~~ | ~~May 2022~~ Deleted |
| ACME Data Camera (#2) | S1101MFA2000 | 1 | March 2023 |
| SoFIE Hard Drive ORU | BT302MA23000 | 2 | May 2022 COMPLETE |
| Adsorber Cartridge | 67212MFAM71000 | 30 | November 2021 COMPLETE |
| SoFIE Air Flow Sensor (Flight Spare) | BT302MA16005 | 1 | July 2023 |
| SoFIE Air Flow Sensor (GIU) | BT302MA16005 | 1 | July 2023 |
| SoFIE Sample Holder | BT302MA12010 | 1 | November 2023 |

#### 4.3.4.1. FOMA Calibration Unit Upgrade (Complete)

#### 4.3.4.2. ACME Data Camera ( Complete)

The contractor shall procure, assemble, test and verify 1 ACME Data Camera part number S1101MFA2000. Contractor will develop the cost basis and delivery schedule based on use of existing inventory, drawings, processes and applicable ISS and safety requirements per the ACME project.

In addition, the contractor shall procure and retain in contractor inventory procured in CCR-396 the electronic COTs assemblies and electronic parts for custom Printed Circuit Boards for 2 additional camera builds.

**COTS Assemblies**

| | | |
|---|---|---|
| RTD EMBEDDED TECHNOLOGIES | ATX104HR-EXPRESS | POWER SUPPLY MODULE |
| PERFORMANCE MOTION DEVICES | PR8258420CP2.4IOAD8.R | PC/104 MOTION CARD |
| FAULHABER MICROMO | AM10E0025 | STEPPER MOTOR WITH ENCODER |
| ALLIED VISION | GC-1380CH | PROSILICA GC CAMERA |
| NAVITAR | 1-22034 | 18 - 108 MM ZOOM LENS |
| DIGI-KEY | A4982SLPTR-T | Microstepping Motor Driver |
| B & H PHOTO VIDEO | 2821A001 ( 4156 ) | 52MM 500D CLOSE-UP LENS |

**Custom PCBs**

| | |
|---|---|
| S1101EFA2119 | CAMERA STEPPER DRIVER BOARD |
| S1101EFA3215 | ACME MOTION CONTROL INTERFACE |
| S1101EFA2120 | ACME CAMERA CONTROL POWER DISTRIBUTION BOARD |
| S1101EFA2216 | HALL EFFECT SENSOR BOARD |

#### 4.3.4.3. Spare FCF Hard Drives (COMPLETE)

Spare hard drive Set #1: The contractor shall procure, assemble, test and verify 1 FCF Hard Drives part number 67211MFAB32050. Contractor will procure an addition 6 COT's SSD drives for future end item deliverables. Contractor will develop the cost basis and delivery schedule based on use of existing inventory, drawings, processes and applicable ISS and safety requirements per the FCF project.

Spare hard drive Set #2: The contractor shall procure, assemble, test and verify 3 each FCF Hard Drives part number 67211MFAB32050. Contractor will develop the cost basis and delivery schedule based on use of existing inventory, drawings, processes and applicable ISS and safety requirements per the FCF project.

Spare hard drive Set #3: The contractor shall procure, assemble, test and verify 3 each FCF Hard Drives of part number 67212MFAB33050. Contractor will develop the cost basis and delivery schedule based on use of existing inventory, drawings, processes and applicable ISS and safety requirements per the FCF project.

#### 4.3.4.4. GC Bottles (COMPLETE)

The contractor shall procure, assemble, test and verify 1 GC Helium Bottle PN 67212MFAM70400 and 4 GC Check Gas Bottle PN 67212MFAM70600 to support SoFIE gas chromatograph analysis requirements. The contractor shall utilize GFE bottles provided from GRC inventory for long lead components needed to build the requested delivery including gas bottle quick disconnects, and valve covers. Unused part from dis-assembly of the GFE bottles to remain in ZIN inventory. Safety data and verification is included; however, flight safety certification will be deferred until a flight manifest is established.

#### 4.3.5. Upgrades (Complete)

The Contractor shall provide the management and engineering to develop hardware and associated software for upgrades to the CIR and FIR, and their associated inserts (MDCA, LMM, ACME, FBCE, SoFIE). These upgrades consist of a new IPSU, LMM Cameras, CIR Cameras, and FIR Laser. If needed, new upgrades shall be proposed by the contractor to NASA to meet new capability requirements identified for future missions and operational efficiencies.

##### 4.3.5.1. IPSU-G Development (Complete)

The contractor shall develop an upgraded IPSU that can support new science capability utilizing modern camera interfaces and significant data generation. Also, the capability to directly interface with the ISS HRDL shall be assessed and incorporated, if possible, to support faster transfer rates for the science data. The quantities and expected delivery dates for the IPSU-G hardware (and associated software) is shown in Table 4.3.5.2-1. The major milestones for the development shall be consistent with contract requirements for space flight hardware development.

Table 4.3.5.2-1 IPSU-G Upgrade Hardware

| Hardware | Qty | Milestone | Delivery Date |
|---|---|---|---|
| Software Development Unit | 2 | Assembled March 2014 | Delete. Not a deliverable. Conitinued susteaining engineering support at ZINContract End (Carried Forward) |

#### 4.3.6 CIR FOMA Sparing Study (Complete)

Transferred to ISS 2030 Extension Assessment.

#### 4.3.7 FCF Hard Drive Replacement (COMEPLETE)

Contractor will perform assessment of a direct ORU replacement for FCF Hard Drives SSD 67212MFAB32050. The replacement drive will meet the existing 2.5 inch drive format and meet the existing electrical and data interfaces provided in the CCU and FCF IPSU-G. The replacement drive will provide a minimum of 1 TB data storage and be analyzed and/or tested for suitability operating in the temperature and radiation environment of the FCF Facilities on the ISS. The contractor will test the candidate drive for performance meeting the IPSU-G data read/write flow simulating the SoFIE experiment operations in the CIR. The contractor will test the candidate drive for performance meeting the CCU data read/write flow simulating the FBCE experiment operations in the FIR. The candidate drive is envisioned to be magnetic spinning disk technology in lieu of Solid State data recorder.

#### 4.3.8 FCF External USB Drive (Carried forward)

Contractor will perform development of an ORU external USB3 drive. The replacement drive will meet the existing electrical and data interfaces provided by FCF IPSU-CL external USB Interface. The USB drive will provide a minimum of 1 TB data storage and be analyzed and/or tested for suitability operating in the temperature and radiation environment of the FCF FIR on the ISS. Contractor design will establish compliance to the requirements of the current revision of SSP 57000. The contractor will develop drawings and associated processes documenting the design of the drive. The contractor will test the candidate drive for performance meeting the IPSU-CL data read/write flow simulating the FBCE experiment operations in the FIR. The contractor will develop the concept for interfacing the drive to the flight IPSU-CL located on the FIR rack with cabling routing and mounting of drive without translation of FIR optics and allowing quick access for crew removal and replacement of the drive. Contractor shall present USB Drive drawings, analysis and requirements compliance at a design review per contractor review criteria and processes.

Contractor shall procure, assembly, test and verification hardware to meet FCF facility, safety and ISS requirements for delivery of interface cables and USB drives as indicated in Table 4.3.8-1

Table 4.3.8-1 USB Drive Deliverables

| Hardware/Task | P/N | Qty | Delivery Date (FHA) |
|---|---|---|---|
| FCF Hard Drive 2 (USB Drive) | 67211MFAB32150 | 9 | August 2022 COMPLETE |
| FCF Hard Drive 2 (USB Drive) | 67211MFAB32150 | 27 | Jan 2023 |
| CCU USB SSD Cable | 67213EFAF40048 | 1 | August 2022 COMPLETE |
| CCU USB SSD Cable | 67213EFAF40048 | 4 | Jan 2023 |
| IPSU-CL USB SSD Cable | 67213EFAF30060 | 1 | August 2022 COMPLETE |
| IPSU-CL USB SSD Cable | 67213EFAF30060 | 4 | Jan 2023 |
| IPSU-G USB SSD Cable | 67212EFAH20723 | 1 | August 2022 COMPLETE |
| IPSU-G USB SSD Cable | 67212EFAH20723 | 4 | Jan 2023 |

### 4.3.9 Component Sparing (Carried Forward)

Contractor will conduct procurement and assembly of replacement components as identified in the table. Components will be tested, verified and manifested for flight for their designated flight usage. The contractor will develop additional drawings and processes as need to support manifesting, stowage and on-orbit installation the components. These processes include crew procedures and on-orbit functional testing. Additional components identified through the in-process FOMA Sparing Study may be added to this set of components.

Table 4.3.9-1 Component Sparing Deliverables

| Component Nomenclature | Part Number | QTY | Delivery Date |
|---|---|---|---|
| IRR Water Return QD | PREECE P/N: 51410-2-06-1-V-TF06-C-G | 2 | March 2023 (was Oct 2022) |
| IRR Water Supply QD | PREECE P/N: 51410-2-06-1-V-TF06-C-GY | 2 | March 2023 (was Oct 2022) |
| ~~IRR High Pressure Nitrogen QD~~ | ~~PREECE P/N: 51129-06-F04VD~~ | | ~~DELETED~~ |
| ~~IRR Diluent / Premixed Gas QD~~ | ~~PREECE P/N: 51316-2-08-F08-V~~ | | ~~DELETED~~ |
| ~~IRR Fuel Manifold QD~~ | ~~67212MFAM10100 QD disconnect~~ ~~PREECE P/N: 942-042F04VD~~ | | ~~DELETED~~ |
| Gas Supply Bottle Manifold QD | 67212MFAM10100 QD Disconnect 51431-06-IXF06VD | 3 | March 2023 (was Oct 2022) |
| ¼" Low Pressure 3-Way Solenoid Valve Assembly (SV23) | 67212MFAM54000 | 2 | Sept 2022 COMPLETE |
| High Flow Inlet with Check Valve Solenoid Assembly (SV19) | 67212MFAM52100 | 2 | Sept 2022 COMPLETE |

| Component Nomenclature | Part Number | QTY | Delivery Date |
|---|---|---|---|
| 1/2" Low Pressure Outlet Solenoid Operated Valve Assembly (SV21) | 67212MFAM56000 | 2 | Sept 2022 COMPLETE |
| 1/4" Low Pressure Inlet Solenoid Operated Valve Assembly | 67212MFAM52000 | 1 | Dec 2022 (was Sept 2022) |
| 1/4" Low Pressure Inlet with Check Valve Solenoid Assembly | 67212MFAM52100 | 1 | Sept 2023 |
| 1/4" Low Pressure Outlet Solenoid Operated Valve Assy. | 67212MFAM53000 | 2 | Sept 2023 |
| 1/4" High Pressure Inlet, Solenoid Operated Valve Assy. | 67212MFAM50000 | 3 | Sept 2023 |
| 1/2" Low Pressure Inlet Solenoid Operated Valve Assembly | 67212MFAM55000 | 1 | Sept 2023 |
| Solenoid Operated Valve Inlet High Flow Assembly | 67212MFAM57000 | 1 | Sept 2023 |
| 1/4" High Pressure Inlet Solenoid Operated Valve w/Check Valve Assy. | 67212MFAM50100 | 1 | Sept 2023 |
| High Flow Inlet with Check Valve Solenoid Assembly | 67212MFAM57100 | 1 | Sept 2023 |
| Gas Chromatograph Solenoid Operated Valve Assembly | 67212MFAM58000 | 1 | Sept 2023 |
| 1/8" Low Pressure Inlet Solenoid Operated Valve | Parker PN 7121FBF4NF00 | 1 | Sept 2023 |

#### 4.3.10 ACME Color Camera – Spare #2 (Carried forward)

Contractor will conduct procurement of parts required for complete of two ACME Color Camera P/N S1101MFA2000. Procurement is exclusive of flight components available in ZIN stock. Parts for the ACME Camera Electronics kits procured under CCR-396 are to be utilized for this effort.

Contractor will perform assembly, test, and verification of a single ACME Color Camera. Contractor will develop the cost basis and delivery schedule based on use of existing drawings, processes and applicable ISS and safety requirements per the FCF project.

#### 4.3.11 Storage and Return of Flight Payloads (Carried forward)

Contractor will coordinate return of ACME flight hardware after completion of its experiment campaign. Contractor will perform cleaning, fluid drain and dryout, and physical configuration changes as needed to prepare ACME return payload equipment for long term storage. Contractor will coordinate with GRC bonded storage to ensure appropriate parts identification and environmental conditions for storage of the hardware.

Contractor will coordinate return of LMM flight hardware after completion of its experiment campaign. Contractor will perform cleaning, fluid drain and dryout, and physical configuration changes as needed to prepare LMM return payload equipment for long term storage and/or updates to support museum exhibit development. Contractor will coordinate with GRC bonded storage to ensure appropriate parts identification and environmental conditions for storage of the hardware. Contractor will coordinate with GRC exhibits to develop the display concept.

#### 4.3.12. SoFIE Hard Drive ORU (COMPLETE)

The contractor shall procure, assemble, test and verify 2 SoFIE Hard Drive ORU's using the existing BT302MA23000 drawing as the design basis. Contractor will ECO the BT302MA23000 drawing or create a new drawing to reflect an update to the COTs SATA drive incorporated to the assembly. The updated drive will meet the existing 2.5 inch drive format and meet the existing electrical and data interfaces provided in the SoFIE AVP.

#### 4.3.13. SoFIE Air Flow Sensor

The contractor shall procure, assemble, test and verify 1 SoFIE Air Flow Sensor ORU for flight manifest using the existing BT302MA16005 drawing as the design basis. .

The contractor shall procure, assemble, and test 1 SoFIE Air Flow Sensor ORU for use in the SoFIE GIU using the existing BT302MA16005 drawing as the design basis. .

#### 4.3.14. SoFIE Sample Holder

The contractor shall procure, assemble, test 1 Sample Holder ORU for flight manifest using the existing BT302MA12010 drawing as the design basis. .

## 5. Milestones & Reviews (Carried forward)

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

a) Integration Reviews/Telecons with JSC per ISS Integration Template (Carried forward from B, A) Carried Forward
b) FCF Weekly Sustaining Engineering meeting. (Carried forward from B, A) Carried Forward
c) NCR Review Board meetings, as required (assume weekly). (Carried forward from B, A) Carried Forward
d) ISS Payload Risk Meeting (Monthly). (Carried forward from B, A) Carried Forward
e) Monthly SpaceDOC II Financial Review meeting (Carried forward from B, A) Carried Forward
f) SW Control Board meeting (assume weekly). (Carried forward from B, A) Carried Forward
g) POIWG Quarterly Meeting (Huntsville, AL) (Carried forward from B, A) Carried Forward
h) SAR Reviews (for all Manifests) (Carried forward from B, A) Carried Forward

## 6. Travel (Carried forward)

The contractor shall support, at a minimum, the following travel requirements:

a) Test support for off-gas test at White Sands, NM
b) FCF Trainer Maintenance at JSC
c) Vendor Coordination meetings, as required
d) JSC Control Board presentation, assume 1 per year (Houston TX)
e) Support at KSC (Delivery, Integration & Coordination)

f) Support at JSC (Delivery, Integration & Coordination)
g) Support Phase 0/1 and Phase II Safety Review at JSC for Payloads
h) Support Integrated Phase III Safety Review at JSC for FBCE and SoFIE
i) JSC Coordination Meetings
j) Radiation Test Facility

## 7. Deliverables (Carried forward)

Document, hardware and software deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL).

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to the following individuals:

**All Deliverables:**

Task Manager, ISS and Human Health Project Office (Ronald Sicker, Mail Stop 77-7, Ronald.J.Sicker@nasa.gov )

Configuration Management Office, MSI/Donna Clements, Mail Stop 54-1, Donna.J.Clements@nasa.gov

**Deliver courtesy copies of cover letter only to:**

Contracting Officer (Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov)

Contracting Officer's Representative, ISS & Human Health Office (Kelly Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )

Program Manager, ISS Research Facility, Mail Stop 333-1 MSI/Kevin M. McPherson, kevin.m.mcpherson@nasa.gov

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

A Contracting Officer letter may accomplish changes to the personnel mentioned above.

### 7.1 Hardware (Carried forward)

The contractor shall deliver the following hardware and software items to the Government with supporting documentation (specifications, drawings, test procedures, analysis/test reports, and operating/maintenance manuals as applicable):

a) Sustaining Engineering Hardware per table 4.3.3-1
b) USB Hard Drives per table 4.3.8-1.
c) Component Sparing Deliverables per table 4.3.9-1

### 7.2 Software (Carried forward)

The contractor shall deliver the following software items to the Government:

a) Software as authorized by SW Configuration Control Board

### 7.3 Documentation (Carried forward)

Document deliveries shall be prepared, documented, and delivered in compliance with the Contract Data Requirements List (CDRL), if applicable.

The contractor shall provide the following documents:

a) Contractor Work Plan, per DID PM-06 within 30 days of contract start
b) Submit a Monthly Task Report in accordance with DID CD-03
c) Lessons Learned Report per DID PA-17 (yearly)
d) CIR/FIR On-orbit Maintenance Reports (frequency per FCF Maintenance Plan) (Carried forward from D, C, B, A)
e) Verification Reports on Manifested Hardware (NASA Concurrence required, by Pre-Ship Review except for packaging) (Carried forward from D, C, B, A)
f) CIR Payload Accommodations Handbook Updates (as required, yearly review for updates required) (Carried forward from D, C, B, A)
g) FIR Payload Accommodations Handbook Updates (as required, yearly review for updates required) (Carried forward from D, C, B, A)
h) Acceptance Data Packages for delivered hardware (per manifested hardware, new spare builds, new hardware) (Carried forward from D, C, B, A)
i) Design Review Packages (per development schedules) (Carried forward from D, C, B, A)
j) Payload-Unique Integration Agreement (IA):
k) Assessment Study to extend the service life of FCF on ISS to 2030

**8. <u>Reporting Requirements (Carried forward)</u>**

a) Contractor Financial Management Reporting per DID CD-01 with the following reporting structure (or similar, approved by NASA) ON-GOING:

I. Project Management/Support
II. Product Assurance
III. Systems Engineering (FCF Integration)
IV. FCF Sustaining Engineering
  i. Logistics & Ground Support
  ii. Software SE
  iii. Hardware SE
  iv. IPSU-G Development
  v. LMM Upgrades
  vi. FIR Laser Upgrade
  vii. CIR IAM Upgrade
  viii. IPSU-CL development

b) Monthly reporting per DID CD-03 ON-GOING

**9. <u>Government Furnished Equipment (Carried forward)</u>**

a) GFE items required in execution of this effort are provided in the listing provided within the RFP. Proper certification and/or identification of needed certifications of any Government provided GFE is the responsibility of the contractor.

b) Hardware and software turned over to the Government (CIR Flight Unit, FIR Flight Unit, FIR GIU, CIR GIU, etc.) shall be made available to the contractor for execution of this delivery order. Hardware that remains in Government facilities will remain the property of the Government and made available for usage when required. Property that will remain at the contractor's site shall be identified and will be provided to the contractor via a DD Form 1149 for usage. The contractor's modification of Government held hardware and software shall be requested via NASA C-652 and a report filed via NASA C-654 upon completion of the modifications.

c) All spares required for manifest that have been turned over to the Government will be provided to the contractor for final testing and verifications to meet the specific launch requirements.

**10. Government Furnished Facilities (Carried forward)**

The following Government facilities shall be available to the contractor, as needed:

a) Power Space Facility (Bldg. 333) – High Bay (100E)
b) Telescience Support Center (Bldg. 333)
c) Thermal Environmental Chambers in Building 333A
d) EMI Laboratory in Building 333A
e) Structural Dynamics Laboratory
f) 2.2 Second Drop Tower Facility
g) Zero G Drop Tower Facility (Bldg. 110)
h) Calibration Lab
i) FOMA Lab in Building 110
j) FBCE Lab in Building 110 and 333
k) Gas Mix Facility in Building 332

**11. Government Contacts (Carried forward)**

The contractor shall have access to the following for consultation:

a) FCF Project Manager
b) FCF Operations Manager
c) CIR Payloads Project Manager
d) FIR Payloads Project Manager
e) FCF Chief Engineer
f) S&MA Lead
g) Mission Integration and Planning Project Manager
h) FBCE Project Manager

**12. Foreign Travel (Carried forward)**

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

**13. Acronym List (Carried forward)**

| Acronym | Description |
|---|---|
| **ACE** | Advanced Colloids Experiments |
| **ACE-T** | ACE-Temperature |
| **ACME** | Advanced Combustion via Microgravity Experiments |
| **ADP** | Acceptance Data Package |
| **ATV** | Ariane Transfer Vehicle |
| **AVP** | Avionics Package |
| **BT** | Base Task |
| **CCB** | Configuration Control Board |
| **CCR** | Configuration Change Request |
| **CCU** | Confocal Control Unit |
| **CDRL** | Contract Data Requirements List |
| **CFI** | Cool Flame Investigation |
| **CIR** | Combustion Integration Rack |
| **COTS** | Commercial Off The Shelf |
| **DID** | Data Item Description |
| **eCC** | electronic Country Clearance |
| **ELP** | Microgravity Investigation (Experiment) of Thermophysical (Levitation) Properties |
| **EM** | Engineering Model |
| **EMI** | Electromagnetic Interference |
| **FBCE** | Flow Boiling Condensation Experiment |
| **FCF** | Fluids and Combustion Facility |
| **FIR** | Fluids Integration Rack |
| **FOMA** | Fuel Oxidizer Management Assembly |
| **GFE** | Government Furnished Equipment |
| **GIU** | Ground Integration Unit |
| **GRC** | Glenn Research Center |
| **GSE** | Ground Support Equipment |
| **HFIT** | Human Factor Integration Test |
| **HRDL** | High Rate Data Link |
| **HTV** | H-II Transfer Vehicle |
| **IA** | Integration Agreement |
| **IAM** | Image Acquisition Modules |
| **ICD** | Interface Control Document |
| **IDD** | Interface Definition Documents |
| **IOP** | Input/Output Processor |
| **IPLAT** | ISS Payload Label Approval Team |
| **IPSU** | Image Processing and Storage Unit |
| **IPSU-CL** | Image Processing and Storage Unit-Camera Link |

| Acronym | Description |
|---|---|
| **IPSU-G** | IPSU-GigE Vision |
| **ISPR** | International Standard Payload Rack |
| **ISS** | International Space Station |
| **JAXA** | Japan Aerospace eXploration Agency |
| **JSC** | Johnson Space Center |
| **KSC** | Kennedy Space Center |
| **LMM** | Light Microscopy Module |
| **LMM-BIO** | Light Microscopy Module Biophysics |
| **MDCA** | Multi-User droplet Combustion Apparatus |
| **MIP** | Mission Integration Planning |
| **MSG** | Microgravity Science Glovebox |
| **MWA** | Maintenance Work Area |
| **NASA** | National Aeronautics and Space Administration |
| **NCR** | NonConformance Report |
| **NPR** | NASA Procedural Requirements |
| **NVR** | Non-Volatile Residue |
| **ORU** | Orbital Replaceable Unit |
| **PDL** | Payload Data Library |
| **PI** | Principal Investigator |
| **PIA** | Payload Integration Agreement |
| **PIM** | Payload Integration Manager |
| **POIWG** | Payload Operations and Integration Working Group |
| **PRCU** | Payload Rack Checkout Unit |
| **PSR** | Pre-Ship Review |
| **S&MA** | Safety and Mission Assurance |
| **SAR** | System Acceptance Review (formerly Pre-Ship Review) |
| **SATA** | Serial Advanced Technology Attachment |
| **SE** | Sustaining engineering |
| **SoFIE** | Solid Fluid Ignition and Extinction |
| **SpaceDOC-2** | Space Flight Systems Development and Operations Contract-2 |
| **SSD** | Solid-State Drive |
| **SSP** | Space Station Program |
| **STS** | Space Transportation System |
| **SW** | Software |
| **TSC** | Telescience Support Center |
| **UML** | Universal Mounting Location |
| **URC** | User Requirements Collection |
| **USLab** | United States Laboratory |
| **VIP** | Vehicle Integration Panel |

**SpaceDOC-2 Base Task-2**
**Acceleration Measurement Project (AMP)**
**Operations and Development**
**Contract Performance Period 01/01/2014 to 03/31/2023**
**For the Performance Period 10/1/2021 to 11/30/2023**

# 1. Introduction

The Acceleration Measurement Project at the Glenn Research Center (GRC) is comprised of three closely related projects: the Microgravity Acceleration Measurement System (MAMS) project, the Space Acceleration Measurement System (SAMS) project, and the Principal Investigator Microgravity Services (PIMS) project. The MAMS and SAMS projects are flight instruments that provide real-time, on-board acceleration measurement on the International Space Station (ISS). The PIMS project provides real-time and offline analysis of the acceleration data received from these unique instruments. As a consequence of the level of interdependence that exists between these projects, the effort to operate these acceleration payloads in the most efficient manner requires a consolidated task. Consequently, this task covers the following payloads and functions: Microgravity Acceleration Measurement System (MAMS), Space Acceleration Measurement System (SAMS) and Principal Investigator Microgravity Services (PIMS).

# 2. Background

The SAMS and MAMS payloads were launched on Space Shuttle Flight 6A (April 2001) and have been operating on board the International Space Station (ISS) since April 2001, with operations through the present time. Given the maturity of these projects, the focus of this task will largely be operations and sustaining engineering, including the completion of any verifications, safety reviews, and integration activities consistent with the long-term support of these instruments and their sustained operations.

The SAMS instrument consists of an ISS laptop based Control Unit (CU) mounted externally to equipment racks in the United States laboratory. The SAMS CU provides the command interface to the ISS for all SAMS equipment and serves as a collection point and downlink interface for all SAMS equipment located within the ISS pressurized work volume.

The SAMS equipment consists of two different sets of vibratory accelerometer packages. The original SAMS technology that flew on flight 6A has two components: an Electronics Enclosure (EE) and a Remote Triaxial Sensor - Sensor Enclosure (RTS-SE). The RTS-SE contains the actual tri-axial accelerometers and the EE serves as a connection point for up to two RTS-SEs, routing their data to the SAMS CU for downlink to PIMS ground software for processing and archival. The second type of SAMS accelerometer package is the Triaxial Sensor Head – Ethernet Standalone (TSH-ES). The TSH-ES communicates directly to the SAMS CU through the ISS Ethernet. Operations and sustaining engineering shall support all current on board SAMS technologies.

The MAMS instrument is located in EXPRESS rack #1 and consists of a locker volume containing two instruments: a SAMS-like sensor called the High-Resolution Accelerometer Package (HiRAP) and the OARE Sensor Subsystem (OSS). In addition to the collection of the HiRAP vibratory acceleration data, the primary purpose of the MAMS instrument is the collection of the quasi-steady acceleration data from the OSS. Both the HiRAP and OSS acceleration data are routing to the ground the MAMS instrument computer, located within the MAMS locker volume.

# 3. Applicable Documents

a) NPR 7120, NASA Space Flight Program and Project Management Requirements
b) NPR 7123, NASA Systems Engineering Processes and Requirements
c) PIMS-ISS-001revB, PIMS Software Requirements for Processing Acceleration Data from the International Space Station
d) PIMS-ISS-100_revBaseline, PIMS International Space Station System Reference Document
e) PIMS-ISS-101_revBaseline, PIMS International Space Station PIMS Acceleration Data File Description Document
f) SAMS-II-003_H, SAMSII Systems Requirements Document
g) SAMS-SPC-001_E, SAMSII System Specification Document
h) SAMS-INT-001_D, SAMSII Agreement and Interface Definition Document (AIDD) for ISS

# 4. Performance Work Statements

The performance for this task is divided into the following sections:

1. AMP Integration
    a. AMP to Payload Integration
    b. AMP to ISS Integration
    c. AMP Hardware Delivery to the ISS

2. Operations – General
    a. AMP Operations and On-Orbit Support
    b. AMP Training
    c. PIMS Ground Operations

3. AMP Sustaining Engineering
    a. Ground Software Support
    b. Software Sustaining Engineering
    c. Hardware Sustaining Engineering

4. AMP Non-ISS Based Acceleration Measurement and Analysis Support
    a. Characterization of NASA GRC's Zero Gravity Facility (ZGF)

## 4.1. AMP Integration (Section Carried Forward)

The AMP integration effort involves efforts required to integrate AMP hardware with other payloads, overall integration with the ISS, conducting integrated verification, hardware safety assessments, and efforts required to manifest AMP hardware for delivery to the International Space Station.

### 4.1.1. AMP to Payload Integration

The AMP acceleration measurement hardware is designed to provide acceleration measurement capabilities for microgravity payloads in a variety of carriers (EXPRESS racks, CIR, FIR, MSG). The contractor team is required to provide integration documentation and integration products to allow the AMP hardware to be utilized in support of microgravity experiments within these carriers.

a. Develop Interface Control Documents (ICD) and Integration Definition Documents to describe AMP hardware

#### 4.1.2. AMP to ISS Integration

The AMP acceleration measurement hardware needs to satisfy integration requirements for operations on the ISS. The contractor team is required to provide the following in this regard:

a. Deliver Certification of Flight Readiness (CoFR) and Requirements Change Assessment Report (RCAR) data requirements for MAMS on-orbit hardware.
b. Deliver Certification of Flight Readiness (CoFR) and Requirements Change Assessment Report (RCAR) data requirements for SAMS on-orbit hardware.

#### 4.1.3. AMP Hardware Delivery to the ISS

The contractor team is responsible for the delivery of any AMP hardware required for flight to the ISS. This includes, but is not limited to, the SAMS Control Unit upgrade.

a. The contractor team is responsible for any verification activities associated with the delivery of AMP hardware to the ISS.
b. The contractor team is responsible for any safety verifications and safety assessment associated with the delivery of AMP hardware to the ISS.
c. The contractor team is responsible for the coordination of any manifest activities associated with the delivery of AMP hardware to the ISS.

### 4.2. Operations - General

MAMS is operating on the ISS supporting various microgravity events, including ISS reboost events, dockings and undocking and various activities including crew exercise. The MAMS payload is located in EXPRESS (Expedite the PRocessing of Experiments to Space Station) Rack 1 on board the ISS.

SAMS is on board the ISS and provides ISS payloads with measurement of the vibratory and transient acceleration environment on the ISS. The SAMS Control Unit (CU) is mounted externally to EXPRESS Rack 1. The remaining powered SAMS components are distributed within the 3 ISS laboratories: the US Lab, the Columbus Module, and the Japanese Experiment Module (JEM).

PIMS work will consist of acceleration data analysis, acceleration data archival, and acceleration data distribution for experiments on board the ISS.

#### 4.2.1. AMP Operations and On-Orbit Support

a. Provide TSC Operations support for AMP, including notification of AMP scheduled operations and plans for microgravity measurement support.
b. Provide on-orbit operations support for SAMS ISS hardware: SAMS Triaxial Sensor Head Ethernet Standalone (TSH-ES), Remote Triaxial Sensor – Sensor Electronics (RTS-SE), Remote Triaxial Sensor – Electronics Enclosure (RTS-EE), SAMS Seat Track Devices (STD), and the SAMS Control Unit (CU).
c. Review, update or provide inputs as required for AMP on-orbit procedures for all AMP on-board hardware.
d. Support increment changeover of password/security maintenance and Mission Operations Plan (MOP) changeovers for AMP ground systems.
e. Maintain the SAMS electronic console logbook capabilities and expand the SAMS electronic console logbook capabilities to include logging capabilities for MAMS.
f. PDL C&DH inputs for the AMP equipment will be provided and maintained to support operations.
g. Track and close out Payload Anomaly Report System (PARS) as they are opened against SAMS or MAMS hardware, software, or operations.

The contractor shall assume:

a. The contractor shall assume that the SAMS/PIMS workstations, and associated equipment, in the TSC will need to be replaced every three years. The contractor shall assume the material costs will be $50K for FY23.

### 4.2.2. AMP Training

a. Review and update the MAMS TSC Console Manual
b. Review and update the SAMS TSC Console Manual
c. Provide AMP crew training briefing support, including an assessment of the development of any on-board Crew Based Training (CBT) videos required to support AMP on-orbit operations.

### 4.2.3. PIMS Ground Operations

a. Create data files and required documentation as requested by Lead Increment Scientist (LIS) or for the Principal Investigators (PI's).
b. Generate microgravity handbook pages to document known acceleration environment disturbance sources for use by the ISS and PI communities.
c. Generate the Acceleration Environment Characterization Research Mini-Book and support Mini-book update efforts.
d. Provide support to maintain the capability to process and store acceleration data from the Japanese Aerospace Exploration Agency (JAXA) Microgravity Measurement Apparatus (MMA).
e. Provide support to maintain the capability to process and store acceleration data from the European Space Agency (ESA) microgravity measurement system.
f. Refresh the PIMS ground computers required for real-time data acquisition every 3 years
g. Evaluate, procure, and implement appropriate updates to the PIMS acceleration data archival systems as required to support ISS operations.

## 4.3. AMP Sustaining Engineering

### 4.3.1. Ground Software Support

The AMP ground software plays and integral role in the operation of the AMP flight hardware and in the processing, archival, and analysis of the acceleration data received from the flight systems.

a. Provide maintenance to the ground software directly supporting real-time and near real-time on-orbit operations, including resolution of anomalies and implementation of enhancements.
b. Provide maintenance to the ground software directly supporting processing, archival, and analysis of acceleration data, including resolution of anomalies and implementation of enhancements.
c. Develop new tools for the processing and analysis of acceleration data.

### 4.3.2. Software Sustaining Engineering

The AMP flight software plays an integral role in the operation of the AMP hardware. The command and telemetry functionality of the flight AMP software systems is critical to the long-term operations and availability of the AMP systems.

a. Provide maintenance to the flight software directly supporting real-time and near real-time on-orbit operations, including resolution of anomalies and implementation of enhancements.
b. Develop new tools for the on-orbit processing and analysis of acceleration data.

### 4.3.3. Hardware Sustaining Engineering

#### 4.3.3.1. Upgrades

The SAMS Control Unit is housed in the current generation ISS laptop and is required to operate in all next generation ISS laptops to address the long-term viability of the SAMS measurement system to provide acceleration measurement support for the International Space Station. The Control Unit upgrade effort will address the migration of all SAMS Control Unit software to all subsequent ISS laptops through the period of performance.

a) The Control Unit Upgrade development will utilize ISS Laptop computers as the host system.
b) The Control Unit upgrade development will support all available SAMS sensor technologies.
c) The Control Unit will not be housed in an ISIS drawer and will operate in EXPRESS Rack Interface Controller (RIC) bypass mode.
d) Unit for the Control Unit Upgrade will be developed and provided for training purposes and for ground unit purposes.
e) Integrated testing will be conducted at the Space System Integrated Test Facility (SSITF) at MSFC and at the Joint Station LAN facility at JSC. Two integrated tests will be conducted at the SSITF, one for unit functionality and one prior to turnover to MSFC for integration.
f) PDL C&DH inputs for the Control Unit will be provided to support early development of MSFC C&DH products required to support integrated testing for the Control Unit upgrades.
g) Upgrades to the SAMS ground software as required to support SAMS Control Unit software changes will be provided.

The contractor shall assume:

a) The contractor shall assume that the development of the CU conversion is complete, however additional testing and on-orbit commissioning needs to occur.

## 4.4. AMP Non-ISS Based Acceleration Measurement and Analysis Support

### 4.4.1. Characterization of NASA GRC's Zero Gravity Facility (ZGF)

NASA Glenn's Zero Gravity Facility (ZGF) is a 5 second drop tower facility used to provide a short duration microgravity environment. The ZGF needs AMP support to characterize the quality of the microgravity environment and to provide recommendations for improving the quality of the microgravity environment experience by investigations using the ZGF for experimentation.

a. AMP will utilize an existing SAMS TSH-ES ground unit to characterize the quality of the basic ZGF microgravity environment.
b. AMP will use the SAMS based characterization data to develop recommendations for additional testing and to develop recommendations for facility improvements to improve the quality of the microgravity environment provided by the ZGF.

The contractor shall assume:

a. One (1) SAMS TSH-ES unit will be available for ZGF microgravity environment characterization.
b. A recommendation package will be generated and presented to the ZGF owners for review and concurrence.

## 5. Milestones & Reviews

The following are key milestones the contractor team shall meet and reviews that require support from the contractor team.

a) PI Teleconferences, as needed (Carried forward from A, B, C)
~~b)~~ NASA management meetings and reviews, as needed (Carried forward from A, B, C)
c) Support procedural review telecons, i.e., Joint Integrate Test (JIT), LIS, and Daily Science Tag as needed. (Carried forward from A, B, C)
d) Engineering recommendation package for improvements to the ZGF environment. – Carried Forward

## 6. Travel

The following are travel support requirements the contractor team shall be required to attend.

a) Semi-annual POIWG at MSFC in support of AMP operations, as needed
b) Conferences to disseminate microgravity environment analysis results – two conferences per year (assume: Denver, CO and Orlando, FL)

## 7. Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Kevin M. McPherson, kevin.m.mcpherson@nasa.gov

Configuration Management Office, MSI/Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, kelly.a.bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

A Contracting Officer letter may accomplish changes to the personnel mentioned above.

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### 7.1. Hardware and Software Deliverables

The contractor shall complete the design, assembly, integration, and test of the hardware as required in the implementation of task.
There are no planned hardware and software deliverables planned during this period of performance.

### 7.2. Documentation

Document deliveries shall be prepared, documented, and delivered in compliance with Contract Data Requirements List (CDRL).

The contractor shall provide the following documents:
a) Contractor Work Plan. ON-GOING – Carried Forward Carried Forward
b) Submit a Monthly Task Report ON-GOING – Carried Forward Carried Forward
c) Lessons Learned Report (annually) ON-GOING – Carried Forward Carried Forward
d) Report for recommendations to the ZGF. – Carried Forward Carried Forward

## 8. Reporting Requirements

a) Contractor Financial Management Reporting per DID CD-01 with the following reporting structure (or similar, approved by NASA) ON-GOING: – Carried Forward Carried Forward

I. Project Management/Support
II. AMP Operations
III. AMP Sustaining Engineering
IV. AMP Non-ISS Based Acceleration Measurement and Analysis Support

b) Monthly reporting per DID CD-03 ON-GOING

## 9. Government Furnished Equipment

The following are GFE for this delivery order.
a) The Space Station Program is supplying the ISS laptops needed for the flight and ground systems required for the SAMS Control Unit upgrade.
b) SAMS TSH-ES ground systems require for verification testing.
c) SAMS RTS-EE and RTS-SE ground systems required for verification testing.
d) MAMS Flight Unit, hardware spares, and MAMS specific Ground Support Test Equipment.

## 10. Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:
a) Thermal Environmental Chambers in Building 333A
b) Structural Dynamics Laboratory.
c) Electromagnetic Interference Laboratory in Building 333A
d) Usage Elective: GRC Instrumentation Shop
e) GRC Acoustics Test Facility
f) GRC Telescience Support Center (TSC, Bldg. 333) and satellite facilities

g) Marshall Space Flight Center (MSFC) Off-Gassing Facilities
h) Marshall Space Flight Center (MSFC) Space System Integration Test Facility (SSITF)
i) Johnson Space Center (JSC) Joint Station LAN Test Facility (JSL)
j) GRC Plum Brook Station

## 11. Government Contacts

The contractor shall have access to consultation with:

a) GRC MAMS, SAMS, PIMS, FCF Project Managers
b) GRC / National Center for Space Exploration Research (NCSER) Project Scientists
c) MSFC ISS Ground Support Personnel
d) MSFC integration discipline engineers
e) MSFC Microgravity Science Glovebox (MSG) personnel
f) GRC QA personnel
g) JSC ISS Structures personnel
h) JAXA Microgravity Measurement Apparatus (MMA) personnel
i) ESA Microgravity Measurement system personnel

## 12. Acronym List

| Acronym | Description |
|---|---|
| AIDD | Agreement and Interface Definition Documents |
| AMP | Acceleration Measurement Program |
| BCTA | Bias Calibration Table Assembly |
| BT | Base Task |
| C&DH | Command and Data Handling |
| CBT | Crew Base Training |
| CDRL | Contract Data Requirements List |
| CIR | Combustion Integration Rack |
| CoFR | Certification of Flight Readiness |
| CU | Control Unit |
| DID | Data Item Description |
| EE | Electronic Enclosure |
| ERB | Engineering Review Board |
| ESA | European Space Agency |
| ExPRESS | Expedite the Process of Experiments to the Space Station Rack |
| FCF | Fluids and Combustion Facility |
| FIR | Fluids Integration Rack |
| FY | Fiscal Year |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| HiRAP | High Resolution Accelerometer Package |
| ICD | Interface Control Document |
| ISS | International Space Station |

| Acronym | Description |
|---|---|
| **JAXA** | **Japan Aerospace eXploration Agency** |
| **JEM** | **Japanese Experiment Module** |
| **JIT** | **Joint Integration Test** |
| **JIT** | **Joint Integrate Test** |
| **JSC** | **Johnson Space Center** |
| **JSL** | **Joint Station LAN Test Facility** |
| **LAN** | **Local Area Network** |
| **LIS** | **Lead Increment Scientist** |
| **MAMS** | **Microgravity Acceleration Measurement System** |
| **MMA** | **Microgravity Measurement Apparatus** |
| **MOP** | **Mission Operations Plan** |
| **MSFC** | **Marshall Space Flight Center** |
| **MSG** | **Microgravity Science Glovebox** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NCSER** | **National Center for Space Exploration Research** |
| **NPR** | **NASA Procedural Requirement** |
| **OSS** | **OARE Sensor System** |
| **PARS** | **Payload Anomaly Report System** |
| **PDL** | **Payload Data Library** |
| **PI** | **Principal Investigator** |
| **PIMS** | **Principal Investigator Microgravity Services** |
| **POIWG** | **Payload Operations and Integration Working Group** |
| **QA** | **Quality Assurance** |
| **RCAR** | **Requirements Change Assessment Report** |
| **RIC** | **Rack Interface Control** |
| **RTS** | **Remote Triaxial Sensor** |
| **SAMS** | **Space Acceleration Measurement System** |
| **SE** | **Sensor Enclosure** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SSITF** | **Space System Integrated Test Facility** |
| **STD** | **Seat Track Device** |
| **TSC** | **Telescience Support Center** |
| **TSH-ES** | **Triaxial Sensor Head-Ethernet Standalone** |
| **ZGF** | **Zero Gravity Facility** |

**Base Task #6 Fluids and Combustion Facility (FCF) Project:**
**Facility Integration and Operations (FIO)**
**Contract Period 1/1/2014 to 3/31/2023**
**For the Performance Period 10/1/2021 to 11/30/2023**

## 1. Introduction

The Fluids and Combustion Facility (FCF) Project consists of the Combustion Integrated Rack (CIR) and the Fluids Integrated Rack (FIR). The CIR also includes its payload inserts, the Advanced Combustion via Microgravity Experiments (ACME) and the Solid Fluid Ignition & Extinction (SoFIE). The FIR also includes its payload inserts, the Light Microscopy Module Enhancements (LMME) and the Flow Boiling Condensation Experiment (FBCE).

The CIR and FIR are in the operations phase that includes the flight unit operations for physical science utilization of the ISS, along with sustaining engineering of the flight and ground infrastructure. The flight units on the ISS, as well as the units on the ground (Ground Integration Units, the Ground Engineering Unit, and the Trainers at NASA JSC) need to be operated and maintained.

This statement of work will be for operations and integration activities which can be broken down between three teams: Operations Team, TSC Team, and MIP Team. The Operations Team is responsible for FCF operations that include development of operations products, on-orbit crew and ground personnel training/certification, and the real time operations of the CIR and FIR on the ISS; this also includes ground support and development activities for the ground units (FIR GIU, FIR GSE, and CIR GIU) and planning and development for their upcoming subracks. The TSC Team provides administration and maintenance support of all hardware located at the TSC and includes sustaining engineering, capability development, test and verification of upgraded systems, facility reconfiguration for new payloads, data distribution, archiving functions, network maintenance and support, and sparing; this also includes support for the ground units. The MIP Team manages and assists GRC payload integrating with the ISS, and manifesting hardware to be launched; facilities supported include FCF, the Space Acceleration Measurement System (SAMS), the Expedite the Process of Experiments to the Space Station Rack (EXPRESS), the Maintenance Work Area (MWA), and the Microgravity Science Glovebox (MSG).

Prior to 2017, BT1 was managed by the ISS Program Vehicle Office (OB) and was responsible for FCF Sustaining Engineering as well as the activities identified in this statement of work. In October 2017, BT6 was created and FCF Sustaining Engineering remained under BT1 and all other responsibilities mentioned in this statement of work moved to BT6. BT1 is managed by OB and BT6 is managed by the ISS Program Utilization Office (OZ).

## 2. Background

FCF and its inserts have been launched and the flight units are installed and operating in the ISS U.S. National Laboratory. The CIR Flight Unit was delivered to the ISS by STS-126 (November 2008). The FIR Flight Unit was delivered to the ISS by STS-128 (August 2009). New payloads are also planned for the FIR and CIR per the current traffic model consisting of the FIR FBCE and the CIR SoFIE. Figure 2-1 shows the CIR Payload Utilization Schedule and Figure 2-2 shows the FIR Payload Utilization Schedule. Any Center for Advancement of Science in Space (CASIS) payloads added late to the utilization schedule will have to be negotiated.

The Mission Integration and Planning (MIP) activities began as a key element of the FCF Development activities to navigate the ISS processes for integration and manifesting. The MIP activities include all GRC FCF, EXPRESS, MWA and MSG payloads on the ISS that require assistance in interfacing and coordinating with the ISS Program. Although the MIP team has been involved in working with all of these facilities, the MSFC MSG team does most of the integration for MSG payloads. Also, the team has been involved in manifesting for most of the launches to the ISS involving Shuttle, Progress, Soyuz, cargo vehicles (HTV, ATV, etc.) and the commercial vehicles. The MIP team has also been involved in the payload Certification of Flight Readiness (CoFR) process required for the ISS flights.

The GRC Telescience Support Center (TSC) facility is located on the first floor in the north wing of Building 333. The facility is housed within a secure area to ensure that all information, systems, equipment, personnel and services are protected from destructive, disruptive, or criminal activities. Access to the TSC is limited to approved, badged personnel. All entrances are equipped with key card access. This limited access facility can accommodate up to 22 different payloads and has room for over 40 cadre positions. The center has been in operation since 2001, providing support for payloads on both Shuttle and the ISS.

The TSC provides various services to the users to support payload mission operations. The TSC receives real time data from ISS payloads via a secure connection with the MSFC HOSC allowing payload developers and project scientists to command their on-orbit hardware and receive real time data and telemetry. The TSC receives real time data from all ISS video channels that can be displayed directly at the user's workstation. The TSC provides over 40 channels of voice loops, including space to ground. Using these voice loops, cadre members coordinate and monitor their activities with planners, HOSC controllers, and if necessary, the on orbit crew. Using TSC-provided workstations, cadre members receive a command and control capability as well as the ability to view their real time telemetry. Facility servers handle data traffic, storage, and archive functions. Over 30TB of online storage is managed by the TSC staff.

The TSC supports various GRC programs in the utilization of the ISS consisting of the Physical Science Research and Acceleration Measurement Program (AMP). The Physical Science Research is performed in the CIR, FIR, MSG, EXPRESS, and the MWA. The planned utilization of the facilities that would need support in the TSC is shown in Figures 2-1, 2-2, 2-3, and 2-4. Figure 2-5 is the current (November 2022) FCF Utilization schedule.

Figure 2-1 CIR Payload Utilization Schedule (Baseline)

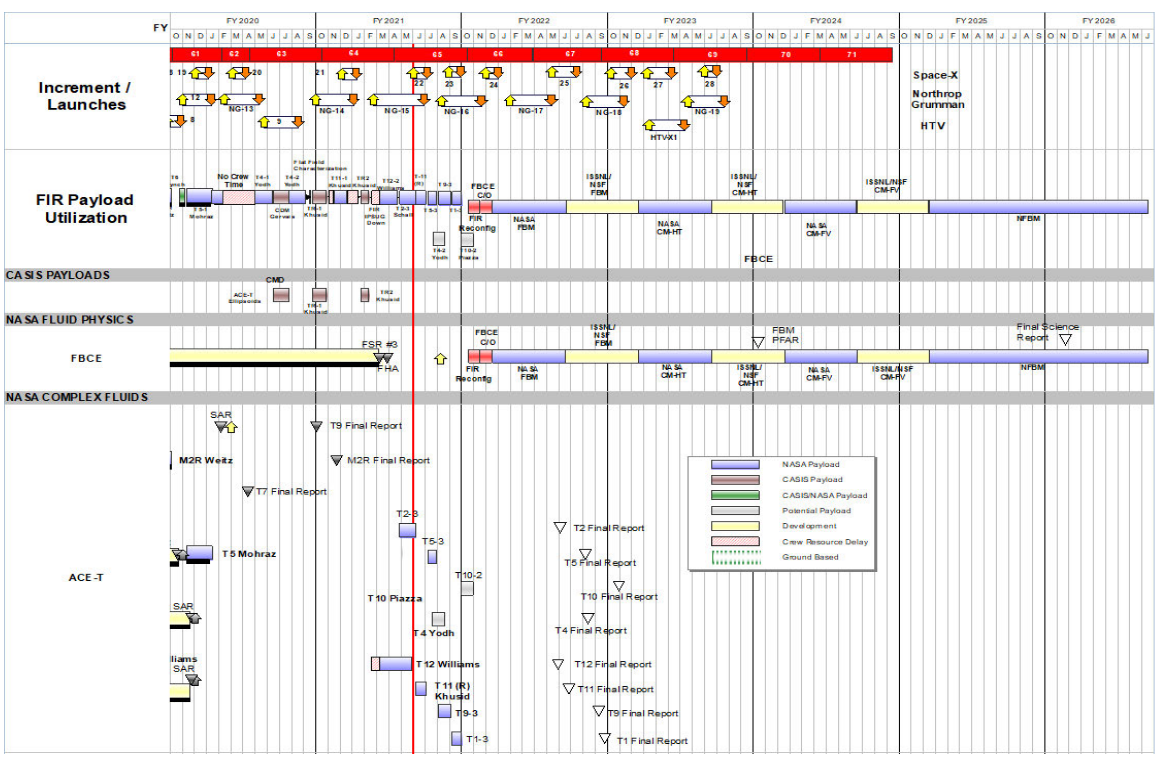


Figure 2-2 FIR Payload Utilization Schedule (Baseline)

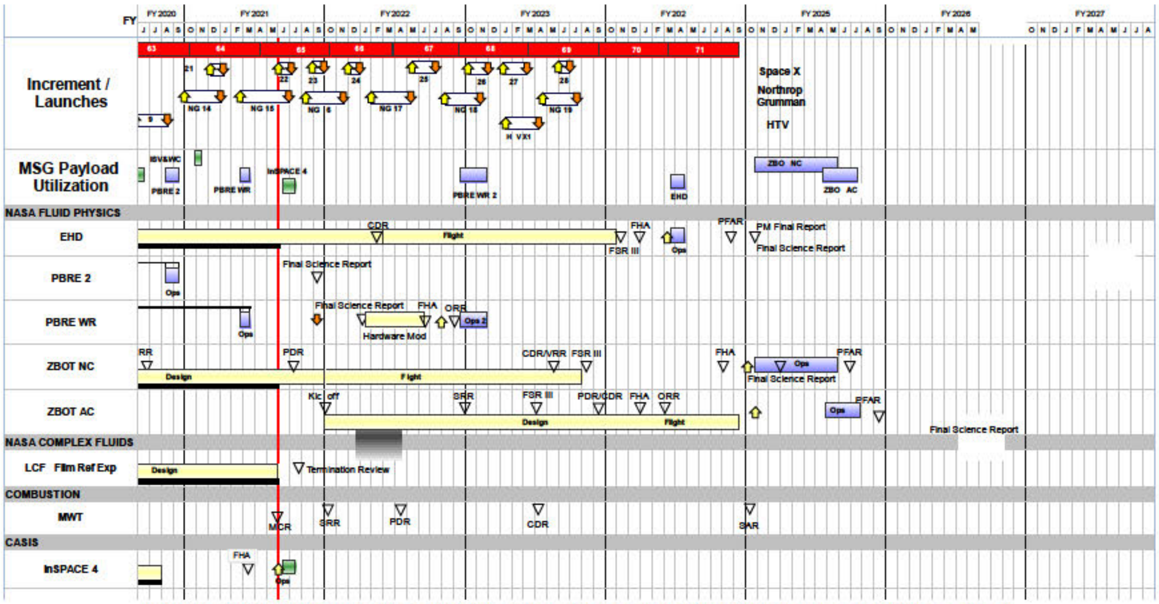

Figure 2-3 MSG Payload Utilization Schedule (GRC Payloads) (Baseline)

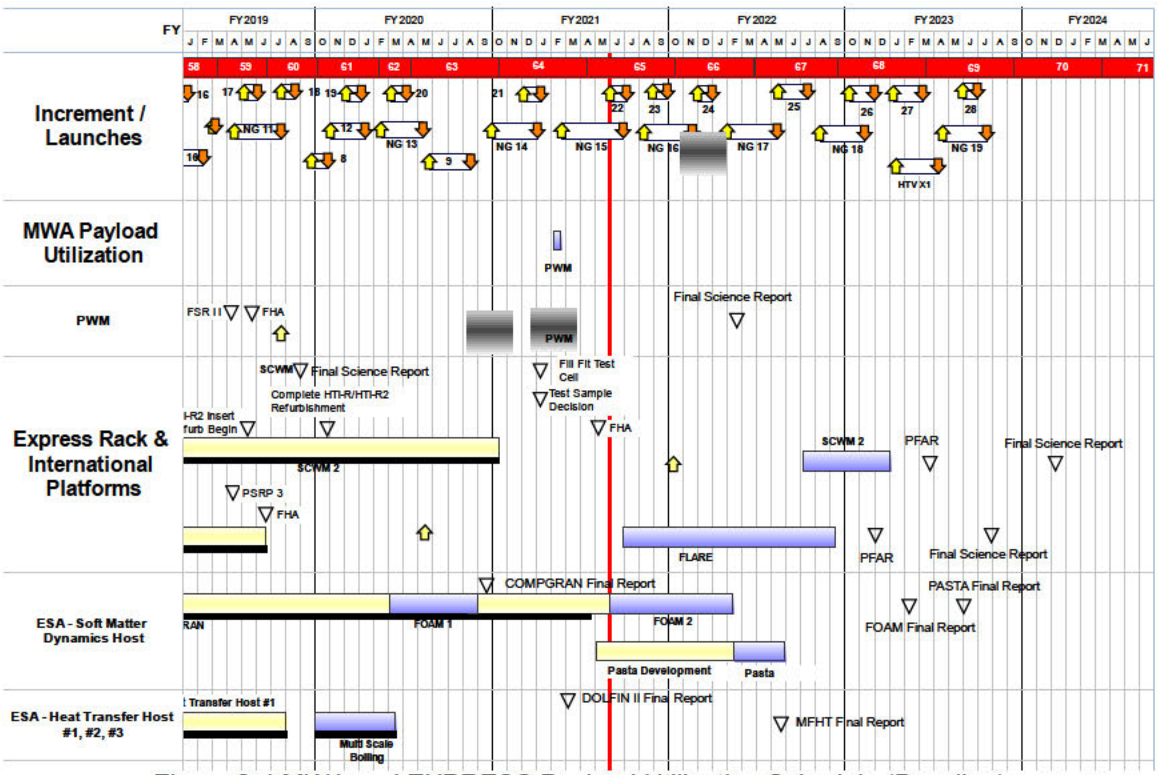

Figure 2-4 MWA and EXPRESS Payload Utilization Schedule (Baseline)

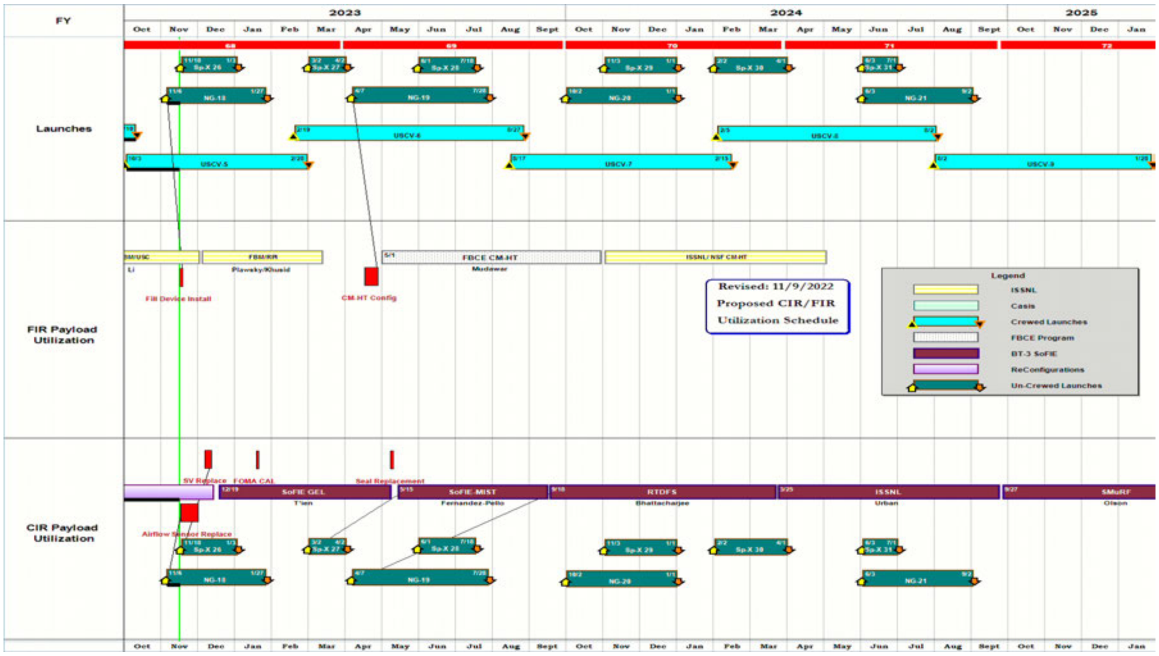


Figure 2-5 Current (November 2022) FCF Utilization Schedule

## 3. Applicable Documents

The contractor shall perform this task in accordance with all applicable contract documents with the additional of the following documents for performing specific FCF activities (note: the contractor shall update any plans to conform to approved changes in procedures/processes implemented):

FCF General SAR Plan, FCF-PO-PLAN-0020
CIR ICD with ISS, SSP-57217C-ICD
FIR ICD with ISS, SSP-57218B-ICD
FCF Utilization Process, FCF-PLN-0875
FCF Maintenance Plan, FCF-PLN-4090
FCF Training and Certification Plan, FCF-PLN-0788
CIR Phase III Flight Safety Data Package, CIR-DOC-3850
FIR Phase III Flight Safety Data Package, FIR-DOC-1712
CIR Payload Accommodations Handbook, CIR-DOC-4064
FIR Payload Accommodations Handbook, FIR-DOC-1863
LMM Payload Accommodations Handbook, LMM-DOC-1463
Payload Developer Interfaces with the LMM, LMM-IDD-1088
LMM Interface Control Document, FCF-ICD-FIR-LMM
FIR Payload Interface Definition Document, FCF-FIR-IDD
CIR Payload Interface Definition Document, FCF-CIR-IDD
GRC Telescience Support Center Requirements Document, TSC-DOC-002
GRC Telescience Support Center Implementation Plan, TSC-DOC-004
GRC Telescience Support Center Description Document, TSC-DOC-009
GRC Telescience Support Center Training and Certification Plan, TSC-DOC-015
ACE to LMM Integration Agreement, FCF-INT-4231
FBCE Agreement Main Volume, FCF-INT-4259
ACME Integration Agreement, FCF-IA-MV-ACME
SoFIE to CIR Integration Agreement, FCF-INT-4367

## 4. Performance Work Statements

In the performance of these performance work statements, the contractor shall maintain and control all applicable records, data, and documents. The five main areas for accomplishing the required work are: FCF Integration, FCF Operations, FCF Sustaining Engineering, Mission Integration and Planning, and Telescience Support Center.

### 4.1. FCF Integration

The FCF integration responsibilities of the contractor consist of PI hardware/software integration into the FCF, FCF overall integration with the ISS, and manifesting activities of hardware to and from the ISS on various logistic vehicles. The contractor shall provide both the engineering integration (physical, analytical, and operational) of the PI specific experiments with the FCF, as well as engineering integration of the integrated payload with the ISS. The FCF to ISS integration process has been defined by the ISS Payloads Office to ensure compatibility with the ISS vehicle accommodations, safety, and resources. The contractor is responsible for identifying hardware to be manifested to the ISS based on meeting the future operational requirements, along with performing the necessary documentation and analysis for launch of the hardware on the specific launch vehicle.

#### 4.1.1. Payload to FCF Integration

The contractor shall book manage and update, as required, all PI specific to FCF integration documentation developed from the blank books and templates for a specific PI experiment and/or increment that consist of:

a) Payload-Unique Integration Agreement (IA)
b) Interface Definition Documents (IDDs)
c) Generic Payload Verification Plans (GPVPs)

The contractor shall provide a liaison to the PI specific hardware teams to facilitate the integration process. The contractor shall provide an updated FCF (CIR, FIR,) Accommodations Handbook to the users in initial development (Phase A/B) and will facilitate the development of the payload specific Interface Control Document (ICD), Integration Agreements (IA), and Payload Verification Plan (PVP), with the specific user in Phase C/D. The Contractor shall also maintain and update the FCF Interface Control Documents (ICDs) based on changes to the interfaces and operational data, if applicable. The Contractor shall maintain and update the FCF Payload Verification Plans including all relevant payload information.

The contractor shall perform the integration activities for FCF and PI specific experiments such as analytical compatibility analysis, mission planning, and verification planning. In addition, the contractor shall manage the PI specific and ISS data products and documentation requirements, perform transportation options (mass/volume) analysis and recommendations on manifesting.

The contractor shall assume:

a) Integration and liaison activities are required for each of the payloads defined in the FIR and CIR Utilization Schedule. CIR: CFIG-2, Flame Design 2, GEL, MIST, AES Flammability Testing, RTDFS, SMuRF, and NCV; FIR:, ACE-T1-3, , ACE-T10-2, FBM, CM-HT, CM-FV, and NFBM (as time allows). Reference Table 4.2-1.

### 4.2. FCF Operations

The FCF operations responsibilities of the contractor consist of operational development, crew and ground personnel training/certification, and the real time operations of the CIR and FIR on the ISS. Operations development, training, and on-orbit operations are authorized for payload activities occurring with-in the SOW period of performance (approximately through Increment 68) as identified in Table 4.2-1 and in accordance with payload schedules as concurred with the published Utilization

Schedule. Changes to the payload operations support will be authorized through the GRC ISS Control Board.

Table 4.2-1

| CIR Payload | Increments |
|---|---|
| ACME CFIG-1 | COMPLETE |
| ACME Flame Design 2 | COMPLETE |
| SoFIE Reconfiguration & Checkout | 66-68 |
| SoFIE GEL | 68 |
| SoFIE MIST | 67-69 |
| SoFIE AES Flammability Testing | 68-TBD |
| SoFIE RTDFS | 69-TBD |
| SoFIE SMuRF | TBD |
| SoFIE NCV | TBD |
| | |
| **FIR Payload** | **Increments** |
| LMME ACE-T1-3 | COMPLETE |
| LMME ACE-T10-2 (Potential Payload) | NOT REQUIRED |
| FBCE Reconfiguration & Checkout | COMPLETE |
| FBCE FBM | 66-69 |
| FBCE CM-HT | 69-70 |
| FBCE NFBM | TBD |

### 4.2.1. Operations Development

The contractor is responsible for the development, coordination and maintenance of the required operations products to effectively plan and operate the on-orbit flight units. The contractor shall develop and maintain standard operational procedures to operate the racks, as well as off nominal procedures. This shall include developing the daily operations plan for the operators, coordinating the operation schedules with the PI and payload developer, establishing the operational resource requirements, coordinating with the ISS Program for operational scheduling, and coordinate operational changes with the ISS Program control center personnel and the FCF operations team. The contractor shall also participate in key operational working group interchanges, such as with the ISS Lead Increment Scientist.

The contractor shall define and maintain the Fight Rules (FR) rules based on ground rules and constraints for ISS payloads working with the payload developers and ISS Program to ensure safe and efficient operations.

The contractor is responsible for developing the crew procedures that are required for any on-orbit activity requiring crew interactions with the CIR and FIR hardware. The contractor shall coordinate and obtain approval of all crew procedures with the ISS Program. The contractor will also work with the JSC Crew Office to obtain feedback on the procedure for improvement.

The contractor shall acquire, process and archive the scientific data obtained during operations, support the correlation of scientific data with mission events, preparation of data products for data dissemination and PI-specific mission summary reports, preparation of unique data analysis data/reports for the PI, and provide an effective data management and dissemination process for the PI and telemetry data.

The contractor shall assume:

a) The CIR Operations Planning team will be staffed to the level required to support utilization, which will consist of tasks including: fuel and oxidizer management, test point operations, data file transfers and downlinks, hardware and software troubleshooting activities, software maintenance, and support of CIR crew activities.

b) The FIR Operations Planning team will be staffed to the level required to support utilization, which will consist of tasks including: test point operations, data file transfers and downlinks, hardware and software troubleshooting activities, software maintenance, and support of FIR crew activities.
c) The central data system at the TSC has an infrastructure in place and meets the FCF requirements.

### 4.2.2. Training

The contractor is responsible for providing the training lesson development, training the crew and ground support personnel, and maintaining the FCF trainers. The Contractor shall work with the payload developer teams, the crew office, and the ISS training organization to develop and implement the requirements for crew and ground team training/certification. The Contractor shall submit payload-training requirements to the ISS Program and participate in the Training Strategy Team (TST) process.

The contractor shall maintain and update as necessary the existing training materials include curriculum, lesson plans, and computer-based training. The contractor shall also update the training materials to be consistent with any hardware modifications and crew procedures. This includes all materials and tools required to train the crew and ground support personnel (GSP), this includes updating the training material to reflect hardware and software for new sub-racks. The Contractor shall develop and maintain the GSP Training and Certification Plan and shall maintain a certification status of the training completed for each person required to support on-orbit operations.

The Contractor shall maintain qualified crew training personnel and perform crew and GSP training as required. The contractor shall perform crew training at NASA JSC per the ISS Integration Template for any crewmember that will need to work with the FIR and CIR. The contractor will be responsible for performing Ground Support Personnel (GSP) training and certification for any new ground support personnel that includes TSC training for voice loops, FCF Displays, off-nominal operations, proficiency testing, etc. The contractor shall also perform, as required, mission simulations with the NASA Operations and Integration Center (POIC) to certify the operations team. The Contractor shall support the Payload Training Dry Runs (PTDR).

The Contractor shall maintain, and update as necessary, the training units for the CIR and FIR (located at JSC) to assure the function as intended to perform the training. Repairs and modifications to the trainers shall be submitted to NASA for approval. Initial delivery of sub-rack inserts for SoFIE and FBCE are the responsibility of their respective project teams.

The contractor shall assume:

a) Crew training at NASA JSC will be required for every increment.
b) Additional GSP Training will be required for each new payload for CIR and FIR.

### 4.2.3. On-Orbit Operations

The contractor has the responsibility for the real-time operations for the FIR and CIR. The contractor shall provide certified operators (certified per the GSP Training and Certification Plan) to properly operate the flight units from the GRC Telescience Support Center (building 333). The contract shall be responsible for the following tasks:

a) For each of the CIR and FIR facilities, the contractor is responsible for review and concurrence of updates to applicable ISS Flight Rules and ISS Payload Regulations.
b) For each of the CIR and FIR facilities, the contractor is responsible for development, review and concurrence of updates to applicable Operational Change Requests as required for operations planning of the facility and its payload.
c) For each of the CIR and FIR facilities, the contractor is responsible for development of crew

procedures related to operations and maintenance of the facility and its payloads. Procedure will be prepared and submitted per applicable ISS program tools and data systems

d) For each of the CIR and FIR facilities, the contractor is responsible for development and distribution of Daily Operations Plan defining the specific procedure steps to be accomplished by the applicable RO, DMO and PD console operators.

#### 4.2.3.1. FIR On-Orbit Operations

The Contractor shall provide trained staff for console operations to support FIR operations and the installed payload (i.e. LMM and FBCE) in accordance with the FCF Utilization Process. Contractor personnel shall be on console when the FIR is active or other planned crew operations are being performed. The Contractor shall be responsible implementing and following the planned FIR operations. The Contractor shall be prepared to respond to crew and ground team communications, and off-nominal situations. The Contractor shall develop/maintain standard FIR procedures to resolve on-orbit problems or anomalies. The Contractor shall provide science mission operations support including coordination of real-time payload and/or carrier requirements with the PI, payload developers, the carrier, and other appropriate entities; acquire, process and archive scientific real-time data; support the correlation of scientific data with mission events; preparation of data products for data dissemination and PI-specific mission summary reports; preparation of unique data analysis reports for the PI; provide operational change, status, planning, inputs with ISSP control center personnel; and participate in working group interchanges.

In order to maximize the utilization of the FIR, the contractor will maintain a certified operations staff capable of supporting an average of 6 operations shifts per week. .

The contractor shall assume:

a) FIR operations will be planned to operate an average of 6 shifts per week, or 312 shifts per year for NASA this delivery order.
b) LMM operations will require one Rack Officer and one Payload Developer (LMM Operator). The Payload Developer is provided under separate delivery order.)
c) FBCE operations will require one RO and initially one DMO; the DMO position will be reassessed after FIR transitions to FBCE. The PD operator is provided under separate delivery order.
d) The PD console position will be staffed by the PD (science team).
e) The Payload Developer's Project Scientist/PI will be provided by the PD (science team).
f) During Crew Tended Operations (FIR is not powered), at least one operator/planner shall be on-console to monitor and assist in the operations.

#### 4.2.3.2. CIR On-Orbit Operations

The Contractor shall provide trained staff for console operations to support CIR operations and the installed insert (i.e. ACME and SoFIE) in accordance with the FCF Utilization Process. Contractor personnel shall be on console when the CIR is active or other planned crew operations are being performed. The Contractor shall be responsible implementing and following the planned CIR operations. The Contractor shall be prepared to respond to crew and ground team communications, and off-nominal situations. The Contractor shall develop/maintain standard CIR procedures to resolve on-orbit problems or anomalies. The Contractor shall provide science mission operations support including coordination of real-time payload and/or carrier requirements with the PI, payload developers, the carrier, and other appropriate entities; acquire, process and archive scientific real-time data; support the correlation of scientific data with mission events; preparation of data products for data dissemination and PI-specific mission summary reports; preparation of unique data analysis reports for the PI; provide operational change, status, planning, inputs with ISSPO control center personnel; and participate in working group interchanges.

In order to maximize the utilization of the CIR/MDCA and CIR/ACME, the contractor will maintain a certified operations staff capable of supporting a average of 6 operations shifts per week.

The contractor shall assume:

a) CIR operations will be planned to operate an average of 6 shifts per week, or 312 shifts per year, for NASA or CASIS listed in this delivery order.
b) All CIR powered operations will require an RO and DMO
c) All CIR test point operations will require a Payload Developer console position staffed by the PD (science team).
d) The Payload Developer's Project Scientist/PI will be provided by the PD (science team).
e) During Crew Tended Operations (CIR is not powered), at least one operator/planner shall be on-console to monitor and assist in the operations.

## 4.3. Mission Integration and Planning (MIP)

MIP is the set of activities that includes payload planning, payload database, ISS Program liaison, MIP website maintenance (eRoom), new payload data coordination, traffic model assessment, teleconference and ISS meeting support, development and maintenance of FCF to Payload blank book and template documentation. The three main areas to accomplish the MIP work consists of Payload Planning, Payload Integration, and Mission Integration.

### 4.3.2. Payload Planning

The contractor is responsible for the strategic GRC payload planning consisting of the initial collection and management of payload data (planning data inputs), resource guideline development and increment planning, and liaison with initial payload development teams, and the anticipated ISS facility. The contractor shall implement the GRC payload planning process for all GRC ISS payloads.

The contractor shall coordinate payload data collection, interface with ISS planners for strategic and tactical plan inputs, be the focus point for interacting with the ISS, and participate in the Increment research planning meetings/teleconferences. The contractor shall work with Payload Developers (PDs) to submit the Change Evaluation Forms (CEF), Manifest Requests (MR), and Operations Change Request (OCR) to ISS Payload Office for changes to payload resource or operation requirements. The contractor shall support development of the GRC ISS Traffic Model, provide updates in GRC payloads manifesting, ISS launch schedules, and increment flight sequences.

The contractor shall provide a liaison to the PI specific hardware teams to facilitate the integration process. The contractor shall participate in the payload reviews, support payload teams in the development of the payload integration products including payload integration agreement (PIA), Payload Safety Data Packages, Payload Interface Control Document (ICD), Payload Verification requirements, etc. Also, the contractor shall assist GRC payload developers (PDs) with the early integration work with the facilities and the ISS.

The contractor shall support GRC in the maintenance of an FCF Payload Integration End-to-End Process that answers typical questions from Payload Developers (PDs) regarding integrating and operating experiments in the FCF, as well as introduces them to the processes necessary to fly a payload to the ISS.

The contractor shall work with the GRC payload community and coordinate the inputs/presentation packages for the ISS Payload special events including Multilateral Science Symposium, 30 Day Reports, Crew Briefings, One Year Science Reports, Increment Lessons Learned, Increment Science Symposiums, Payload Summary 1- -pagers, integration schedules for the payloads, etc.

The contractor shall assume:

a) The contractor shall assume the submit payload data for ISS manifesting, Multi-Increment and/or Increment Datasets to MSFC/MSG, JSC/OZ will be three times a year. The contractor shall assume the support the following teleconferences: Research Planning Working Group (RPWG), ISS Program Science Forum-United States (PSF-US). Payload Control Board (PCB), Daily Science Tag-up, Payload Technical Review (PTR), and Certification of Flight Readiness (CoFR) Reviews (6 telecons per week @ 1 hour long, along with the LIS tag-up @ 1 hour).
b) The contractor shall assume participation at the semi-annual face-to-face POIWG meeting in Huntsville, AL.
c) The contractor shall assume participation in one (1) safety review at JSC per year to support the payload developer teams.

### 4.3.3. Payload Integration

The contractor is responsible for GRC payload integration activities to assist and coordinate in ISS/facility requirement identification, assist in verification submittals to the ISS Program, tactical ISS integration, management of key FCF integration documentation, manifesting options for payload hardware, and updates to the web based information available to the payload developers.

The contractor shall implement the Preliminary Interface Revision Notice (PIRN), SSP Increment Definition and Requirements Documents (IDRD), ISS Change Request (CR), and ISS/FCF Exception review process that consists of tracking and review for the GRC payload community. As part of the process, the contractor shall provide coordination and submittal of all GRC comments for PIRNs, IDRDs, CRs, and ISS/FCF Exceptions. This shall consist of maintaining a list of applicable PIRNs, CRs, and ISS/FCF Exceptions, selecting reviewers, assembling technical, cost and schedule comments, and submitting comments to the appropriate NASA program offices. The contractor shall review and provide inputs to the Increment Research Plans, Increment Definition and Requirements Documents (IDRD), and Payload Integration Template (PIT). Also, the contractor shall submit the increment payload data include Payload data/payload summaries (1-Pagers) and Investigation Summary Forms (ISF) to the ISS OZ Requirements Baselining and Integration Tool (ORBIT).

The Contractor shall integrate all relevant inputs from the payload development teams and maintain and update all required documents and data deliverables for the ISS program on an increment or continuous basis. Deliverables to ISS will be negotiated through the Payload Integration Manager (PIM) at JSC and agreed to through the PIM schedule. For each ISS Increment, the contractor shall be responsible for consolidating this data into a single electronic submittal to the ISS Payload Data Library (PDL) and the Interim User Requirements Collection (iURC) web based tool (http://iurc.nexus.nasa.gov/) for each FCF rack and integrated Payload. The PDL acts as a central repository for the payload data and is maintained by the ISS program. The iURC data inputs, also made on an increment and flight-specific basis, define the investigation operations, which include the procedures, power, thermal and data resource requirements and investigation timeline information for flight planning purposes. The contractor will coordinate with the ISS Program and other space flight centers to evaluate and beta test a software interface for payload data. The contractor will attend team meetings, test the software updates with sample payload data, and report the status of activities to the GRC Base Task 6 Manager.

The contractor, in conjunction with FCF Increment Engineering activities, shall provide generic PI specific documentation required for integration of payloads into the FCF and for facilitation of information to the ISS in the form of "blank books" and templates. The blank books and templates consist of Payload-Unique Integration Agreement (IA), and Generic Payload Verification Plans (GPVPs). The contractor shall also provide an updated FCF (CIR, , FIR, , FBCE) Accommodations Handbook to the users in initial development (Phase A/B) and will facilitate the development of the payload specific Interface Control Document (ICD), Integration Agreements (IA), and Payload Verification Plan (PVP), with the specific user in Phase C/D based on the generic "blank book" templates.

The MIP payload integration responsibilities of the contractor consist of overall integration with the ISS and manifesting activities of hardware to and from the ISS on various logistic vehicles. The contractor shall integrate and coordinate payload data submittals for manifesting GRC payloads launched/returned on the ISS flights, and for on-orbit payloads operating in the ISS. The contractor shall maintain the payload manifesting data for the GRC payloads, submit to the ISS Payload Office. In addition, the contractor shall work with the Payload Developers to perform transportation options (mass/volume) analysis and recommendations on manifesting. Also, the contractor shall provide input and tracking of the various change traffic involved in integration and manifesting of FCF hardware such as, Change Evaluation Forms, and Open Work Tracking Logs.

The contractor shall provide the most current integration information to the Payload Developers. The contractor shall maintain the integration data on the MIP eRoom, or equivalent server that is provided by NASA.

The contractor shall assume:

a) The contractor shall assume the MIP eRoom is available to the contractor and any maintenance/usage costs associated with eRoom are paid directly by NASA.
b) The contractor shall assume submission of PIRN, CR, and ISS/FCF Exception tracking matrix reports on a monthly basis. These reports shall include the PIRN, CR, or ISS/FCF Exception number, description, date received, due date, date sent to JSC/OZ, GRC reviewers, impact, and status.
c) The contractor shall assume to provide integrated ISS Payload Data Library submittals of four per year.

### 4.3.4. Mission Integration

The contractor shall provide a liaison with the ISS that serves as a counterpart to the Payload Integration Managers role on the ISSP side, and functions to orchestrate integration and operations activities amongst GRC payloads. This will include interfacing with the various ISS Offices, the payloads' PIMs (Boeing), and the ISS Research Integration Managers (RIMs) to help resolve payload integration/operation issues. As part of these duties, the contractor shall participate in the Research Payload Working Group (RPWG), Payload Control Board (PCB) teleconferences, and other payload teleconferences.

The contractor shall work with the NASA MIP manager to develop and submit the ISS Certificate of Flight Readiness (CoFR) products using the applicable ISS tools and datasystems for launched/returned and operated payloads in the defined flight stages. This activity shall include developing the payload checklists, maintaining the open work tracking logs, participation in the Increment/Flight CoFR reviews when required, and the presentation of the status of payload open work at the reviews. The contractor shall assist in the development and submittal to the HQ, JSC, and MSFC the required CoFR letters and endorsement products for the GRC payloads.

The contractor shall support flight hardware deliveries, late load turnovers and payload reviews at GRC and, if needed, the launch sites. The contractor shall coordinate the requirements for the return of payload samples/materials/hardware from the landing site to the Payload Developers. Also, the contractor shall coordinate with NASA to provide to the ISS Program the export control information, technical data sheets, and information necessary to be manifested. This also includes appropriate memos and information requests, and the return or trash of payload hardware. The contractor shall also assist and assure that "ship and shoot" hardware from GRC meets the IPLAT/HFIT requirements per the GRC Payload Ground Processing and Preparations for Space Flight document.

The contractor shall assume:

a) The contractor shall assume that all flight hardware shipped from GRC will require IPAT/HFIT processing prior to shipment.
b) The contractor shall assist that NASA MIP Manager in developing the Flight Readiness Assessment (FRA) and the CoFR products for each of the ISS Flights/Increments.
c) The contractor shall assume that two (2) trips per year will be required to JSC and one (1) trip per year to KSC for launch coordination.
d) The contractor shall assume one (1) trip per year to JSC for coordination with the PIMs/RIMs for payload integration issues.

## 4.4. Telescience Support Center (TSC)

The Contractor shall maintain and operate the Telescience Support Center (TSC) located in GRC's building 333 for ISS payloads to perform payload operations activities. The two main areas for accomplishing the TSC work consists of TSC Sustaining Engineering and TSC Operations.

### 5.5.1. TSC Sustaining Engineering

The contractor shall be responsible for the overall administration and maintenance support of all hardware located at the TSC, which includes any sustaining engineering, capability development, and test and verification of any upgraded systems. These activities include updating facility configuration for new payload teams, establishing and maintaining a system to allow for distributing and archiving science data, and troubleshooting TSC-to-Payload Operations and Integration Center (POIC) and TSC-to-payload team network and interface problems.

The contractor shall implement a ground system for telescience operations that meets the ISS programmatic design and verification requirements defined in the International Ground Segment Specification (IGSS) document (SSP-54500). The Contractor shall assure that adequate connectivity for power/voice/video/data is available. The Contractor shall maintain all workstations in the TSC User work area. The Contractor shall evaluate and implement NASA approved user-generated changes to TSC capabilities and configurations.

The contractor shall develop and submit the ISS Certificate of Flight Readiness (CoFR) products required for TSC increment readiness using the applicable ISS tools and datasystems, and CoFR submittals for each ISS Operations Increment.

The Contractor shall recommend changes and updates to the TSC facilities based on changes to ISS requirements, projected payload utilization and established life cycle replacement of TSC facility equipment. The contractor shall maintain performance records, develop TSC performance reports, anomaly tracking. The contractor shall prepare a yearly recommendation for TSC facility upgrades and costs in time to support subsequent fiscal year financial planning processes. The contractor shall be responsible for the physical and automated information systems security for the TSC facility.

The contractor shall assume:

a) The central data system at the TSC has an infrastructure in place and meets the FCF requirements.
b) The contractor shall assume an annual ODC budget of $25K to support software license renewals.
c) The contractor shall assume an annual budget materials budget of $60K for purchases to support the data archive system, upgrades, and other miscellaneous costs (unanticipated hardware failures).
d) The contractor shall implement an upgrade to the existing Symantec Backup Appliance including SAN array storage for building 333 and redundant arrays in building 142 with an aggregate 750TB usable storage.

### 5.5.2. TSC Operations

The TSC operations responsibilities of the contractor consist of operational development, ground personnel training/certification, and the real time operations of the TSC; this is not limited ISS Program activities. The contractor shall be responsible for the operation of the TSC facility, workstations and TReKs, and support systems for GRC and remote user locations. The contractor shall conduct technical interchange meetings, requirements reviews, readiness reviews, and assist payload developers in the development, documentation, and implementation of increment specific telescience requirements.

The contractor shall provide for the delivery of telemetry data to payload specific hardware located at the TSC facility. The contractor shall ensure the storage, retrieval, and archival of telemetry data in accordance with the IGSS. The contractor shall assist payload developers in integrating increment specific hardware into the Telescience Support Center. Any TSC systems that are actively supporting customer operations within the facility shall require TSC operations staff per customer operating profiles.

The contractor shall develop, offer, and conduct training courses and simulations to demonstrate the use of Telescience Support Center capabilities and assure the proficiency of console operators either at the TSC or at remote sites. The contractor shall provide personnel for all phases of operations as required that include appropriate trained personnel for on-console operations during mission simulations and real time operations. The contractor shall certify the Operational Readiness of the system and operators. The contractor shall be responsible for managing all external interfaces to the GRC TSC, including, but not limited to, GRC Computer Services Division, MSFC POIC, JSC, NISN, Facility Power and HVAC.

## 6. Milestones & Reviews

The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations. The contractor shall meet the following milestones and participate in the following meetings and reviews.

a) Integration Reviews/Telecons with JSC per ISS Integration Template.
b) Operational Readiness Reviews.

Travel

The contractor shall support, at a minimum, the following travel requirements:

a) POIWG Quarterly Meetings at MSFC
b) Crew Training (Houston TX)
c) Support annual American Society for Gravitational and Space Research (ASGSR) and/or ISS Research and Development conference as directed by the GRC Project Manager.

## 7. Deliverables

Document, hardware, and software deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL).

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to the following individuals:

**All Deliverables:**

Task Manager, MSI/Ronald J. Sicker, MS 77-7, ronald.j.sicker@nasa.gov

Configuration Management Office, MSI/Donna Clements, Mail Stop 54-1, Donna.J.Clements@nasa.gov

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, ISS Research Facility, Mail Stop 333-1 MSI/Kevin M. McPherson, kevin.m.mcpherson@nasa.gov

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov

A Contracting Officer letter may accomplish changes to the personnel mentioned above.

### 7.1 Hardware

The contractor shall deliver the following hardware items to the Government with supporting documentation (specifications, drawings, test procedures, analysis/test reports, and operating/maintenance manuals) as applicable:

NONE identified

### 7.2 Software

None identified

### 7.3 Documentation

Document deliveries shall be prepared, documented, and delivered in compliance with the Contract Data Requirements List (CDRL), if applicable.

The contractor shall provide the following documents:

a) Contractor Work Plan, per DID PM-06 within 30 days of contract start
b) Submit a Monthly Task Report in accordance with DID CD-03
c) Operations Readiness Review package for new On-orbit Configurations

## 8. Reporting Requirements

a) Contractor Financial Management Reporting requirements per DID CD-01 with the following reporting structure (or similar, approved by NASA) ON-GOING are the following:

   a. Project Management/Support
   b. Product Assurance
   c. FCF Operations
      i. Operations Development & Training
      ii. FIR Operations
      iii. CIR Operations
   d. Mission Integration and Planning
   e. Telescience Support Center

b) Monthly reporting per DID CD-03 ON-GOING

## 9. Government Furnished Equipment

a) GFE items required in execution of this effort are provided in the listing provided within the RFP. Proper certification and/or identification of needed certifications of any Government provided GFE is the responsibility of the contractor.

b) Hardware and software turned over to the Government (CIR Flight Unit, FIR Flight Unit, FIR GIU, FIR GSE, CIR GIU, etc.) shall be made available to the contractor for execution of this delivery order. Hardware that remains in Government facilities will remain the property of the Government and made available for usage when required. Property that will remain at the contractor's site shall be identified and will be provided to the contractor via a DD Form 1149 for usage. The contractor's modification of Government held hardware and software shall be requested via NASA C-652 and a report filed via NASA C-654 upon completion of the modifications.

c) All spares required for manifest that have been turned over to the Government will be provided to the contractor for final testing and verifications to meet the specific launch requirements.

## 10. Government Furnished Facilities

The following Government facilities shall be available to the contractor, as needed:

a) Power Space Facility (Bldg. 333) – High Bay (100E)
b) Telescience Support Center (Bldg. 333)

## 11. Government Contacts

The contractor shall have access to the following for consultation:

a) FCF Project Manager
b) FCF Operations Manager
c) TSC Project Manager
d) CIR Payloads Project Manager
e) FIR Payloads Project Manager
f) FCF Chief Engineer
g) S&MA Lead
h) MIP Project Manager
i) SoFIE Project Manager
j) FBCE Project Manager

## 12. Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 13. Acronym List

| Acronym | Description |
|---|---|
| ACE | Advanced Colloids Experiments |
| ACE-T | ACE-Temperature |
| ACME | Advanced Combustion via Microgravity Experiments |
| AMP | Acceleration Measurement Program |
| ASGSR | American Society for Gravitational and Space Research |
| ATV | Ariane Transfer Vehicle |
| BT | Base Task |
| CASIS | Center for the Advancement of Science in Space |
| CDRL | Contract Data Requirements List |
| CEF | Change Evaluation Forms |
| CFI | Cool Flame Investigation |
| CIR | Combustion Integration Rack |
| CoFR | Certification of Flight Readiness |
| CR | Change Request |
| DID | Data Item Description |
| DMO | Data Management Officer |
| eCC | electronic Country Clearance |
| EXPRESS | Expedite the Process of Experiments to the Space Station Rack |
| FBCE | Flow Boiling Condensation Experiment |
| FCF | Fluids and Combustion Facility |
| FIO | Facility Integration & Operations |
| FIR | Fluids Integration Rack |
| FR | Flight Rules |
| FRA | Flight Readiness Assessment |
| GFE | Government Furnished Equipment |
| GIU | Ground Integration Unit |
| GPVP | Generic Payload Verification Plan |
| GRC | Glenn Research Center |
| GSE | Ground Engineering Unit |
| GSP | Ground Support Personnel |
| HFIT | Human Factor Integration Test |
| HOSC | Huntsville Operations Support Center |
| HQ | Headquarters |
| HTV | H-II Transfer Vehicle |
| HVAC | Heating Ventilation and Air Conditioning |
| IA | Integration Agreement |
| ICD | Interface Control Document |
| IDD | Interface Definition Documents |
| IDRD | Increment Definition and Requirements Document |

| | |
|---|---|
| **IGSS** | **International Ground Segment Specification** |
| **IPLAT** | **ISS Payload Label Approval Team** |
| **IPSU** | **Image Processing and Storage Unit** |
| **IPSU-G** | **IPSU-GigE Vision** |
| **ISF** | **Investigation Summary Forms** |
| **ISS** | **International Space Station** |
| **ISSPO** | **ISS Program Office** |
| **iURC** | **Interim User Requirements Collection** |
| **JSC** | **Johnson Space Center** |
| **KSC** | **Kennedy Space Center** |
| **LMM** | **Light Microscopy Module** |
| **LMME** | **Light Microscopy Module Enhancements** |
| **MDCA** | **Multi-User Droplet Combustion Apparatus** |
| **MIP** | **Mission Integration Planning** |
| **MR** | **Manifest Requests** |
| **MSFC** | **Marshall Space Flight Center** |
| **MSG** | **Microgravity Science Glovebox** |
| **MWA** | **Maintenance Work Area** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NISN** | **NASA Integrated Science Network** |
| **NPR** | **NASA Procedural Requirement** |
| **OB** | **NASA ISS Program Vehicle Office** |
| **OCR** | **Operations Change Request** |
| **ODC** | **Other Direct Cost** |
| **ORBIT** | **OZ Requirements Baselining and Integration Tool** |
| **OZ** | **NASA ISS Program Utilization Office** |
| **PCB** | **Payload Control Board** |
| **PD** | **Payload Developers** |
| **PDL** | **Payload Data Library** |
| **PI** | **Principal Investigator** |
| **PIA** | **Payload Integration Agreement** |
| **PIM** | **Payload Integration Manager** |
| **PIRN** | **Preliminary Interface Revision Notice** |
| **PIT** | **Payload Integration Template** |
| **POIC** | **Payload Operations and Integration Center** |
| **PSF-US** | **Program Science Forum-United States** |
| **POIWG** | **Payload Operations and Integration Working Group** |
| **PTDR** | **Payload Training Dry Run** |
| **PTR** | **Payload Technical Review** |
| **PVP** | **Payload Verification Plan** |
| **RFP** | **Request for Proposal** |

| | |
|---|---|
| **RIM** | **Research Integration Managers** |
| **RO** | **Rack Officer** |
| **RPWG** | **Research Planning Working Group** |
| **SAMS** | **Space Acceleration Measurement System** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SoFIE** | **Solid Fluid Ignition and Extinction** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SSP** | **Space Station Program** |
| **STS** | **Space Transportation System** |
| **TReK** | **Telescience Resource Kit** |
| **TSC** | **Telescience Support Center** |
| **TST** | **Training Strategy Team** |

**Base Task 7**
**Cognitive Communications (Cog-Com)**
**For Contract Period of Performance 10/1/2019 through 3/31/2023**
**For DO the Performance Period 10/1/2021 to 11/30/2023**

## 1. Introduction

The Cognitive Communications project is a research and technology development project that investigates the applications of artificial intelligence (AI), machine learning (ML), and autonomy to NASA's space communications capabilities. Cognitive communication platforms are intelligent across the communication stack, from physical layer to application layer, allowing real-time decision-making and seamless connectivity. Examples of cognitive communications products include:

- Point-to-point radio and optical link optimization algorithms, including interference mitigation
- Space communication network storage, forwarding, and routing protocols
- Communication relay scheduling techniques using machine-to-machine interfaces
- AI/ML algorithms for learning, decision-making, and optimization for space communications
- Low Size, Weight, and Power (SWaP) hardware supporting the above objectives

The Cognitive Communications project has demonstrated its research using the Space Communication and Navigation (SCaN) Testbed on the International Space Station (ISS) from 2014 through 2019. Following the decommissioning of SCaN Testbed, the project entered formulation for a demonstration flight mission. HQ leadership subsequently modified the project scope to focus on ground technology development and demonstration activities.

The majority of the work on the Cognitive Communications project involves software development. The project develops code for microprocessors, field programmable gate arrays (FPGAs), and graphics processing units (GPUs) as part of ground-based, laboratory demonstrations.

Depending on the decision that NASA makes regarding its lunar communications architecture, future project work could involve flight platforms in near-earth, lunar, or high-earth orbits. In this case, the project may amend the base task to include systems engineering, integration and test, flight software development, and safety and mission assurance functions. The current focus of Cognitive Communications is the research and development of cognitive technologies, in addition to the demonstration of these technologies through a Cognitive Ground Testbed.

NASA intends to reserve unlimited rights to the software developed under this Base Task and may release software to the public as open-source. Therefore, in accordance with contract clause 52.227-17 – Rights In Data - Special Works, the Government shall have unlimited rights to all data produced in performance of this effort and to all data delivered under this effort.

## 2. Background

The contractor shall:

- Perform software development, integration, and checkout activities supporting communications research and development, including 1) development of interface layers for Cognitive Engine – 1 (CE-1) and the Cognitive Ground Testbed (CGT), 2) integrate AutoCAT software onto Technology Education Satellite (TES) platforms, and 3) AutoCAT suite checkout and over-the-air demonstrations.
- Continue to execute and manage the configuration management (CM) plan for AutoCAT software.

## 3. Reference Documents

NPR 7120.5, NASA Space Flight Program and Project Management Requirements
NPR 7123.1, NASA Systems Engineering Processes and Requirements
NPR 7150.2, NASA Software Engineering Requirements
NASA-STD-8719.13B, Software Safety Standard
NASA-STD-8739.8, Software Assurance Standard
GLPR 8739.1, Software Assurance Procedure
GLPR 7120.5.30, GRC Space Assurance Requirements

## 4. Performance Work Statements

Overview: The contractor shall be responsible for the configuration management (CM) and data management (DM) activities for software delivered to the Cognitive Communications Project. The contractor shall also be responsible for development and sustaining engineering of avionics capabilities as described in this statement of work.

### 4.1. Configuration Management/Data Management (CM/DM)

The contractor shall be responsible for the CM/DM activities for the AutoCAT suite and other software products delivered to the Cognitive Communications Project.

The contractor shall operate and sustain the Cognitive Communications Configuration Management System (C4MS), or equivalent, for configuration management. The contractor shall implement proper controls to receive, store/archive, reproduce and distribute AutoCAT, or other developed software, documentation. The contractor shall perform daily backups of the C4MS data. C4MS shall reside physically at the contractor site with remote access from the NASA Glenn Research Center (GRC) campus network. Sensitive But Unclassified (SBU) documents may be stored in C4MS if the system is certified for such use; otherwise, the contractor shall propose an appropriate system, such as eRoom, for storage of SBU documents.

The contractor shall propose an appropriate system, such as Sharepoint or Box, for data management, including SBU content. The contractor shall implement proper controls to receive, store/archive, reproduce and distribute project-related flight software in the data management system. The contractor shall facilitate data management system access, maintain documentation as necessary, monitor the size and use of the data management system contents, and work with the data management system provider to help resolve any issues.

The contractor shall continue to execute and manage the CM/DM plan documenting the processes and procedures for handling documents and flight software for the project. The CM plan shall implement workflows for handling document approvals in C4MS. Any items considered Sensitive But Unclassified (SBU) shall be handled in accordance with NASA Procedural Requirement (NPR) 1600.1, shall be clearly marked as SBU, and shall reside in a system certified to handle such items.

The contractor shall deliver to the project at the conclusion of this Base Task all CM documents generated during the execution of the Cognitive Communications project. Delivery shall occur in a format agreed upon by the contractor and government representative. Additionally, the contractor shall deliver to the project at the conclusion of this Base Task all data and flight software stored in the data management system.

For all contractor-developed software, the contractor shall update and maintain a server-based version of Subversion or equivalent to configuration manage the software. The contractor’s software CM responsibilities include making and merging branches; creating, documenting, and implementing procedures related to builds and deployments, and creating/maintaining a software CM plan.

The contractor shall provide the necessary staff and shall be responsible for the implementation of these CM/DM functions. The contractor shall maintain the CM/DM system in an organized, logical fashion, and shall provide training and/or training products to project personnel on CM/DM system and product review process as necessary.

**4.2. Management, Safety, and Product Assurance**

The contractor shall furnish necessary computer network services, procurement services, financial and schedule reporting, and property management of project hardware. The contractor shall provide all desktop computer hardware and software for general use by the SpaceDOC team members assigned to work this Base Task. The contractor shall purchase hardware needed to perform unique elements under the appropriate work item. The contractor shall authorize specific technical training as required.

The contractor shall provide safety personnel, including software safety personnel, as needed to meet the safety and mission assurance needs for work conducted under this base task. The contractor shall comply with all relevant NASA safety and software safety standards.

The contractor shall provide presentation material and technical expert presenters for work completed under this base task as needed for SCaN program reviews.

**4.3. Support of Fast Forward Checkout**

NASA plans to conduct an over-the-air demonstration to exercise the TDRSS Fast Forward capability of AutoCAT. The contractor shall provide support, as necessary, to these tests. Support may include assisting NASA personnel with installation of software on lab computers, configuration of software components with terrestrial interfaces of service providers, generation of scenario files for the tests, and collection of data. No major software development is anticipated for this task.

NASA will send a request for service over the Demand Access System using a single-board computer, software-defined radio, and ground station antenna to emulate a user spacecraft. The ground-side AutoCAT software components will schedule a Single Access Return event for data transfer and a “Fast Forward” Multiple-Access Forward event to return scheduling info (a “molecule”) to the emulated spacecraft.

The contractor shall ensure that a team member familiar with AutoCAT suite and capable of troubleshooting issues is on-site for the initial TDRSS Fast Forward Checkout.

**4.4. Support of TechEdSat User-Initiated Service Experiment**

NASA is planning an on-orbit technology demonstration of user-initiated service through a TechEdSat CubeSat operated by Ames research center. The CubeSat will use an Iridium Short Burst Data modem to send small (300 byte) low-rate (1kbps) messages through the Iridium constellation. This Iridium link will be the control channel over which UIS request messages and their responses (including molecules) are transferred. The CubeSat will use an S-band radio to communicate with AWS or NASA GRC as the scheduled data channel. This campaign will demonstrate the ability of AutoCAT to operate with fully-commercial services.

The contractor shall assist the NASA team with integrating the AutoCAT software with Iridium, AWS, and NASA GRC services and integration of the spacecraft-side software onto TechEdSat.

**Software Port to Spacecraft Processor**
The contractor shall port the AutoCAT spacecraft-side software to the planned processor for the CubeSat mission, a Digi Connect Core 6UL. The contractor will assist with integration of AutoCAT into the software framework used by the TechEdSat team at NASA Ames to control spacecraft communications.

**Iridium Control Channel Test**
NASA procured an engineering model of the Iridium modem and the support hardware necessary to perform ground experiments with the Iridium constellation. The contractor shall support, as necessary,

demonstrations of sending UIS request messages from the Iridium modem to the Event Manager through the Iridium constellation. These tests will evaluate the abbreviated communications scheme in which AutoCAT sends the minimal number of messages between space and ground. From these tests the contractor shall identify and execute any software modifications or bug fixes required for the abbreviated communications mode to function over the Iridium constellation.

**TechEdSat Integration**
The contractor shall provide support, as necessary, to NASA personnel during integration of the AutoCAT software into the TechEdSat platform. This final integration will ensure messages are properly routed between the two computers and software-defined radio onboard the spacecraft. This effort may involve one trip to NASA Ames for integration activities.

**Experiment Operations**
The contractor shall provide support, as necessary, to NASA personnel during the TechEdSat experiment campaign. This may involve being on-site at GRC during planned passes and coordinating experiment plans with NASA Ames over phone/email.

## 4.5. AutoCAT Suite Phase 5 Development

The contractor shall develop enhancements to AutoCAT suite and related software components to fulfill needs for the Reactive and Cognitive systems being developed by the Cognitive Communications project. The contractor shall design, develop, and test the following enhancements which are briefly described:

**Cognitive Scheduler**
The Cognitive Scheduler is a component of the AutoCAT suite which shall take as input a list of candidate events generated by Event Manager and select one or more to be scheduled. Cognitive Scheduler shall make calls into the existing scheduling logic framework (such as Event Scheduler) to execute the scheduling process. Cognitive Scheduler shall be capable of scheduling multiple events in response to one request message. It shall also be capable of cancelling previously scheduled events in response to new information. The contractor shall define and document the interface for Cognitive Scheduler and ensure the component is compatible with the rest of AutoCAT Suite. The contractor shall provide an example implementation of Cognitive Scheduler.

**Ancillary Data**
Along with the selected event(s), the Event Selection Service and/or Cognitive Scheduler will generate a set of JSON-formatted ancillary data parameters. AutoCAT and the Contact Plan Manager shall be modified to include these parameters in the contact plan. The software shall ensure ancillary data appears listed within the proper corresponding contact(s).

**Generic Scheduling Interface**
The interface between the Event Scheduler component and the interface layers corresponding to specific scheduling systems (e.g. AWS, TDRSS) shall be made generic such that each interface sends/receives the same information to/from Event Scheduler and no provider-specific information is exchanged. Each scheduling interface layer shall be able to translate from the generic parameters provided by Event Scheduler to the specific API calls into the provider's scheduling system with all necessary parameters. Interface layers already developed (EvAWS and Tempus) shall be modified to meet this new interface.

AutoCAT suite and the interface layers shall be capable of supporting multiple service configurations per provider. A configuration identifier will be returned from Event Selection Service / Cognitive Scheduler and will be passed to Event Scheduler, the interface layers, and ultimately the flight nodes. This configuration identifier will uniquely map to a set of physical and link-layer parameters (e.g., symbol rate, modulation, coding, packet format). The interface layers will translate the configuration identifier into API calls into provider scheduling interfaces to configure a provider's service for this set of parameters.

AutoCAT suite shall allow an arbitrary number of these interface layers to be instantiated. The interface to Event Scheduler shall be documented such that a user should be able to create their own interface layer corresponding to an arbitrary service provider. This generic scheduler interface capability will be used to emulate the scheduling systems of a large number of service providers in the Cognitive Testbed.

**Lunar Request Routing**
The User-Initiated Service Processor (UISP) component shall be modified to route service request messages based on the message's destination node ID field. Requests containing node IDs associated with Earth will be passed to the existing flight-side AutoCAT suite software components (i.e. Flight Service Manager). Requests containing node IDs associated with the Moon will be passed over a network socket connection to a NASA-developed lunar scheduling agent.

**Distance Vector**
AutoCAT suite shall be modified to provide a distance vector for each candidate event to Event Selection Service or Cognitive Scheduler to aid in selection of a contact to schedule. Each element of the distance vector shall be the distance between the user spacecraft and the provider asset, in kilometers, at each time step of the contact. The time between elements shall be set by the timestep of the Astro Engine instruction set ("molecule").

**Beta / Final Deliverables**
The contractor shall deliver three beta versions in addition to a final version of the enhanced software. The beta deliveries shall include:

Beta #1

- Cognitive Scheduler
- Ancillary Data in the Contact Plan
- Test Code for the Generic Scheduler
- Generic Scheduling Interface

Beta #2

- Lunar Scheduling Requests
- AE to provide Distance Vector
- ESS/CogScheduler Provided Distance Vector for processing
- ESS/CogScheduler matching flight and ground radio configurations
- Provide support for a Cognitive Radio Selector

Beta #3

- Generic Interface to Tempus
- Generic Interface to EvAWS
- Fix EvAWS Rejections Bug
- EvM Start up with existing scheduling

The final software version shall comply with NPR 7150.2C following requirements corresponding to the original classification of each component (either Class C or Class E) which was modified. In the final delivery the contractor shall deliver updated design documentation to reflect the new and modified components. In particular, each interface between components shall be defined and documented.

Delivery of each release (both betas and final) in this section shall include both software executables and source code for AutoCAT suite and required related components. The file structure of the delivered source code shall, to the greatest extent possible, match the file structure of the Cognitive Communication Gitlab project (gitlab.grc.nasa.gov/cogcomm/systems/uis/autocat-suite).

### 4.6. Workflows for integrating datasets into System Tool Kit (STK) Software package for Lunar LTE Studies (LunarLiTES)

The contractor will develop workflows for importing LIDAR data along with Lunar and Earth terrain datasets for use in STK simulations of line-of-sight viewsheds, dynamic link budgets over vehicle paths, and direct-to-Earth links from the Lunar surface. The contractor will demonstrate the workflow using LIDAR data from the Lunar Reconnaissance Orbiter (LRO), the Black Rock Lava Flow in Arizona, and the Armstrong Test Facility at GRC. The contractor will also develop workflows for linking on-vehicle antenna patterns and terrain-induced multipath data products from Ansys HFSS simulations to STK scenarios.

### 4.7. Implementation of lunar scenarios in STK for Lunar LTE Studies (LunarLiTES)

The contractor shall create, execute, and analyze results from a variety of STK scenarios in support the LunarLiTES project objectives. The contractor will work with the LunarLiTES team to define analysis products that may include line-of-sight viewsheds, dynamic link budgets, and assessment of antenna pattern and multipath impacts on communication system performance. The contractor will also work with the LuanrLiTES team to define scenario specifics in the following areas:

**Surface-to-Surface Scenarios**

- Earth Surface-to-Surface use case including local field tests at Armstrong Test Facility and D-RATS remote test sites.
- Lunar Surface-to-Surface use case including LTE Band 3 links between the CLPS IM-2 lander and a representative rover in motion with a propagation distance up to 4km.

**Lunar Backhaul Link Scenarios**

- Lunar Surface-to-Earth use case including the IM-2 lander to an Earth ground network (i.e., LEGS, DSN).
- Lunar Surface-to-Relay use case including the IM-2 lander to orbital relays in 12-hour frozen lunar orbits (i.e., IM-2 commercial relay, Gateway).
- Lunar Relay-to-Earth use case including a lunar orbital relay to Earth ground station (i.e., LEGS, DSN).

**Artemis Scenarios**

- Artemis III/ V surface to surface use case including communications from astronaut on EVA to a representative lander, through a portable LTE hotspot.
- Artemis Base-Camp use case including a surface network of multiple LTE cells with users transitioning between towers.

### 4.8. Implementation of Reactive System Networking Requirements

NASA's Cognitive Communications project is developing Cognitive Engine – 1 (CE-1) to manage future spacecraft communications needs. CE–1 is being built incrementally, starting with automated capabilities, followed by reactive, and finally predictive/cognitive capabilities. The Cognitive Communications project demonstrated automated CE-1 capabilities in FY22 but requires additional contractor support to develop and demonstrate reactive capabilities in FY23.

CE-1 relies on HDTN to fulfill multiple functions within each capability increment. To demonstrate CE-1 reactive capabilities, HDTN requires modifications to its 1) storage policy manager, 2) data re-routing functions, and 3) request decision process. The HDTN software modifications should be delivered in a beta and final version. The beta version will be used for preliminary integrated testing with the CE-1 reactive system. This will allow for tuning, debugging, and refinement of the HDTN modifications prior to completion of the final version.

The details of the deliverables for each module are described below. The main HDTN codebase is currently NPR 7150.C Class D software but is being matured toward Class B. The modifications required for the CE-1 reactive system should be developed at the Class E level, in accordance with the Cognitive Communications Project Plan. The contractor shall work with the Cognitive Communications Project Networking Team Lead to develop an appropriate software development workflow to achieve this. The modifications should be kept up to date with any significant changes to the HDTN master branch. HDTN has been publicly released under the NASA Open-Source Agreement. NASA intends to reserve unlimited rights to the software developed by the contractor. When the software modifications have been delivered, they may be publicly released at the discretion of the Cognitive Communications project.

The HDTN software is currently hosted on the public NASA GitHub at https://github.com/nasa/HDTN and well as an internal GRC GitLab development repository. The contractor can be given access to the internal GRC development repository. When the contractor delivers the software, the new and/or updated modules will be uploaded to the public NASA GitHub by the Cognitive Communications team. Significant revisions to the HDTN software will be pushed to the public NASA GitHub. The software delivered by the contractor must be compatible with the current released HDTN version.

The contractor shall design and implement the following modifications to NASA's existing HDTN software implementation:

**Storage Policy Manager**
The existing HDTN storage module stores data according to link status events from the HDTN scheduler module. Data is stored during a "link down" event and released during a "link up" event. Currently, data is released according to two parameters: bundle expiration time and priority. The contractor will modify the HDTN storage module so that users can configure policies to:

- Delete or continue storing expired data.
- Refuse to accept new data if the onboard storage limit is reached.
- Attempt to forward data if the onboard storage limit is reached.
- Incorporate message fragmentation. Messages in storage that are too large for the current contact can be split among multiple contacts.

**Re-routing After Failed Attempts**
Currently CE-1's automated increment uses HDTN to detect when a contact has failed based on LTP status. To meet reactive increment needs, CE-1 will need to request additional service when HDTN identifies a contact failure. The HDTN request decision process (RDP) is a Python module which serves as the interface between the HDTN storage module and UIS. The storage, scheduler, and router modules use a ZeroMQ-based API to exchange control messages between HDTN, RDP, and UIS. The contractor will modify NASA's existing HDTN implementation to:

- Generate metadata regarding network latency and delays between nodes. This measured latency will be used to make decisions based on the current state of the network, including congestion or other delays beyond the predetermined contact plan.
- Compute and/or request alternate paths that can be used if the active contact has failed. The HDTN Contact Graph Routing and scheduler modules can be extended with Yen's k-Shortest Path algorithm to achieve this.
- Update the HDTN request decision process module and underlying HDTN ZeroMQ API calls to handle unsuccessful contacts.
- Ensure that high priority data is successfully delivered before lower priority data.

**Support integration, testing, and bug-fixing of HDTN modifications**
The contractor shall perform static analysis, develop unit tests, integrated tests, and other test related applications needed to assure that the software functions correctly. The contractor shall address any defects found during CE-1 reactive system testing. The contractor shall ensure that the developed modifications are compatible with the latest HDTN master branch at the time of delivery to NASA.

**Identify and design HDTN modifications for next CE-1 increment**
The contractor shall provide a design document for the CE-1 predictive/cognitive system. The modifications developed during the reactive system will be used to evolve towards the next CE-1 increment. The new design shall be compatible with the latest HDTN master branch and all software shall be kept up to date.

## 5. Milestones & Reviews

The contractor shall participate in the Cognitive Communications team meetings (approximately bi-weekly) CARRIED FORWARD

The contractor shall hold reviews as necessary to meet CM/DM and software process requirements. CARRIED FORWARD

The contractor shall participate in the Lunar LiTES team meetings (approximately weekly)

## 6. Travel

The contractor may use contract funding as necessary for required travel.

## 7. Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). The contractor shall deliver documentation as electronic copy, applicable hard copy, and required cover letter to:

**All Deliverables:**

Configuration Management Office:
LCN/Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov

Task Manager:
MSC/Peter Schemmel, Mail Stop 142-3, peter.j.schemmel@nasa.gov

**Deliver courtesy copies of cover letter only to:**

Contracting Officer:
Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative:
Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov

Alternate Contracting Officer's Representative:
MSI/Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov

Program Manager:
MSC/Jacki Houts, Mail Stop 142-3, jacquelynne.houts@nasa.gov

Chief, ISS and Human Health Project Office:
MSI/Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### 7.1. Hardware

a) Task 4.2 – Hardware purchased using contract funding, at the conclusion of the Base Task. CARRIED FORWARD

### 7.2. Software

The following are the expected software deliverables identified in the Performance Work Statements:

a) Task 4.1 – CM/DM system(s) software if required to read project CM/DM data, at the conclusion of the Base Task. CARRIED FORWARD
b) Task 4.4 – AutoCAT spacecraft-side software ported to Digi Connect Core 6UL, by 02/01/23.
c) Task 4.4 – Bug fixes for AutoCAT minimal communications mode over Iridium constellation, if applicable, by 04/01/23.
d) Task 4.5 – Source code and executables for features identified in the Beta #1 deliverable, by 4/1/22.
e) Task 4.5 – Source code and executables for features identified in the Beta #2 deliverable, by 6/10/23.
f) Task 4.5 – Source code and executables for features identified in the Beta #3 deliverable, by 10/21/23.
g) Task 4.5 – Final source code and executables for all features in Task 4.5, by 11/17/23.
h) Task 4.6 – STK scenario files (.sca) used to demonstrate workflows for integrating LIDAR datasets, and HFSS data products into STK simulations, by 11/01/22.
i) Task 4.7 – STK scenario files (.sca) used to create analysis report on surface-to-surface scenarios, by 11/01/22.
j) Task 4.7 – STK scenario files (.sca) used to create analysis report on lunar backhaul scenarios, by 01/01/23.
k) Task 4.7 – STK scenario files (.sca) used to create analysis report on Artemis scenarios, by 05/01/23.
l) Task 4.8 - Beta source code for HDTN modifications, by 06/01/23.
m) Task 4.8 - Final source code for HDTN modifications, by 08/01/23.

### 7.3. Documentation

The contractor shall provide the following data and documentation deliverables:

a) Task 4.1 – Project documents, data, and software in the CM/DM system(s), at the conclusion of the Base Task. CARRIED FORWARD
b) Task 4.1 – C4MS operation and maintenance manuals if delivery of the CM/DM system software is required to read project CM/DM data, at the conclusion of the Base Task. CARRIED FORWARD
c) Task 4.2 – Presentation material on the Cognitive Communications capabilities developed under this base task, due as necessary for SCaN program reviews. CARRIED FORWARD
d) Task 4.5 – AutoCAT documentation for Phase 5 capabilities to coincide with the final software release dates above.
e) Task 4.6 – Documentation of workflows for integrating LIDAR datasets, and HFSS data products into STK simulations, by 11/01/22.
f) Task 4.7 – Report containing analysis results from STK simulations for surface-to-surface scenarios, by 11/01/22.
g) Task 4.7 – Report containing analysis results from STK simulations for lunar backhaul link scenarios, by 01/01/23.
h) Task 4.7 – Report containing analysis results from STK simulations for Artemis scenarios, by 05/01/23.
i) Task 4.8 - HDTN design document that details the planned HDTN software modifications, by 03/31/23.
j) Task 4.8 – HDTN software documentation detailing modifications made, by 08/01/23.
k) Task 4.8 – Design document for next CE-1 increment HDTN modifications, by 11/01/23.

## 8. Reporting Requirements

a) Contractor Work Plan per DID PM-06. CARRIED FORWARD
b) Contractor Financial Management Reporting per DID CD-01. Report financials to the 4.x level. CARRIED FORWARD
c) Monthly reporting per DID CD-03 ON-GOING CARRIED FORWARD

## 9. Government Furnished Equipment

a) GRC Risk Management and Information (RMIT) System
b) NASA eRoom / Sharepoint / Box data management solutions
c) One Digi Connect Core 6UL board

d) NASA Gitlab version control software
e) Access to the internal GRC HDTN development repository

**10. Government Furnished Facilities**

Not Applicable

**11. Government Contacts**

The contractor shall have access to the following for consultation:

a) GRC Cognitive Communications project team
b) GRC quality assurance personnel

**12. Foreign Travel**

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

**13. Acronym List**

| Acronym | Description |
|---|---|
| AE | Astro Engine |
| AI | Artificial Intelligence |
| API | Application Programming Interface |
| AWS | Amazon Web Services |
| BT | Base Task |
| C4MS | Cognitive CommuniCations Configuration Management System |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| CE | Cognitive Engine |
| CGT | Cognitive Ground Testbed |
| CLPS | Commercial Lunar Payload Service |
| CM | Configuration Management |
| Cog-Com | Cognitive Communications |
| DID | Data Item Description |

| | |
|---|---|
| **DM** | **Data Management** |
| **DSN** | **Deep Space Network** |
| **eCC** | **electronic Country Clearance** |
| **ESS** | **Event Selection Service** |
| **EVA** | **Extravehicular Activity** |
| **EvAWS** | **Event Scheduler for Amazon Web Services** |
| **EvM** | **Event Manager** |
| **FPGA** | **Field Programmable Gate Array** |
| **GLPR** | **GRC Procedural Requirement(s)** |
| **GPU** | **Graphics Processing Units** |
| **GRC** | **Glenn Research Center** |
| **HDTN** | **High-Speed Delay Tolerant Networking** |
| **HQ** | **Headquarters** |
| **IM-2** | **Intuitive Machines 2** |
| **ISS** | **International Space Station** |
| **LEGS** | **Lunar Exploration Ground Systems** |
| **LIDAR** | **Light Detection and Ranging** |
| **LRO** | **Lunar Reconaissance Orbiter** |
| **LTE** | **Long-Term Evolution** |
| **LTP** | **Licklider Transmission Protocol** |
| **ML** | **Machine Learning** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **RMIT** | **Risk Management and Information** |
| **SBU** | **Sensitive But Unclassified** |
| **SCaN** | **Space Communications and Navigation** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **STK** | **Systems Tool Kit** |
| **SWaP** | **Size, Weight and Power** |
| **TDRSS** | **Tracking and Data Relay Satellite System** |
| **TES** | **Technology Education Satellite** |
| **UIS** | **User Initiated Service** |
| **UISP** | **User-Initiated Service Processor** |

**SpaceDOC-2 NNC14CA02C**
**DO-213 ExMC**
**Exploration Medical Capability (ExMC)**
**Delivery Order Period January 1, 2014 to March 31, 2023**
**FOR THE PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH MARCH 31, 2024**

# 1 OVERVIEW

The work is divided into several tasks, including leading the flight hardware development and operations for ExMC ISS Technology Demonstrations, supporting the development and verification of the IMPACT software tool suite, and Systems Engineering and Integration (SE&I) Functions. For those sections without headings, every item in the section applies to all tasks in the Period of Performance.

Overall, the Contractor will baseline and maintain a resource-loaded schedule for all deliverables and related subtasks, and support bi-weekly schedule status meetings with the GRC PM and schedule analyst to track progress versus plan.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through March 31, 2024.

## 1.2 GOVERNMENT CONTACTS

The Contractor shall have access to the following for consultation:

**ISS Flight Technical Demonstrations**

1. GRC ExMC Project Manager
2. GRC HRP Lead Systems Engineer
3. Representative of the Research Operations and Integration (ROI) element of the Human Research Program. This individual will be appointed by JSC.

**Systems Engineering and Integration (SE&I) Functions including IMPACT**

1. GRC ExMC Project Manager
2. IMPACT Project Manager
3. IMPACT Software Process Manger
4. GRC HRP Lead Systems Engineer
5. IMPACT Requirements Lead at JSC

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1. Project Plan
2. Science Requirements Document (SRD)
3. Experiment Data Management Plan (EDMP)

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

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## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**Task Manager, ISS and Human Health Office, MSI**

DO Manager (Courtney Schkurko, Mail Stop 77-7, NASA Glenn Research Center, Cleveland, OH 44135, courtney.m.schkurko@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric T. Hartman Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, GRC Human Research Program (Kelly Gilkey, Mail stop 77-7,)
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1. Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly. ON-GOING
2. Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06 ON-GOING
3. Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4. Monthly reporting, per DID# CD-02, ON-GOING
5. Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6. Lessons Learned Report per DID PA-17 ON-GOING
7. Meeting Summaries ON-GOING

In addition to the standard document deliverables listed above, the Contractor shall provide the NASA GRC PM with brief weekly activity reports for any active elements of this DO, highlighting status, deliverables met, progress toward plan, and any issues/concerns.

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## 3 GOVERNMENT FURNISHED

### 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

- NASA-provided computer systems (laptops via the NASA NEST contract) including Microsoft Teams and Microsoft SharePoint capabilities
- NASA-provided MagicDraw, Teamwork Cloud, and Cameo Requirements Modeler software licenses
- Philips Tempus Pro / ALS
- rHEALTH AWESOME laboratory analyzer prototype
- LifeBot multifunctional integrated medical device

### 3.2 GOVERNMENT FURNISHED FACILITIES

The following government facilities shall be available to the Contractor as needed:

1. Microgravity Emissions Lab and Acoustics Lab
2. Thermal Environmental Chambers in Building 333A
3. EMI Laboratory in Building 333A
4. GRC Telescience Support Center
5. 2.2 Second Drop Tower Facility
6. Zero G Drop Tower Facility
7. Lab Space in Building 110
8. Lab on a chip flow loops and microscopes

# 4 PROJECT SPECIFIC SOW

## 4.1 Imaging Integration THIS SECTION COMPLETED

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Imaging technologies can form the basis for being able to diagnose and treat a broad range of conditions. NASA and its contractors, the NASA Translation Research Institute for Space Health (TRISH) cooperative agreement, grantees of the National Institutes of Health (NIH), as well as the private sector all perform work in this area. As a result of the broad scope of effort, NASA must carefully follow technology developments to ensure that exploration missions are equipped with the best technology possible, as well as avoid duplicative effort.

The objectives for Imaging Integration are to:

- Inform ExMC and its stakeholders about X-ray based technology by developing an X-ray Level of Care (LOC) IV/V ConOps, X-ray level 5 functional requirements, assumptions, and an X-ray presentation.
- Procure a renal trial on human subjects for a renal stone lodged in the ureter.
- Inform ExMC and its stakeholders about an Integrated Ultrasound System (IUS) based on Flexible Ultrasound System (FUS) technology by developing Ultrasound LOC IV/V ConOps, Ultrasound level 5 functional requirements, an Ultrasound presentation and by identifying project/program risks and assumptions,. Include a continuation of the existing GE support contract and include an Ultrasound Model Based System Engineering (MBSE) model and any SE &I functions needed to perform the above effort.
- Develop content for strategic plans for imaging technology development and spaceflight demonstration by reviewing and providing content about the current state of the art (SOA) in spaceflight imaging capabilities and recommendations for technical advancement.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | The Contractor shall produce a MBSE model for the Ultrasound requirements | September 30, 2021 (was 4/2020, 12/2019) Carried Forward COMPLETE |
| 2 | Disposition the X-Ray ConOps comments from the ExMC CB, update the X-Ray ConOps based upon the comments from the ExMC CB and deliver an updated X-Ray ConOps | September 30, 2021 (was 12/2020) Carried Forward COMPLETE |

| Milestone Number | Milestone | Date |
|---|---|---|
| 3 | Disposition the Ultrasound ConOps comments from the ExMC CB, update the Ultrasound ConOps based upon the comments from the ExMC CB and deliver an updated Ultrasound ConOps | April 30, 2021 (was 12/2020) COMPLETE |
| 4 | Disposition the X-Ray Level 5 Functional Requirements Doc with updates from element review, and deliver baselined requirements doc | September 30, 2021 (was 1/2021) COMPLETE |
| 5 | Disposition the Ultrasound Level 5 Functional Requirements Doc with updates from element review, and deliver baselined requirements doc | April 30, 2021 (was 2/2021) COMPLETE |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Ultrasound MBSE model | 1 |
| Updated X-Ray ConOps | 2 |
| Updated Ultrasound ConOps | 3 |
| Baselined X-Ray Level 5 Functional Requirements | 4 |
| Baselined Ultrasound Level 5 Functional Requirements | 5 |

## 4.2 Exploration Laboratory Analysis (ELA) THIS SECTION COMPLETED

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Exploration Medical Capability provides the information and tools necessary to treat serious medical conditions that may arise during Exploration Class missions. Some of these conditions may require blood analyte diagnosis. Due to the mass penalties associated with flying multiple blood analyte platforms or a large lab bench platform that allows for the total number of analytes expected to be assayed, NASA would like to develop a platform with minimal consumables, blood loss and overhead required for a four year assay reagent shelf life.

The objectives of ELA are to:

- Inform ExMC and its stakeholders about assayer technologies that encompass biomarker assay capabilities identified as necessary by ExMC by developing:
    - ELA LOC IV/V ConOps
    - ELA Level 5 functional requirements
    - Any SE&I functions needed to perform the above effort
- Identify project/program risks and assumptions
- Provide strategic plan content about the current state of the art (SOA) in spaceflight analyte platforms and recommendations for technical advancement.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | The Contractor shall deliver an ELA MBSE model based on the Level 5 Functional Requirements | September 30, 2021 COMPLETE |
| 2 | Disposition the ELA Level 5 Functional Requirements Doc with updates from element review, and deliver baselined requirements doc | October 15, 2021 (was 9/2021) COMPLETE |
| 3 | Disposition the ELA ConOps comments from the ExMC CB, update the ELA ConOps based upon the comments from the ExMC CB and deliver the baselined ELA ConOps | October 15, 2021 (was 9/2021) COMPLETE |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| ELA MBSE model | 1 |
| Baselined ELA Level 5 Functional Requirements Doc | 2 |

| Document Deliverables | Milestone Number |
|---|---|
| Baselined ELA Level 5 ConOps for Level of Care IV/V | 3 |

### 4.3 Medical Oxygen Patient Interface (MOPI) THIS SECTION COMPLETED

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Exploration Medical Capability provides the information and tools necessary to treat serious medical conditions that may arise during Exploration Class missions. Some of these conditions may require flight surgeons to treat an ill or injured crew member using oxygen therapy. The scope of this task is after the supplemental oxygen source output to the patient and the patient's relevant physiological parameters. The objective of MOPI is to inform ExMC and its stakeholders of technologies and methodologies associated with the delivery of medical oxygen. The MOPI scope of work consists of development of MOPI LOC IV/V ConOps, MOPI level 5 functional requirements, identified project/program risks and assumptions, and a MOPI presentation. Include a MBSE model and any SE&I functions needed to perform the above effort.

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Deliver an updated version of the MOPI ConOps for LOC IV/V and Level 5 Requirements based upon comments from the ExMC CB review | September 30, 2021 COMPLETE |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Baselined MOPI LOC IV/V ConOps and Level 5 Requirements Docs | 1 |

## 4.4 Medical Suction Patient Interface (MSPI) THIS SECTION COMPLETED

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Medical suction for exploration missions could be necessary to clear the airway, empty the stomach, decompress the chest, keep an operative field clear or as treatment for pneumothorax. The scope of this task is from the vacuum source after the phase separator to the patient (exclusively) and the patient's relevant physiological parameters. The objective of MSPI is to inform ExMC and its stakeholders of technologies and methodologies associated with medical suction capabilities. The MSPI scope of work consists of development of MSPI LOC IV/V ConOps, MSPI level 5 functional requirements, identified project/program risks and assumptions, and a MSPI presentation. Include a MBSE model and any SE&I functions needed to perform the above effort.

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Deliver an updated version of the MSPI LOC IV/V ConOps and Level 5 Requirements based upon comments from the ExMC CB review | September 30, 2021 COMPLETE |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Baselined MSPI LOC IV/V Con Ops and Level 5 Requirements | 1 |

## 4.5 COTS Analyte Assayer – HemoCue THIS SECTION COMPLETED

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Exploration Medical Capability provides the information and tools necessary to treat serious medical conditions that may arise during Exploration Class missions. Some of these conditions may require analyte diagnosis. Due to the high cost of developing assayer platforms, associated reagent formulations and securing FDA (510k) approvals, NASA would like to investigate existing assayers devices that may be able to operate in a low gravity environment. Because of the existence of assayers in the market place, ExMC is planning ISS demonstrations of candidate assayers that can be classified as COTS devices using JSC's work instruction, OA-WI-003, latest version, to certify. The COTS Analyte Assayer effort here in will be a series of smaller tasks that will map to specific marketed products. A commercial product, HemoCue, was identified for demonstration by the Element in FY18, but in future years a limited tech watch may be performed or further Element guidance may be provided in order to down select other such classes of devices for subsequent spaceflight demonstrations. The Contractor shall support ISS operations from the GRC Telescience Support Center (TSC).

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Deliver HemoCue Final Report | April 30, 2021 COMPLETE |
| 2 | Knowledge Capture – COTS Process and Lessons Learned from ground and flight demonstrations | May 31, 2021 COMPLETE |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.5.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| HemoCue Final Report | 1 |
| HemoCue Lessons Learned Report | 2 |

## 4.6 ISS Technical Demonstrations of Medical Devices

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Exploration Medical Capability provides the information and tools necessary to treat serious medical conditions that may arise during Exploration Class missions. Some of these conditions may require analyte diagnosis, imaging, or vital signs monitoring. The project has been focused on laboratory analyzer devices (successfully demonstrating the HemoCue analyzer on ISS in 2021 and flying the rHEALTH device in 2022), but the focus is expanding to other device types based on market survey and trade study analyses.

Both the ExMC and the medical operations community are interested in technology demonstrations of multi-functional integrated medical devices. The Philips Tempus Pro has been identified as a COTS candidate for a technology demonstration. The assumption is that the Tempus hardware will be flight-certified by the European Space Agency (ESA) and manifested to ISS, and NASA will establish necessary agreement(s) to perform in-flight operations on ISS to execute the NASA Test Objectives for the Tempus, augmenting the ESA Test Objectives. The NASA Test Objectives will focus on increasing autonomous operation and enabling Earth-Independent Medical Operations (EIMO).

A secondary multi-functional medical device, the LifeBot, has also been identified as a candidate medical device for an ISS technology demonstration. Based on a trade-study conducted by NASA Exploration Medical Integrated Product Team (XMIPT) in partnership with Yet2, both the Tempus Pro and LifeBot offer similar capability and a more detailed ground-based comparison is warranted.

**NASA Tempus Pro Detailed Test Objectives (summary as of December 14, 2022):**

Ground-based work:

- **Support** development of the NASA Tempus Pro ISS Demonstration:
    - NASA will determine the medical procedures and scenario(s) to use during the ISS demonstration (*Discuss with ExMC & XM-IPT Scientists and Clinicians*)
        - A medical contingency scenario consisting of a non-emergent, non-traumatic medical condition of flank pain has been selected for Phase 2
            - Crewmember complains to caregiver about mild to moderate flank pain
            - The caregiver needs to diagnose the reason, which could be from: Nephrolithiasis, Urinary tract infection, or Urinary retention
            - The caregiver collects the history of the present illness, evaluates ABC's, reviews past medical history and reviews symptoms of the current complaint
            - The Tempus is used to collect vital signs, including:
                - Blood pressure
                - Heart rate
                - Oxygen saturation
                - Temperature
                - Respiratory rate

        - The Tempus is also used to measure ECG, if applicable, and to perform an ultrasound of the abdominal area

    - Use the following to help inform medical procedure development to include within the scenario:

        - Discussion with Med Ops clinicians

        - ISS medical procedures (possibilities):

            - 2.8.305 SGA Tube Placement

            - 2.7.303 ECG Device – Obtain Electrocardiogram (ECG)

            - 2.0.306 Digital Otoscope

            - 2.0.301 Vital Signs

            - 2.0.106 Periodic Health Exam

            - 1.102 AED Assisted CPR

  - NASA will determine what types of communications to use during the ISS demonstration (i.e. real-time, delayed or none) for the autonomous operations demonstration and determine how to achieve this operationally. (*Discuss with ExMC & XM-IPT Scientists and Clinicians*)

  - **The contractor will support** development of criteria for evaluation and selection of possible procedural guidance technologies to use as part of the ISS demonstration. Develop and test procedural guidance modules developed from iAssist, with ISS Procedures Viewer (PV) and with the advanced technologies. We will consider an Autonomous Medical Officer Support (AMOS) module, building upon and leveraging previous ExMC work. (*Discuss with ExMC & XM-IPT Scientists and Clinicians*)

  - **The contractor will support** identification/modification of a survey focused on use of the Tempus Pro in a microgravity environment and of a survey for use with ground-based evaluation and testing. We will determine what objective performance metrics can be obtained in addition to subjective surveys. Incorporate suggestions received from LaRC Human Factors (HF) SMEs on their review of the Tempus Pro ISS demonstration scientific objectives and leverage the Military's usability assessment (described within the documents sent by Shean Phelps, ExMC Associate Scientist) to avoid unnecessary duplication. (*Discuss with NASA HF SMEs from ARC and LaRC*)

- **The contractor will support** an evaluation to determine if the all-in-one TEMPUS PRO/ALS is a feasible replacement for the current suite of medical devices, assess the potential value of incorporating the TEMPUS PRO into an exploration medical system and determine what it can replace and what additional capabilities will be needed that the Tempus Pro doesn't provide. Focus on capabilities beyond the Periodic Health Survey (PHS) function, which is ESA's main objective – i.e., augment ESA's evaluation.

- **The contractor will not** be responsible for custom software development related to Tempus Pro data capture beyond what is needed to collect basic information/data (e.g. Tempus generated PDFs) and user experience results. The contractor may need to support conversations or deliver preliminary test data to the CHP-IDA team in support of their integration efforts.

**<u>NASA LifeBot Detailed Test Objectives (summary as of December 14, 2022):</u>**

<u>Ground-based work:</u>

- Contractor will not be responsible for procuring a LifeBot unit and associated plug-ins – NASA will obtain and provide (captured in GFE section).
- **Support** development of the NASA LifeBot ground-based demonstration:
  - **The contractor will support development** of medical procedures for a technology demonstration for the same medical contingency scenarios identified for the Tempus Pro technology demonstration.
  - NASA will determine what types of communications to use during the ISS demonstration (i.e. real-time, delayed or none) for the autonomous operations demonstration and determine how to achieve this operationally.
- **The contractor will support** an environmental assessment of the LifeBot based on documented specifications and technical discussions with LifeBot SMEs to identify any areas of concern for performance within the Exploration Atmospheres chamber and in a spaceflight (ISS) Environment.
  - The assumption is that the LifeBot would be treated as JSC Class 1E payload and that major modifications to the hardware or software would not be necessary or in scope for the period of performance of this DO.
    - The assumption is that the contractor may identify gaps in the capability of the hardware/software and that customization of the hardware may need to be performed by LifeBot, etc.
  - TBD – Perform additional environmental testing if needed (e.g. EMI) if LifeBot specifications don't meet spaceflight hardware requirements.
- **The contractor will not** be responsible for custom software development related to LifeBot data capture beyond what is needed to collect basic information and user experience results. The contractor may need to support conversations or deliver preliminary test data to the CHP-IDA team in support of their integration efforts.

- **The contractor will support** an evaluation to determine if the all-in-one LifeBot is a feasible replacement for the current suite of medical devices, assess the potential value of incorporating the LifeBot into an exploration medical system and determine what it can replace and what additional capabilities will be needed that the LifeBot provide.

- The project is targeting a Launch of the LifeBot device to ISS in February 2024; and USCV-8 increment does not start until February 2024. It is our assumption that operations of the tech demo would likely be outside the POP for this DO due to crew scheduling constraints.

    - The contractor will support development of an ROI Feasibility assessment and will be responsible for development of Safety Data Package for the LifeBot COTS payload.

**ISS Technical Demonstrations** - The contractor shall provide a Payload Developer (PD) console operator to support operations and participate in the meetings and reviews. An Operations Readiness Review (ORR) shall be completed prior to the start of operations for each Phase II Tempus TD and LifeBot TD.

<u>Exploration Atmosphere Chamber Studies Collaboration for Tempus Pro & LifeBot:</u>

- NASA will plan to use the Exploration Atmospheres Chamber as a test bed for developing the ISS Demonstration for both the Tempus Pro/ALS and LifeBot, including testing performance of the medical scenario, determining how to operationally establish the delayed communications and test any new procedural guidance technology that will be used as part of the demonstration.

- **The contractor will support** use of this ground analog as a test bed to help with the determination of whether the all-in-one TEMPUS PRO/ALS or LIFEBOT is a feasible replacement for the current suite of medical devices, assessment of the potential value of incorporating the TEMPUS PRO or LIFEBOT into an exploration medical system and determination of what it can replace and what additional capabilities will be needed that the Tempus Pro or LIFEBOT doesn't provide.

    - **The following can help inform this evaluation:** MORD_SSP 50260 - International Space Station Medical Operations Requirements Document (ISS MORD)

- **The contractor will support** the development and the collection of performance metrics, including subjective survey information from test subjects

- Contractor should plan to have key individuals obtain CITI certification (Institutional Review Board on-line training course – cost is free, but completion of the training takes ~ 8 hrs) if they have not already obtain certificates. This will allow Co-Investigator participation in the chamber study.

- Contractor should plan for travel to Houston, TX (NASA Johnson Space Center) – 2 individuals for 10 days for coordination meetings and study support.
    - Exploration Atmospheres chamber 11-day test study is coordinated by JSC Human Health & Performance
- Plan to support the TEMPUS PRO & LifeBot hardware materials certification and hazard analysis to meet requirements for Exploration Atmospheres Chamber Study. Plan to provide support to a Test Readiness / Operational Readiness Review ~~and preparation of safety documentation,~~ top level Concept of Operations and Test Plan as required.
        - The Tempus Pro & LifeBot should not have issues with the lower pressure environment (~ 8 psia).
        - The increased oxygen concentration may pose a concern (34% - up to 40% oxygen). It is a process to get devices approved by the materials safety group at JSC. They will need info such as what kind of housing, type of battery, etc.
    - After completion of the Exploration Atmospheres chamber study, the contractor will complete a ground-based comparison of the Tempus Pro and LifeBot devices based on performance metrics, subjective and objective feedback, and other figures of merit.

<u>ISS Demonstration – NASA's rough plan as of December 2022 (currently still in development at the time of this writing):</u>

- The assumption is that an ISS Demonstration (Phase II) of the Tempus Pro will not take place earlier than February 2024 and operations supporting activity is likely out of scope for the performance period of this DO. Information is included below as additional context.
- Crew performs medical scenario(s) consisting of various medical procedures that require use of the Tempus Pro
- Demonstrate autonomous operations by varying the type of communications used during performance of the scenarios (i.e. real-time, delayed or none). Determine how to achieve this operationally.
- Use various procedural guidance technologies, including iAssist, ISS Procedural Viewer and AMOS or other advanced technology.
- Collect subjective and possible objective feedback from the crew as they use the Tempus Pro on ISS. Focus the survey on questions specific to use of the Tempus Pro in a microgravity environment.

Contractor will not be responsible for procuring a Tempus Pro/ALS unit and associated plug-ins – NASA will obtain and provide (captured in GFE section).

Because of the existence of commercial medical devices in the market place, ExMC is further planning ISS demonstrations of candidate medical devices that can be classified as COTS or follow the Class IE Payload Process using JSC's work instruction, OA-WI-003, latest version, to certify COTS, and JPD7120.9 to certify via the Class IE Payload Process. The JPD7120.9 process allows COTS and other non-complex, non-critical hardware to be designated as Class 1E. All required safety processes will remain enforced and applicable to Class 1E payloads. Class 1E payloads shall comply with safety and interface requirements of the host vehicle.

The contractor will manage all verification activities and verification closure reports, safety data package development, integration with ROI, all crew procedure inputs and training materials to setup, operate and stow the medical device payloads. These materials will be provided to ROI.

The contractor will conduct flight ops ground (PI) support via the Glenn ISS Payloads Operations Center (GIPOC) for operations required to execute the ISS Tech Demos, including space-ground communications, data downlink and retrieval, etc.

Contractor shall update the Market Survey and Trade Study analysis of medical devices available in the marketplace and through NASA-funded efforts (e.g., Small Business Innovative Research) and deliver an updated report at the end of each FY detailing down select criteria and updated recommendations. NASA will provide further direction on the content needed.

Include travel to support attendance at the Human Research Program Investigator's Workshop (HRP IWS) (Galveston, TX) for 4 persons, 3 day conference in the event the rHEALTH abstract is selected for a podium presentation and for ExMC SE&I collaboration. Current understanding is that conference will be in-person in February 2023. Include travel to support attendance for 2 persons at the 2024 HRP IWS targeted for February 2024 in anticipation of a COTS multi-functional medical device related abstract submission and presentation.

### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | The Contractor shall produce a Phase 3 Safety Data Package for rHEALTH ONE | September 9, 2021 (was 7/2021, 5/2021, 8/2020, 12,2019) COMPLETE |
| ~~2~~ | ~~Assembly/Hardware Drawings~~ | ~~June 30, 2021 (was 4/2021 5/2020)~~ DELETE |
| 3 | Verification and Validation Reports for rHEALTH ONE | January 5, 2022 (was 9/2021, 6/2021, 5/2021, 6/2020) COMPLETE |

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~4~~ | ~~Procure or produce design, testing and delivery of vials for the rHEALTH ONE device that are functional in the microgravity environment~~ | ~~September 30, 2021 (was 2/2021 3/2020)~~ DELETE |
| 5 | Perform a DRR for the rHEALTH ONE flight unit with NASA QA observing | January 5, 2022 (was 11/2021,9/2021, 7/2021) COMPLETE |
| 6 | Deliver the rHEALTH ONE flight unit to NASA | January 6, 2022 (was 11/21, 9/2021 7/2021) COMPLETE |
| 7 | Deliver Market Survey and Trade Study Report for next ISS Tech Demo Recommendation / Presentation | September 30, 2021 COMPLETE |
| ~~8~~ | ~~Deliver Task Synopsis based on continued Market Survey and Trade Study (leveraging Milestone 7) for a FY23 ISS Technology Demonstration~~ | ~~September 30, 2022~~ DELETE |
| 9 | Deliver rHEALTH Final Report | December 15, 2022 COMPLETE |
| 10 | Deliver updated Market Survey and Trade Study Report for next ISS Tech Demo Recommendation / Presentation | March 1, 2024 (was 3/2023, 9/2022) |
| 11 | Deliver a Feasibility Assessment / Plan for use of Tempus Pro in the Exploration Atmospheres chamber studies | June 30, 2022 COMPLETE |
| 12 | Deliver materials certification for Tempus Pro use in the Exploration Atmospheres Chamber | May 31, 2023 (was 11/2022, 9/2022) |
| 13 | Deliver Tempus Test Readiness package for Exploration Atmospheres Chamber Study (e.g. test/crew procedures) | July 31, 2023 (was 3/2023, 1/2023) |
| ~~14~~ | ~~Deliver Safety Data Package for Tempus Pro use in the Exploration Atmospheres Chamber~~ | ~~February 16, 2023~~ DELETE |
| 15 | rHEALTH Abstract for IWS 2023 | October 14, 2022 COMPLETE |
| 16 | Deliver materials certification package for LifeBot for use in the Exploration Atmospheres chamber | May 31, 2023 |
| 17 | Deliver LifeBot Test Readiness Review package for Exploration Atmospheres Chamber Study | July 31, 2023 |

| Milestone Number | Milestone | Date |
|---|---|---|
| 18 | Support 11-day Exploration Atmospheres chamber testing for Tempus Pro & LifeBot | August - September 2023 |
| 19 | Environmental Assessment of capability of LifeBot complete | September 29, 2023 |
| 20 | Safety Review for LifeBot (Phase 0/I/II) | September 2023 |
| 21 | Abstract for IWS 2024 | October 6, 2023 |
| 22 | Deliver report on comparison of Tempus & LifeBot COTS products performance & capability | November 30, 2023 |
| 23 | Safety Review for LifeBot (Phase III) | December 2023 |
| 24 | LifeBot Hardware Delivery | February 2024 |
| 25 | IWS 2024 | February 2024 |
| 26* | LifeBot ORR | April 2024 |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| ~~Microgravity rHEALTH ONE vials~~ | ~~4~~ DELETE |
| rHEALTH ONE flight unit with microgravity modifications | 6 |
| LifeBot flight unit | 24 |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase 3 Safety Data Package for rHEALTH ONE | 1 |
| ~~rHEALTH ONE Assembly/Hardware Drawings~~ | ~~2~~ DELETE |
| rHEALTH ONE Verification and Validation Reports | 3 |

| Document Deliverables | Milestone Number |
|---|---|
| Baseline Market Survey Trade Study Report | 7 |
| ~~Task Synopsis~~ | ~~8~~ DELETE |
| rHEALTH Final Report | 9 |
| Updated Market Survey and Trade Study Report for next ISS Tech Demo Recommendation / Presentation | 10 |
| Feasibility Assessment / Plan for use of Tempus Pro in the Exploration Atmospheres chamber studies | 11 |
| Materials certification and safety data package for Tempus Pro use in the Exploration Atmospheres Chamber | 12 |
| Test Readiness Review / Operational Readiness Review package for Exploration Atmospheres Chamber Study | 13 |
| ~~Deliver Safety Data Package for Tempus Pro use in the Exploration Atmospheres Chamber~~ | ~~14~~ DELETE |
| rHEALTH Abstract for IWS | 15 |
| Materials certification package for LifeBot for use in the Exploration Atmospheres chamber | 16 |
| LifeBot Test Readiness Review package for Exploration Atmospheres Chamber Study | 17 |
| Crew Procedures for Exploration Atmospheres chamber study | 18 |
| Phase 0/I/II Safety Data Package | 20 |
| Abstract for IWS 2024 | 21 |
| Final report on comparison of Tempus Pro & LifeBot COTS products performance & capability | 22 |
| Phase 3 Safety Data Package | 23 |
| IWS 2024 | 25 |
| Tempus Pro Phase 2 & LifeBot ISS Technical Demonstration - ORR | 26* |

* Outside of the period of performance

### 4.7 Systems Engineering & Integration (SE&I) Functions

The Exploration Medical Capability Element of the Human Research Program is assigned the gap: We do not have the capability to implement medical resources that enhance operational innovation for medical needs (MED 13). Exploration Medical Capability provides the information and tools necessary to treat serious medical conditions that may arise during Exploration Class missions. Some of these conditions may require imaging or blood analyte diagnosis and/or may require the capability to supply medical oxygen or medical suction. The objectives of the SE&I effort are to inform ExMC and its stakeholders through ConOps and functional requirements, to identify project/program risks and assumptions, and provide presentations. SE&I functions, such as requirements tracing, are often needed to perform the above effort.

The contractor will support Medical System Development for the medical system foundation MBSE model effort, which is led out of JSC. This effort will include ConOps scenario development and decomposition, requirements development: assessing functions and capabilities for new requirements, allocating requirements to the new system models, assessing for any changes to the requirement text or rationale, tracing requirements to functions, capabilities, and other model elements as needed, and partaking in review of requirements.

The specific tasks, deliverables, and planned deliverable dates are summarized below, along with target fractional levels of support for each area – note, deliverables are to the JSC SE&I team directly, and not captured in deliverables tables in this SOW. It is expected that the contractor will manage workflow and deliverables, and keep the JSC SE&I team leads appraised of progress. The contractor will make best faith effort to meet the schedule demands and SE&I team needs for Concept of Operations and Requirements development and documentation, and lead Cradle integration with the Foundation model.

- **Cradle integration with foundation model**
    - Populate Cradle with requirements
    - Review and confirm tracing and formatting of content
    - Create templates and/or processes for importing/exporting
    - Lead (Co-lead) weekly Cradle meetings and weekly report
    - Define objectives for Cradle
    - Develop, manage and report on team task list and accomplishments
    - Identify, collate and post training material to OneNote

- **Earth Independent Medical Operations (EIMO)**
    - Support development of the EIMO ConOps
    - Support the MBSE team with the EIMO model
        - Support EIMO modeling for ConOps, including the development of activity diagrams
        - Support the EIMO system model
        - **The contractor shall** develop advanced techniques for presenting model content upon request
    - Support the SE-EIMO requirements team

        - Responsible for developing and reviewing EIMO requirements
        - Primary responsibility is to maintain requirements in Cradle and provide configuration management

- **Mars Crew Health & Performance (CHP) System model**
    - Support development of the Mars CHP ConOps
    - Support the MBSE team with the Mars CHP model
        - Support modeling for ConOps, including the development of activity diagrams
        - Support the inclusion of a ConOps in the model
        - **The contractor shall** develop advanced techniques for presenting model content upon request
    - Support the SE-Mars CHP Requirements team
        - Responsible for the initial drafting of Mars CHP requirements
        - Primary responsibility is to maintain requirements in Cradle and provide configuration management

- **IMPACT Mapping File**
    - The contractor shall provide configuration management of LDLOLS mapping file content in Cradle and the LDLOLS model
    - Produce mapping file upon request from IMPACT
        - The assumption is this may happen 2-3 time from 4/1/23 thru 3/31/24

**IMPACT – Informing Mission Planning via Analysis of Complex Tradespaces**
An additional objective of the ExMC SE&I functions is to develop, demonstrate and use a software tool named IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces). The IMPACT tool suite consists of six (6) individual software components including two databases; MedID (a database holding medical resource information), Evidence Library (a database holding clinical information), which are combined into a single database entity known as the IMPACT Medical Database (IMPACT-MD) (1), IMPACT Desktop (2), IMPACT Run (3), Request Repository (4), MSFM SysML Model (5), and Tableau (6). IMPACT also uses Java and JavaFX code for capturing operator input and for integration among the five tools. The current version of IMPACT is being used to perform trade studies on the contents of a potential medical system for an exploration mission. Development and demonstration of future versions of IMPACT is also underway. The Contractor scope of work necessary for supporting IMPACT includes:

- The Contractor shall become proficient in performing IMPACT simulations by obtaining an understanding of how to access and use all of the tools of IMPACT, including MedID, Evidence Library, MEDPRAT, CHPSM, and Tableau post processing tools. The Contractor will also develop an understanding of the Java/Java FX code being used to integrate the tools together. Once proficiency is attained, the Contractor shall perform IMPACT simulations associated with trade studies defined by the IMPACT team and develop Tableau post processing workbooks that allow visualization of the trade study results.

- The Contractor shall perform a full sensitivity analysis of the IMPACT input parameters to determine parameters that both highly influence risk metric outcomes and do not influence risk metric outcomes. The Contractor shall also identify how uncertainty in the input parameters propagate to risk metric outcomes including unknown uncertainty. The Contractor shall use post-processing methods to provide a visualization of results and document the findings in a presentation.

- The contractor shall support software configuration management for IMPACT, including software configuration management for all of the tools that make up IMPACT. The contractor will write software configuration management plan which could be a standalone document or included in another plan. Determine storage and computational requirements for IMPACT and implement software configuration management for IMPACT by establishing version control for the IMPACT software tool components and establish change request tracking. The contractor shall support documentation configuration management for IMPACT, by establishing version control and change request tracking. The contractor shall provide training to the IMPACT team on version control and change request process. Once the IMPACT documentation configuration management and software configuration management is established, the Contractor shall maintain the system and make any necessary updates. ZIN CoMET system shall be used IMPACT software configuration management. The Contractor shall support requirements definition for IMPACT as directed by the GRC IMPACT Leadership Team. The Contractor shall work with the IMPACT Requirements Lead at JSC and shall meet with customer and stakeholders to collect requirements and document agreed-upon requirements. The Contractor shall also prepare content for the software requirements review and update requirements based on review outcome.

- The Contractor shall provide software programming support as the defined requirements are implemented into IMPACT. This work will occur within the IMPACT Desktop tool (JavaFX) at a minimum, but may involve other parts of the tool suite as well and as needed. Additionally, the following skillsets are required:
-
    - o IMPACT Service Request App Developer
      A web content developer is needed to design, code and test a web-based application that captures, stores tracks and documents the high-level information about formal IMPACT requests from stakeholders who are not versed in how the IMPACT tool suite operates. The system will prompt the user for information about the input conditions for the mission they wish to simulate (i.e., mission events and crew) and the type of trade space analysis that they would like an IMPACT trained operator to perform for them. Examples of this include, but are not limited to, varying mass/volume allocation, research prioritization, direct medical system tradeoffs, trading on the mission parameters or crew complement, etc. Most requests will align with one of the use case scenarios in the IMPACT ConOps. The developer will work closely with the IMPACT human factors and IMPACT Medical Database (IMPACT-MD) teams at JSC to produce a high quality, high usability product.

    - o IMPACT Software developer

A code developer with a background in Java and Java FX, as well as SQL database programming, is needed to help design and code the IMPACT Desktop application and to help design and code the user interfaces for the IMPACT Medical Database. This developer will work closely with the leads on these two tools at ARC, LaRC and JSC to produce high quality, high usability interfaces. This developer will also work closely with the IMPACT human factors team to enhance and optimize the overall user experience with the IMPACT tool suite. If needed, this developer will also assist with running user requests on the recently delivered IMPACT prototype v0.1.

- The Contractor shall develop and execute verification, validation, and credibility (V,V&C) plans for IMPACT based on the acceptance criteria established by the IMPACT team, customers and stakeholders. The plans should contain V&V testing and credibility assessment of the individual tools and for the whole IMPACT system. The Contractor shall develop V&V testing methods/scripts and perform V&V testing and credibility assessments. The Contractor shall deliver a V&V test and credibility assessment report. VV&C efforts should meet the guidance provided in NPR 7150.2 and NASA-STD-7009A, tailored to IMPACT and based on its software classification. Software classification for IMPACT will be performed by Code Q at GRC.

- The Contractor shall develop figures of merit content for the IMPACT medical resources, including but not limited to, factors associated with the resources' interaction with the space environment, their dependencies on the vehicle, their technology readiness level, their stability and shelf life, their commercial availability and their FDA approval status. The Contractor shall coordinate with LaRC IMPACT team members, who will incorporate the content within MedID, on data formatting. Additionally, the Contractor shall assist with populating MedID with multiple alternative resources within a specific category.

- Further, the contractor shall perform the following IMPACT support functions on an ongoing basis:

| |
|---|
| o Schedule and conduct technical and administrative meetings across the IMPACT Project in coordination with IMPACT Project Manager as needed |
| o Track the IMPACT Schedule and provide monthly deviation reports to the IMPACT Project Manager |
| o Identify and track IMPACT risks in RMIT, conduct monthly risk management meetings and develop risk mitigation strategies |
| o Track IMPACT action items and facilitate resolution |
| o Collect and document lessons learned during the IMPACT Sprint Retrospective Meetings and implement continuous improvement based upon the lessons learned |

| |
|---|
| o Maintain access to the IMPACT SharePoint site |

- The Contractor may be asked to support face to face meetings at NASA JSC, LaRC or ARC, subject to NASA travel guidelines.

The Contractor shall establish a consulting agreement with a clinician for ad hoc project documentation reviews as appropriate, meeting attendance and general project consultation. Support expected to be episodic and at no-cost.

- All documents delivered for this DO shall follow the NASA HRP ExMC Configuration Management (CM) Process. Documents shall use the ExMC document nomenclature, which will be provided by the NASA PM/PS. ZIN shall use the NASA ExMC template provided by the NASA PM or PS for consistency across project documentation.

- To comply with NASA and federal government cyber and data security standards, ZIN shall complete all work for this DO on NASA-provided computer systems only. NASA is responsible for the costs of the NASA-provided laptops; **ZIN is not responsible for the costs of the NASA-provided computer systems.**

- All systems engineering and MBSE models developed for this DO shall follow the NASA HRP ExMC Systems Engineering Management Plan (SEMP), NPR 7123.1C NASA Systems Engineering Requirements, and the NASA Systems Engineering Handbook (2016 or newest version).

- ZIN shall develop MBSE models using NASA MagicDraw and Teamwork Cloud. NASA is responsible for the costs of the software licenses for NASA MagicDraw, Teamwork Cloud, and Cameo Requirements modeler on NASA-provided computer systems. **ZIN is not responsible for the costs of these software licenses.**

### 4.7.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Provide requirements documentation as requirements are collected via the Agile software development cycles | September 30, 2021 (was 3/2021, 12/2020) COMPLETE |
| 2 | Provide revisions to requirement documentation resulting from the SRR | June 30, 2021 COMPLETE |
| 3 | Provide software programming for prototype v0.3 in order to implement the defined requirements. IMPACT software development will continue for the later version releases (each version releases in 6 month increments, find these in table below) | September 30, 2021 COMPLETE |

| | | |
|---|---|---|
| 4 | Baseline IMPACT verification & validation testing and credibility assessment plan | April 28, 2022<br>(was 3/2022)<br>(was 6/2021; 6/2022)<br>Moved Earlier<br>COMPLETE |
| 5 | ~~Develop V&V testing methods and associated software scripts~~ | ~~May 31, 2022~~<br>~~(was 3/2022)~~<br>~~(was 9/2021)~~<br>DELETE |
| ~~6~~ | ~~Perform V&V testing and credibility assessment~~ | ~~February 28, 2022*~~<br>~~(was 3/2023) Moved Earlier~~ DELETE |
| 7 | Deliver V&V test and credibility assessment report package | February 10, 2023<br>(was 1/2023, 6/2022, 3/2022) |
| 8 | Deliver an updated IMPACT ConOps for IMPACT v1.0 (Rev B) | September 30, 2021<br>COMPLETE |
| 9 | Deliver a baselined IMPACT Requirements Document for IMPACT v1.0 | September 30, 2021<br>COMPLETE |
| 10 | Deliver a baselined IMPACT Interfaces Document for IMPACT v1.0 | September 30, 2021<br>COMPLETE |
| 11 | Deliver updates to the IMPACT User Documentation for IMPACT v1.0 | January 31, 2023<br>(was 1/2023, 9/2022) |
| 12 | Deliver a recommendation, with justification, for an ISS Technology Demo (to be demonstrated in FY22) | September 30, 2021<br>(was 6/2021, 12/2020)<br>COMPLETE |
| 13 | Deliver a Draft IMPACT Software Design Document (SDD) | June 30, 2021<br>COMPLETE |
| 14 | Deliver an IMPACT Lessons Learned Document | September 30, 2022<br>(was 9/2021)<br>COMPLETE |
| 15 | Deliver an updated version of the Ventilator System ConOps based upon comments from the ExMC CB review | October 30, 2021<br>(was 9/2021)<br>COMPLETE |
| 16 | Deliver an updated version of the Ventilator System ConOps based upon comments from the ExMC CB review | October 30, 2021<br>(was 9/2021)<br>COMPLETE |
| ~~17~~ | ~~Baseline the Software Design Document (SDD) for IMPACT CDR~~ | ~~April 28, 2022~~<br>DELETE |
| 18 | Provide software programming in order to implement the defined requirements for IMPACT v1.0 | 10/31/2022<br>(was 8/2022)<br>COMPLETE |
| 19 | Provide software programming in order to implement the defined requirements for IMPACT v1.1 | November 30, 2023<br>(was 3/2023) |
| 20 | Provide software programming in order to implement the defined requirements for IMPACT v1.2 | May 30, 2024*<br>(was 9/2023) |

| | | |
|---|---|---|
| 21 | Provide software programming in order to implement the defined requirements for IMPACT v1.3 | November 30, 2024* (was 3/2024) |
| 22 | Provide software programming in order to implement the defined requirements for IMPACT v2.0 | May 30, 2025* (was 9/2024) |
| ~~23~~ | ~~Deliver an updated IMPACT Lessons Learned Document~~ | ~~September 30, 2022~~ DELETE |
| ~~24~~ | ~~Deliver an updated IMPACT ConOps for IMPACT v1.0 (Rev C)~~ | ~~August 25, 2022~~ ~~(was 9/2022)~~ DELETE |
| ~~25~~ | ~~Deliver a revised IMPACT Requirements Document for IMPACT v1.0~~ | ~~August 25, 2022~~ ~~(was 9/2022)~~ DELETE |
| ~~26~~ | ~~Deliver a revised IMPACT Interfaces Document for IMPACT v1.0~~ | ~~August 25, 2022~~ ~~(was 9/2022)~~ DELETE |
| 27 | Draft Report with recommendations for incorporating Agile processes to ExMC Systems Engineering | August 5, 2022 COMPLETE |
| 28 | Final Report (incorporating Element feedback) for incorporating Agile processes to ExMC Systems Engineering | September 30, 2022 COMPLETE |
| 29 | IMPACT Service Request (CRM tool) for v1.0 | September 30, 2023 (was 8/2022) |
| 30 | IMPACT Sensitivity Analysis | January 31, 2023 (was 1/2023, 8/2022) |
| 31 | IMPACT Software Management Development Plan (SMDP) | April 14, 2022 COMPLETE |
| 32 | SE&I – EIMO ConOps Development Complete | September 2023 |
| 33 | SE&I – EIMO Requirements Development | March 2024 |
| 34 | SE&I – Mars CHP System ConOps Development Complete | March 2024 |

* Outside of the period of performance

### 4.7.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Provide software programming in order to implement the defined requirements | 3 |
| Develop V&V testing methods and associated software scripts | 5 |
| Provide software programming in order to implement the defined requirements for IMPACT v1.0 | 18 |
| Provide software programming in order to implement the defined requirements for IMPACT v1.1 and bug fixes for v1.0 | 19 |

| HW/SW Deliverable | Milestone Number |
|---|---|
| Provide software programming in order to implement the defined requirements for IMPACT v1.2 and bug fixes for previous versions | 20* |
| Provide software programming in order to implement the defined requirements for IMPACT v1.3 and bug fixes for previous versions | 21* |
| Provide software programming in order to implement the defined requirements for IMPACT v2.0 and bug fixes for previous versions | 22* |
| IMPACT Service Request (CRM tool) for v1.0 | 29 |
| Provide system modeling support, including the development of activity diagrams, for the EIMO Conops | 32 |
| Provide support for development & configuration management of EIMO requirements in Cradle | 33 |
| Provide system modeling support, including the development of activity diagrams, for the Mars CHP Conops | 34 |
| Provide support for development & configuration management of Mars CHP requirements in Cradle | 34 |

* Outside of the period of performance

### 4.7.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Revisions to requirement documentation resulting from the IMPACT SRR | 2 |
| Baselined IMPACT verification & validation testing and credibility assessment plan | 4 |
| IMPACT V&V test and credibility assessment report | 7 |
| Updated IMPACT ConOps for IMPACT v1.0 | 8 |
| Baselined IMPACT Requirements Document for IMPACT v1.0 | 9 |
| Baselined IMPACT Interfaces Document for IMPACT v1.0 | 10 |
| Updated IMPACT User Documentation | 11 |

| Document Deliverables | Milestone Number |
|---|---|
| A recommendation, with justification, for an ISS Technology Demo | 12 |
| Draft IMPACT Software Design Document | 13 |
| Deliver an IMPACT Lessons Learned Document | 14 |
| ~~Baseline the Software Design Document (SDD) for IMPACT CDR~~ | ~~17~~ DELETE |
| ~~Deliver an updated IMPACT Lessons Learned Document~~ | ~~23~~ DELETE |
| ~~Deliver an updated IMPACT ConOps for IMPACT v1.0 (Rev C)~~ | ~~24~~ DELETE |
| ~~Deliver a revised IMPACT Requirements Document for IMPACT v1.0~~ | ~~25~~ DELETE |
| ~~Deliver a revised IMPACT Interfaces Document for IMPACT v1.0~~ | ~~26~~ DELETE |
| Deliver a draft report for incorporating Agile processes to ExMC Systems Engineering | 27 |
| Deliver a Final Report for incorporating Agile processes to ExMC Systems Engineering | 28 |
| IMPACT Sensitivity Analysis | 30 |
| IMPACT Software Management Development Plan (SMDP) | 31 |
| SE&I – Deliver draft EIMO ConOps | 32 |
| SE&I – Deliver draft EIMO Requirements | 33 |
| SE&I – Deliver draft Mars CHP System ConOps | 34 |
| SE&I – Deliver draft of Mars CHP System Requirements | 34 |
| Deliver document revision updates *as requested* to support IMPACT V1.1 release (including but not limited to):<br>• IMPACT Desktop SW Test Procedure, VDD, & SRS<br>• IMPACT SMDP<br>• IMPACT End-to-End Test Report & VV&C Plan<br>• IMPACT Sensitivity Analysis<br>• IMPACT User Documentation<br>• IMPACT Configuration Management Plan | 19 |
| Deliver document revision updates *as requested* to support IMPACT V1.2 release (including but not limited to): | 20 |

| Document Deliverables | Milestone Number |
|---|---|
| • IMPACT Desktop SW Test Procedure, VDD, & SRS<br>• IMPACT SMDP<br>• IMPACT End-to-End Test Report & VV&C Plan<br>• IMPACT Sensitivity Analysis<br>• IMPACT User Documentation<br>• IMPACT Configuration Management Plan | |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AED | Automated External Defibrillator |
| ALS | Advanced Life Support |
| AMOS | Autonomous Medical Officer Support |
| ARC | Ames Research Center |
| CCR | Configuration Change Request |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CHPSM | Crew Health and Performance System Model |
| CITI | Collaborative Institutional Training Initiative |
| CM | Configuration Management |
| CoMET | Configuration Management System at ZIN |
| ConOps | Concept of Operations |
| COR | Contracting Officer Representative |
| COTS | Commercial Off The Shelf |
| CPR | Cardiopulmonary Resuscitation |
| CRM | Customer Relationship Management |
| DID | Data Item Description |
| DO | Delivery Order |
| DRR | Delivery Readiness Review |
| eCC | electronic Country Clearance |
| ECG | Electrocardiogram |
| EDMP | Experiment Data Management Plan |
| EIMO | Earth-Independent Medical Operations |
| ELA | Exploration Laboratory Analysis |
| EMI | Electromagnetic Interference |
| ESA | European Space Agency |
| ExMC | Exploration Medical Capability |
| ExMC CB | Exploration Medical Capability Control Board |
| FDA | Federal Drug Administration |
| FUS | Flexible Ultrasound System |
| FY | Fiscal Year |
| GE | General Electric |
| GFE | Government Furnished Equipment |
| GIPOC | Glenn ISS Payloads Operations Center |
| GRC | Glenn Research Center |
| HF | Human Factors |
| HRP | Human Research Program |

| | |
|---|---|
| **HW** | **Hardware** |
| **IMPACT** | **Informing Mission Planning via Analysis of Complex Tradespaces** |
| **IMPACT-MD** | **IMPACT Medial Database** |
| **ISS** | **International Space Station** |
| **ISS MORD** | **International Space Station Medical Operations Requirements Document** |
| **IUS** | **Integrated Ultrasound System** |
| **IWS** | **Investigator's Workshop** |
| **JSC** | **Johnson Space Center** |
| **LaRC** | **Langley Research Center** |
| **LOC** | **Level of Care** |
| **MBSE** | **Model-Based System Engineering** |
| **MED** | **Miniature Exercise Device** |
| **MEDPRAT** | **Medical Extensible Dynamic Probabilistic Risk Assessment Tool** |
| **MOPI** | **Medical Oxygen Patient Interface** |
| **MSPI** | **Medical Suction Patient Interface** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NIH** | **National Institutes of Health** |
| **NPR** | **NASA Procedural Requirement** |
| **ORR** | **Operational Readiness Review** |
| **PD** | **Payload Developer** |
| **PHS** | **Periodic Health Survey** |
| **PI** | **Principle Investigator** |
| **PM** | **Project Manager** |
| **PS** | **Project Scientist** |
| **PV** | **Procedures Viewer** |
| **QA** | **Quality Assurance** |
| **rHEALTH** | **Reusable Handheld Electrolytes And Lab Technology for Humans** |
| **RMIT** | **Risk Management and Information** |
| **ROI** | **Research Operations and Integration** |
| **SDD** | **Software Design Document** |
| **SE** | **Sustaining Engineering** |
| **SE&I** | **Systems Engineering and Integration** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SGA** | **Supraglottic Airway (E.g. Laryngeal Mask Airway)** |
| **SMDP** | **Software Management Development Plan** |
| **SME** | **Subject Matter Experts** |
| **SOA** | **State of the Art** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |

| | |
|---|---|
| **SRD** | **Science Requirements Document** |
| **SRR** | **System Requirements Review** |
| **SRS** | **Software Requirements Specification** |
| **SW** | **Software** |
| **TBD** | **To be Determined** |
| **TRISH** | **Translation Research Institute for Space Health** |
| **TSC** | **Telescience Support Center** |
| **V&V** | **Validation and Verification** |
| **VDD** | **Version Description Document** |
| **VV&C** | **Verification, Validation and Credibility** |
| **XM-IPT** | **Exploration Medical Integrated Product Team** |

**SPACEDOC-2 NNC14CA02C**
**DO-222 ZBOT-2**
**Zero Boil-Off Tank-2 Project (ZBOT-2)**
**Contract Performance Period October 1, 2015 through March 31, 2023**
**FOR DO PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH MARCH 31, 2024**

# 1 OVERVIEW

NASA Glenn Research Center (GRC) is developing the Zero Boil-Off Tank (ZBOT)-2* experiment for operations in the Microgravity Science Glovebox (MSG) facility aboard the International Space Station (ISS). ZBOT-2 is the second in a series of small-scale simulant fluid experiments that will be used to obtain valuable microgravity empirical data for cryogenic storage tank pressure control design and archival science data for model validation. They will be used to build a science base for future space storage tank engineering efforts by elucidating the roles of the various interacting transport and phase change phenomena that impact tank pressurization and pressure control in variable gravity. The project science team will develop, validate, and verify two-phase CFD models for tank pressure control that can be used to aid the future scale-up tank design.

ZBOT was the first experiment in the series delivered to the ISS aboard Cygnus spacecraft flight OA-7, which launched on April 18, 2017. Operations were successfully conducted between September 18 and December 1, 2017. The results from ZBOT will show the feasibility of a Zero-Boil-Off (ZBO) pressure control scheme for microgravity and variable gravity applications by examining the effect of forced mixing of the bulk liquid on destratification and pressure reduction in a ventless Dewar. However, noncondensable gases can significantly affect ZBO storage tank pressurization and pressure control, especially, in microgravity. ZBOT-2 will investigate three important effects of noncondensables on the transport and phase change phenomena that control tank pressure. These effects can be best studied when they are readily unmasked in microgravity:

- The effect of noncondensable gas on microgravity vapor transport in the ullage during pressurization.
- The creation of thermocapillary convection induced by noncondensable gas and its effect on mixing, stratification and destratification in the liquid.
- The penetration of noncondensable gases into the Knudsen layer and its impact on condensation during microgravity pressure control.

The development approach for ZBOT-2 will be to modify the ZBOT hardware and diagnostics for non-condensable gas studies. Observations and results from ZBOT may also drive additional changes to the system design and capabilities including, but not limited to, replacing the existing Digital Particle Image Velocimetry (DPIV) diagnostic with a new approach and capability for making fluid velocity and/or thermometry measurements.

ZBOT-2 will be used to obtain microgravity data to determine the effect of the noncondensables on tank pressurization, thermal destratification, and pressure reduction through mixing/cooling in microgravity. The science team will expand the existing ZBOT two-phase CFD model by incorporating the non-condensable gas kinetics, species transport, and Marangoni convection submodels. Results from ZBOT-2 will be used to validate the expanded two-phase CFD model and submodels.

*Per direction received from NASA Headquarters in the spring of 2018, the name of the ZBOT-2 project has been changed to Zero Boil-Off Tank-Noncondensables (ZBOT-NC). In order to minimize changes to documentation associated with this Delivery Order, the ZBOT-2 nomenclature is retained herein. The ZBOT-NC name is to be used for all other project activities and in other project documentation.

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2021 through March 31, 2024.

### 1.2 Government Contacts

The contractor shall have access to consultation with:

1) Project Manager, Dan Brown/GRC (MSI)
2) Project Scientist, Dr. Howard Pearlman/GRC (LTX)

### 1.3 Available Project Specific Documentation

1) ZBOT-NC Project Plan, ZBOT-NC-PLN-001, Revision A
2) ZBOT-NC Science Requirements Definition, ZBOT-NC-REQ-002, Revision B
3) ZBOT-NC Experiment Data Management Plan, ZBOT-NC-PLN-004, Revision Baseline
4) ZBOT Science Requirements Definition (SRD), Version 5.0

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the

Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Delivery Order Manager, ISS and Human Health Projects Office, (Daniel F. Brown, MS 77-7, NASA Glenn Research Center, Cleveland, OH 44135, daniel.f.brown@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, SpaceDOC-2 (Kelly Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17, Draft due at the end of the PoP

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) Residual ZBOT-1 property that has been transferred to the government for storage may be requested and furnished for use on ZBOT-NC as needed to aid in the hardware development.

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis for this period of performance:

a) GRC Calibration Lab

Usage shall be agreed upon by and coordinated with the NASA Project Manager

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# 4 PROJECT SPECIFIC SOW

## 4.1 FLUID DISCOLORATION

During the course of hardware activities and testing for ZBOT, it was observed that the PNP test fluid that was removed from the flight system was discolored (darkened). Chemical analyses of the fluid were performed and the results were summarized by the contractor. For ZBOT-2, the contractor shall develop a plan to identify the source(s) of the contaminants in the flight system and or Ground Support Equipment (GSE) and to assess the compatibility of the PNP test fluid with these materials over time. The contractor shall execute this plan and deliver a report on the results, which is to include an assessment of any impacts, risks and recommended mitigations associated with the development of ZBOT-2.

Any milestones and deliverables associated with this work element have been completed in previous periods of performance.

## 4.2 FLUID RESERVOIR ASSEMBLY (FRA) LEAK ISSUES

The contractor shall conduct additional leak testing of the flight FRA in order to identify the specific leak source(s) that contributed to the excessive assembly level leak rates that were measured during testing conducted under ZBOT Mission Integration and Operations (MIO) DO-233. The contractor shall prepare a report documenting the results that also includes conclusions and recommendations for any other activities that would be necessary to determine why specific point sources leaked and/or activities that would be necessary in order to correct or mitigate the leaks. Recommended modifications to the flight hardware shall be tested on the Engineering Model (EM) FRA and shown to be successful prior to Flight FRA implementation. EM test results shall be documented in a report.

Identification of the specific FRA leak source(s) and recommendation of modifications have been completed in previous periods of performance. The remaining work to be completed in the current period of performance involves testing of recommended modifications on the EM FRA and eventual implementation on the Flight FRA.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.2.1.1 | Complete leak testing and reporting for EM FRA with recommended modifications | no later than 9/30/21 (was 9/30/20) Carried Forward Complete |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Report documenting the leak testing results using EM FRA with recommended modifications | 4.2.1 Carried Forward Complete |

### 4.3 System Requirements Review (SRR)

The contractor shall:

1) Provide preliminary assessments of draft science requirements developed by the science team, considering feasibility, impacts to the design of the ZBOT system and associated risks. Requirement changes are likely to include, but may not be limited to the following:
    a. Development of a flow visualization/thermometry diagnostic
    b. Elimination of boiling at the nozzle, Liquid Acquisition Device (LAD), solenoid valve SV1 and inline heaters based on results obtained from ZBOT ISS operations
    c. Surveillance video of the test tank
    d. Pinning of the ullage bubble in place
    e. Tank fill level control. This corrects issues encountered during ZBOT ISS operations.
2) Develop design and operational concepts that minimize changes to the ZBOT flight system while utilizing the existing flight and ground systems to the extent possible.
3) Provide a plan that identifies the testing to be performed and breadboards and ground support equipment to be utilized/developed/procured. The plan and activities shall include significant procurements or fabrication efforts.
4) Conduct breadboard testing and analyses to assess the feasibility of the science and engineering requirements.

5) Conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the SRR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.

The milestones and deliverables associated with preparing for and conducting the SRR have been completed in previous periods of performance.

### 4.4 Preliminary Design Review (PDR)

The contractor shall:

1) Provide preliminary assessments of science requirements developed by the science team, considering feasibility, impacts to the design of the ZBOT system and associated risks. Requirement changes are likely to include, but may not be limited to the following:
    a. Development of a thermometry diagnostic
    b. Elimination of boiling at the nozzle, Liquid Acquisition Device (LAD), solenoid valve SV1 and inline heaters based on results obtained from ZBOT ISS operations
    c. Surveillance video of the test tank
    d. Pinning of the ullage bubble in place
    e. Tank fill level control. This corrects issues encountered during ZBOT ISS operations.
2) Develop design and operational concepts that minimize changes to the ZBOT flight system while utilizing the existing flight and ground systems to the extent possible.
3) Provide a plan that identifies the testing to be performed and breadboards and ground support equipment to be utilized/developed/procured. The plan and activities shall include significant procurements or fabrication efforts. The contractor shall purchase as necessary any equipment needed to increase the storage capacity of the ZBOT-NC image server.
4) Conduct Engineering Model testing and analyses to assess the feasibility of the science and engineering requirements.
5) Conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the PDR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.

The milestones and deliverables associated with preparing for and conducting the PDR have been completed in previous periods of performance. The remaining work to be completed in the current period of performance involves conducting activities and providing documentation required for the disposition/closure of any engineering related actions, agreements, or Requests for Action resulting from the PDR.

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.4.1.1 | Disposition/Close engineering related actions, agreements or Requests for Action (RFAs) resulting from the PDR | no later than 12/31/21 (was 8/2020) Carried Forward Complete |

#### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

### 4.5 Critical Design Review (CDR)

The contractor shall:

1) Provide final design to meet the science requirements including:
    a. Vacuum Jacket center section window orthogonality modifications
    b. Vacuum Jacket heat transfer improvements (gasket and window material)
    c. Test Tank strip heater and RTD location updates for lower fill levels
    d. Disposition on Liquid Acquisition Device removal
    e. Inlet nozzle modifications to address bubbling issues
    f. Test Tank temperature rake modifications for lower fill levels
    g. Replacement of SV1 with magnetically latching version, including solenoid driver board
    h. Addition of check valve to protect pump from non-condensable gases
    i. Updated water pump with improved reliability
    j. Gas Delivery System design

k. Updated camera and illumination package design for Quantum Dot Thermometry diagnostic
l. Updated lighting technique for ullage imaging
m. Update FRA plumbing design to eliminate minor leak
n. Update DACU design to accommodate imaging and data storage requirements

2) Develop detailed schedule to CDR that allows roll-up to a summary level (or provide MS Project filter) suitable to assess status of the individual planned design modifications as described in item 1) above.
3) Provide plan(s) that identifies the flight testing to be performed. The plan and activities shall include significant flight procurements or fabrication efforts.
4) Conduct Engineering Model testing and analyses to assess the feasibility of the science and engineering requirements.
5) Conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the CDR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.
6) Support a CDR (meeting and Technical Review Board to be convened by NASA GRC).

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.5.1.1 | Critical Design Review | no later than 9/30/22<br>(was 9,8/2021)<br>Carried Forward<br>Complete |
| 4.5.1.2 | Disposition/Close engineering related actions, agreements or Requests for Action (RFAs) resulting from the CDR | 3/30/23<br>(was 9/2021)<br>Carried Forward |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.5.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Plan to CDR (baselined with agreed-to review artifacts) | 4.5.1.1 (minus 6 months)<br>Complete |
| Flight Procurement, Fabrication, and Test Plan | 4.5.1.1<br>Complete |
| Engineering artifacts required to meet the Entrance and Success Criteria for CDR, any modifications must be agreed to by NASA | 4.5.1.1<br>Carried Forward<br>Complete |
| CDR Presentation Materials | 4.5.1.1<br>Carried Forward<br>Complete |

### 4.6 System Acceptance Review (SAR)

The contractor shall:

1) Develop detailed schedule to FHA that allows roll-up to a summary level (or provide MS Project filter) suitable to assess status of implementing and verifying individual planned design modifications.
2) Conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the SAR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.
3) Support the SAR (Convened and Chaired by NASA GRC)

#### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.6.1.1 | System Acceptance Review (SAR) | no later than 9/30/2024*<br>(was 1/17/24) |
| 4.6.1.2 | Flight Hardware Environmental Testing Complete (Vibroacoustic, EMI, Thermal Cycle) | no later than 3/31/24 |

**date occurs beyond delivery order period of performance*

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| ZBOT-NC Flight Hardware (with installed flight software) | 4.6.1.1<br>Carried Forward |
| Ground Software necessary for flight hardware operations | 4.6.1.1 |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Plan to SAR (baselined with agreed-to review artifacts) | 4.6.1.1 (minus 6 months) |
| Engineering artifacts required to meet the Entrance and Success Criteria for SAR, any modifications must be agreed to by NASA | 4.6.1.1 |
| SAR Presentation Materials | 4.6.1.1 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CCR** | **Configuration Change Request** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CFD** | **Computational Fluid Dynamics** |
| **DACU** | **Data Acquisition and Control Unit** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **DPIV** | **Digital Particle Image Velocimetry** |
| **eCC** | **electronic Country Clearance** |
| **EM** | **Engineering Model** |
| **FRA** | **Fluid Reservoir Assembly** |
| **GRC** | **Glenn Research Center** |
| **GSE** | **Ground Support Equipment** |
| **ISS** | **International Space Station** |
| **LAD** | **Liquid Acquisition Device** |
| **MIO** | **Mission Integration and Operations** |
| **MSG** | **Microgravity Science Glovebox** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NC** | **Noncondensable** |
| **NPR** | **NASA Procedural Requirement** |
| **PDR** | **Preliminary Design Review** |

| Acronym | Description |
|---|---|
| **PM** | **Program Manager** |
| **PNP** | **Perfluoro-N-Pentane** |
| **PRACA** | **Preventive and Corrective Action** |
| **RFA** | **Request for Action** |
| **RTD** | **Resistive Temperature Devices** |
| **SAR** | **System Acceptance Review** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **SRR** | **System Requirements Review** |
| **SV** | **Solenoid Valve** |
| **ZBO** | **Zero-Boil-Off** |
| **ZBOT** | **Zero Boil-Off Tank** |
| **ZBOT-NC** | **Zero Boil-Off Tank-Noncondensables** |

**SpaceDOC-2 NNC14CA02C**
**DO-230 Packed Bed Reactor Experiment (PBRE) - MI&O**
**For the Contract Performance Period August 1, 2017 through March 31, 2023**
**For the DO Performance Period December 1, 2022 through January 31, 2024**

# 1 OVERVIEW

The PBRE experiment operated on board the ISS in June 2016 and February 2017 in the Microgravity Science Glovebox. This DO supports all the MI&O for PBRE in the future. This includes getting the hardware to a readiness for future flights and operations. The PBRE-2 will consist of a re-flight with 2mm glass bead packing material and Principal Investigator Brian Motil. The PBRE-WR will consist of a re-flight of a test module with an alumina packing material with Layne Carter as the Principal Investigator. The PBRE-WRS will consists of a modification to the existing PBRE flight hardware with eight test sections from the Principal Investigator Jill Williamson.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from December 1, 2022 through January 31, 2024.

## 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, Jennifer Wetzel
2) GRC Project Scientist, Tyler Hatch
3) MSFC EC Representative, Jill Williamson

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) PBRE Project Plan PBRE-PLN-015
2) PBRE Science Requirements Document (SRD) PBRE-REQ-002
3) GRC ISS Projects SEMP-01 System Engineering Management Plan
4) NRP 7120.5 NASA Space Flight Program and Project Management Requirements

## 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

# 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

> Task Manager, MSI/Jennifer Wetzel, MS 77-7, Jennifer.E.Wetzel@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)
>
> Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

> Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov
>
> Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
>
> Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

Eight Test Sections provided by MSFC (see Section 4.4)

PBRE Engineering Model modified by MSFC, as required

PBRE Flight Fidelity Hardware leftover PBRE-1 and PBRE-2, as required

### 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) Thermal Environmental Chambers in Building 333A
2) Lab Space in Building 77
3) MSFC MSG payload testing support facilities
4) Calibration Lab
5) Vibration Lab

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## 4 PROJECT SPECIFIC SOW

### 4.1 Pack Bed Reactor Experiment (PBRE) Repair and Re-Flight - COMPLETED

During initial operations the video camera frame rate was lower than verified on the ground. Onboard diagnostics isolated the problem to the Data Acquisition Control Unit (DACU). The focus of this task will be to confirm the problem and develop procedures to test and repair the flight hardware to return the PBRE experiment to nominal operating condition.

The PBRE flight hardware will be tested and repaired. The procedure to test the PBRE flight hardware will be written and testing performed. When the problem with the PBRE flight hardware is isolated, the repair plan/procedure will be developed. When the repair procedure is validated, the PBRE flight hardware will be repaired. The list below outlines the work planned to test and repair and re-fly the PBRE flight hardware.

1. Sample flight water and send out for analysis
2. Develop troubleshooting plans
3. Perform a functional test on flight system
4. Perform troubleshooting
5. Hold a ZIN ERB to review troubleshooting results and plan forward
6. Provide an option to implement changes to Engineering Unit and Test (authority to proceed with this will be done on a DO modification)
7. Implement changes on Flight System
8. Perform functional test on Flight System
9. Generate Test Report
10. Close ERB
11. Prepare Flight System for re-flight (drain and flush with clean biocide water, then drain)
12. Dry out both flight columns.
13. Prepare one test column for re-flight with Brian Motil (GRC) selected pack bed material (PBRE-2) including these steps:
    a. Modify inlet to eliminate mixing section and fill with additional packing.
    b. Remove gas line check valves at column inlet.
    c. Repack test column with 2 mm glass beads.

14. Prepare one test column (Teflon column with modifications) for re-flight with Layne Carter (MSFC) selected pack bed material (PBRE-Water Recovery) including these steps:
    a. Modify inlet to eliminate mixing section and fill with additional packing.
    b. Remove gas line check valves at column inlet.
    c. Repack test column with 3 mm alumina beads.
15. Ship the PBRE Engineering Model unit to MSFC for Layne Carter testing at MSFC.
16. Prepare one test column with new pack bed material for re-flight (PBRE-2), include environmental testing, Acceptance Data Package and Pre-Ship Review.
17. Integrate and operate the PBRE investigations into the MSG on ISS. Launch on next available launch after FHA.
18. Streamline approach shall be used since this is a re-flight and we want to minimize the wear on the hardware. This needs to be worked with CE and CSO.
19. During the PBRE system functional test two items did not meet the requirements of the test. The PBRE low flow section in the Water Control Module and the LED light bar for one of the cameras did not meet test requirements. The PBRE team will perform diagnostic tests on the low flow section and the LED light bar. The PBRE tasks outlined below include test procedures and documentation to diagnose, test and repair the PBRE flight hardware.
20. Develop test plan to test the LED light bar that is not functioning properly.
21. Perform thermal test of the LED light bar.
22. Isolate to LED light bar and replace with new LED light bar, test after repair.
23. Flush fluid systems with mixture of de-ionized water and isopropyl alcohol.
24. Conduct ZIN ERB/Delta ERBs as required.
25. Develop test plan to test low flow circuit in Water Module.
26. Open Water Module and disconnect the low flow pump.
27. Build a test harness to interface with the low flow pump.
28. Test the PBRE system while observing the flow of the low flow pump voltage.
29. Bench test the replacement low flow pump.
30. Disassemble the Flight low flow pump, filter, and solenoid from the Water Module and perform bench tests.
31. Based on test results, replace appropriate component(s) and reassemble Water Module. Re-install Water Module into PBRE system.
32. Perform a PBRE system functional test on PBRE-2.
33. Perform a PBRE System Proof and Leak Test.
34. Prepare Flight System for re-flight (drain and flush with clean biocide water, then fill for flight)
35. Dry out test column with 2mm glass beads (PBRE-2) to prepare for re-flight.
36. Develop plan for the reverification of the PBRE flight hardware.
37. Develop flight operations products in preparation for PBRE-2 and PBRE-WR operations in the Microgravity Science Glovebox
38. Conduct Operational Readiness Review (ORR) for PBRE-2 and PBRE-WR before operations begin on ISS.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| N/A | | |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

## 4.2 PBRE Reflight Estimates - COMPLETED

Collaboration with AES has defined 3 objectives that turn into 3 investigations. Please develop an estimate per objective, see attached chart package, and an estimate assuming we do them all assuming there will be cost savings in multiple efforts.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| N/A | | |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| N/A | |

## 4.3 PBRE-2 and PBRE-WR Operations and hardware return - COMPLETED

The PBRE-2 and PBRE-WR operations to be conducted from the GRC Telescience Support Center. Once operations are completed the PBRE hardware will be returned and processed.

1. Ship all 7 shipping containers down to JSC (CMC) Cargo Management Center prior to down massing the PBRE flight hardware from the ISS. Carried Forward
2. Acquire all stored PBRE ground support equipment (frames, regulator, power supply, GN2 bottle, computers, etc.). Carried Forward
3. Pack at JSC CMC and ship all PBRE flight hardware to GRC, then to ZIN; or ship directly to ZIN. Carried Forward
4. Unpack PBRE flight hardware and perform incoming inspection with ZIN QA to ensure hardware can be brought in as Qual. 1 hardware. Carried Forward
5. Complete the next 5 steps using the 2mm Glass Beads Test Module; then swap it for the 3mm Alumina Beads Test Module and repeat these 5 steps. Carried Forward
6. A. Setup PBRE in Vertical Test Configuration with the specified Test Module installed. Carried Forward
7. B. Run a functional test using (PBRE-TST-012) to verify functionality. Carried Forward
8. C. Drain Water Module using (PBRE0PRO-008), then refill it with Clean Water/OPA mixture using (PBRE-PRO-007). If this is the second round with the 3mm Alumina Beads Column, skip the refill. Carried Forward
9. D. Perform drying procedure (PBRE-PRO-011) on the Column. Carried Forward
10. E. Remove the Test Module from the vertical frame, uninstall outlet end cap, remove packing material, and reinstall end cap. Carried Forward
11. Send post-flight sample of Water/OPA to Pace Analytical for comparison to historic data. Carried Forward
12. Once functionality is confirmed, and system is drained, de-integrate all the PBRE hardware. Carried Forward
13. Evaluate and determine if either of the Test Columns and/or the Water Module need to be disassembled and have their tubing and components cleaned separately. Carried Forward
14. If required disassemble, clean, and reassemble hardware. If not required, skip to next step. Carried Forward
15. Pack all PBRE hardware in its shipping containers, and either store at ZIN or GRC for possible re-flight, or extended storage. Carried Forward
16. Perform structural analysis on the PBRE-2 and PBRE-WR Test Columns to evaluate the loads during return on SpaceX return vehicle. The Original packaging for return flight is not available. (new task) Carried Forward

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| N/A | | |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| N/A | |

### 4.4 PBRE-Water Recovery (PBRE-WR) Series

The PBRE-2 and PBRE-WR experiment test sections most recently operated on the International Space Station (ISS) in March of 2021 in the Microgravity Science Glovebox. During the operations of the PBRE-WR test section experiment fine particles from the Alumina beads were released from the test section and flowed into the separator. It was observed that the water flow rates in the low flow rate pump and mass flow meter dropped below the set point. The flow loop in general and this leg in particular will need to be cleaned and the flow rate performance verified in order to return the PBRE experiment to nominal operating condition.

The PBRE flight hardware and two test sections have been returned from International Space Station (ISS). The PBRE flight hardware returned on SpaceX-23 in March 2022. The PBRE flight hardware was received at GRC and transferred to ZIN to be cleaned and perform the necessary modifications. The plan is to modify the test module and launch the PBRE-WR Series. The Principal Investigator (PI) for the PBRE-WR Series (PBRE-WRS) of experiments is Jill Williamson (MSFC).

The contractor shall ensure that the eight government furnished test sections shall fit and operate within the PBRE hardware.

The existing PBRE hardware shall be modified to accommodate these test sections and the requirement to be exchanged in situ while operating in the MSG. These modifications shall include but are not limited to:

- Add two manifold adapters to the test module.
- Modify Test Section rail brackets, and a mounting bracket to the outlet end cap, to allow the new Test Sections to be installed & removed on-orbit. (does not increase the Test Section Module envelope).

- Replace the ¾ inch flex hose with a ¼ inch flex hose and adapter fittings to mate to the existing ¾ inch tubes.
- There are eight (8) unique new test sections, each with an identical overall length, but with varying diameters. The test sections are designated as follows.
- Test sections include the following (ZIN Part Numbers may be used in place of the number listed here):
  - "WR-BF" brine filter PBRE0022-101
  - "WR-UF" urine filter PBRE0021-101
  - "WR-PF" purge filter PBRE0023-101
  - "WR-CV" check valve PBRE0025-101
  - "WR-OR1" orifice #1 PBRE0024-101 800L Lee Jet*
  - "WR-OR2" orifice #2 PBRE0024-103 1700L Lee Jet*
  - "WR-OR3" orifice #3 PBRE0024-105 680L Lee Visco Jet*
  - "WR-OR4" orifice #4 PBRE0024-107 1900L Lee Visco Jet*

  *To be provided to ZIN

The Contractor shall perform the following environmental and/or safety tests the 8 test sections for the PBRE-WR Series, as required.

- Vibration Tests
- Proof Tests

The Contractor shall perform Leak Tests on all hardware prior to final functional tests, either at the test section & module level as each is built or modified, or at the system level.

The Contractor shall evaluate whether the camera and light bar in the current configuration satisfies the imaging requirement as noted in PBRE-WRS-REQ-001 for each test section. Additionally, the Contractor will provide images to the PI for final evaluation. The Contractor will identify and give a cost/schedule estimate for any requested modifications to the camera and light bar configuration.

The PBRE Avionics Module sustained corrosion while on orbit. After examination and per Engineering Review Board recommendations, the Avionics Module will be rebuilt. The Contractor shall:

- Disassemble the Avionics Module, remove all electronic components and replace with new electronic components. Reuse the aluminum box.
- Tear it apart, rebuilt it including some redesign due to obsolete parts to create a next generation avionics box that is functionally equivalent to the first generation one.
- Perform box level testing on Avionics Module, DACU, Water Control Module.
- Perform environmental testing, Electrical, Pressure test on fluid system, EMI test and full functional test on system.

The Contractor shall conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the SAR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest.

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Flight Hardware Available (FHA) for PBRE-WR Series | December 2023 (was November 2022) |
| 2 | Safety Package for PBRE-WR Series | September 2023 (was September 2022) |
| 3 | Acceptance Data Package w/flight certifications for PBRE-WR Series | January 2023 (was September 2022) |
| ~~4~~ | ~~Presentation Package for Operational Readiness Review (ORR) for PBRE-WR Series~~ | ~~October 2022~~ DELETED |
| 5 | Critical Design Review (CDR) for PBRE-WR Series | January 2023 |
| 6 | System Acceptance Review (SAR) for PBRE-WR Series | December 2023 |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| PBRE-WR Series flight hardware (H/W) deliverable | 2 |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Safety Package for PBRE-WR Series | 2 |
| Acceptance Data Package w/flight certifications for PBRE-WR Series | 3 |
| Concept of Operations for PBRE-WR Series | 5 |
| Critical Design Review Presentation for PBRE-WR Series | 5 |
| Systems Acceptance Review Presentation for PBRE-WR Series | 6 |

## 4.5 Mission Integration and Operations

For this delivery order, PBRE-WRS MI&O consists of the milestones and products described within the ISS Science, Technology & Exploration (ST&E) Integration Flow SSP 57057. These milestones & products are tailorable, per project, to those required to demonstrate to the ISS program that the investigation is considered safe, ready for launch and ready for operations. When possible, the products for previous investigations will be referenced based upon similarity, re-flight and series.

The contractor shall complete the necessary PBRE-WRS and ISS programmatic activities required to integrate PBRE-WRS into the Microgravity Science Glovebox (MSG). Payload integration activities include: operations planning, Integrated Verification Testing (IVT) with the MSG ground unit at the MSFC, providing any integration or operations relevant input to a Phase III Safety Data Package, conducting the Phase III or equivalent safety review, compiling and submitting all ISS requirement verifications to the ISS, attending ISS POIWG in support of PBRE-WRS programmatic payload integration and operations.

IVT activities include conducting a Test Readiness Review, creating a payload integration procedure, and creating the needed operations procedures for testing.

The contractor shall act as liaison on behalf of PBRE-WRS to the ISS program, supporting telecons and meetings as necessary to continue PBRE-WRS integration and operations. The contractor shall perform launch integration activities for PBRE-WRS, including but not limited to:

- Launch Manifesting
- Electronic Launch Return On-Orbit Data Set (eLRODS)
- Systems Acceptance Review (SAR)
- Shipping Logistics
- Final Human Factors Implementation Team (HFIT) requirements and Label Inspections
- Support Certificate of Flight Readiness (CoFR)

Additionally, the contractor shall develop the strategic operations planning products (including estimates for crew time) and develop crew training materials and procedures.

Following the launch of PBRE-WRS hardware, the contractor shall continue with level-of-effort integration and operations activities for the operation of the PBRE-WRS experiments.
Work required to support PBRE-WRS integration and operations may include, but is not limited to:

- Mission Sequence Testing (aka Operations Simulations)
  Note: MST might occur simultaneously with system functional testing.
- Console Training
- Console Operations (ZIN operators to be trained to sit console from the GRC TSC)
- Operations planning
- Ground Software support
- Data Management Support
- Anomaly Resolution
- Creation and submittal of Weekly Operations Summary Reports.

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Integrated Verification Testing | October 2023 |
| 2 | Phase III Flight Safety Review | November 2023 |
| 3 | PBRE-WRS Hardware Turnover to NASA | December 2023 |
| 4 | Bench Review | December 2023 |
| 5 | Ship to Launch Integrator | January 2024 |
| 6 | Operational Readiness Review (ORR) | February 2024 |
| 7 | PBRE-WRS Operations | April 2024 |

### 4.5.2 Deliverables

| Deliverables | Milestone Number |
|---|---|
| PBRE-WRS Manifest Change Evaluation Form (CEF) | 1 |
| Crew Procedures | 3 |
| Console Operations Procedures | 5 |
| Operations Readiness Review (ORR) Presentation | 6 |
| PBRE-WRS Operations Summary Report | 7 + 4 months |

# 6 ACRONYM LIST

| Acronym | Description |
|---|---|
| AES | Advanced Exploration System |
| CCR | Configuration Change Request |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CE | Chief Engineer |
| CEF | Change Evaluation Form |
| CMC | Cargo Management Center |
| CoFR | Certificate of Flight Readiness |
| CSO | Chief Safety Officer |
| DACU | Data Acquisition and Control Unit |
| DID | Data Item Description |
| DO | Delivery Order |
| EC | Exploration Capabilities |
| eCC | electronic Country Clearance |
| eLRODS | Electronic Launch Return On-Orbit Data Set |
| EMI | Electromagnetic Interference |
| ERB | Engineering Review Board |
| FHA | Flight Hardware Acceptance |
| GRC | Glenn Research Center |
| HFIT | Human Factors Implementation Team |
| H/W | Hardware |
| ISS | International Space Station |
| IVT | Integrated Verification Testing |
| JSC | Johnson Space Center |
| LED | Light Emitting Diode |
| MIO (MI&O) | Mission Integration and Operations |
| MSFC | Marshall Space Flight Center |
| MSG | Microgravity Science Glovebox |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| OPA | ortho-Phthalaldehyde |
| ORR | Operations Readiness Review |
| PBRE | Packed Bed Reactor Experiment |
| PBRE-WR | Packed Bed Reactor Experiments – Water Recovery |
| PBRE-WRS | Packed Bed Reactor Experiments – Water Recovery Series |
| PFAR | Post-Flight Assessment Review |
| PI | Principal Investigator |
| PM | Program Manager |
| POIWG | Payload Operations and Integration Working Group |

| | |
|---|---|
| **PRACA** | **Preventive and Corrective Action** |
| **QA** | **Quality Assurance** |
| **SAR** | **System Acceptance Review** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **ST&E** | **Science, Technology & Exploration** |
| **TSC** | **Telescience Support Center** |
| **WR** | **Water Recovery** |

# SPACEDOC-2 NNC14CA02C
# DO- 234 FLOW BOILING AND CONDENSATION EXPERIENCE (FBCE)-
# MISSION INTEGRATION AND OPERATIONS (MIO)
# DO PERFORMANCE PERIOD OCTOBER 1, 2017 THROUGH MARCH 31, 2023
# FOR THE PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH NOVEMBER 30, 2023

## 1 OVERVIEW

The purpose for the Flow Boiling and Condensation Experiment (FBCE) is to build an ISS Fluids Integrated Rack (FIR) insert to serve as a platform for obtaining two-phase flow heat transfer data in microgravity. The experiment hardware consists of data acquisition modules, a boiling heater module, two fluid system modules, and two interchangeable modules designed to study flow boiling and condensation. Experiment software is executed on the CCU and experimental data will be recorded to the FIR-provided IPSU-CL.

The FBCE flight hardware and software and its first test module, Flow Boiling Module (FBM) launched to ISS on board NG-16 on August 10. It was installed in the FIR on December 7 and 9th and started operations on December 23, 2021. The FBM appeared to be leaking fluid therefore a set of Test Fluid Dispensers were designed, built, tested and launched to the ISS on NG-18 and SpX-26. The second test module, Condensation Test Module is expected to be launch to ISS no earlier than February 2023. The third test module, FBCE Transfer Line (TL) is currently in the Pre-Phase A/Phase A development.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through November 30, 2023.

### 1.2 GOVERNMENT CONTACTS

1) FBCE Project Manager, Nancy Hall
2) FBCE Software Lead, Rochelle May
3) GRC FBCE Condensation Test Module Product Lead, Jeff Mackey
4) GRC BPS Program Manager, Kelly Bailey

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) FBCE Interface Control Document, FBCE-ICD-4204
2) FBCE Integration Agreement, FCF-INT-4529

### 1.4 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) FBCE Design Description Document, FBCE-DOC-025
2) FBCE Flight Avionics Signals List, Rev B, FBCE-DOC-040
3) FBCE Mission Operations Document, Rev A, FBCE-DOC-074
4) FBCE Master Schedule, FBCE-DOC-182
5) FBCE Phase II Safety Data Package, FBCE-DOC-194
6) FBCE CONOPS, FBCE-PLN-010
7) FBCE Experiment Data Management Plan, FBCE-PLN-033

8) FBCE Software Architecture Design Description Document, FBCE-DOC-042
9) FBCE Software Data Dictionary, FBCE-DOC-046
10) FBCE Experiment Data Management Plan, FBCE-PLN-033
11) FBCE Software Requirements Specification, FBCE-REQ-043
12) FBCE Software Management and Development Plan, FBCE-PLN-006
13) FBCE-SW-CPM-059 NPR 7150.2B Class C Safety Critical Software Compliance Matrix

### 1.5 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/N. Hall, MS 77-7, Office (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Configuration Management Office, Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Program Manager, Physical Science Research, (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov)

ISS & Human Health Office and Chief, (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) Telescience Support Center (TSC) TReK Work Stations and Software

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) GRC Building 333, Telescience Support Center and Bldg 333 highbay
2) GRC Building 110, Clean Room
3) GRC Building 110, Room 220 FBCE Integrated Requirements & Software Test Environment (FIRSTE) lab, (new location of the FBCE brassboard)
4) GRC Building 110, Room 127, FBCE TL lab

# 4 PROJECT SPECIFIC SOW

## 4.1 FBCE Payload Integration

The contractor shall complete the necessary FIR and ISS programmatic activities required to integrate the FBCE FBM payload into the FIR facility by ISS Increment 66. Payload integration activities include: creating and updating a payload Integration Agreement and Interface Control Document, providing any integration or operations relevant input to an integrated Phase III Safety Data Package, participating in the Phase III or equivalent safety review, reviewing and approving all ICD requirement closures submitted by the project, supporting the FCF Integration Team integration activities for FBCE, attending ISS POIWG in support of FBCE programmatic payload integration and operations activities and continue the successful operation of FBCE science, and coordinating with FBCE & FCF the integrated verification activities including the scheduling of GIU and HFIT activities. GIU activities include conducting a Test Readiness Review support, creating a payload integration procedure, and creating the needed operations procedures for testing. The contractor should produce a schedule for all the support activities that are needed in order to prepare for GIU testing.

Additionally, the contractor will support weekly FBCE meetings with support to other technical meetings such as ERB/PCBs, MRBs and TIMs. The contractor will participate in FBCE safety reviews and assist with issue resolution where coordination from the FCF Integration Team is necessary. Additionally, the contractor shall develop the strategic operations planning products (including estimates for crew time), develop crew training materials and procedures, and provide FIR console certifications training for the FBCE operations team. Note: The FBCE project will train FBCE console operators on the FBCE system, displays and science operations. The contractor will also support integration functions such as the Phase III Integrated Safety Review. ITCS water servicing at KSC and launch integration activities.

The contractor shall provide data management support to FBCE to support downloading and the conversion of data via RAW2EU program from the FBCE hardware during GIU integration, verification and testing.

The contractor shall support MI&O activities related to the FBCE Test Fluid Dispenser such as the Phase0/II/II/ III Integrated Safety Review, SAR and launch integration.

Following the launch of the FBCE FBM hardware and then the CMHT and Avionics-1 hardware, the contractor shall continue with Level-of-Effort integration and operations planning activities for the sustaining operations efforts of the FBM and the CM-HT for launch, integration and operations:

- Console Training
- Console Operations (at least 3 ZIN PDs to be trained and occasionally on console)
- Operations planning
    - Inputs from FBCE Console Operators and FBCE Science Team to the FCF Planners will be required.
- Ground Software support
- Data Management Support
- Anomaly Resolution
- Creation and submittal of Daily, Weekly and Monthly Operations Summary Reports.
- Mission Sequence Testing: Planning and Execution
    - Note: MST might occur simultaneously with CM-HT system functional testing.
- Integrated FIR/FBCE verifications for CM-HT.
- Launch integration activities for CM-HT, including but not limited to:
    - Launch Manifesting
    - eLRODS
    - Shipping Logistics
    - ITCS Servicing at KSC
    - Final HFIT and Label Inspections
- Act as Liaison on behalf of FBCE to the ISS program, supporting telecons and meetings as necessary to continue FBCE integration and operations.
- Support the two ISS National Lab PI teams for FBM, identified as of March 15, 2022 as:
    - FBCE-FBM RPI (Rensselaer Polytechnic Institute)

  - FBCE-FBM USC (University of South Carolina)
- Support the two ISS National Lab PI teams for CM-HT:
  - FBCE-CM-HT RPI (Rensselaer Polytechnic Institute)
  - FBCE-CM-HT USC (University of South Carolina)

## 4.2 Milestones for FBCE Payload Integration

The contractor shall complete the necessary FIR and ISS programmatic activities required in order to integrate the next FBCE test module - Condensation Module Heat Transfer (CM-HT) payload into the FIR facility on ISS. Payload integration activities include the following: participating in an integrated Phase III Safety Review and provide inputs and review to the Phase III Safety Data Package, closing out all integrated safety requirements, reviewing and approving all ICD requirement closures submitted by the project, supporting the FCF Integration Team integration activities for FBCE, attending ISS POIWG in order to commence early FBCE programmatic payload integration activities, and coordinating with FBCE & FCF the integrated verification activities including the scheduling of GIU and HFIT activities, as needed. GIU activities include conducting a Test Readiness Review support, creating a payload integration procedure, and creating the needed operations procedures for testing. The contractor should produce a schedule for all the support activities that are needed in order to prepare for GIU testing.

### 4.2.1 Milestones for FBCE Payload Integration

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | ISS Payload Operations and Integration Working Group | AS NEEDED<br>Carried Forward |
| 7 | FBCE Launch (UID 325) | August 10, 2021<br>(was 7, 2/2021; 3/2020)<br>Carried Forward<br>COMPLETED 8/10/21 |
| 8 | FBCE Operations Readiness Review (UID 326) | October 2021<br>(was 2/2021; 8/2020)<br>Carried Forward<br>COMPLETED 11/15/21 |
| 9 | CM-HT/Avionics -1 Phase III Integrated Safety Review | December 1, 2022<br>COMPLETED |
| 10 | CM-HT/Avionics -1, System Acceptance Review | January 13, 2023<br>(was 3/2022, 12/2022) |
| 11 | CM-HT/Avionics -1, Launch (NG-19) | March 12, 2023<br>(was 5/2023) |
| 12 | CM-HT Operational Readiness Review | March 30, 2023 |
| 13 | FBCE-USC PI Operational Readiness Review | August 15, 2022<br>COMPLETED |

| Milestone Number | Milestone | Date |
|---|---|---|
| 14 | FBCE-RPI PI Operational Readiness Review | November 28, 2022<br>(was 10/2022)<br>COMPLETED |
| ~~15~~ | ~~FBCE GIU Mission Sequence Test/Acceptance Test~~ | ~~January 19, 2023~~<br>DELETED |
| 16 | FBCE Test Fluid Dispenser Phase 0/I/II/III Review | September 13, 2022<br>COMPLETED |
| 17 | FBCE Test Fluid Dispenser SAR | September 16, 2022<br>COMPELTED |
| 18 | FBCE Test Fluid Dispenser Launch (NG-18) | October 28, 2022<br>COMPLETED |
| 19 | FBCE Test Fluid Dispenser Launch (SpX-26) | November 15, 2022<br>COMPLETED |
| 20 | FBCE-CM-HT USC PI Operational Readiness Review | October 31, 2023 |
| 21 | FBCE-CM-HT RPI PI Operational Readiness Review | November 30, 2023 |

### 4.2.2 Hardware/Software Deliverables for FBCE Payload Integration

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.2.3 Document Deliverables for FBCE Payload Integration

| Document Deliverables | Milestone Number and Date |
|---|---|
| Updated Schedule of Activities for Integrated System Testing | AS NEEDED<br>Carried Forward |
| Updated - FIR Console Start Up/Shut Down procedure for GIU Testing | 3<br>COMPLETED |
| FBCE Crew Procedures | 8<br>December 20, 2021<br>Carried Forward<br>COMPLETED |
| FCF/FBCE Crew Training Materials | 7<br>December 20, 2021<br>Carried Forward<br>COMPLETED |

| Document Deliverables | Milestone Number and Date |
|---|---|
| ORR TADS, Console Training, and On-orbit Crew Procedure Status Presentation | 8<br>December 20, 2021<br>(was 2/2021)<br>Carried Forward<br>COMPLETED |
| FBCE Crew Procedures for CM-HT activities | 10<br>November 30, 2022<br>(was 6/2022)<br>COMPLETED |
| FCF/FBCE Crew Training Materials for CM-HT | December 15, 2022<br>(was 9/2022)<br>COMPLETED |
| ORR TADS, Console Training, and On-orbit Crew Procedure Status Presentation for CM-HT | March 15, 2023<br>(was 12/2022) |
| ORR TADS, Console Training, and On-orbit Crew Procedure Status Presentation for FBM-USC PI | July 15, 2022<br>COMPLETED |
| ORR TADS, Console Training, and On-orbit Crew Procedure Status Presentation for FBM-RPI PI | October 15, 2022<br>COMPLETED |
| FBCE Crew Procedures for Test Fluid Dispenser Activities | October 15, 2022<br>COMPLETED |
| ORR TADS, Console Training, and On-orbit Crew Procedure Status Presentation for CMHT-USC PI | October 31, 2023 |
| ORR TADS, Console Training, and On-orbit Crew Procedure Status Presentation for CMHT-RPI PI | November 30, 2023 |

### 4.3 FBCE Payload developer (PD) software

The contractor shall develop, deliver, and maintain the FBCE Payload Developer (PD) operational software using the TReK/TADS development kit. Software commanding and data display screens will be developed in consultation with the FBCE software team and project scientist. A preliminary software deliverable will be provided to the FBCE team to support brassboard testing in May of 2018 (COMPLETE). An updated release will be made available in April 2020 to support integrated testing in the GIU. PD software will continue to be updated and maintained through experiment operations as needed for CMHT and the ISSNL FBM PIs.

### 4.3.1 Milestones for PD Software

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | FBCE Flight Software Verification Testing (UID 983, 16) | October 28, 2020 (was 7/2020; 9/2019) Carried Forward COMPLETED |
| 2 | FBCE Flight System Verification Test -FIR GIU (UID 38) | November 12, 2020 (was 7/2020; 10/2019) Carried Forward COMPLETED |
| 3 | FBCE Mission Sequence Test (UID 351) | January 13, 2021 (was 9/2020; 10/2019) Carried Forward COMPLETED |
| 4 | FBCE Systems Acceptance Review-2 (UID 321) | March 18, 2021 (was 3/3/2021; 11/2019) Carried Forward COMPLETED |
| 5 | FBCE Integration Into FIR & FBCE On-orbit Operations (UID 315) | March 3, 2021 (was 8/2020) Carried Forward COMPLETED |
| 6 | CM-HT Mission Sequence Test | March 20, 2023 |
| 7 | CM-HT -USC PI Mission Sequence Test | October 15, 2023 |
| 8 | CM-HT -RPI PI Mission Sequence Test | November 15, 2023 |

#### 4.3.2 Hardware/Software Deliverables for PD Software

| HW/SW Deliverable | Milestone Number and Date |
|---|---|
| Final TReK/TADS PD Software Updates | 5<br>December 20, 2021<br>(was 3/2021)<br>Carried Forward<br>COMPLETED |
| TReK/TADS PD Software Updates for CMHT | March 2023 |
| TReK/TADS PD Software Updates for FBM-USC PI | July 15, 2022<br>COMPLETED |
| TReK/TADS PD Software Updates for FBM-RPI PI | October 15, 2022<br>COMPLETED |
| TReK/TADS PD Software Updates for CMHT-USC PI | October 1, 2023 |
| TReK/TADS PD Software Updates for CMHT-RPI PI | November 1, 2023 |

#### 4.3.3 Document Deliverables for PD Software

The contractor shall develop and deliver the following documents:

- FBCE Ground Software Design Description- Document describing the FBCE ground software design of the ground software
- FBCE Ground Software Version Description- A software version description for a software release of the FBCE ground software
- FBCE TADS Software Verification Plan to define the verification activities leading to qualification of the FBCE ground software TADS of the FBCE ground software TADS
- FBCE Ground Software 7150.2B Compliance Matrix Plan to document the compliance matrix against requirements in NPR 7150.2B
- FBCE TADS Software Requirements Document to establish the software requirements for the FBCE ground software TADS
- FBCE MIO Software Assurance Classification Report (SACR) and Software Safety-Critical Assessment to describe the design of the FBCE ground software that will receive and display MSFC Enhanced HOSC System (EHS) data from the payload avionics and send ground commands through the MSFC EHS System
- FBCE TADS Ground Software Test Procedure to test the TADS functionality against the requirements.
- FBCE TADS Version Description Document to document the version of TADS for the Systems Acceptance Review
- FBCE TADS Software Verification Report to document the proper function of the TADS for FBCE from the test procedure,

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| CCR | Configuration Change Request |
| CCU | Confocal Control Unit |
| CDRL | Contract Data Requirements List |
| CM-HT | Condensation Module Heat Transfer |
| DID | Data Item Description |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| ERB | Engineering Review Board |
| FBCE | Flow Boiling & Condensation Experiment |
| FBM | Flow Boiling Module |
| FCF | Fluids and Combustion Facility |
| FIR | Fluids Integration Rack |
| FIRSTE | FBCE Integrated Requirements & Software Test Environment |
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| HFIT | Human Factor Integration Test |
| ICD | Interface Control Document |
| IPSU-CL | Image Processing and Storage Unit-Camera Link |
| ISS | International Space Station |
| ISSNL | International Space Station National Lab |
| KSC | Kennedy Space Center |
| MIO (MI&O) | Mission Integration and Operations |
| MRB | Materials Review Board |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| ORR | Operations Readiness Review |
| PCB | Payload Control Board |
| PD | Payload Developers |
| PI | Principal Investigator |
| POIWG | Payload Operations and Integration Working Group |
| PRACA | Preventive and Corrective Action |
| RPI | Rensselaer Polytechnic Institute |
| SAR | System Acceptance Review |
| SOW | Statement of Work |
| SpaceDOC-II (2) | Space Flight Systems Development and Operations Contract-II (2) |
| SW | Software |
| TADS | Telemetry and Display System |
| TIM | Technical Interchange Meeting |

| | |
|---|---|
| **TL** | **Transfer Line** |
| **TReK** | **Telescience Resource Kit** |
| **TSC** | **Telescience Support Center** |
| **USC** | **University of South Carolina** |

# SPACEDOC-2 NNC14CA02C
# DO- 242 SCAN-NGC
# SCAN NEXT GENERATION RELAY CAPABILITY (SCAN-NGC)
# FOR THE DO PERIOD OF PERFORMANCE JULY 1, 2018 THROUGH MARCH 31, 2023
# FOR THE PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH NOVEMBER 30, 2023

## 1 OVERVIEW

The NASA Space Communications and Navigation (SCaN) program is developing a Wideband COMSATCOM Ka-band User Terminal. This Technology Development is a wide bandwidth Ka-band spacecraft communication terminal that spans from 17.2 GHz to 40 GHz. The goal for these Software-Defined Radios (SDRs) is to be capable of storing and running NASA, DoD and commercial waveforms. Missions would be able to connect to government and commercial networks that best fit their needs. A key component to the approach is to leverage the work through the Space and Missile Systems Center (SMC) which has developed a Flexible Modem Interface (FMI) design for terrestrial terminals, which NASA is being requested to extend to the space domain through software defined techniques.

In a related effort, there is a new NASA program to provide a transition from NASA-owned communication services to commercially provided satcom services that meet NASA's mission requirements. The Communication Services Program (CSP) has been established to: 1) Demonstrate the feasibility of commercially provided satellite communications (satcom) capabilities 2) Acquire future commercial satcom services, and 3) Phase out reliance on NASA-owned and operated systems. The CSP will initially pursue opportunities that will allow future NASA missions to deploy flight qualified capabilities for near-Earth users to get satcom services from commercial providers. Longer-term, CSP will be responsible for the acquisition, management, and costs of future operational satcom services, as government assets are retired. The benefits include offering flexible, cost-effective, state-of-the-art satcom services to satisfy NASA mission needs; and promoting a diverse and growing commercial satcom industry. This work is not under SCAN but sponsored by the Commercial Spaceflight Development Division.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through November 30, 2023.

### 1.2 GOVERNMENT CONTACTS

1) Wideband Terminal
   a) GRC Wideband Terminal project manager
   b) GRC Wideband Terminal project team
   c) Space and Missile Systems Center (SMC) personnel
2) Communication Services Program (CSP)
   a) GRC CSP Program Manager
   b) GRC CSP Deputy Program Manager
   c) GRC CSP program team

### 1.3 Available Project Specific Documentation

1) Wideband Terminal Formulation Plan
2) CSP Formulation Plan

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSC/Thomas Kacpura, Mail Stop 142-3, thomas.kacpura@nasa.gov

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov
Program Manager, Elias T Naffah, Mail stop 142-3, elias.t.naffah@nasa.gov
Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

Not applicable

## 3.2 GOVERNMENT FURNISHED FACILITIES

1) Conference rooms on-site at NASA GRC

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# 4 PROJECT SPECIFIC SOW

## 4.1 BROAD AREA ANNOUNCEMENT (BAA) SUPPORT COMMUNICATION SERVICES PROGRAM (CSP) FORMULATION PHASE

NASA envisions a 3-phase strategy for transitioning NASA's satcom traffic from government-owned and operated assets to commercial satellite communications capabilities. The first phase is the formulation of the Communication Services Program. As part of the formulation, there is a need identify characterize, and quantify NASA's mission future communication needs, and determine the available commercial industry capability to meet these needs. NASA's mission needs will define overall CSP strategy, analyze NASA's satcom usage and future demand, and engage with NASA satcom stakeholders. NASA will then begin interacting with industry and preparing for Phase 2. Next, the Commercial Capability Development and Demonstrations will begin with multiple awards for partnerships to develop and demonstrate capabilities and will last approximately 2-3 years.

A program plan will need to be developed to outline the program activities is envisioned. The contractor will provide the expertise to develop this strategic plan. Some personnel working this base task will require Top Secret / Secret Compartmentalized Information (TS/SCI) clearance in order to attend classified briefings with Department of Defense (DoD) agencies. Attendance at meeting will be required where information is expected to be discussed in both open and classified forums. It is not anticipated that the contractor will be required to handle hold or generate classified documents at the contractor facility.

The GRC CSP Project has successfully completed all agency milestones to begin the detailed formulation activities.

During the Formulation period, CSP will focus on demonstrating the feasibility of commercially provided SATCOM services to NASA missions. As a primary objective, CSP aims to demonstrate commercially provided space-based relay communications and navigation (C&N) services appropriate for NASA's near-Earth spacecraft users. The demonstrations will result in an evaluation of technical and operational performance, cost of services, business case, and security compliance to inform a recommendation for the acquisition for operational commercial services.

The GRC CSP will support the establishment of multiple partnerships between NASA and commercial Satellite Communications (SATCOM) service providers to develop and demonstrate capabilities that can meet NASA mission needs and begin planning for acquisition of commercial SATCOM services. These partnerships will bolster American industry, significantly reduce the cost of SATCOM services to NASA, and maximize interoperability between government and commercial service providers while promoting a diverse commercial market. The CSP intends to minimize the need for NASA unique capabilities for spacecraft communications in favor of being one of many users of commercial SATCOM capabilities and subsequent services.

The CSP will perform initial acquisition planning for transitioning near-Earth NASA users to suitable commercial SATCOM services. The CSP will pursue opportunities to allow future NASA missions to deploy flight-qualified capabilities for use with commercially-provided services. The CSP will work with industry to identify requirements and explore opportunities that are mutually beneficial to NASA and industry and will develop an acquisition model for incorporating commercial communications services into operations.

The contractor shall:

A. Initial Formulation
    a. Develop CSP Program Commitment Agreement (PCA);
    b. Develop CSP Program Plan;
    c. Support NASA's attendance at Satellite 2020 by scheduling meetings at the conference with commercial service providers to coordinate NASA CSP needs. Deliver a document report on the Commercial Service Providers that were contacted including the name and contact info the company's POC that was contacted, the date(s) on which the POCs were contacted, the outcome of the contact (resulting in the acceptance of a meeting or declining to meet), the schedule for the meetings that have been confirmed or a rationale/explanation on the meetings that were declined. This should be provided no later than two weeks advance of Satellite 2020. Travel to and attend Satellite 2021 in Washington, DC in Spring 2021 (dates are TBD).
    d. Develop an interface design report that defines the NASA capability needs for the spacecraft to service interface and the enterprise management control (EMC) to mission operations center (MOC) user. This report should include a status on the service interface requirements for a spacecraft to connect through the enterprise management control (EMC) to the Mission Operations Center (MOC). This report should include the current state of DoD's implementation of EMC standard for its terrestrial users, the specific characteristics needed between the spacecraft and the

services offered, the ground terminal to interface with the EMC standard, and finally, the ground terminal to the MOC user;

e. Prepare a report which defines the activities that the DoD is conducting for using commercial satellite communication services and highlight the relationship of those activities which are of interest to the CSP;
f. Support of the 26th Annual Ka and Broadband Communications Conference through attendance and participation in the plenary meetings throughout the fiscal year to advocate for CSP. Develop and submit for publication at the Ka Conference technical papers on the status, challenges, demonstrations, and future work related to CSP formulation efforts in FY20. Travel (domestic) to 26th Annual Ka and Broadband Communications Conference support in Washington, DC in late September 2020 as participants in plenary sessions and presenters;
g. Support of the 27th Annual Ka and Broadband Communications Conference through attendance and participation in the plenary meetings throughout the fiscal year to advocate for CSP. Develop and submit for publication at the Ka Conference technical papers on the status, challenges, demonstrations, and future work related to CSP formulation efforts in FY21. Travel (foreign) to 27th Annual Ka and Broadband Communications Conference support in Italy (city is TBD) in late September 2021 as participants in plenary sessions and presenters.

B. Acquisition Strategy Meeting (ASM) Products
   a. Prepare OV-1 High Level Operational Concept Graphic in DoDAF Enterprise architecture framework for the top level CSP operating scenarios. (The OV-1 describes a mission, class of mission, or scenario. It also shows the main operational concepts and interesting or unique aspects of operations.) A diagram should be prepared for each top level services: (1) forward data delivery, (2) return data delivery, (3) radiometric, (4) science, and (5) calibration services.
   b. CSUG Data Analysis – Analyze the output from the Communication Services User Group (CSUG) meetings, planned quarterly, and define the user needs and the resulting use cases for the NASA CSP service scenarios. The results of these data analyses shall be in the form of DoDAF models, as described by DoDAF CV-2 Capability Taxonomy model and a CV-4 Capability Dependencies model.
   c. Define a sample model contract for sample demonstration(s) which addresses the scope of government versus partner contributions.

C. Program Strategy Meeting (PSM) Products
   a. Gap Analysis - Prepare a report that extracts the Commercial capability (as described from the BAA) versus user needs which are created CSUG data analysis. The results of these data analyses shall be in the form of DoDAF models, as described by a DoDAF CV-6 Capability to Operational Activities Mapping model and a DoDAF CV-7 Capability to Services Mapping model.
   b. Develop a report which describes the Enterprise Service Management (ESM) CONOPS for End-to-End Commercial Services.
   c. Interface Requirements Definition (IRD) – Prepare a document which expands the DoDAF DIV-3 Physical Data models descriptions of the following interfaces that were shown on each of the CSP OV-1 models that defined the high-level services:

i. NASA Spacecraft User to Commercial Service
ii. Service Enterprise Service Management to NASA Mission Operation Center (MOC)
iii. Define these interfaces for each range of NASA mission classes (large, medium, small)

D. Updated Organizational Conflict of Interest (OCI)

a. In accordance with the NFS 1852.237-72, Access to Sensitive Information, it is requested that ZIN submit with their subcontractors shall submit an updated Organizational Conflicts of Interest (OCI) Avoidance Plan on the work with the Communications Services Program (CSP) Capability Development and Demonstration announcement.
b. This should be provided as soon as possible upon receipt of this Statement of Work, to facilitate the work being performed.

E. Enterprise Service Management (ESM) Tasks

a. Study the existing practices of commercial service providers for providing Enterprise Service Management (ESM) of major GEO Constellations (ComSat) and provide a summary report and presentation of the key attributes suitable for the CSP ESM.
b. Develop an ESM Concept of Operations (CONOPS) report for CSP including the application of a Flexible Modem Interface. Deliver a CONOPS report and a presentation. (LinQuest)
c. Develop tools and models to further refine and enhance the FY20 Pre-Phase A ESM study that will enable NASA to evaluate Enterprise Service Management approaches and Systems.
d. Pre-Phase A studies for ESM will complete in FY21. Develop a technical, cost and schedule for ESM DDT&E strategy beginning with Phase A in FY 22. The study and plan should leverage the commercial capability demonstrations and synergistic efforts for ESM involving Space Force and Other Government Agencies.
e. Phase A is expected to start on or around Q1 FY22.

F. Commercial Services Transition Studies

a. Prepare a summary report and conduct a briefing of the commercialization studies performed for SCaN (Teltrium), focusing on the commercialization elements applicable to Communications Services Program (CSP).
b. Conduct an assessment of the TDRS Flyout Chart with SCaN Current and Future Mission System Level Agreement (SLA) requirements and identify the impacting changes and resulting dates when the SCAN Space Network (SN) can no longer meet capacity requirements for customers. Prepare a report and presentation. (Teltrium)
c. Identify opportunities and challenges with World Radio Conference (WRC) 23 and 27 Agenda Items for Space-to-Space Frequency and Mobile Satellite Services frequency allocations. Prepare a report and presentation. (Teltrium)
d. Review the Next Gen Broad Agency Announcement (BAA) Final Report to assess the commercial satellite communications industry ability to provide commercial

services to CSP. Prepare an integrated presentation of the existing summaries. (ZIN/LinQuest/ComSat)

G. Acquisition Support

a. Support the development by CSP for the Capability Development and Demonstration Announcement. Review the announcements and supporting documentation and provide comments and edits. (ZIN/COMSAT)
b. Support the evaluation of the CSP Capability Development and Demonstration proposals. This effort consists of conducting evaluation of announcements, industry day materials, and demonstration deliverables. Evaluate the proposed responses for concept of operation alignment with CSP and provide a summary of comments. (ZIN/COMSAT)
c. Provide technical, programmatic and Subject Matter Expert (SME) review and feedback on the CSP Announcement as well as support the acquisition responses through review, evaluation, and feedback. Provide SME support to NASA for the development of the Announcement, the NASA participant evaluation panel and the demonstrations. This effort will be conducted throughout the period of performance.

    i. Pete Vrotsos will serve as a Subject Matter Expert on the review panel.
    ii. Provide a Venture Capital Subject Matter Expert for the development and evaluation of the CSP Capability Development and Demonstration proposals. The requirement is a technically proficient expert who can evaluate the suitability of the proposal for whether their business case will close and meet the demonstration objectives and also will be suitable for the eventual service. (OAI)
        1. The results of this activity will include a summary presentation in Microsoft PowerPoint that describes the business cases for commercial service providers to provide SATCOM services of which NASA can be one of many customers
    iii. Provide SPECTRUM Subject Matter Expert for acquisition support to consult on the announcement, subsequent evaluations of the responses from industry and evaluation of the demonstration performance milestones.
    iv. Provide from a Commercial SATCOM Subject Matter Expert for acquisition support to consult on the announcement, subsequent evaluations of the responses from industry and evaluation of the demonstration performance milestones.
d. Iterate on the draft project plan to develop a refined version of the document that incorporates the CSP project baseline, phase 1and phase 2 for the lifecycle reviews and Human Exploration and Operation Mission Directorate (HEOMD) Key Decision Point (KDP).
e. In collaboration with the CSP Project Office, develop a draft Formulation Authorization Document (FAD) in preparation for KDP 0.
f. Iterate on the draft CM/DM plan to develop a version of the document that incorporates the CSP project baseline, phase 1, and phase 2 for the lifecycle reviews

and Human Exploration and Operation Mission Directorate (HEOMD) Key Decision Point (KDP).

i. As CSP continues to prepare for the Capabilities Demonstration announcement, Zin will provide additional support and insight into the following project elements that will further consider the commercial SATCOM service provider challenges and perspectives.
   1. Zin will provide support in the development and review of plans and documents required for CSP Industry Day.
   2. Zin will provide support in the development and review of the CSP industry announcement.
   3. Zin will provide support in the development and review of selection criteria, with a focus on the business challenges and lessons-learned for Low Earth Orbit (LEO) start-ups as compared with select legacy commercial service providers. Successful business planning is essential to the long-term delivery of reliable services. Zin will provide a study and briefing on key lessons learned and the technical evaluation criteria most sensitive to the business planning, for potential incorporation into the selection process.

g. NASA is also interested in having a better understanding of the membership, governance, and operation of a successful SATCOM not-for-profit organization such as the Mobile Satellite User Association (MSUA). Zin will conduct a study, analysis and submit a report on the key strengths and benefits of such organizations with a focus on the MSUA, with regards to the CSP mission.

H. Interoperability

a. Study the establishment of a commercial space satellite communications Consortium and provide a summary assessment report of the concept, and develop a plan to develop and operate it. (OAI)

b. From the initial development plan, generate a Consortium Implementation Plan to include details on the necessary steps to execute the consortium, including resources, POCs, methodologies, etc. This should provide a higher fidelity approach(es) that are most aligned with CSP needs, based on the feedback received during the NASA CSP briefing of the initial plan (~October 2020).
   i. The updated plan will deliver the level of detail necessary to understand the resources required to implement that version of the consortium, the standards for interoperability that are recommended and how input and feedback will be solicited from industry, as well as how those standards will be integrated and synthesized.

c. Develop a verification and validation plan for the following demonstrations:
   i. The purpose of the V&V Plan is to identify the activities that will establish compliance with the CSP requirements (verification) and will establish that the system will meet the demonstration expectations (validation) and to define a

reference architecture to negotiate the milestones and success criteria of the capability demonstrations.

1. Small to medium size science mission
2. Low data rate command and telemetry
3. Low science data return data rate
4. Medium to large size science mission
5. Low data rate command and telemetry
6. High science data return rate
7. Medium science data commanding
8. Navigation and timing

ii. Include aspects at each phase of development.

1. Phase A: Concept Development (planning), Phase B: Preliminary design, Phase C/D (Design and Development), Phase E (Operations) with contingency and extended operations.

iii. Iterate on the draft capability use case development and verification and validation plan to develop a refined version of the document needed for CSP lifecycle reviews and HEOMD KDP that incorporates the program baseline, phase 1, phase 2. Focus on milestones towards achieving the objectives of the reference architecture using the verification and validation methods required to define and negotiate the milestones.

1. Each successive capability Demonstration period will more than likely focus on a different capability, hence need of a modified V&V plan.
2. Include a reference architecture against which the V&V plan will be evaluated.

I. Systems Engineering

a. In collaboration with the NASA Lead Systems Engineer:

i. Develop the systems engineering documentation to support the CSP Systems Requirements Review (SRR)

ii. Develop all the technical information required to conduct a CSP System Definition Review (SDR).

iii. Support the development of a project-level CSP Systems Engineering Management Plan (SEMP) in support of KDP 1. Technical Authority to be provided by NASA. SEMP to be developed by the CSP Lead Systems Engineer.

iv. Develop the next-level details on implementing the SEMP relative to CSP and the project's unique needs

J. Formulation Support

a. Business Formulation Support

The following business support is requested:

i. Provide logistical support for project meetings, activities and reviews including Quarterly Stakeholder Reviews

ii. Prepare meeting agendas and packages incorporating data from CDD, ESM, and Systems Engineering

iii. Manage all logistics including invitations and advanced scheduling of dates, times, locations, virtual set-ups

iv. Provide summary of meeting notes, minutes, actions, tracking, comments, RFAs
v. Provide documentation management and archiving
vi. Integrate, synthesize, and assess business data received from CDD, ESM and Systems Engineering for project life cycle reviews including quarterly stakeholder reviews
vii. Provide logistical support for project life cycle reviews
viii. Conduct SpaceDoc monthly to provide progress updates
ix. Provide project management support including Project Planning and Control (PP&C), Strategic Communications, risk management and project document development
   - To support the long term effort for Strategic Communications, a Strategic Marketing Plan shall be developed which addresses the strategic approach for engagement and NASA PAO interaction. Updates to the plan should be provided on an annual basis.
   - Within the Strategic Communications effort, address requirements for marketing communications products and activities including but not limited to: speaking and event support, content development, media relations, STEM future innovation, digital media and engagement for international entities, stakeholders and missions and professional associations. Updates to the plan should be provided on a quarterly basis.
x. Develop the content for the annual HEO briefing

b. Phase A Technical Support

The following technical formulation support is requested:

i. Provide technical support for project meetings, activities and reviews including for Quarterly Stakeholder Reviews
ii. Integrate, synthesize, and assess technical data received from CDD, ESM and Systems Engineering for project life cycle reviews including quarterly stakeholder reviews
iii. Provide technical support for project life cycle reviews
iv. Identify and develop initial technical products required for the KDP-B/C
v. Perform quarterly trade studies needed to support life cycle reviews
vi. Identify and develop other CSP systems engineering technical products
vii. Provide technical integration for the project

c. Space Communications Consortium

The following support is requested for the Space Communications Consortium supporting CSP activities:

i. Research, define and facilitate a Space Communications consortium with industry to pursue and promote commercial SATCOM services in Near Earth

d. Phase A Systems Requirement Review (F-SRR) Subject Matter Expert Support

i. A number of SATCOM subject matter experts (SMEs) are required to support the NASA GRC CSP Formulation – Systems Requirement Review (F-SRR). The F-SRR Goal is to align project scope & activities with key project driving requirements. The F-SRR Project Requirements are not system functional, performance requirements or operational use requirement. The SMEs shall provide expert guidance at the F-SRR review, comment on key Project Driving Requirements, focus on the project's end products and requirement assumptions/constraints and risks/concerns.

ii. It is estimated that each SME shall provide up to 80 hours of time reviewing materials, attending presentations and the F-SRR meeting. Each SME shall provide comments on the Project Requirements and review success criteria to the review chairman.

iii. Required skill needed for the staffing the F-SRR should include:
- Co-chairs with experience in conducting similar type scope reviews
- SME's with commercial & government SATCOM services experience
- Co-Chairs and SME's with an understanding of commercial SATCOM operational constructs

iv. Specific Activities
- Attend a review kickoff meeting with the Review Co-chairs
- Review Document Prior to the review:
  a. Draft Project Requirements Document
  b. Requirements Review Tables
  c. F-SRR Entrance & Success Criteria
  d. Draft Preliminary Project Plan
  e. CSP FA and FAD
  f. Announcement for Proposals (AFP) and supporting materials
- Review Team Members participate in pre-review presentations and meetings
- Attend the F-SRR
- Provide comments, insight, guidance at the F-SRR and summarize with written notes
- Support the Review Team Co-chairs to assemble and report out comments to the CSP Project Manager

v. Review Activities
- Attend review kickoff meeting with the Review Co-chairs remotely via electronic means (4 Weeks prior to Review)
- Receive and Start Document Review (3 Weeks prior to Review)

- Attend F-SRR pre briefing remotely via electronic means (2 Weeks prior to Review)
- Attend F-SRR Question/Comments Meeting remotely via electronic means (1 Week prior to Review)
- Attend F-SRR in person, if possible (April 7, 2022)
- Review Team Co-chairs Finding/Comments Presentation to Project Manager (2 Weeks after the Review)

vi. Organizational Conflict of Interest (OCI)

- If requested by NASA, ZIN may be requested to verify complicance with OCI for this activity.

K. Capability Development and Demonstration

a. Subject Matter Expert (SME) Support

Provide Subject Matter Expert (SME) support for the CSP CDD evaluation of 1) Industry responses to the Announcement for Proposals (AFP), and 2) the post award performance milestones.

The Contractor will continue to provide:

i. Venture Capital SME(s) to evaluate the feasibility of proposed private financing, business case, capitalization, and return on investment
ii. A spectrum SME to evaluate the feasibility of the proposed spectrum management approach
iii. A commercial SATCOM Subject Matter Expert to evaluate feasibility of the proposed business case for the future service
iv. A senior network operations SME to evaluate the feasibility of the proposed demonstration, the future service, the business model, the acquisition model and the operational constructs
v. A senior commercial SATCOM architecture SME to evaluate the feasibility of the proposed demonstration, the future service, the business model, the acquisition model and the operational constructs

b. Demonstration Evaluations, and Management Support

Provide technical and project management support to the CDD Manager (CDDM). Provide internal and external coordination and integration support to the CDDM.

The Contractor will provide the technical and project management support for the awarded CDD Funded Space Act Agreements.

The Contractor will:

i. Develop and maintain CDD documents, plans, and schedules, processes and procedures
ii. Provide logistical support for each of the performance milestone evaluations

iii. Evaluate and assess performance milestone entrance and success criteria in support of CDD's validation process
iv. Provide logistical support for the processing of performance milestones including acceptance, payment, rejection, and postponement
v. Provide technical and logistical support to the CDDM to administer and implement NASA's responsibilities under the FSAA's
vi. Facilitate communications with each CDD Industry Partner through onsite and in person meetings and appropriate communications. The Contractor would be responsible for management of relationships, collection of required information, reporting of the vendor/team views, reporting of other concerns, and communication back to vendor and NASA CSP team. Support the government insight through onsight presence as necessary. Prepare CDD progress reports for distribution to CSP Project management.
vii. Support unfunded Space Act Agreements with monthly meetings and two milestone meetings annually.

L. Enterprise Service Management (ESM)

The contractor will provide technical and project management support to the ESM Manager (ESMM). The products developed will support the identification of a suitable ESM for commercial services. The products will include an emulator for validation purposes, which will be developed in a phased approach. The emulator will validate that analytical analysis of performance capabilities and certify proposed commercial SATCOM services and their readiness to support NASA mission requirements. The Testbed shall also address the validation of the ESM approaches identified by the Analysis of Alternatives. It will also demonstrate the commercial system with the ESM and interfaces to the spacecraft and to the Mission Operation Center. This function of the testbed will be used to mitigate the risk for mission acceptance for commercial services.

The Contractor will:

i. Support the definition of ESM through Phase A, identifying the activities, processes, policies, and supporting tools needed to deliver commercial SATCOM services to NASA missions
ii. Support the development planning for ESM including but not limited to the following key elements expected to comprise an ESM:
iii. Mission service planning that meets required SLAs
iv. SATCOM service acquisition and onboarding
v. Service testing, provisioning, activation, and monitoring
vi. Business systems, analytics, and support
vii. Network and Security Management
viii. Identify ESM solution(s) to support an early acquisition of commercial SATCOM services

ix. Evaluate commercial SATCOM operational constructs, acquisition models, business models and interface requirements obtained from the CDD to inform the design of ESM

x. NASA Commercial Service Acquisition Approach
   a. Compile information based on CDD partner acquisition models and provide annual updates
   b. Compile business models based on CDD information and provide update annually
   c. Detail the NASA acquisition processes, with input from NASA acquisition subject matter experts (SMEs), that are applicable to the service acquisition
   d. Align the COMSATCOM Service Providers acquisition approaches with applicable NASA acquisition processes
   e. Compare and contrast industry and NASA engineering approaches and standards, identify applicable processes and standards for NASA service acquisition plan
   f. Support the development of the NASA service acquisition plan

M. CSP Testbed

xi. Develop the emulator/testbed prototype to support activities including simulation, emulation, and end-to-end testing of communication networks, and testing of the interfaces, waveforms, and protocols, including for evaluation of performance when providing service to real users.
   a. Create a testbed development plan including development of key components and a phased integration approach
   b. The testbed should address the following items:
      i. Analysis and model validation
         1. Utilize for accurate evaluation and verification of data presented in the CDD milestones
         2. Emulate the individual communication links in the testbed to ensure compatibility with NASA communication standards and protocols
         3. Confirm the ability of the selected COMSATCOM service providers to meet the specific NASA mission requirements
      ii. Prototyping of the ESM alternative approaches
         1. The testbed shall allow the hardware emulation of different ESM approaches
      iii. Support mitigation of mission acceptance risk
         1. The testbed shall allow for mission users to understand commercial services
         2. Testbed functionality for the Service – User Spacecraft and Service – Mission Operation Center/PI

3. Plug-in functionality for different commercial services

N. Analyisis of Alternatives

Analysis of Alternatives (AoA) - An Analysis of Alternatives (AoA) is a documented assessment of the performance, effectiveness, and cost of proposed solution alternatives that meet identified capabilities required for an implemented solution to be successful. Performing an AoA allows for the most effective and/or efficient alternative to be selected for implementation based on the results of the analysis. Varying service management solutions have been identified as initial alternatives for the AoA; these alternatives are described in the AoA document along with the processes and products needed to prepare for and conduct the AoA.

xii. The contractor shall prepare a plan to lead an integrated SpaceDoc team to execute the AoA for NASA CSP, providing key orchestration, planning, support staff and execution expertise to the NASA/CSP AoA lead.

xiii. The contractor will support the development and execution of an Analysis of Alternatives (AoA) which will evaluate different methods for NASA to certify, procure, and manage commercial communications services to support NASA missions in near Earth space.

xiv. The Contractor will provide technical support for the development of the Analysis of Alternatives (AoA) Plan and the execution of the AoA Plan as needed to define and recommend an approach for NASA to onboard, certify, manage, and generally obtain commercial SATCOM services to support NASA missions in near Earth space.

xv. The contractor will provide Analysis of Alternatives (AoA) documentation including briefings, technical reports, interim drafts, and final versions of the assigned tasks within the Analysis of Alternatives process.

O. CSP Transition Plan

The transition plan should describe the actions that must be taken to successfully transition NASA missions from use of TDRSS to use of commercial SATCOM services
The Transition Plan should identify all considerations and factors that will contribute to the success of the mission using commercial services.

xvi. Prepare and deliver a Transition Plan documenting the steps that need to be undertaken and changes that must occur with NASA to transition from the present system of using the TDRSS satellite system to using commercial services to provide communications to NASA near Earth missions.

xvii. The Contractor will develop and provide technical support for the preparation of a Transition Plan to document recommended actions, steps, and processes for NASA to transition from using NASA-owned current TDRSS satellite system to using commercial SATCOM services.

a. The Contractor will engage with relevant Stakeholders as necessary in the planning process, in close collaboration with other stakeholder engagement activities including the CSP CSUG, identifying POCs, developing and managing relationships, determining processes and resources and otherwise supporting all transition planning activities.

xviii. The Contractor will facilitate review of the outline and proposed content for the document early in the process to facilitate feedback from the team—inclusive of NASA. Workshops may be used to effectively solicit input and review.

P. Consortium Development

a. The contractor shall support the creation of an industry consortium for commercial communciations to spacecraft. The goal is to develop an industry lead consortium of the full ecosystem of supporting efforts as well as the users.
b. The consortium approach shall leverage the support of the Seamless Alliance, to extend their development of standards and collaboration to commercial spacecraft satellite communciations.
c. The contractor shall sponsor organizing meetings to include the interested parties to formulate the effort. The focus of the meetings will be to determine the consortium interests, starting with standards and interface definitions.
d. The contractor shall develop the initial consortium meeting, with the CDD Industry participants together with their partners and suppliers, as well as the Commercial Services User Group participants.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | LEO Startup Lessons-Learned Study and Briefing **OPEN** | 10/15/2021 |
| 2 | SATCOM Organization Not-For-Profit Report **OPEN** | 10/15/2021 |
| | *Project Management* | |
| 3 | Logistical support summary for project meetings, activities, and reviews | Monthly |
| 4 | Monthly SpaceDoc Report | Monthly |
| 5 | Final CSP Formulation Project Plan incorporating feedback from Center, HEOMD and Headquarters reviews | 12/03/2021 Complete |
| 6 | Updated CSP Project Plan | 09/30/2022 Complete |
| 7 | Preliminary ConOps document development | 11/30/2022 Complete |
| ~~8~~ | ~~Complete initial Analysis of Alternatives (AoA) trade studies~~ | ~~09/30/2022~~ Delete |

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~9~~ | ~~Technical requirements development support (including F-SRR and SRR)~~ | ~~03/31/2023~~ Delete |
| 10 | Space Communications Consortium Plan | 03/31/2022 Complete |
| ~~11~~ | ~~Test market the consortium concept and development plan with select industry stakeholders and iterate on the plans accordingly~~ | ~~06/30/2022~~ Delete |
| ~~12~~ | ~~Initiate a consortium public launch campaign~~ | ~~09/30/2022~~ Delete |
| 11 | Strategic Marketing Plan, ANNUAL UPDATES | 9/30/2023 |
| 12 | Communications Plan, with subsequent QUARTERLY UPDATES | 3/31/2023<br>6/30/2023<br>9/30/2023 |
| | *Capability Development and Demonstration (CDD)* | |
| | *Proposal Evaluation Support Documents* | |
| 13 | Synthesis and summary of reviewer comments | 11/03/2021 Complete |
| 14 | Summary of Business Plan Review for each proposal (from Venture Capitalist) PROCUREMENT SENSITIVE | 10/18/2021 Complete |
| 15 | Spectrum SME Technical Review of each proposal PROCUREMENT SENSITIVE | 10/18/2021 Complete |
| 16 | Commercial SATCOM SME Technical & Business Review of each proposal PROCUREMENT SENSITIVE | 10/18/2021 Complte |
| 17 | Senior network operations SME review of each proposal PROCUREMENT SENSITIVE | 10/18/2021 Complete |
| 18 | Senior commercial SATCOM architecture SME review of each proposal PROCUREMENT SENSITIVE | 10/18/2021 Complete |
| | *Demonstration Evaluations, and Management Support Documents* | |
| 19 | CDD status report with schedule for each industry participants | In monthly report |
| 20 | Quarterly Milestone Assessment and Validation report | Quarterly |
| 21 | Overall Participant Summary – business, logistical and issue report | Quarterly |
| 22 | Monthly report of CDD industry participants summary status and feedback for phase B/C acquisition strategy | Monthly report |
| 23 | Prepare CDD internal progress presentation supporting Quarterly Stakeholder Reviews | Quarterly presentation |
| | *Enterprise Service Management (ESM) Development Documents* | |
| 24 | ESM Concept and Description, draft | 03/31/2022 Complete |
| 25 | ESM Concept and Description, final | 09/30/2022 Complete |
| 26 | ESM Plan, draft | 03/31/2023 |

| Milestone Number | Milestone | Date |
|---|---|---|
| 27 | ESM Elements Report | Every six months-<br>03/31/2022 Complete<br>09/30/2022 Complete<br>03/31/2023 |
| | • Transition and mission service planning that meets required SLAs | |
| | • SATCOM service acquisition and onboarding | |
| | • Service testing, provisioning, activation, and monitoring | |
| | • Business systems, analytics, and support | |
| | • Network and Security Management | |
| 28 | Identify ESM solution(s) to support an early acquisition, draft | 09/30/2022 Complete |
| 29 | Commercial SATCOM demo report obtained from the CDD to inform the design of ESM | Quarterly |
| 30 | Support Systems Requirement Review (F-SRR) and Provide Summary documents due | 04/07/2022 Complete |
| | Provide Key Project Driving Requirement comments to the Review Team Co-chairs | 4/21/2022 Complete |
| | • Provide Review Team Co-chairs an F-SRR Success Criteria evaluation | 4/21/2022 Complete |
| | • Co-chairs to provide findings/comments to CSP Project Manager | 4/21/2022 Complete |
| 31 | Enterprise Service Management (ESM) | |
| | CDD partner acquisition models summary with annual updates | 3/1/2023 |
| | CDD business models summary with annual updates | 4/1/2023 |
| | NASA acquisition processes that are applicable to the service aquisition | 6/1/2023 |
| | COMSATCOM Service Providers acquisition approaches aligned with suitable NASA acquisition processes | 8/1/2023 |
| | Applicable processes and standards for NASA service acquisition plan | 10/1/2023 |
| | NASA service acquisition plan draft | 11/30/2023 |
| 32 | Testbed Implementation Plan | 3/1/2023 |
| | Report of testbed implementation including architecture, phasing, and related products | Monthly |
| | Demonstrate a prototype of a COMSATCOM ESM Satellite emulator to test the interfaces, waveforms, and protocols with Summary Report | 08/31/23 |
| | Provide status update on emulation of the ESM System Elements Prototyping | 5/01/23<br>11/30/23 |
| 33 | Analysis of Alternatives (AoA) Plan, Preliminary | 1/30/2023 |
| | Analysis of Alternatives (AoA) Plan, Final | 2/23/2023 |

| Milestone Number | Milestone | Date |
|---|---|---|
| | Briefing of AoA activities, progress and products including planning phase and execution phase, per the AoA plan. | Monthly |
| 34 | CSP Transition Plan Interim Draft | 2/15/2023 |
| | CSP Transition Plan Final | 5/1/2023 |
| | | |
| 35 | Consortium Report Approach | 2/1/2023 |
| | Organizing Meeting Summaries | 6/1/2023 |
| | Consortium Meeting Summary Report | 11/30/2023 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| General | |
| LEO Startup Lessons-Learned Study and Briefing | 1 |
| SATCOM Organization Not-For-Profit Report | 2 |
| *Project Management Documents* | |
| Logistical support summary for project meetings, activities, and reviews | 3 |
| Monthly SpaceDoc Report | 4 |
| Final CSP Formulation Project Plan incorporating feedback from Center, HEOMD and Headquarters reviews | 5 |
| Updated CSP Project Plan [see note in milestones] | 6 |
| Preliminary ConOps document development | 7 |
| Complete initial Analysis of Alternatives (AoA) trade studies [see note in milestones] | 8 |
| Technical requirements development support (including F-SRR and SRR) – Draft SRR [see note in milestones] | 9 |
| Space Communications Consortium Plan | 10 |
| ~~Test market the consortium concept and development plan with select industry stakeholders and iterate on the plans accordingly~~ | ~~11~~ |
| ~~Initiate a consortium public launch campaign~~ | ~~12~~ |
| Strategic Marketing Plan, ANNUAL UPDATES | 11 |
| Communications Plan, with subsequent QUARTERLY UPDATES | 12 |
| ~~*Proposal Evaluation Support Documents*~~ | |
| Synthesis and summary of reviewer comments | 13 |
| Summary of Business Plan Review for each proposal (from Venture Capitalist) PROCUREMENT SENSITIVE | 14 |

| Document Deliverables | Milestone Number |
|---|---|
| Spectrum SME Technical Review of each proposal PROCUREMENT SENSITIVE | 15 |
| Commercial SATCOM SME Technical & Business Review of each proposal PROCUREMENT SENSITIVE | 16 |
| Senior network operations SME review of each proposal PROCUREMENT SENSITIVE | 17 |
| Senior commercial SATCOM architecture SME review of each proposal PROCUREMENT SENSITIVE | 18 |
| *Demonstration Evaluations, and Management Support Documents* | |
| Demonstration Kick-offs | |
| CDD status report with schedule for each industry participants | 19 |
| Quarterly Milestone Assessment and Validation report | 20 |
| Overall Participant Summary – business, logistical and issue report | 21 |
| Monthly report of CDD industry participants summary status and feedback for phase B/C acquisition strategy | 22 |
| Prepare CDD internal progress presentation supporting Quarterly Stakeholder Reviews | 23 |
| *Enterprise Service Management (ESM) Development Documents* | |
| ESM Concept and Description, draft | 24 |
| ESM Concept and Description, final | 25 |
| ESM Plan, draft | 26 |
| ESM Element Report | 27 |
| • Transition and mission service planning that meets required SLAs | |
| • SATCOM service acquisition and onboarding | |
| • Service testing, provisioning, activation, and monitoring | |
| • Business systems, analytics, and support | |
| • Network and Security Management | |
| ESM solution(s) report to support an early acquisition, draft | 28 |
| ESM Demo Report: Evaluate commercial SATCOM demo information obtained from the CDD to inform the design of ESM | 29 |
| F-SRR: Key Project Driving Requirement comments to the Review Team Co-chairs | 30 |
| F-SRR: Review Comments from Team Co-chairs on F-SRR Success Criteria evaluation | 30 |
| Co-chairs to provide findings/comments to CSP Project Manager | 30 |
| CDD partner acquisition models summary with annual updates | 31 |
| CDD business models summary with annual updates | 31 |
| NASA acquisition processes that are applicable to the service aquisition | 31 |
| COMSATCOM Service Providers acquisition approaches aligned with suitable NASA acquisition processes | 31 |
| Applicable processes and standards for NASA service acquisition plan | 31 |
| NASA service acquisition plan draft | 31 |
| Testbed Implementation Plan | 32 |
| Report of testbed implementation including architecture, phasing, and related products | 32 |

| Document Deliverables | Milestone Number |
|---|---|
| Summary Report of Demonstration of prototype COMSATCOM ESM Satellite emulator testing the interfaces, waveforms, and protocols | 32 |
| Status report on emulation of the ESM System Elements Prototyping | 32 |
| Analysis of Alternatives (AoA) Plan, Preliminary | 33 |
| Analysis of Alternatives (AoA) Plan, Final | 33 |
| Briefing Report: AoA activities, progress and products including planning phase and execution phase, per the AoA plan. | 33 |
| CSP Transition Plan Interim Draft | 34 |
| CSP Transition Plan Final | 34 |
| Consortium Report Approach | 35 |
| Organizing Meeting Summaries | 35 |
| Consortium Summary Report | 35 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AFP | Announcement for Proposals |
| AoA | Analysis of Alternatives |
| ASM | Acquisition Strategy Meeting |
| BAA | Board Area Announcement |
| CDD | Capability Development and Demonstration |
| CDDM | CDD Manager |
| CDRL | Contract Data Requirements List |
| CM | Configuration Management |
| COMSATCOM | Commercial Satellite Communication |
| ConOps | Concept of Operations |
| CSP | Communications Services Program |
| CSUG | Communication Services User Group |
| DDT&E | Design, Development, Test and Evaluation |
| DID | Data Item Description |
| DM | Data Management |
| DO | Delivery Order |
| DoD | Department of Defense |
| eCC | electronic Country Clearance |
| EMC | Enterprise Management Control |
| ESM | Enterprise Service Management |
| ESMM | ESM Manager |
| FAD | Formulation Authorization Document |
| FMI | Flexible Modem Interface |
| FSAA | Funded Space Act Agreement |
| F-SRR | Formulation – Systems Requirement Review |
| FY | Fiscal Year |
| GRC | Glenn Research Center |
| HEOMD | Human Exploration and Operations Mission Directorate |
| IRD | Interface Requirements Definition |
| ISS | International Space Station |
| KDP | Key Decision Point |
| LEO | Low Earth Orbit |
| MOC | Mission Operations Center |
| MSUA | Mobile Satellite User Association |
| NASA | National Aeronautics and Space Administration |
| NGC | Next Generation Relay Capability |
| NPR | NASA Procedural Requirement |

| Acronym | Description |
|---|---|
| **OCI** | **Organizational Conflict of Interest** |
| **PCA** | **Program Commitment Agreement** |
| **POC** | **Point of Contact** |
| **PP&C** | **Project Planning and Control** |
| **PRACA** | **Preventive and Corrective Action** |
| **PSM** | **Program Strategy Meeting** |
| **Q** | **Quarter** |
| **SATCOM** | **Satellite Communication** |
| **SCaN** | **Space Communications and Navigation** |
| **SCI** | **Sensitive Compartmented Information** |
| **SDR** | **Software Defined Radio** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SLA** | **System Level Agreement** |
| **SMC** | **Space and Missile Systems Center** |
| **SME** | **Subject Matter Experts** |
| **SN** | **Space Network** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-2** |
| **SRR** | **System Requirements Review** |
| **TBD** | **To Be Determined** |
| **TDRSS** | **Tracking and Data Relay Satellite System** |
| **TS** | **Top Secret** |
| **V&V** | **Validation and Verification** |
| **WRC** | **World Radio Conference** |

**SPACEDOC-2 NNC14CA02C**
**DO- 248 SCAET**
**SPACE COMMUNICATION ARCHITECTURE EMULATION TOOL (SCAET)**
**CONTRACT PERFORMANCE PERIOD October 1, 2020 through March 31, 2023**
**DO PERFORMANCE PERIOD October 1, 2021 through November 30, 2023**

# 1 OVERVIEW

The NASA Space Communication and Navigation (SCaN) Program needs the ability to assess the simulate performance of communication services for existing and future space communication networks that support NASA missions to make informed programmatic decisions and provide optimal services to NASA space user missions. This includes ground and space networks for near earth, moon and mars-based communications architectures. This requires evaluating and emulating end-to-end operations that includes the interoperability of both government and commercial services while also utilizing autonomous scheduling. By modeling the assets and the required data flow (assessments and operational performance could be assessed. In the past this modeling was done with the SCENIC tool. In FY20 HQs requested SCENIC be decommissioned while at the same time leveraging the SCENIC capability and equipment investment for the future. Due to the COVID-19 shut down of Glenn Research Center, the decommissioning plan was delayed.

The objective of the task is to:
- Maintain/leverage a Proof-of-Concept (PoC) SCENIC Simulator to demonstrate to interested agencies the appropriate architecture complexity consistent with the ability assess CONOPS Requirements, Definition, Design, Development, Testing, and Operations/Training. This will include NASA defined User Missions, Ground Stations (both User Mission MOC and NASA MOC) and relays systems while including a ground distribution system until no longer needed and/or the end of FY21. This system will be PoC only and not the full scale SCENIC system.
- Maintain the security plan for the SCENIC equipment as needed until the equipment can be dispositioned physically.
- Participate in Technical Integration discussions related to leveraging the SCENIC capability for SCaN and how it may relate to existing GRC Technology Development efforts including the Surrogate Mission Team (SMT).
- Sub-Contract directly with Comsat (developed and has continuing extensive knowledge of existing PDMA data schema) to support data management and application development for the SCaN Program Data Management and Analysis (PDMA) Headquarters task

This task requires leveraging existing SCENIC high-fidelity architecture/CONOPS simulation capability that can simulate current and future integrated communications networks. This simulation software may include the end-to-end communication system consisting of:

- User Mission Operations Centers (MOC) that represents User in The Loop (UITL) requests
- NASA Mission Operations Centers and Relays Systems
- Ground Distribution Systems

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2021 through November 30, 2023

### 1.2 Government Contacts

1) GRC Project Manager, Jennifer Rock

### 1.3 Available Project Specific Documentation

NA

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSC Jennifer Rock, jennifer.l.rock@nasa.gov, Mail Stop 162-5, NASA Glenn Research Center, Cleveland, Ohio 44135

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, Jacquelynne Houts, Mail Stop 142-2, jacquelynne.houts@nasa.gov

Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

N/A

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

N/A

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# 4 PROJECT SPECIFIC SOW

## 4.1 SPACE COMMUNICATIONS ARCHITECTURE EMULATION TOOL PROOF OF CONCEPT DEMONSTRATION

Understand simulation benefits of space communication CONOPS modeling, required architecture fidelity, benefits, issues and limitations for a PoC simulation tool to evaluate an earth-based communication architecture. This includes its use for supporting Requirements/Design, Diagnostics, Testing, Operations and Training as a SCENIC demo PoC demonstration

The Proof-of-Concept simulation shall include:

- Government proposed PoC architecture CONOPS prototype that incorporates a Government and Commercial interoperable space communication network that represents User In The Loop (UITL) operations
- Graphic visualization features (including supporting result interpretation)

- Ability to tailor communication networks

This is not intended to be an operational tool and there should not be anyone outside of this effort accessing the final solution, but the team should plan for demonstrations of the prototype throughout the effort. In addition, the team will support Technical Integration of SCaN technology development project technical baselines and planning. NASA maintains ownership over the data and source code for this prototype/proof of concept and for PDMA.

Zin shall provide support for Systems Engineering to the technology development projects at GRC by supporting implementation of a Surrogate Mission Team for GRC SCaN.

Zin shall support Comsat in adding SCaN data to PDMA and for the use of PDMA data to address System Engineering modeling development. Assumptions are the PDMA data may be maintained at both the GRC Data Center and the SCaN HQs AWS environment.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Proof of Concept Demonstration Plan | November 30, 2020 |
| 2 | Progress Demonstration | January 29, 2021 |
| 3 | External Information System Security Plan (SSP) (Draft) | January 29, 2021 |
| 4 | External Information System Security Plan (SSP) (Final) | March 31, 2021 |
| 5 | Final Equipment Disposition Report | August 31, 2021 |
| 6 | Draft Lunar surface wireless communications model | September 30, 2023 |
| 7 | Final Lunar surface wireless communications model integration into SCaN Network digital Twin | November 30, 2023 |
| 8 | Summary report on SCaN network capabilities to support NASA missions per Surrogate Mission Team (SMT) processes | November 30, 2023 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Proof-of-Concept applications software and CONOPS Model to assess primary modeling and simulation performance, perform analysis calculations, and provide NASA Demonstration.<br>• Provide NASA access to the appropriate models, software<br>• Demonstrate best practices in utilizing the software and model | 5 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Proof of Concept Roadmap (PowerPoint) | 1 |
| Final Equipment Disposition Report | 5 |
| Detailed follow-on technical, cost and schedule updated for technical integration meetings | 5 |
| Draft Lunar surface wireless communications model (Magic Draw and/or Visio) | 6 |
| Final Lunar surface wireless communications model integration into SCaN Network digital Twin (Magic Draw) | 7 |
| Final summary report on SCaN capability support to NASA mission per SMT processes (PowerPoint) | 8 |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AWS | Amazon Web Service |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| ConOps | Concept of Operations |
| COR | Contracting Officer Representative |
| DID | Data Item Description |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| GRC | Glenn Research Center |
| HQ | Headquarters |
| ISS | International Space Station |
| MOC | Mission Operations Center |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| PDMA | Program Data Management and Analysis |
| PoC | Proof-of-Concept |
| SCAET | Space Communication Architecture Emulation Tool |
| SCaN | Space Communications and Navigation |
| SCENIC | Scan Center for Engineering, Networking, Integration and Communication |
| SMT | Surrogate Mission Team |
| SpaceDOC-2 | Space Flight Systems Development and Operations Contract-2 |
| SSP | System Security Plan |
| UITL | User in The Loop |

# SPACEDOC-2 NNC14CA02C
# DO-250 IVGEN-MINI AND AMIS
## EXPLORATION MEDICAL INTEGRATED PRODUCT TEAM TECHNOLOGY DEVELOPMENT EFFORTS FOR ISS TECHNOLOGY DEMONSTRATION
## CONTRACT PERFORMANCE PERIOD OCTOBER 1, 2020 THROUGH MARCH 31, 2023
## FOR DO PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH MARCH 31, 2024

## 1 OVERVIEW

The Exploration Medical Integrated Product Team (XMIPT) under the Mars Campaign Development Division is focused on identifying and addressing gaps in medical capabilities and medical system design to ensure and optimize crew health and performance during exploration missions. This development has been identified as part of a larger effort to develop key technologies that will be needed for long duration exploration missions that will require crew to venture into deep space where the real-time communications, frequent resupply, and rapid abort scenarios we rely on today will not be possible.

**IVGen Mini Overview**

Intravenous Fluid Generation (IVGen) has been identified by the XMIPT as having too low of a Technology Readiness Level (TRL) to be incorporated into current mission plans. The XMIPT is tracking a gap in exploration medical capabilities which involves the need for regenerable intravenous (IV) fluids.

Miniaturizing and leveraging the successful IVGen technology to generate sterile water for injection (SWI) and produce intravenous fluids requires balancing capabilities with mission and medical requirements. The original IVGen system flight demonstration objectives on Expedition 23 included: purification via packed bed, bubble removal, sterilization, microgravity mixing, and USP tested compliance. The original IVGen project documentation, lessons learned, and final report are all available and under Contractor configuration management (CM) to leverage for this effort.

**IVGen Mini Work Plan Overview**

The technical goals and objectives of the IVGen Mini project are the engineering and design, build, testing, integration, verification, and ISS operations (in FY25, beyond this POP) to validate a demonstration system in microgravity. A Final Report will be produced at the culmination of the demonstration and within 1 year of flight and post-flight test data having been received.

For this DO Period of Performance, planned work is summarized below:

- Develop Phase 0/1 Safety Data Package (SDP) at preliminary design stage and Phase II SDP at critical design review stage
- Based on successful systems requirements development phase and breadboarding, develop design for an ISS Technology Demonstration of a flight system based on

approved system requirements from Systems Requirements Review (ZIN Internal termed 'Planning and Requirements Review') successfully completed in FY21, and conduct ZIN Internal preliminary design review (PDR) with stakeholder participation.
- Procure long-lead items for flight system
- Conduct a ZIN-lead Critical Design Review (CDR) for IVGen Mini based on a design that uses a solid-salt approach (eliminates the need for concentrated saline syringe or bag and reduces overall system mass/volume).
    - The assumption is that the solution will homogenize over time and that IV fluid generation would not require urgent homogenization or mixing based on use cases defined.
- Begin flight build after successful CDR

Overall project milestones are shown in the Table 1 below;

| Milestone | Date |
|---|---|
| Planning and Requirements Review (PRR) | 3/2021 |
| Preliminary Design Review (PDR) | 12/2021 |
| Critical Design Review (CDR) | 2/2024 |
| IVGen Mini Phase 3 Safety Review | 9/2024 |
| Delivery Readiness Review (DRR) | 12/2024 |
| Operational Readiness Review (ORR) | 2/2025 |

**Table 1. IVGen Mini Project Milestones (note: Phase 3 Safety Review, DRR, and ORR are beyond Period of Performance for this contract version).**

**IVGen Mini Assumptions/Technical Challenges**

The ability of the IVGen system to produce IV Fluid and the complexity of the system is dependent on the type of source water used (current plan is to use spacecraft potable source water).

Sterilizing the salt via radiation would be advantageous, need to revisit the USP's determination that a change in color is acceptable for intravenous fluid. The IVGen team will lean on the JSC Pharmacy SMEs for support.

Determine if a quality resin is commercially available, perform quality control testing, and provide hermetically sealed cartridges.

Determine if degradation of the soft goods (bags, tubing, etc.) due to deep space radiation exposure affects design.

Determine if mold/bacterial growth in wetted materials affects the design.

**Automated Medical Inventory System (AMIS) Overview**

Accurate medical inventory will become crucial as exploration progresses to longer duration missions beyond low Earth Orbit (BLEO) with little to no resupply. An Automated Medical Inventory System (AMIS) has been identified by XMIPT as a key capability that must be developed to help meet the need for accurately managing medical system inventory in real-time.

The AMIS will be composed of a database, a database management system, supporting hardware, and software. Supporting systems will be responsible for transmitting and receiving data as well as storing and syncing data across multiple users (ground and in-flight). The original Medical Consumables Tracking (MCT) project documentation, lessons learned, and final report are all available under Contractor CM to leverage for this effort.

**Work Plan Overview:**

The technical goals and objectives of the AMIS project are the engineering and design, build, testing, integration, verification, and ISS technical demonstration (in FY27, beyond this POP) to validate an AMIS in microgravity. A Final Report will be produced at the culmination of the demonstration and within 1 year of flight and post-flight test data having been received.

Early work will focus on Pre-Phase A and Phase A development effort with the goal of understanding the commercial trade-space, developing a technical development plan, Concept of Operations, and understanding integration points with other development projects.

For this DO Period of Performance, planned work is summarized below:

- Perform a review of work done to date, including leveraging the Market Survey, Technology Development Plan, preliminary ConOps and Requirements drafts from the XMIPT “MediSCOPE” team and Yet2.com technology survey that was sponsored by XMIPT
- Create a Technology Development Plan and perform a Technology down-select with stakeholder participation
- Engage with Crew Health and Performance (CHP)-Integrated Data Architecture (IDA) and REALM (RFID-Enabled Autonomous Logistics Management) projects, to determine potential dependencies and technical integration opportunities
- Develop draft Concept of Operations and Requirements Documentation
- Develop draft plan to ZIN internal Preliminary Design Review (responsive to NASA System Requirements Review entrance/success criteria)
- Conduct ZIN Internal SRR with stakeholder participation
- Develop Phase 0/1 Safety Data Package (SDP) at preliminary design stage and Phase II SDP at critical design review stage
- Based on successful systems requirements development phase and breadboarding, develop design for an ISS Technology Demonstration of a flight system based on approved system requirements from Systems Requirements Review
- Conduct ZIN Internal preliminary design review (PDR) with stakeholder participation
- Begin development of bread board-like prototype hardware and software

Overall project milestones are shown in the Table 2 below, note, all are beyond the current Period of Performance:

| Milestone | Date |
|---|---|
| Planning and Requirements Review (PRR) | 10/2023 |
| Preliminary Design Review (PDR) | 3/2024 |
| AMIS Phase 0/1 Safety Review | 5/2024 |
| Critical Design Review (CDR) | 4/2025 |
| AMIS Phase 2 Safety Review | 6/2025 |
| AMIS Phase 3 Safety Review | 8/2026 |
| Delivery Readiness Review (DRR) | 11/2026 |
| Operational Readiness Review (ORR) | 1/2027 |
| ISS Technology Demonstration | FY27 |

**Table 2. AMIS Project Milestones**
**(Note: all items beyond PDR are outside this period of performance)**

**Assumptions/Technical Challenges**

AMIS development has a dependency to integrate with the Crew Health and Performance Integrated Data Architecture (CHP-IDA) data system that is currently in development. There is a risk that either CHP-IDA will not be mature enough in the time needed and may delay or stall the AMIS development.

A multi-faceted tracking or tagging approach may be needed to account for tracking of the various medical inventory types (pharmaceuticals, diagnostic equipment, consumable treatment items, etc.) This may include a variety of techniques including radio frequency identification (RFID) tags, barcodes, quick response (QR) codes, Bluetooth low energy (BLE), EveryWear App for medication use tracking, and others.

Stakeholders will include Medical Operations as well as XMIPT sponsors.

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2021 through March 31, 2024.

### 1.2 Government Contacts

1) GRC project manager, PM
2) GRC lead systems engineer, LSE

3) GRC project scientist, PS
4) XMIPT and stakeholders

### 1.3 Available Project Specific Documentation

1) Project Plan, baselined at PDR – PM Responsible
2) Science Requirements Document (SRD) – PS Responsible

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager (Courtney M. Schkurko, MSX/Exploration Systems Office, courtney.m.schkurko@nasa.gov, NASA Glenn Research Center, Mail Stop 77-7, Cleveland, OH 44135)

Configuration Management Office, (Donna J. Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.govContracting Officer's Representative, ISS & Human Health Office Kelly A Bailey, Kelly.A.Bailey@nasa.gov, and Alternate COR Nancy R. Hall, nancy.r.hall@nasa.gov)

Program Manager, Human Health Projects, SpaceDOC-2 (Kelly M. Gilkey, Mail Stop 77-7, kelly.m.gilkey@nasa.gov)

Chief, ISS and Human Health Project Office (Robert R. Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06.
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING.
4) Monthly reporting, per DID# CD-02, ON-GOING.
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING.
6) Lessons Learned Report per DID PA-17.

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) Laboratory hardware located in GRC Building 333 Bonded Storage. Includes original IVGEN and Medical Consumables Tracking flown hardware.

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: Thermal Environmental Chambers in Bldg. 333A
2) Usage Elective: Microgravity Environment Laboratory (MEL)
3) Usage Elective: Acoustical Testing Lab
4) Usage Elective: Electromagnetic Interference Lab in Bldg. 333

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# 4 PROJECT SPECIFIC SOW

## 4.1 EXPLORATION MEDICINE - IVGEN MINI LIFECYCLE DEVELOPMENT AND ASSOCIATED MILESTONES AND DELIVERABLES

IVGen Mini requirements in support of ISS experiments are documented through the Stakeholder Requirements (IVGM-MEM-002) and Engineering Requirements Document (IVGM-REQ-001). Based on those requirements, the contractor's engineering team will develop a design to accomplish the system requirements. The design shall also meet all safety, product assurance, and carrier requirements.

The engineering requirements also reference product assurance, safety, and carrier requirements. Verification tracking for all requirements will be contained in the IVGM Verification Tracking Log and database maintained by the contractor.

The development and operation of the IVGen Mini hardware development is contracted to the SpaceDOC-II, Delivery Order (DO) 250; the contractor is responsible for the design, engineering, testing, verification/validation of the final product deliverable, and operations. The contractor is also responsible for supporting all ground and in-flight demonstration of the IVGen Mini system.

The IVGen Mini contractor will submit a monthly progress report to the PM, as specified by this DO, that provides information on the progress of the project during the previous month in the areas of technical accomplishments, status against schedule, budget, planned activities for the following month, and other information pertinent to the tracking and management of the project. Project status meetings are held regularly to communicate information and keep the project personnel up to date on activities, status, and issues. The contractor will also provide minutes to these meetings and track actions and their closure.

The contractor shall conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the Critical Design Review as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements, or Requests for Action (RFAs) resulting from these reviews.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Market Survey / Feasibility Assessment Complete | January 15, 2021 COMPLETE |
| 2 | ZIN Internal Systems Requirements Review (SRR) Kickoff | March 5, 2021 COMPLETE |
| ~~3~~ | ~~Preliminary Design and Phase 0/1 Safety Data Package Draft Documentation complete (PDR planned for FY22, beyond POP)~~ | ~~September 30, 2021~~ DELETE (replaced with new milestone) |
| 4 | Phase 0/1 Safety Data Package for review by NASA and ISRP | November 15, 2021 COMPLETE |
| 5 | ZIN Internal Preliminary Design Review (PDR) Kickoff | December 15, 2021 COMPLETE |
| 6 | IVGen Phase II Safety Data Package for review by NASA | March 31, 2024 (was 2/2023, 10/2022) |

| Milestone Number | Milestone | Date |
|---|---|---|
| 7 | IVGen ZIN Internal Critical Design Review (CDR) Kickoff | February 6, 2024 (was 3/2023, 11/2022) |
| 8 | IV Fluid Validation Testing Plan | September 30, 2022 COMPLETE |
| 9 | ZIN updated plan to CDR and technical progress review | June 2023 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Market Survey Memo | 1 |
| Feasibility Assessment Memo | 1 |
| System Requirements Review (SRR) Documentation Package including SAR checklist | 2 |
| Phase 0/1 Safety Data Package Draft | 4 |
| Preliminary Design Review (PDR) and Validation Approach Documentation Draft Package | 5 |
| Phase II Safety Data Package Draft | 6 |
| Critical Design Review (CDR) Draft Package | 7 |
| IV Fluid Validation Testing Plan | 8 |
| ZIN Plan to CDR | 9 |

## 4.2 Exploration Medicine - Automated Medical Inventory System (AMIS) and Associated milestones and deliverables

XMIPT has developed an initial AMIS Concept of Operations outlining key goals and objectives of the project and initial stakeholder functional requirements. Based on those requirements, the contractor's engineering team will develop a design to accomplish the system requirements. The design shall also meet all safety, product assurance, and carrier requirements. Additional work shall support:

- Perform feasibility assessment to address technical challenges and identify integration activity leveraging market research report from XMIPT and yet2
- Technology down-select and development plan
- Engagement with CHP-IDA and REALM projects to determine potential dependencies or technical integration efforts
- Conduct ZIN internal SRR with NASA stakeholder participation

AMIS hardware and software development and operation is contracted to the SpaceDOC-II, Delivery Order (DO) 250; the contractor is responsible for the design, engineering, testing, verification/validation of the final product deliverable, and operations. The contractor is also responsible for supporting all ground and in-flight demonstration of the AMIS.

The AMIS contractor will submit weekly updates and a monthly progress / financial report to the PM, as specified by this DO, that provides information on the progress of the project during the previous month in the areas of technical accomplishments, status against schedule, budget, planned activities for the following month, and other information pertinent to the tracking and management of the project. Project status meetings are held regularly to communicate information and keep the project personnel up to date on activities, status, and issues. The contractor will also provide minutes to these meetings and track actions and their closure.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Market Survey / Technology Downselect Complete | May 2023<br>(was 1/2023) |
| ~~2~~ | ~~ZIN Internal Planning and Requirements Review (PRR) Kickoff~~ | ~~May 4, 2023~~<br>DELETE |
| 3 | ZIN Plan to PDR | February 28, 2023 |
| 4 | MCT Assessment | March 24, 2023 |
| 5 | ZIN Internal Planning and Requirements Review (PRR equivalent to NASA System Requirements Review (SRR)) Kick-off | October 2023 |
| 6 | ZIN Internal Preliminary Design Review (PDR) Kick-off | March 8, 2024 |

| Milestone Number | Milestone | Date |
|---|---|---|
| 7 | Phase 0/1 Safety Data Package for Review by NASA and ISRP | May 6, 2024* |

***Milestone beyond Period of Performance end date**

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Technology Downselect Memo | 1 |
| Concept of Operations Draft (leveraging existing XMIPT doc) | 1 |
| ~~System Requirements Draft (leveraging existing XMIPT doc)~~ | ~~1~~ DELETE |
| Plan to PDR | 3 |
| Documentation Package/Presentation overview of MCT project including lessons learned | 4 |
| Planning and Requirements Review (PRR/SRR) Documentation Package including SAR checklist | 5 |
| Preliminary Design Review (PDR) and Validation Approach Documentation Draft Package | 6 |
| Phase 0/1 Safety Data Package Draft | 7* |

***Milestone beyond Period of Performance end date**

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AMIS | Automated Medical Inventory System |
| CCR | Configuration Change Request |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CHP-IDA | Crew Health and Performance Integrated Data Architecture |
| CM | Configuration Management |
| COR | Contracting Officer Representative |
| DID | Data Item Description |
| DO | Delivery Order |
| DRR | Delivery Readiness Review |
| eCC | electronic Country Clearance |
| GRC | Glenn Research Center |
| IPT | Integrated Product Team |
| ISRP | ISS Safety Review Panel |
| ISS | International Space Station |
| IV | Intravenous |
| IVGEN | Intra Venous Water GENeration for exploration |
| MCT | Medical Consumables Tracking |
| MEL | Microgravity Environment Laboratory |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| ORR | Operations Readiness Review |
| PDR | Preliminary Design Review |
| PM | Project Manager |
| POP | Period of performance |
| PRACA | Preventive and Corrective Action |
| PRR | Planning and Requirements Review |
| PS | Project Scientist |
| REALM | RFID-Enabled Automated Logistics Management |
| RFA | Request for Action |
| RFID | Radio Frequency Identification |
| SDP | Safety Data Package |
| SEMP | Systems Engineering Management Plan |
| SME | Subject Matter Experts |
| SpaceDOC-2 | Space Flight Systems Development and Operations Contract-2 |
| SRD | Science Requirements Document |
| SRR | System Requirements Review |
| TRL | Technology Readiness Level |
| USP | United States Pharmacopeia |

| Acronym | Description |
|---|---|
| **XMIPT** | **Exploration Medical Integrated Product Team** |

# SPACEDOC-2 NNC14CA02C
# DO- 252 ZBOT-NC-MIO
# ZERO BOIL OFF TEST – NON-CONDENSABLE GAS (ZBOT-NC) – MISSION INTEGRATION AND OPERATIONS (MIO)
# CONTRACT PERFORMANCE PERIOD OCTOBER 1, 2020 THROUGH MARCH 31, 2023
# DO PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH NOVEMBER 30, 2023

## 1 OVERVIEW

ZBOT-NC will investigate three important effects of non-condensable gases on the transport and phase change phenomena that control tank pressure for cryogenic fluid storage. These effects will be studied in a microgravity environment aboard the International Space Station.

The design and development of the ZBOT-NC experimental hardware is performed under Delivery Order 222 of the SpaceDOC II contract. This delivery order (DO-252) includes the mission integration and operations (MIO) activities that support the ZBOT-NC investigation.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through November 30, 2023. Some of the milestones and deliverables for this delivery order occur beyond the stated period of performance; however, necessary integration and safety tasks/support will take place during this period of performance.

### 1.2 GOVERNMENT CONTACTS

1) Project Manager, Daniel F. Brown/GRC (MSI)
2) Project Scientist, Howard G. Pearlman/GRC (LTX)

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) ZBOT-NC Project Plan
2) ZBOT-NC Science Requirements Definition (SRD)
3) ZBOT-NC Experiment Data Management Plan (EDMP)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

> Delivery Order Manager, ISS and Human Health Projects Office, Daniel F. Brown, Mail Stop 77-7, NASA Glenn Research Center, Cleveland, OH 44135, daniel.f.brown@nasa.gov
>
> Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

> Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov
>
> Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)
>
> Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) [1]Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) [1]Monthly reporting, per DID# CD-02, ON-GOING
5) [1]Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) [1]Lessons Learned Report per DID PA-17

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[1] Deliverable can be provided as a part of DO-222 standard document deliverable for as long as DO-222 is active.

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

N/A

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) GRC Tele-Science Center (TSC)

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# 4 PROJECT SPECIFIC SOW

## 4.1 ISS/Carrier Integration – Design and Analyze Phase

The Design and Analyze Phase is the third phase of the ST&E Integration Flow as defined in SSP 57057. The first two phases consisted of low-level activities that were completed as part of DO-222. During the Design and Analyze Phase, the PD may conduct a Preliminary Design Review (PDR) and/or Critical Design Review (CDR) to assess the fidelity of the payload design. These design reviews are conducted as part of the hardware development delivery order, DO-222, but are mentioned here because the integration timeline is relative to the payload design maturity. Additionally, a Phase II Safety Review is conducted where any safety non-compliances identified are defined and discussed. Major events occurring during the Design and Analyze Phase include the PD receiving training on operations processes and documentation, crew training needs assessment, and initial procedures and planning product development. A key milestone in this phase is the assignment of a flight for the payload.

At the end of the Phase, the ISS Program conducts Sync Point 2. The purpose of Sync Point 2 is to ensure the ISS Program process owners/supporting organizations understand the maturity of the payload/experiment design as well as any risks as the payload proceeds to fabrication and verification.

The detailed task and milestone definitions for each activity in the Design & Analyze Phase are found on the ST&E Integration Flow Website under ST&E Integration Flow Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration tasks is also provided in Appendix A of this Delivery Order.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.1.1.1 | Phase II Safety Review | no later than 9/30/22<br>Complete |

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase II Safety Review Inputs/Package | 4.1.1.1 |

### 4.2 ISS/Carrier Integration – Verify Phase

It is important and crucial for the ISS Program to understand the payload readiness for: a) final delivery, b) launch/return c) on-orbit ISS integration, and d) operations. The ISS Program is informed of the payload readiness during the Verify Phase of the ST&E Integration Flow. This Phase includes verification submittals and a Phase III Safety Review with the associated approvals. The ISS Program conducts its final Sync Point, Sync Point 3, at the end of the Verify Phase to ensure all ISS Program's process owners/supporting organizations understand the payload readiness for shipment and launch vehicle integration.

The detailed task and milestone definitions for each activity in the Verify Phase is found on the ST&E Integration Flow Website under ISS Program Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration activities is also provided in Appendix B of this Delivery Order.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.2.1.1 | Integrated Verification Testing Complete | Outside of Period of Performance |
| 4.2.1.2 | Verification Submittals | Outside of Period of Performance |
| 4.2.1.3 | Human Factors Implementation Team Inspection Complete | no later than 11/30/2023 |
| 4.2.1.4 | Phase III Safety Review | no later than 11/30/2023 |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase III Safety Review Inputs/Package | 4.2.1.4 |

### 4.3 ISS/Carrier Integration – Deliver Phase

Launch vehicle integration and delivery to ISS occurs during the Deliver Phase, phase five of ST&E Integration Flow. All late load and other launch site activities are included in this phase as well as coordination of the flight's launch campaign requirements. Additionally, the ISS Program conducts its Certification of Flight Readiness (CoFR) in this Phase. PDs provide input into CoFR through the Open Work Tracking Log (OWTL). The Deliver Phase concludes with launch of the payload to ISS.

Note: *Readiness for delivery and launch is reviewed/tracked as a part of the CoFR process/plan. The PDs review payload readiness at the Open Work Tracking Log (OWTL) meeting. If necessary, the ISS Program will conduct the payload readiness review at Stage Operations Readiness Review (SORR).*

The detailed task and milestone definitions for each activity in the Deliver Phase are found on the ST&E Integration Flow website under ISS Program Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration activities is also provided in Appendix C of this Delivery Order.

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.3.1.1 | Bench Review | Outside of Period of Performance |
| 4.3.1.2 | ZBOT-NC Hardware Turnover | Outside of Period of Performance |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

## 4.4 ISS/Carrier Integration – Operations and Post-Operations Phase

The final Phase of the ST&E Integration Flow is the Operate and Post Operations Phase where the payload is operated on ISS and where post operations integration activities occur once the Operations Phase has ended. The Operations portion of the Phase includes verifying the ISS Program and PD teams are ready for operations, conducting experiment operations, and implementing real-time changes if necessary. The Post Operations portion of the Phase includes removing the payload from the ISS, communicating the science results, and removing the payload from the IPL.

The detailed task and milestone definitions for each activity in the Operate and Post Operations Phase are found on the ST&E Integration Flow Website under ISS Program Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration activities is also provided in Appendix D of this Delivery Order.

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.4.1.1 | Operations Readiness Review | Outside of Period of Performance |
| 4.4.1.2 | Flight Operations Begin | Outside of Period of Performance |
| 4.4.1.3 | Science Data Delivery | Outside of Period of Performance |
| 4.4.1.4 | Project Closeout Review | Outside of Period of Performance |

## 5 ACRONYM LIST

Acronym List

| Acronym | Description |
|---|---|
| **CCR** | **Configuration Change Request** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CoFR** | **Certification of Flight Readiness** |
| **COR** | **Contracting Officer Representative** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EDMP** | **Experiment Data Management Plan** |
| **GRC** | **Glenn Research Center** |
| **IPL** | **Integrated Payload List** |
| **ISS** | **International Space Station** |
| **MIO (MI&O)** | **Mission Integration and Operations** |
| **NC** | **Non-Combustable Gas** |
| **NPR** | **NASA Procedural Requirement** |
| **OWTL** | **Open Work Tracking Log** |
| **PD** | **Payload Developers** |
| **PDR** | **Preliminary Design Review** |
| **SORR** | **Stage Operations Readiness Review** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirement Definition** |
| **SSP** | **Space Station Program** |
| **ST&E** | **Science, Technology & Exploration** |
| **TSC** | **Telescience Support Center** |
| **ZBOT** | **Zero Boil-Off Tank** |

# 6 APPENDIX A – INTEGRATION ACTIVITIES– DESIGN AND ANALYZE PHASE

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COLEP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | Provide D&A Data Set | Provide D&A Data Set | Provide data that is needed by the program. Data deliveries may be spread throughout the phase. For specific details on data deliveries in this phase, refer to Provide Research Planning Data, Provide Revised Topology Data, and Provide Imagery Activity Data. | | | | | | | | | | | | | | PD | D/A |
| 200.1 | | Provide Research Planning Data | Provide data needed by the ISS Program to begin planning for increment and flight activities. Data provided will include estimated transportation (mass, volume, etc.) and on-orbit (crew time, power, data, etc.) resource needs. | PD | | Provide inputs after the Ops Concept has been assessed and updated if necessary. | Assess Ops Concept + 1 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 200.2 | | Provide Revised Topology Data | If revisions to the initial topology data is identified during the design phase (e.g., CDR), the PD submits revised data needed by Payload Topology Forum to update and finalize the on-orbit placement study. | PD | | Updates are provided as soon as they are known (typically after CDR). | CDR + 0.5 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 200.3 | | Provide Imagery Activity Data | If Imagery is requested, the PD provides activity level data to the ISS Program identifying the requested imagery activities (what, when, where, how, etc.). The inputs are used to produce IDRD Annex 3. | PD, OC/Imagery team | Rebecca Difard | Initial inputs provided after design and ops concept are firm. | Provide Inputs to Ops Products + 0.25 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 201 | Ops Considerations Discussion | Ops Considerations Discussion | The Ops Lead will discuss the definitions of Payload Regs, Flight Rules, and Planning Constraints (Gr&Cs), how they affect/impact operations, who is the responsible party, and how they are developed. This will include a preliminary discussion on foreseen payload operational constraints. | POI | Ops Lead, PARC, POIC OC | | PDR - 0.5 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 202 | Add to Research Plan | Add to Research Plan | The Multilateral Research Planning Working Group (MRPWG) consolidates and integrates research requirements and objectives from NASA and International Partners/Participants into a continuous Research Plan based on partner allocations, payload readiness, on-orbit required date(s), science priority, crew time availability/phasing, and constrained resources (facility throughput, power, launch vehicle big bags, etc.). The Research Plan portrays these requirements at the increment level. The Science Resource Tracking Database (SRTD) breaks down these requirements to the weekly level and includes specific information regarding investigation start/stop dates, flexibility in execution, crew member assignments, crew time requirements per investigation activity, and constraints on the investigation activities. | OZ5 | T. C. Judd | | Provide Research Planning Data + 1 | X | X | X | X | X | X | X | X | | ISS | D/A |
| 203 | PD Trng TST | PD Trng TST | POI Trainers will provide an overview of PD Training milestones, including an overview of the train-the-trainer concept, and will establish a PD Team training plan for the PD Team Trainer based upon Ground Data Services requests. The PD Team training plan will outline training requirements for the PD team. The TST is conducted by telecom and web conference. Required participants are PD Team Trainers, Payload Integration Engineer (PIE), and POI Trainers. | PD, HP26 | POI PD Trainers | This could occur any time in Design & Analyze or Verify phase. | Flight Assignment + 0.75 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 204 | Provide PDR data package | Provide PDR data package | The PD provides access to their Preliminary Design Review (PDR) data package, if they request ISS Program review support. | PD | | PDR data packs should be submitted to the ISS Program 1 week before PDR to allow sufficient time for review and comment development. | PDR - 0.25 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 205 | PDR Prep | PDR Prep | The PIM coordinates ISS Program support to the PDR, and the PIRE coordinates support among the Systems Engineering and Integration (SE&I) Subject Matter Experts (SMEs). The applicable ISS Program representatives review the Provide PDR data package from the PD for compliance to the interface requirements and implications to ISS operations, and provide development guidance to the PD. A checklist is used to help organize the ISS Program review. Comments are coordinated back with the PD during the PDR. | ISS Program | | | Provide PDR data package + 0.25 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 206 | PDR | PDR | Payload Project conducts a Preliminary Design Review (PDR). Some Payload projects, as part of their design effort, may conduct a PDR (or other equivalent review) when their design reaches 10% maturity. A PDR may not be held by all PDs. The PDR is the completion activity of the Classical Project Development Cycle Phase B (reference NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook). The PDR demonstrates and baselines a feasible and credible design that will accomplish the stated goals within the constraints imposed by the fiscal and operating environment. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | D/A |
| 207 | Approve VV ICD | Approve VV ICD | Following the iterative process for the development and review of the VV ICD, the Launch Vehicle Provider releases the approved ICD. This milestone is only required to document non-standard interfaces (usually for external or powered pressurized payloads only). | PD, ON | Launch Vehicle Provider | | TBD - VV ICD Inputs + 4.0 (Jason Smith / ON) | X | | X | X | X | X | X | X | X | Both | D/A |
| 208 | Identify Exceptions | Identify Exceptions | PD identifies known ISS and vehicle interface requirement Exceptions. Not all payloads will have Exceptions. When identified, Exceptions are communicated to the ISS Program to assess and document approval. This milestone can be repeated as necessary. | PD | | Exceptions are identified after the IRB is approved and the payload design requires deviations. | Approve IRB + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 209 | Disposition Exceptions | Disposition Exceptions | ISS Program supports the PD in Identify Exceptions, by proactively identifying known Exceptions. Additionally, the ISS Program assesses and coordinates recommendations and/or risk assessment for each Exception. The PIRE enlists support from Subject Matter Experts in the review of Exceptions via the PIRN review process. Disposition of the Exception (acceptance or rejection) is documented and communicated to the PD. | OB6 | PIRE, SME | Duration of the Exception review is dependent on the technical complexity, with nominal duration being 1 month. | Identify Exception + 1.0 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 210 | Final Topology Assessment | Final Topology Assessment | For payload located in ISS facilities or deployed in the aisle, the Payload Topology Forum reviews the Provide Revised Topology Data from the PD and performs a final Placement Study. The study identifies specific operational on-orbit location(s) and potential issues or exceptions. The results are used by the PD and ISS Program for product development (e.g., procedures). Results for payloads commanding using 1553 are used for Software development. | OM2, OB / Facility Project Manager | Craig Gordon | After Research Plan and PDR. Desire to have completed in time for PD to incorporate inputs into CDR. | Add to Research Plan + 1.0 | X | X | X | | | | | | X | ISS | D/A |
| 211 | Flight Assignment Assessment | Flight Assignment Assessment | After the PD provides a minimum set of cargo data (Provide Research Planning Data) the ISS Program will identify (and update as the Flight Program changes) a set of candidate flights that meet PD defined on-orbit need dates. As detailed cargo data matures and research requirements are baselined in the ISS Research Plan a target flight assignment can be made. Note that the number and type of constraints identified for launching / returning cargo will drive the timeframe in which flight assignment is finalized. | OC, OZ5/RPWG | | Candidate Flights are identified when a minimum cargo data set and on-orbit need dates are defined. Target flight assignment occurs only after Research Plan assignment and cargo data reaches sufficient maturity and may differ for each cargo item based on defined constraints. | Add to Research Plan + TBD | X | X | X | X | X | X | X | X | | ISS | D/A |
| 212 | Flight Assignment | Flight Assignment | The ISS Program assigns specific flights for the delivery and return/removal of the payload from ISS and communicates the flight assignment to the PD. Flight assignment in the Design and Analyze phase is necessary for certain powered locker, cold stowage and/or late load cargo as part of the Research Plan process of optimizing limited resources. A Flight Assignment change after initial assignment can occur due to PD or ISS Program changes (e.g., change in Hardware Readiness date, revision to flight schedule), and will be communicated to all impacted organizations. | OC | | Flight assignment occurs after payload has been included in the Research Plan (which defined the on-orbit need date) and kit-level manifest data has been provided. | Flight Assignment Assessment + TBD | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 213 | Dev. Testing | Dev. Testing | PD performs development testing to verify the payload design. If ISS Program facilities or resources are needed, they are identified in the PIA, and tracked in the schedule. | | | | | | | | | | | | | | Both | D/A |
| 213.1 | | JSC Dexterous Manipulator Trainer (DMT) | The JSC DMT provides an SPDM trainer which can be used for payload robotic interface engineering unit testing and training. | OM, OB, ER | Michael Wright | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | PDR + 1.0 | | | | X | X | X | X | X | X | ISS | D/A |
| 213.2 | | C&DH Development Testing | ECFs, PCFs, HPEG Configuration, and Command and Telemetry database are made available to the PD by the ISS Program. These products can be used by the PD for development testing.<br><br>**Add statement about coordination.** | PD, OD, POI | | Each product listed has its own schedule, and could have multiple dependencies, or none at all. Check PSCP website/agendas for Flight Product Schedules which has readiness date for many of these products. PSCP website/agenda also has dates for HOSC Database availability. | Build HOSC Databases for Test + 1 | X | X | X | X | X | X | X | | X | PD | D/A |
| 213.3 | | DCLA | TBD - If needed by the PD, the PD provides models to support the development of a Visiting Vehicle Design Coupled Loads Analysis (DCLA). | PD, ON | | | TBD | | | | X | X | X | X | | X | PD | D/A |
| 214 | Phase II Safety Review Inputs | Phase II Safety Review Inputs | The PD requests the ISS Program schedule a Phase II Safety Review with the ISS Safety Review Panel (ISRP). The PD performs a safety assessment based on the guidelines in SSP 30599 and safety requirements in SSP 51700 submits the Phase II Safety Data Package (including Hazard Reports (HRs)) for review via the ISS Hazard System (IHS) tool. If support is required during input development, the SPE can coordinate Working Group meetings with Subject Matter Experts to discuss any questions. | PD | | Tie to design maturity close to CDR, but complete enough to support inputs for CDR. Inputs should be provided 20 working days before the Phase II Safety Review to allow Safety Panel members time to review and provide comments. | PDR + 1.0 | X | X | X | X | X | X | X | X | X | PD | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EP | | | | |
| 215 | Phase II Safety Review Prep | Phase II Safety Review Prep | The SPE coordinates the scheduling of the Phase II Safety Review meeting, reviews the Phase II Safety Inputs from the PD, and distributes to the Safety Subject Matter Experts for review and comment. Comments are coordinated back with the PD to allow the PD to prepare responses prior to the Phase II Safety Review. If necessary, the SPE coordinates Working Group meetings with Subject Matter Experts to discuss comments and pre-coordinate responses.<br><br>During the review of the Phase II Safety Data Package, the PD will receive and review comments from Subject Matter Experts provided by the SPE and prepare responses. Responses will be discussed either during working groups in preparation for the review or during the formal Phase II Safety Review. Working Groups will be coordinated by the SPE with Subject Matter Experts. | PD, OE | SPE | | Phase II Safety Inputs + 0.75 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 216 | Phase II Safety Review | Phase II Safety Review | If requested, a Phase II Safety Review is held with the PD and ISS Safety Review Panel (ISRP). The PD presents their Phase II Safety Inputs to the ISRP, and the ISRP provide concurrence and/or recommendations. The objectives of the Phase II Safety Review are to:<br>• Obtain safety review panel approval of updated safety analysis that reflect the critical design and concept of operations of the payload and its interfaces,<br>• Update hazard causes defined at Phase I<br>• Assure all appropriate hazard controls have been implemented,<br>• Assure all verification methods are documented,<br>• Identify potential safety non-compliances in detail,<br>• Document newly identified hazards in existing or additional Hrs. | PD, OE | SPE | | Phase II Safety Inputs + 1.0 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 217 | Define NCR Approach | Define NCR Approach | The ISS Program / OE will review the results of the Phase II Safety Review and, if required, develop a strategy for each Non Compliance Report (NCR). | PD, OE | SPE | Identify a strategy as each NCR is identified, typically beginning after Phase II Safety Review. | Phase II Safety Review + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 218 | Initial Operability Review | Initial Operability Review | If requested by the PD, the ISS Program reviews the payload design (prototype, engineering unit, etc.) for engineering and operations considerations (Human Factors Integration Team (HFIT) requirements compliance, crew operability, procedure realism, label application, etc.). This is nominally accomplished by a review of a payload hardware prototype or engineering unit either at the PD site or in an ISS mockup.<br><br>Participation from the ISS Program nominally includes the Ops Lead, PARC, HFIT rep., crew office rep., IPLAT rep., POI OC and PIM, but other folks could be added if appropriate (e.g., Topology rep., ISS Plug in Plan rep, JSC/PLUTO, EVA, etc.). Lessons and results from the evaluation are incorporated into various products including the procedures, HFIT verification CoC (and identification of potential exceptions), and Label Plan. | SF, OB, POIF | PD, Ops Lead, PARC, HFIT rep., crew office rep., IPLAT rep., POI OC and PIM | After payload hardware design is mature. | PDR + 0.75 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 219 | Cargo Processing Rqmts | Cargo Processing Rqmts | The PD working with the ISS Program / OC review the standard cargo processing capabilities for the assigned flight, and identify if there are any anticipated unique cargo processing requirements for the cold stowage or Cargo Mission Contract teams. Unique requirements will be documented in the appropriate request form: Cold Stowage Form (Cold Stowage team) or Request for Services (RFS) (Cargo Mission Contract). | OC, PD | | After flight assignment, the cargo processing capabilities are reviewed, and special needs identified and coordinated with the appropriate provider. | Flight Assignment + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 220 | Vehicle Processing Rqmts | Vehicle Processing Rqmts | The PD working with the ISS Program / ON review the standard vehicle processing capabilities for the assigned flight, and identify if there are any unique vehicle processing requirements for the Vehicle Provider teams. Requirements will be documented in the appropriate document: Space-X ICD, Orbital-ATK Interface Control Agreement (ICA), etc.. | ON, PD | | After flight assignment, the transportation interfaces are reviewed, and special needs identified and coordinated with the appropriate provider. | Flight Assignment + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 221 | PAS Tag up | PAS Tag up | This tag with the PD outlines the process to deliver EXPRESS/WORF Laptop Payload Application Software (PAS) to the PSIVF for integrated laptop verification testing. | PD, OD | | | PDR + 0.5 | X | X | X | | | | | X | X | Both | D/A |
| 222 | Initial C&DH Inputs | Initial C&DH Inputs | The Command and Data Handling (C&DH) Data Set is a collection of data input by the Payload Developers into the Payload Data Library. This data defines the flight unique software interface requirements (including command and telemetry definitions) between Integrated Payload Systems and ISS flight data handling elements. Data from the C&DH data set is used to build the Payload Multiplexer/Demultiplexer (MDM) Configuration Files, EXPRESS Logistics Carrier Configuration Files, the Portable Computer System (PCS) Payload Displays, the POIC Command and Telemetry Databases, and the Software Interface Control Documents (ICDs). C&DH data set requirements are documented in SSP 57000 (pressurized) or 57003 (unpressurized / ELC). | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COLEP | | | | |
| 223 | Generate SIM/ENG HOSC Export | Generate SIM/ENG HOSC Export | Date the data from the Payload Data Library is exported and sent to the HOSC for incorporation into engineering telemetry and commanding databases. Database can be used for payload testing. | OD | | Data is currently included in an increment product. Dates are coordinated at the PSCP. | Initial C&DH Inputs + TBD | X | X | X | X | X | X | X | | | ISS | D/A |
| 224 | Review Interim SW ICD | Review Interim S/W ICD | A documentation review for the Interim Software (SW) ICD. The data in the Interim Software ICD is expected to be used in the implementation of the payload software. The MSFC Payload Rack Officer (PRO) is the POI position that leads this task. | MSFC PRO, PD, OD, SPE | | | TBD | X | X | X | X | X | X | X | | X | Both | D/A |
| 225 | Generate & Complete Interim S/W ICD | Generate & Complete Interim S/W ICD | The Generate & Complete Interim S/W ICD process synthesis the inputs from multiple sources into an easily assimilate textual format used to develop and test payload software and configure ground systems for test. Sources include the payload developer (payload commands and telemetry), Plan OPS (payload topology) and the Payload Data Library (PDL) (other integration data). As comments and redlines are found during the review process, changes are made in the master dataset that produces the software ICD and the interim ICD is corrected for release as the final software ICD. | SE&I PSI, OD | PSIE | | Review Interim S/W ICD + 0.5 | X | X | X | X | X | X | X | | X | Both | D/A |
| 226 | Deliver ISS Configuration Files for Test | Deliver ISS Configuration Files for Test | After the creation of the increment-based Engineering Payload Configuration Files (PCFs) and the EXPRESS Logistics Carrier Configuration Files (ECFs) but before they are tested, these files are placed into Payload Data Management Tool (PDMT) and the MBF for use by the payloads in development testing without flight hardware. | OD | | | Initial C&DH Inputs + TBD | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 227 | Submit Interim EXPRESS/WORF Laptop PAS | Submit Interim EXPRESS/WORF Laptop PAS | The Payload Developer is required to submit the EXPRESS or WORF payload application software (PAS) to the PSIV Team for testing and step-up to flight maturity. An interim version of the EXPRESS or WORF Laptop Payload Application Software (PAS) is required to be provided to the PSIVF before the final PAS is submitted. This interim delivery allows the PSIVF to check out many of the characteristics of the PAS in order to get familiar with the software before the final version of the PAS is submitted by the PD. | PD, OD | | | CDR + 0.5 | X | X | X | | | | | | X | Both | D/A |
| 228 | Generate KuIP Export | Generate KuIP Export | The task Generate Ku Band Internet Protocol (KuIP) Export provides KuIP configuration and attribute information used to build a ground HOSC Payload Ethernet Gateway (HPEG) Configuration File. The export ensures that on-board and ground systems are configured in concert. The export is available to the Ops Integration swim lane and made available to the POIC (Configure HOSC Systems for Test). Exports are accomplished whenever new data is available and therefore these exports may occur in any phase of the Manage Interfaces (Software) ST&E Flow. For simplicity, we elected to show this export just one time in the phase we most expected the new KuIP configuration to be defined. | OD | | Ku IP exports/reports are generated when new information is provided by OD to POI. POI uses this information to configure systems for test and flight. NET completion C&DH/GDS coordination meeting. | PDL + TBD | X | X | X | X | X | X | X | | | ISS | D/A |
| 229 | Build HOSC Databases for Test | Build HOSC Databases for Test | HOSC command and telemetry databases incorporate PDL inputs provided by PDs as well as ISS system data definitions. These databases are built for each increment and include any payloads that have worked with the PSCP/PDL to be included for testing during that increment/timeframe as well as payloads that will be onboard ISS during that increment. These databases can be used for various tests that include the HOSC as part of the data flow path (ODTE, ORTs, simulations) or they can be used to pull definitions that will be included in a TReK database for other localized testing. | POIC | | It takes approximately one month to build and checkout command & telemetry databases. | Generate SIM/ENG HOSC Export + 1 | X | X | X | X | X | X | X | | X | ISS | D/A |
| 230 | Configure HOSC Systems for Test | Configure HOSC Systems for Test | HOSC systems must be configured with the proper command and telemetry databases and HPEG configurations, as well as voice, video, and telemetry routing prior to tests so that the services needed during that test are available to the user. | POIC | | | Build HOSC Databases for Test + 0.1 | X | X | X | | | | | | | ISS | D/A |
| 231 | Deliver Initial Crew Displays | Deliver Initial Crew Displays | Deliver initial crew displays to Payload Displays Review Team (PDRT). Initial displays are subject to review and usability verification by the PDRT, the IDAGS Team and the JSC Astronaut Office. Initial displays should provide a static depiction (screenshots) of the crew graphical user interface (crew GUI) that will support the payload nominal operational tasks. Initial displays should begin to outline the basic GUI architecture, the essential software monitoring/control functions and the operational sequence required to service the payload. | HP26, PD | PDRT | | CDR - 0.25 | X | X | X | X | X | X | X | | X | ISS | D/A |
| 232 | Provide CDR data package | Provide CDR data package | The PD provides access to their Critical Design Review (CDR) data package, if they request ISS Program review support. | PD | | CDR data packs should be submitted to the ISS Program 1 week before CDR to allow sufficient time for review and comment development. | CDR - 0.25 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 233 | CDR Prep | CDR Prep | The PIM and PIRE coordinates ISS Program support to the CDR. The applicable ISS Program representatives review the Provide CDR data package from the PD for compliance to the interface requirements and implications to ISS operations, and provide development guidance to the PD. Comments are coordinated back with the PD during the CDR. The ISS Research Integration Office also reviews the CDR data package for implications to ISS payload integration, and to provide verification guidance to the PD. A checklist is used to help organize the ISS Program review. | ISS Program | | | Provide CDR data package + 0.25 | X | X | X | X | X | X | X | X | X | ISS | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
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| 234 | CDR | CDR | Payload Project conducts a Critical Design Review (CDR). Most Payload projects, as part of their design effort, may conduct a CDR (or other equivalent review) when their design reaches 90% maturity. CDR may not be held by all PDs, i.e., re-flight or serial hardware. The CDR represents completion of the classical Project Development Cycle Phase C (reference NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook). The CDR demonstrates a "build-to" detailed design baseline to fabricate, integrate and verify. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | D/A |
| 235 | Deliver Cargo Analytical Products | Deliver Cargo Analytical Products | TBD - The PD provides inputs to the launch vehicle provider to support development of the Mission Resource Allocation Document (MRAD). The initial MRAD shall contain current analytical data related to: electrical power and energy, command and data requirements, orbital vehicle dynamics and mass properties, robotics and berthing requirements, orbital vehicle Computer-Aided Design (CAD) models, orbital vehicle structural math model, plume history, thruster firing history, propellant types, launch to activation (LTA) analysis for external cargo.<br><br>Check with Jason Smith. | PD | | After CDR (design is mature). | CDR + 0.5 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 235.1 | | HF Mockup | If a payload requires cold stowage, the PD ships a High fidelity (HF) mockup to Cold Stowage (CS) team to allow that team to perform an integrated fit check. Alternatively, the PD can ship flight hardware or provides a CAD model suitable for 3D printing. | PD, OC/CS team | | CS performs integrated fit check at L-7.5 months. | CDR + 0.5 | X | X | X | | | | | | X | PD | D/A |
| 236 | MRAD | MRAD | Mission Requirements and Allocations Document (MRAD) captures extensive mission and cargo unique data and analyses, including vehicle and cargo physical configuration, electrical power budgets, communication and data budgets, coupled loads analysis results, crew utilization, flight operation support, vehicle design changes, a mission training plan, and other specific information. | ON | | MRAD data provided to needed teams at L-13. | Deliver Cargo Analytical Products + 10.5 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 237 | Crew Training TST | Crew Training TST | The Training Strategy Team (TST) is a structured planning and decision-making group who determine crew training requirements for each payload. The required TST participants are the CTC, Ops Lead, User, FOD Rep (Crew Office Rep), and if there are displays, the Payload Displays Review Team (PDRT). A TST may be held for either a new payload, an increment payload complement, or for any update that warrants a change to existing crew training strategy. | PD, POIF, FOD | | | Flight Assignment + 0.25 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 238 | EIR | EIR | TBD - External Integration Review (EIR).<br><br>Get with Jason Smith | ON | | | Deliver Cargo Analytical Products + 3.0 | | | | X | X | X | X | X | X | Both | D/A |
| 239 | PV Assessment | PV Assessment | The Procedure Validation (PV) Assessment is a structured meeting to determine the procedure validation plan for each payload. The plan will include the validation method, hardware fidelity, location, timing, and participants. The participants can include Ops Lead, PARC, FOD Rep, PD, and POI OC. | Ops Lead | Ops Lead | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 240 | Provide Inputs to Ops Products | Provide Inputs to Ops Products | PD provides inputs to the PARC/Ops Lead to develop draft crew procedures and planning products (Payload Activity Requirements Document (PARD), Payload Planning Overview (PPO), and planning Ground rules and Constraints (Gr&C)). This begins an iterative process between the Ops Lead, PARC, POI OC, and PD to fully mature the ops products. | PD | | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 241 | Begin Ops Products Coordination | Begin Ops Products Coordination | PARC/Ops Lead begin coordination with PD to develop draft crew procedures and planning products (PPO, PARD and planning Gr&C). This begins an iterative process between the Ops Lead, PARC, POI OC, and PD to fully mature the ops products. | POIF | PARC, Ops Lead | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 242 | Build Timeliner | Build Timeliner | POIF and PD work together on Timeliner bundles for a payload for testing | PD, POIF | Timeliner Lead on the MSFC PRO team | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 243 | Approve Exceptions | Approve Exceptions | An Exception to a requirement may be submitted when a requirement cannot be met but sufficient rationale exists for the condition to be accepted. | OB | | | CDR + 1.0 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 244 | CSS Inputs | CSS Inputs | PSO contacts the PD teams to assess their customer satisfaction. | PD, ISS Program | PSO Rep | Prior to Sync Point Reviews | | X | X | X | X | X | X | X | X | X | Both | D/A |
| 245 | Sync Pt 2 | Sync Pt 2 | Internal ISS Program review intended to sync up NASA organizations and review issues coming out of payload design efforts and before verification. Specific topics include reviewing PIM Schedule, approving PIA updates, and communicating risks among the ISS Program management. More information is included in the Sync Point 2 Charter. | OZ6 | PIM | Schedule after PD completes their design efforts. | CDR + 1.0 | X | X | X | X | X | X | X | X | | ISS | D/A |

# 7 APPENDIX B – INTEGRATION ACTIVITIES– VERIFY PHASE

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
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| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL EP | | | | |
| 300 | Provide Verify Data Set | Provide Verify Data Set | Provide data that is needed by the program. Data deliveries may be spread throughout the phase. For specific details on data deliveries in this phase, refer to FCC License. | PD | | | | | | | | | | | | | PD | V |
| 300.1 | | FCC License | PD receives approval for their FCC license. | PD | | | Apply for FCC License + 6 | | | | X | X | X | X | X | X | PD | V |
| 301 | Complete H/W Fabrication | Complete H/W Fabrication | PD completes their fabrication of hardware for testing and flight. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | V |
| 302 | Develop Ground Command Procedures | Develop Ground Command Procedures | Ground Command Procedures (GCPs) developed by POIF Payload Rack Officers (PRO) are used to send commands for managing resources to payloads and/or take action if necessary to save Payload science and/or hardware. Inputs are provided from OD (Final PCFs and ECFs into PDMT, and Build HOSC Databases). This begins an iterative process between the PRO and PD to fully mature/baseline the GCPs. | POIF, PD | MSFC PRO | L-6 months for nominal payloads L-12 months for complex payloads. | Launch - 6 | X | X | X | X | X | X | X | | X | Both | V |
| 303 | Submit Cargo Processing RFS | Submit Cargo Processing RFS | If necessary, the PD completes a Request for Services (RFS) to identify any requested part-specific standard cargo processing services from the Program. This could include unique packing materials (foam, zip locks, bags, etc.) or special cargo processing services. | PD | | Request should be provided 30 days before the Service need date. | TBD | X | X | X | | | | | X | X | PD | V |
| 304 | Submit Manifest Rqmts | Submit Manifest Rqmts | The PD completes a Manifest Request (MR) itemizing part names, numbers, mass and dimensions for each requested piece of hardware to be transported to or from ISS.<br><br>**Talk with Christian, Brad on relationship with Research Plan.** | PD, Payload Manifest Lead | | | CDR + 2.0 | X | X | X | X | X | X | X | X | X | PD | V |
| 304.1 | | Hardware OpNom | TBD - PD provides recommended Operations Nomenclature (OpNom) name to be used by the ISS Program for each hardware item that will be delivered to ISS or used on-orbit. Naming guidelines and official approval are administered by the Operations Data File Control Board (ODFCB). | PD, FOD, OC/CMC | | All hardware OpNoms should be approved before Final Operability Review. | TBD | X | X | X | X | X | X | X | X | X | Both | V |
| 305 | Integrate Manifest Rqmts | Integrate Manifest Rqmts | The ISS Program integrates all Manifest Request (MR) received. As the requests are approved, the MR data is transitioned from the ORBIT/MR database to the MIDAS database.<br><br>**Talk with Christian, Brad on relationship with Research Plan.** | OC | | | Submit MR + 0.05 | X | X | X | X | X | X | X | X | | ISS | V |
| 306 | Submit Stowage Rqmts | Submit Stowage Requirements | The PD, with help from the ISS Program/Payload Stowage Coordinator, completes an electronic Launch, Return, On-orbit Data Set (eLRODS) to identify packing / stowage requirements for each payload hardware item. | PD, Payload Stowage Coordinator | OZ/Virginia Spaniel | | Submit MR + 1.0 | X | X | X | | | | | X | X | Both | V |
| 307 | Develop Stowage Layouts | Develop Stowage Layouts | The ISS Program Cargo Processing team produces integrated stowage layouts for all hardware on a per flight basis using the data provided in the eLRODS submissions. | OC, CMC | | | Submit eLRODS + 1.0 | X | X | X | | | | | X | X | ISS | V |
| 308 | Complete Final C&DH Updates | Complete Final C&DH Updates | This is the last opportunity for the PD to update any previously entered C&DH data prior to the programs formal build and test process. After this update process completes the data is locked down and placed under configuration management. Additional changes must be accompanied by a Data Set Change Request (DSCR) and approved by the PSCP. PSCP approval is governed by the balance between the risk to operations of non-incorporation and the resulting schedule impacts to other payload customers and the program caused by incorporating the late data entry.<br><br>The Command and Data Handling (C&DH) Data Set is a collection of data input by the Payload Developers into the Payload Data Library. This data defines the flight unique software interface requirements (including command and telemetry definitions) between Integrated Payload Systems and ISS flight data handling elements. Data from the C&DH Data Set is used to build the Payload Multiplexer/Demultiplexer (MDM) Configuration Files, the Portable Computer System (PCS) Displays, the POIC Command and Telemetry Databases, and the Software Interface Control Documents (ICDs). C&DH Data Set requirements are defined in SSP 57002, Payload Software Interface Control Document Template. | PD, OD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 309 | Generate Final HOSC Export | Generate Final HOSC Export | Date the data from the Payload Data Library is exported and sent to the HOSC for incorporation into flight telemetry and commanding databases. These HOSC databases are used to decommutate the data received from the payload systems on-orbit before the data is viewed on the ground. | OD | | Final C&DH inputs must be complete 1 to 2 weeks prior to a planned export. Data is currently included in an increment product. Dates are coordinated at the PSCP. | Complete Final C&DH Updates + 0.5 | X | X | X | X | X | X | X | X | | ISS | V |
| 310 | Build HOSC Databases for Flight | Build HOSC Databases for Flight | HOSC command and telemetry databases incorporate PDL inputs provided by PDs as well as ISS system data definitions. These databases are built for each increment and include any payloads that have worked with the PSCP/PDL to be included for testing during that increment/timeframe as well as payloads that will be onboard ISS during that increment. These databases will be used for flight operations during the increment. | POIC | | | Generate Final HOSC Export + 1.0 | X | X | X | X | X | X | X | X | | ISS | V |
| 311 | Deliver Final PCFs and ECFs | Deliver Final PCFs and ECFs | The date PSIVF delivers the Engineering mature versions of the Payload Configuration Files (PCFs) and the EXPRESS Logistics Carriers Configuration Files (ECFs) to the MBF and PDMT. These products have been integration tested but no formal testing has been performed. Only after formal verification testing the Payload Configuration Files (PCFs) and EXPRESS Logistics Carrier Configuration Files (EFCs) are moved to FQT and Flight Mature. | OD | | | TBD | X | X | X | X | X | X | X | | X | ISS | V |
| 313 | Submit Final EXPRESS/WORF Laptop PAS | Submit Final EXPRESS/WORF Laptop PAS | The PD submits the final version of their EXPRESS or WORF Laptop Payload Application Software (PAS) to PSIVF. | PD | | | TBD | X | X | X | | | | | | X | PD | V |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EFP | | | | |
| 314 | Flight Test & Deliver Final EXPRESS/WORF Laptop PAS | Flight Test & Deliver Final EXPRESS/WORF Laptop PAS | The date the EXPRESS/WORF Payload Application Software (PAS) (i.e., payload laptop applications) is moved to flight mature status and can be manifested, uplinked, installed, and used on-orbit. EXPRESS and WORF laptop applications are tested by the PSIV Team to ensure that: (1) the payload application software can close open verification, (2) integrates and works nominally with the entire payload complement of payload laptop applications, and (3) identifies and documents any constraints for operating the payload laptop. The final version of the laptop software will configuration managed by the ISS Program, given a unique part number and provided to payload operations. | OD | | | TBD | X | X | X | | | | | | X | ISS | V |
| 315 | Complete Test PPIL Inputs | Complete Test PPIL Inputs | | OD | | | | | | | | | | | | | | |
| 316 | Baseline Test PPIL | Baseline Test PPIL | The date the PD must complete their input to their Test Payload Product Integrated List (PPIL) to document the complete C&DH payload software configuration for the verification test.<br><br>Test PPIL is a managed list of software products to be used with the Payload Rack Checkout Unit (PRCU) or other functional checkout units during formal C&DH payload verification testing prior to a specific increment. Includes the same basic information categories as the Flight PPIL. | PD, OD | | | TBD | X | X | X | X | | | | | X | PD | V |
| 317 | Identify Media Manifesting Rqmts | Identify Media Manifesting Rqmts | PD submits request to ISS Program/OD to build and transport software media to ISS. Media can include CDs/DVDs, thumb drives, SD/microSD cards. | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 318 | Flt Media Manifesting Process | Flt Media Manifesting Process | ISS Program / OD builds and verifies software media for flight. Media can include CDs/DVDs, thumb drives, SD/microSD cards. | OD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 319 | Order / receive labels | Order / Receive Labels | | | | | | | | | | | | | | | | V |
| 319.1 | | Order Labels | PD submits request for hardware labels to the ISS Payload Label Analysis Team (IPLAT). | PD | | Labels should be ordered to arrive after hardware is fabricated. | Submit Manifest Requirements + 1.0 | X | X | X | | | | | X | X | PD | V |
| 319.2 | | Receive Labels | ISS Payload Label Analysis Team (IPLAT) fabricates the hardware labels and delivers them to the PD for application on the PD hardware. | SF | IPLAT rep. | Nominal order takes 30 days from request to delivery. | Order labels +1.0 | X | X | X | | | | | X | X | ISS | V |
| 320 | Final Operability Review | Final Operability Review | Pressurized and External description. | | | | | | | | | | | | | | | V |
| 320.1 | | Final Operability Review | For pressurized payloads, the ISS Program reviews the payload for engineering and operations requirements compliance (Human Factors Integration Team (HFIT) requirements, crew operability, procedure validation, label application, etc.). This is nominally accomplished by a review of the as-built payload hardware, displays and draft procedures either at the PD site or in an ISS mockup.<br><br>During the procedure validation every procedure is checked for technical accuracy, that it executes as written, that it achieves its desired objectives, and that it assures crew safety. Also, the overall operability is checked to ensure that the procedures are in sync with the layout of the planned activities. The procedure validation method/plan is outlined and agreed to during the PV Assessment.<br><br>Participation from the ISS Program nominally includes the Ops Lead, PARC, HFIT rep., crew office rep., IPLAT rep., and PIM, but other folks could be added if appropriate (e.g., Topology rep., ISS Plug in Plan rep, JSC/PLUTO, etc.). Results from the review are used to close HFIT and labeling requirements, identify necessary exceptions, and validate flight crew procedures.<br><br>If displays are included, a Usability Review is incorporated and PDRT is also invited. Usability Verification advances both the displays and the procedures to NASA acceptance as flight and training products. PDRT conducts integrated usability verification tests (or trials) on mature graphical user interfaces (GUIs) that are compliant with the payload display design standards/guidelines. Usability testing is supported by the Payload Developer and the JSC Astronaut Office. Separate time will need to be set aside to complete the specific Usability objectives during the Final Operability Review. | SF, OB, POIF | PD, Ops Lead, PARC, HFIT or VITT rep., crew office rep., IPLAT rep., PIM and PDRT (if displays) | After payload hardware design and displays are mature, procedures are drafted, and labels have been received. Must be done before verifications are due and hardware turnover. | Complete Payload Fabrication + 1.0 | X | X | X | | | | | X | X | ISS | V |
| 320.2 | | VITT Review | For external payloads, the ISS Program reviews the payload for engineering and operations requirements compliance (applicable EVA interface requirements (bolt gauging, tool fit checks and sharp edge inspections), crew operability, procedure validation, etc.). This is nominally accomplished by coordinating with PD and can be performed at the PD site or after delivery for launch. Results are documented and reported through the CoFR process.<br><br>Participation from the ISS Program nominally includes the Crew Office rep., EVA Office rep., Ops Lead, PARC, and PIM, but other folks could be added if appropriate (e.g., Robotics rep., etc.). Results from the review are used to close requirements, identify necessary exceptions, and validate flight crew procedures. | CA, XX, OB, POIF | PD, Crew Office rep., EVA Office rep., Ops Lead, PARC, and PIM | After payload hardware design is mature. Must be done before verifications are due. | Complete Payload Fabrication + 1.0 | | | | X | X | X | X | | X | ISS | V |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | | External | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EP | | | | |
| 321 | Verification Testing | | The specific tests that the PD requests ISS Program facility or support will be itemized below and tracked individually in the payload unique schedules. | PD | | | | | | | | | | | | | | V |
| 321.1 | | 1553 RT Validation Test | Each payload requiring 1553 commanding needs to perform a MIL SPEC 1553 Remote Terminal (RT) Validation Test to ensure that the payload hardware is compliant with the 1553 protocols. The ISS Program offers this test capability at the SCTF RT Validation lab. | OD | Kevin Calvin | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.2 | | JSL Testing | Payloads can perform a functional demonstration test of their payload Ethernet interface at the Joint Station LAN (JSL) laboratory located at the SCTF or via connection to JSL Lab via the Space Station Integration and Test Facility (SSITF). Payloads using external wireless Ethernet for communications can request to perform a functional demonstration test of their payload Ethernet interface at the JSL lab located at the SCTF. In addition, JEM-EF installed payloads are required to perform a functional demonstration test that their payload Ethernet interface can communicate with the LEHX hardware found on the JEM.<br>Note 1: All testing will be coordinated utilizing the current SDIL test process which identifies all testing and necessary resources via a SIF.<br><br>**TBD: Need to identify how the PD can test Ethernet interoperability without using the JSL Lab. Incorporate Ethernet Test Suite and RAPTR.** | OD | Margaret Sterling | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.3 | | Frequency Management Analysis | Ensures that payloads with Radio Frequency transmissions do not interfere with ISS frequencies. The PD is required to provide data into the JSC Frequency Management database. | OD/EV | Cathy Sham | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.4 | | Power Quality Testing | This testing can help ensure the PD is collecting power data in a manner that satisfies the electrical interface verification requirements. The ISS Program offers power testing support to payloads using various electrical interfaces on ISS. This test service is available at JSC in the SCTF Integrated Power Lab (IPL), at KSC in the SSPF, or it can be performed at the payload's development site with the proper coordination. The JSC Energy System Test Area (ESTA) Power Testing Lab also can support power quality testing to verify a payload works properly with the various electrical power supplied by ISS. This testing includes 120Volt (V) Direct Current (DC), 28VDC, 120V Alternating Current (AC), and various DC load testing. The ESTA lab can also test compliance with turn on/off current, AC and DC impedance, and voltage excursions. Since JSC ESTA lab services are independent of the ISS Program, there typically is cost associated with use of this lab. | OD/EA | Casey Adams | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.5 | | PRCU Testing | Utilized to test payload hardware interfaces to the ISS and conduct end-to-end development or functional testing. In this capacity the Payload Rack Checkout Unit (PRCU) serves as a high fidelity emulator of on-orbit ISS interfaces (C&DH, laptop, power, cooling, vacuum, etc.) and allows experiment developers to ensure that their payload will interact properly once connected on-orbit. PRCUs are located at NASA JSC, KSC, MSFC, and GRC. | OD | MSFC/Rob West KSC/Rob Kuczajda JSC/ GRC/Terry O'Malley | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.6 | | RITF Testing | JSC Receiving, Inspection, and Testing Facility (RITF) is available to perform a variety of mechanical testing, such as fastener testing. | OB | Raani Francis/OB, Cheryl Corbin/NT4 | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.7 | | KSC Testing | Kennedy Space Center (KSC) is available to perform a variety of testing prior to vehicle integration (e.g., EXPRESS Logistics Carrier (ELC) testing). | KSC/UB-A | Robert Kuczajda | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.8 | | WFF Testing | Wallops Flight Facility (WFF) is available to perform a variety of testing prior to vehicle integration. | KSC/UB-A | Robert Kuczajda | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | X | X | ISS | V |
| 321.9 | | Flight Media Production/Testing | The PSIVF can be utilized to create and test flight certified media (Compact Discs [CDs] or Digital Video Discs [DVDs]) containing payload software for launch to ISS. The ISS CD Library Process owned by JSC/ISS Avionics & Software Office (OD) is the ISS Program's preferred method for manifesting media for use onboard ISS. The Payload Software Control Panel (PSCP) allows PDs to simply turnover their payload media and supporting documentation to the PSIVF for all ISS CD Library processing. The PSIVF and the Software Configuration Management team will then build, verify, and deliver flight media which meets the requirements in SSP 50613, ISS CD Library Requirements Document. Using a PSCP-owned and managed media duplicator and the process described in the Payload CD Library Process flow diagram, the PSCP will ensure a consistent, timely, repeatable, and highly successful flight media delivery process for the PD. | OD/PSIVF | Jill Travers | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | | X | ISS | V |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL EFP | | | | |
| 321.1 | | SSC Software / Integration Testing | Testing of PD provided software can occur in the SCTF along with integration into ISS Service Packs. | OD | Keith Chuvala | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | | X | ISS | V |
| 321.11 | | Freezer Verification Testing | The Cold Stowage team can provide freezer verification testing for payload containers if negotiated and coordinated in advance. | OB | Larry Cotton | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | | X | ISS | V |
| 321.12 | | Coordinated External Contamination Analysis | The standard service provided by the Boeing External Contamination Group becomes a coordinated service if out-gassing and venting properties for materials used by the PD are not readily available.<br>Note: This service will not be available for Payloads that integrate to the JEM-EF or the COL EPF. | OB | Ron Mikatarian | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | | | | X | X | | | X | X | ISS | V |
| 321.13 | | EVA Worksite Analysis | For payloads robotically installed on to a USOS payload site, with the exception of JEM element sites, NASA via Boeing EVA and Systems Engineering and Integration will be responsible for payload contingency EVA data products and requirements definition. This includes an EVA Analysis Report (EAR) for each payload and an EVA Verification Report for each payload's integrated EVA requirements. These reports will be provided to the PD and will include all documentation required to support verification closure of the payload's integrated EVA requirements.<br>For payloads robotically installed on to JEM elements, EVA verification NASA and JAXA, with input from the PD, shall jointly determine if the payload has unique EVA requirements not enveloped by existing JEM-EF verification work. If an agreement is not reached, the discussion shall be brought to the EVA Analysis Integration Team (AIT) for resolution. When required, EVA verification shall be performed by JAXA. JAXA shall develop the Integrated EVA verification analysis report (worksite and translation path) and provide it to the NASA Vehicle Office. NASA Vehicle Office representatives shall be responsible for producing any necessary exceptions paperwork, which shall be reviewed by JAXA and presented to the EVA AIT for approval. The JAXA report of the Integrated EVA verification analysis shall be archived as part of the payload verification records. | OM, OB, XX | Linda Thomas | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | | | | X | X | X | X | X | X | ISS | V |
| 321.14 | | Glint/Obstruction Analysis | The JSC Graphics Research and Analysis Facility Lab is used for glint analysis of an ISS external payload and can also be used for truss site Payload Attach System (PAS) obstruction analysis. | OM, OB | | | | | | | X | X | X | X | X | X | ISS | V |
| 321.15 | | HOSC Verification Test | Test with HOSC to verify PDs can receive Telemetry and send commands and/or data via HOSC services. | POIC | PIE/Marshall Ops | | | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.16 | | Conduct Timeliner Testing | POIF Timeliner leads works with PD to test Timeliner sequences and bundles. | POIF | | | | X | X | X | X | X | X | X | | X | ISS | V |
| 321.17 | | Dragon Force Test | For new powered lockers flying on SpX, a Dragon Force test is available to verify power interfaces with the SpX Dragon. It is an avionics test bed in Hawthorne, CA, but a reduced fidelity unit is available to be transported to the PD location if shipping to Hawthorne is not practical. | PD, ON | | | | | X | X | | | | | | X | ISS | V |
| 321.18 | | Cygnus Test | Powered payloads flying on Cygnus for the first time may be required to be power tested at Dulles with the spacecraft. In addition, a fit check of the unit is required to ensure any needed shimming or installation procedure development can be in place. | PD, ON | | This testing should take place at or before L-12 months. | | | X | X | | | | | | X | ISS | V |
| 322 | Submit I/F Verification Data | Submit I/F Verification Data | PD submits verification data to demonstrate adherence to the ISS Program requirements for Hardware and Software Interfaces. This line item does not account for planned late load related verifications (provided in the Deliver phase). | PD | | Verification data should be submitted as soon as each type of data is available. Verification dependent on testing typically takes longer than Certificate of Compliance (CoC) or Analysis. | Perform payload testing + 0.5 | X | X | X | X | X | X | X | X | X | PD | V |
| 323 | Accept and Close I/F Verifications | Accept and Close I/F Verifications | ISS Program reviews verification inputs provided by PD for adherence to ISS requirements.<br><br>**Add description of OB L-2 ops constraint process if verifications are not closed.** | OB, OD, OM, SF | | | Submit Interface Verification Data + 0.5 | X | X | X | X | X | X | X | X | X | ISS | V |
| 324 | Submit Unique VV Verification Data | Submit Unique VV Verification Data | If there are unique Visiting Vehicle (VV) requirements, the PD submits verification data to demonstrate adherence to the ISS Program requirements for Visiting Vehicle Interfaces. | PD | | Verification data should be submitted as soon as each type of data is available. Verification dependent on testing typically takes longer than Certificate of Compliance (CoC) or Analysis. | Perform payload testing + 0.5 | X | | X | X | X | X | X | X | X | PD | V |
| 325 | Accept and Close Unique VV Verifications | Accept and Close Unique VV Verifications | If there are unique Visiting Vehicle (VV) requirements, the ISS Program and Visiting Vehicle provider reviews verification inputs provided by PD for adherence to Visiting Vehicle requirements. | ON | | | Submit VV Verification Data + 0.5 | X | | X | X | X | X | X | X | X | ISS | V |
| 326 | Review Final Software ICD | Review Final Software ICD | The ISS Program / OD documentation review of the Final Software ICD for completeness and verification of compliance with Program requirements. The data in the Final Software ICD is expected to be a review of the final as-built data used in the implementation of the payload software. | PD, OD, MSFC PRO | Michael Coats | | TBD | X | X | X | X | X | X | X | | X | Both | V |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EP | | | | |
| 327 | Configure HOSC systems for Flight | Configure HOSC systems for Flight | HOSC systems must be configured with the proper command and telemetry databases and HPEG configurations, as well as voice, video, and telemetry routing for a particular increment so that the services needed during the increment are available to all the payload users. | POIC | | HOSC systems are configured prior to increment transitions - generally 2 weeks prior to the start of the onboard increment. | Increment - 0.5 | X | X | X | X | X | X | X | | | ISS | V |
| 328 | Phase III Safety Review Inputs | Phase III Safety Review Inputs | The PD requests the ISS Program schedule a Phase III Safety Review with the Safety Panel. The PD performs a safety assessment based on the guidelines in SSP 30599 and submits the Phase III Safety Data Package to the SPE via the ISS Hazard System (IHS) tool. The PD then reviews comments from the Safety Subject Matter Experts provided by the SPE, and prepares responses to be discussed during the Phase III Safety Review. If necessary, the SPE can coordinate Working Group meetings with Subject Matter Experts to discuss comments and pre-coordinate responses. | PD | | Inputs should be provided 20 working days before the Phase III Safety Review to allow Safety Panel members time to review and provide comments. | PD Driven | X | X | X | X | X | X | X | X | X | PD | V |
| 329 | Phase III Safety Review Prep | Phase III Safety Review Prep | The SPE coordinates the scheduling of the Phase III Safety Review meeting, reviews the Phase III Safety Review Inputs from the PD, and distributes to the Safety Subject Matter Experts for review and comment. Comments are coordinated back with the PD to allow the PD to prepare responses prior to the Phase III Safety Review. If necessary, the SPE coordinates Working Group meetings with Subject Matter Experts to discuss comments and pre-coordinate responses. | PD, OE | SPE | | Phase III Safety Review Inputs + 0.75 | X | X | X | X | X | X | X | X | X | Both | V |
| 330 | Phase III Safety Review | Phase III Safety Review | Phase III Safety Review is held with the PD and ISS Safety Review Panel (ISRP). The PD presents their Phase III Safety Inputs to the ISRP, and the ISRP provide concurrence and/or recommendations. The objectives of the Phase III Safety Review are to:<br>• Obtain safety review panel final approval of the safety analysis that reflects the design and concept of operations of the payload and its interfaces.<br>• Present the final safety analysis that identifies all hazards and hazard causes, resolves any safety non-compliances, and identifies all safety verification methods, status of verification closures, and status of remaining open items transferred to Safety Verification Tracking Log (SVTL) and status.<br><br>For hardware that is considered to be series or reflown hardware, a Series/Reflown Hardware Safety Assessment should be performed. It is typically reviewed around the time when a Phase III review would occur. | PD, OE | SPE | | Phase III Safety Review Inputs + 1.0 | X | X | X | X | X | X | X | X | X | Both | V |
| 331 | Science Symposium | Science Symposium | A multi-day event for Principal Investigators to present their science objectives, testing approach, and measurement methods to agency scientists, managers, and other investigators. Participation is encouraged (but not required) to gather a global picture of the science planned to be performed on ISS during a specified timeframe (usually increment pair). | PD, Steward Discovery | PSO | | TBD | X | X | X | X | X | X | X | X | X | Both | V |
| 332 | Approve NCRs | Approve NCRs | The ISS Program must review, assess risk to ISS, and approve each Non Compliance Report (NCR) prior to the payload deviating from established safety requirements. The ISS Safety Review Panel will identify the appropriate approval authority for each Non Compliance Report (NCR). The PD is responsible to provide the necessary information to the approval authority to allow sufficient review and understanding of the risk to ISS prior to approval. | OE | | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |
| 333 | Provide Phase III SDP for VV internal safety review | Provide Phase III SDP for VV internal safety review | If payloads have any Safety Hazards that could impact the transportation vehicle, the transportation vehicle will be responsible for presenting integrated vehicle hazards to the ISS Safety Review Panel for review and approval. These integrated hazards must be closed to consider the payload certified for flight. | VV int. | | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |
| 334 | Ground Crew Training | Ground Crew Training | PD team conducts ground crew training for their experiment. This can also be done by a POI representative on behalf of the PD team if agreed to at the Crew Training TST. POI facilitates the crew training session. Other POI members, such as Ops Leads and OCs, may attend to gain better ops understanding. | PD, POIF | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 335 | Submit Flight Safety Certificate | Submit Flt Safety Certificate | PD submits flight safety certification request via IHS (Form 906). This information for each flight includes payload part numbers, hardware description, vehicle applicability, and owner responsibility. | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 336 | Review & Sign Flight Safety Certificate | Review & Sign Flight Safety Certificate | The ISS Safety Review Panel reviews and approves the Form 906, assuming the associated Safety Data Package is complete and all safety related issues have been resolved. | OE | SPE | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |
| 337 | PD Training | PD Training | PD is provided training on POI ground systems and interfacing with the POIC cadre. This training will prepare the PD to support ISS real time operations for their payload. At their request, PDs may also participate in voice loop exercises and simulations. | PD, POI | | Will not train until ISS Program knows when they will operate. | Submit Inputs to CoFR Checklist – 0.25 | X | X | X | X | X | X | X | X | X | ISS | V |
| 338 | Submit Ground Safety Checklist / Hazard Reports | Submit Ground Safety Checklist / Hazard Reports | TBD | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 339 | Coordinate Ground Safety Checklist/Hazard Reports | Coordinate Ground Safety Checklist/Hazard Reports | TBD | Plan and Process Cargo | | | TBD | X | X | X | X | X | X | X | X | | ISS | V |
| 340 | Review and approve Ground Safety Checklist / Hazard Reports | Review and approve Ground Safety Checklist / Hazard Reports | TBD | OE, Launch site | | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |

| PD Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EF | | | | |
| 342 | Provide Inputs to PL Reqs & FRs | Develop PL Reqs and FR's | Ops Lead works with PD to develop any necessary Payload Regs and/or Flight Rules based on ops constraints. Ops Lead normally submits constraints on behalf of the PD team; however, the PD may make the inputs directly to the Book Managers. | PD, HP26 | Ops Lead | Normally occurs after Final Operability Review; however, results from Phase III Safety Review may lead to additional constraints being submitted. | Final Operability Review + 1.0 | X | X | X | X | X | X | X | X | X | Both | V |
| 343 | Submit Ground Processing Requirements (PSRD/PRD) & Technical Requirements | Submit Ground Processing Requirements (PSRD/PRD) & Technical Requirements | The PD submits inputs to the Payload Support Requirements Document (PSRD). The PSRD documents the advanced planning for ground processing support requirements necessary to process ISS payloads at KSC or Wallops. Payload support provided by KSC or Wallops may comprise some or all of the following phases of the payload life cycle: simulations, preflight, in-flight, and post-flight phases. This includes both hardware and science items to be processed at KSC or Wallops. | PD | | | | X | X | X | X | X | X | X | X | X | PD | V |
| 344 | Assess & Implement Ground Processing Requirements (PSRD/PRD) | Assess & Implement Ground Processing Requirements (PSRD/PRD) | KSC assesses PD requests, documents ground processing support requests in the PSRD, and provides the support as agreed. | Plan and Process Cargo | KSC/Jennifer Wahlberg | | | X | X | X | X | X | X | X | X | | ISS | V |
| 345 | Hold Cargo Integration Review (CIR) | Hold CIR | Cargo Integration Review (CIR): | ON | | | | | | | | | | | | | ISS | V |
| 345.1 | | Hold Cargo Integration Review (CIR) | Cargo Integration Review (CIR):<br>HTV<br>Confirms that the manifested cargo complement can be integrated in the HTV.<br>Approves the final layout of the cargo in the HTV and confirms the availability of all the related procedures and application of the related procurement plans. Confirms the cargo integration schedule. Authorizes the start of the cargo physical integration. | HTV | | | | X | X | X | X | X | X | X | X | | ISS | V |
| 345.2 | | Hold Cargo Integration Review (CIR) | Cargo Integration Review (CIR):<br>SpaceX<br>Verify that ground processing facilities are ready to receive NASA cargo and the Dragon Spacecraft is on-track for cargo integration activities. Verify that cargo staging facilities are in place, cargo is under environmental control and monitoring, stowage planning and procedures are completed and released including the readiness level to allow timely cargo integration and launch of the Dragon Spacecraft, Falcon 9 launch vehicle and pad systems. | SpX | | | Launch - 4 | X | X | X | X | X | X | X | X | | ISS | V |
| 345.3 | | Hold Cargo Integration Review (CIR) | Cargo Integration Review (CIR):<br>Orbital-ATK<br>CIR is an in-process review of on-going mission-specific cargo integration activities. Orbital provides confirmation that ground processing facilities are ready to receive NASA cargo and that the Cygnus spacecraft is on-track for cargo integration activities. This includes reporting results of all analytical assessments (e.g., integrated loads, launch-to-activation thermal assessments) showing cargo compatibility with the Antares launch vehicle and Cygnus spacecraft. | Orbital-ATK | | | | X | X | X | X | X | X | X | X | | ISS | V |
| 346 | Review KSC Technical Requirements & Baseline OMRS | Review KSC Technical Rqmts & B/L OMRS | TBD | KSC | Jennifer Wahlberg | | | X | X | X | X | X | X | X | X | | ISS | V |
| 347 | Payload handling training for VV. Deliver Ground Handling/IVT documentation | | TBD | PD, KSC | | | | X | X | X | X | X | X | X | X | X | Both | V |
| 348 | Return PFE | Return PFE | The PD returns Program Furnished Equipment (PFE) provided by the ISS Program, per the agreements documented in the PIA. The unique schedules will track each item/group of items per owner and return date. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | V |
| 349 | CoFR Checklist | CoFR Checklist | The PD provides inputs to the Certification of Flight Readiness (CoFR) Endorsement Checklist and Open Work Tracking Log (OWTL) per requirements referenced in SSP 52054.<br>All OZ certifying organizations are required to submit a CoFR Endorsement checklist and OWTL. | PD, OZ | | | | X | X | X | X | X | X | X | X | X | Both | V |
| 350 | Hold VV Preship Review (externals) | | TBD | PD, ON | | | | | | | X | X | X | X | | X | Both | V |
| 351 | CSS Inputs | CSS Inputs | PSO contacts the PD teams to assess their customer satisfaction. | PD, ISS Program | PSO Rep | Prior to Sync Point Reviews | | X | X | X | X | X | X | X | X | X | Both | V |
| 352 | Sync Point 3 | | Internal ISS Program review intended to sync up NASA organizations and review issues coming out of payload verification efforts. Specific topics include reviewing PIM Schedule, approving PIA updates, and communicating risks among the ISS Program management. More information is included in the Sync Point 3 Charter. | OZ6 | PIM | Schedule after PD completes their verification efforts, and before hardware delivery for integration. | Deliver Payload - 0.25 | X | X | X | X | X | X | X | X | | ISS | V |

# 8 APPENDIX C – INTEGRATION ACTIVITIES – DELIVER PHASE

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 | Provider Deliver Data Set | Provider Deliver Data Set | Provide data that is needed by the program. Data deliveries may be spread throughout the phase. For specific details on data deliveries in this phase, refer to FCC License. | PD | | | | | | | | | | | | X | PD | D |
| 402 | Launch Site Badging & Import Permits | Launch Site Badging & Import Permits | For Payload Developer personnel that will require access to Launch Site to support payload/sample hardware ground processing, Visitor Requests must be submitted so that the Launch Site can issue Temporary Badges. US PD personnel can obtain a non-escort badge; International PD personnel must obtain escort badges a Foreign Visitor Information Sheet must be provided for each person with a copy of passport. Need words import permits. Jennifer Wahlberg.<br><br>If PD team members will require access to Launch Site (e.g., KSC) for payload hardware/sample processing prior to turnover, coordination with the badging office is required. The PIM will contact the badging office to obtain the list of attributes required for processing and will coordinate with the PD team for submittal. Processing for IP PD teams is lengthy. The Launch Site will determine the PD training required after badge receipt (standard safety training for handling, etc.) | PD, OZ, KSC | | Amanda emailed Sharon Lozado on 11/10/16 to request timing info. | | X | X | X | X | X | X | X | X | X | Both | D |
| 403 | Deliver RCF Inputs | Deliver RCF Inputs | Process Owner: Manage Interfaces (Software)<br><br>The delivery of the EXPRESS Rack RIC Configuration Files to OPS Integration. These files are used to configure the EXPRESS Racks for the increment by payload. Milestones does not require data defined in ATTG from PD | OD | | | | | | | | | | | | | ISS | D |
| 405 | Complete Flight PPIL Inputs | Complete Flight PPIL Inputs | Process Owner: Manage Interfaces (Software)<br><br>The date the PD must complete their input to the Increment Flight PPIL to document the complete C&DH payload software configuration.<br><br>The Payload Product Integrated List (PPIL) is a managed list of software products to be used on-orbit or on the ground to support payload operations during a specific increment. Includes Product Type (rack, subrack, pallet, sub-pallet, core element, and ground), Part Number/Version, Version Description Document Number, Maturity Level, Provider Name and Compatibility/Known References. | OD | | | | | | | | | | | | | | D |
| 406 | Build & Test EXPRESS Config | | TBD - Pat Patterson. Milestones does not require data defined in ATTG from PD | POI | | | | | | | | | | | | | ISS | D |
| 407 | Baseline Flight PPIL | Baseline Flight PPIL | Process Owner: Manage Interfaces (Software)<br><br>The date the Flight PPIL is approved and baselined for the Increment. This baseline is a required dependency to load the payload software flight products on-orbit.<br><br>The Payload Product Integrated List (PPIL) is a managed list of software products to be used on-orbit or on the ground to support payload operations during a specific increment. Includes Product Type (rack, subrack, pallet, sub-pallet, core element, and ground), Part Number/Version, Version Description Document Number, Maturity Level, Provider Name and Compatibility/Known References. | OD | | | | | | | | | | | | | | D |
| 408 | Deliver Media Transfer Case | Deliver Media Transfer Case | Process Owner: Manage Interfaces (Software)<br><br>The date the CD Transfer Case is delivered to the Cargo Mission Contract for packing in the launch vehicle. | OD | | | | | | | | | | | | | | D |
| 409 | Complete P1, P2, and Cadre Training | Cadre Training Products | Cadre training consists of payload specific products deemed necessary to prepare the cadre for upcoming operations. The intent of these training products is to educate flight controllers on the concepts, constraints, and technical data associated with a payload required for it to operate. The PD is a courtesy reviewer for the product. | POI, PD | Ops Lead | | L- 1.25 | X | X | X | X | X | X | X | X | X | Both | D |
| 410 | OWTL | OWTL | The PD provides Certification of Flight Readiness Endorsement Checklist and Open Work Tracking Log (OWTL) inputs to the ISS Program per requirements referenced in SSP 52054. OZ6 conducts a review of all PD CoFR open work to focus and identify any potential issues/threats and CoFR exceptions. Emphasis is made to prioritize work to close open endorsements prior to OZ Stage Operations Readiness Review (SORR). | PD, OZ | | | L- 1.4 | X | X | X | X | X | X | X | X | X | Both | D |
| 411 | Cargo Layouts | Cargo Layouts | The Cargo Mission Contractor (CMC) develops Cargo Layouts for the planned launch configuration based on approved Manifest Request (MR) Loaders. The Stowage PIM distributes CMC Cargo Layouts for review by the PDs. The PD/PIM review the information with respect to the payload volume, and relevant orientation and/or placement constraints if they exist for the payload. | PD, OC/CMC | SPIM | On Dock minus 6 to 8 weeks. Needed to support Packing Readiness Review. | Hardware Readiness - 2 | X | X | X | | | | | X | X | Both | D |
| 412 | TGHR | TGHR | PDs provide input to the ISS Program/OC-KSC to develop the Time-Critical Ground Handling Requirements (TGHR) table if their hardware or samples have time-critical requirements. Time-critical requirements include prelaunch late turnover, launch delay, power interrupt constraints, and payload orientation requirements. The TGHR may also include time-critical requirements for non-payload items. OC distributes the draft Time-Critical Ground Handling Requirements (TGHR) input and will review the captured constraints for time-critical PD hardware and/or sample turnover. | KSC, OC, OZ | | OC distributes the draft TGHR input and will review the captured constraints for time-critical PD hardware and/or sample turnover and will provide input. | As required prior to Launch | X | X | X | X | X | X | X | X | X | Both | D |
| 413 | Hardware Readiness | Hardware Readiness | Date the hardware is ready to ship to either the Cargo Integrator (e.g., Cold Stowage or Cargo Mission Contract (CMC)) or Launch Vehicle Provider, and Launch related Safety and Verifications have been approved by the ISS Program and/or Launch Vehicle Provider. | PD, OZ, OB, OC, OE, ON | PIM | | | X | X | X | X | X | X | X | X | X | PD | D |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EF | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 414 | Deliver Payload to ISS Program | Deliver Payload to ISS Program | The PD delivers the external payload to the appropriate Visiting Vehicle integration team. For payloads requiring ground processing, On-Dock (O/D) dates are based on the payload's unique processing schedule of activities which occur prior to turnover (T/O). At T/O, the payload hardware custodianship is passed from/to the hardware owner to/from the ISS program integration organization. T/O may or may not coincide with O/D dates, depending on the payload's unique processing schedule of activities.<br><br>The PD delivers the pressurized payload hardware to the Cargo Mission Contractor. At delivery, the payload hardware custodianship is passed from/to the hardware owner to/from the ISS program integration organization.<br><br>**TBD - Describe Form 1149.** | PD | | | Hardware Readiness + 0 | | | | X | X | X | X | | X | PD | D |
| 415 | Integrate External Payload | Integrate External Payload | The Visiting Vehicle team integrates the external payload hardware based on Ground Processing Requirements coordinated and agreed to within the Verify Phase. | VV | | | Hardware Readiness + 0 | | | | X | X | X | X | | | ISS | D |
| 416 | Nominal cargo delivery | Nominal cargo delivery | The Cargo Mission Contractor (OC) takes ownership of payload delivered hardware and packages the payload hardware based on approved Cargo Layouts and eLRODS requirements. The Cargo Mission Contractor ships fully packaged payload hardware to the Visiting Vehicle. | OC, VV | | | | X | X | X | | | | | | | ISS | D |
| 416.1 | | Pre-Turnover Review | If needed for late load payloads, Stowage PIM works with the PIM/PD to schedule a pre turnover review of the hardware at late load processing facility prior to turnover to CMC. CMC does shadow in this meeting to capture barcodes, serial numbers for population in manifest to support MITR deliverables. | OZ, PD | SPIM | On Dock minus ~7-3 days for Dragon and ~14-4 days for Cygnus | Nominal cargo delivery - 0.5 | X | X | X | | | | | | | | |
| 417 | Internal CoFR | Internal CoFR | OZ consolidates all payload CoFR inputs for presentation at the Stage Operations Readiness Review (SORR). Reference SSP 57054, CoFR Plan, for more definition. | OZ | | | TBD | X | X | X | X | X | X | X | X | | ISS | D |
| 420 | Final Ops Products Reviewed | Final Ops Products Reviewed | PD team participates in Pre-ECR check, ECR Review, and ECR Meeting to baseline procedures and planning products (Payload Activity Requirements Document (PARD), Payload Planning Overview (PPO), and planning Ground rules and Constraints (Gr&C)). | POI, PD | | | L - 2 | X | X | X | X | X | X | X | X | X | Both | D |
| 422 | Launch Campaign Constraints | Launch Campaign Constraints | For payload hardware or samples with critical pre-launch processing timing requirements, the PD will provide input to the Experiment Constraint Questionnaire. The ISS program evaluates this to understand the impact to PDs when launch go/no go decisions are to be made. Data is collected regarding long lead decision points, pre-processing timeline, lifetime of hardware/sample on the launch vehicle prior to launch, multiple sets of payload hardware/samples to be processed for multiple launch opportunities, critical activation/operations points in time. The ISS program evaluates this to understand the impact to PDs when launch go/no go decisions are to be made.<br><br>The ISS program evaluates Experiment Constraint Questionnaire input from all PDs to understand the impact to PDs when launch go/no go decisions are to be made.<br><br>**Add sentence about "Prepare launch Related communication package".** | PD, OZ | | | L - TBD Ask Mary Walsh | X | X | X | | | | | | X | Both | D |
| 423 | SORR | SORR | The Stage Operations Readiness Review (SORR) certifies that the Visiting Vehicle/Cargo Element ground support facilities and personnel are ready to support the flight, stage, and/or increment. Additionally, it certifies the readiness of the on-orbit stage configuration to accept the Visiting Vehicle/Cargo Element and readiness for on-orbit increment operations.<br>This review applies to the cargo elements and on-orbit stage, as well as payloads and logistics items, consumables, and facilities and personnel associated with launch and on-orbit operations. The NASA CoFR endorsement is signed at the SORR. Each IP/P presents its CoFR at the SORR. | OZ | | | L minus 3.5 wks | X | X | X | X | X | X | X | X | | ISS | D |
| 424 | Develop Real-Time Team Contact List | Develop Real-Time Team Contact List | TBD - LIS/Brad Files needs to provide definition. POI is the user of this list. This should be compiled from each PD Team, GDSBB Input, team members. | LIS | | | | X | X | X | X | X | X | X | X | X | Both | D |
| 425 | Accept and Close Late Load Verifications | Accept and Close Late Load Verifications | SE&I Discipline Experts review Late Load Verification submittals made by the PD. | OB | | | | X | X | X | X | X | X | X | X | | ISS | D |
| 425.1 | | Conduct Late Load Burr Inspection and Label Check | An inspection of Burrs on late load payload hardware is required per the IRB. The SE&I HFIT organization can close relevant Burrs verification based on either PD Quality or CMC Quality physical inspection. The Stowage PIM will check all hardware labels for conformance to documented expectations. | PD, OZ, OC | | | Prior to Turnover | X | X | X | | | | | | | ISS | D |
| 425.2 | | Closeout of open work (HMST) | If the payload contains Hazardous Materials, JSC Toxicology will issue a Verification (V-2) form to the PD team to verify that the materials loaded are exactly as listed in the verified HMST for the payload. The PD will complete and sign the form, and will return it to JSC Toxicology. | PD, Tox | | Just following the completion of HMST loading in the payload hardware. | | X | X | X | X | X | X | X | X | X | Both | D |
| 426 | Preflight BDC | Preflight BDC | This is refers to completion of preflight BDC, if applicable. If the BDC isn't completed per requirements, the payload may not be ready for on-orbit operations (might still launch the hardware, but payload readiness will be a question at SORR). | PD, CB, SA | | BDC is generally completed around 6 to 8 weeks prior to crewmember launch. | Increment - 2.0 | X | X | X | | | | | | X | Both | D |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL EP | | | | |
| 427 | Late Load cargo delivery to next level integrator | Late Load cargo delivery to next level integrator | Hardware received from the PD, and packaged by CMC or the Cold Stowage Team is turned over to the Launch Provider for final loading. | PD | | | | X | X | X | | | | | | X | PD | D |
| 427.1 | | Pre-Turnover Review | If needed for late load payloads, Stowage PIM works with the PIM/PD to schedule a pre turnover review of the hardware at late load processing facility prior to turnover to CMC. CMC does shadow in this meeting to capture barcodes, serial numbers for population in manifest to support MITR deliverables. | OZ, PD | SPIM | On Dock minus ~7-3 days for Dragon and ~14-4 days for Cygnus | Pack & deliver late load cargo - 0.5 | X | X | X | | | | | | X | Both | D |
| 428 | Cold Stowage Late Load Launch Services | Cold Stowage Late Load Launch Services | The Cold Stowage team can perform late Cold bag and GLACIER integration of PD hardware later than L-48hrs, if appropriate scientific rationale is documented in the PIA. | OC | | | L - 48 hrs. | X | X | X | | | | | | X | ISS | D |
| 429 | Pack & deliver late load cargo | Pack & deliver late load cargo | Hardware received from the PD is packaged by CMC or the Cold Stowage Team per eLRODS input. | OC, CMC | | | | X | X | X | | | | | | | ISS | D |
| 430 | Install Cargo | Install Cargo | Hardware received from the PD (nominal or late load), and packaged by CMC or the Cold Stowage Team is turned over to the Launch Provider for final loading. | VV | | | | X | X | X | | | | | | | ISS | D |
| 431 | CSS Inputs | CSS Inputs | PSO contacts the PD teams to assess their customer satisfaction. | PD, ISS Program | PSO Rep | Prior to Sync Point Reviews | | X | X | X | X | X | X | X | X | X | Both | |
| 432 | Launch | Launch | We have liftoff! | VV | | | L :) | X | X | X | X | X | X | X | X | | | D |

# APPENDIX D – INTEGRATION ACTIVITIES – OPERATIONS AND POST OPERATIONS PHASE

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD View of PIMS Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL EFP | | | | |
| 500 | Submit Console Support Plan | Submit Console Support Plan | TBD - Pat Patterson | POI | | | | X | X | X | X | X | X | X | X | | ISS | O |
| 501 | Document Console Support Plan | Document Console Support Plan | TBD - Pat Patterson | POI | | | | X | X | X | X | X | X | X | X | | ISS | O |
| 502 | Operations Readiness | Operations Readiness | All operations products have been verified for first time use by the POI Readiness Check process defined in POH Vol 2 SOP 7.14/Readiness Check for Payload Operations. All Operational Constraints have been lifted. | PD, POI, OZ, OB, OC, OE, ON | | | | X | X | X | X | X | X | X | X | X | Both | O |
| 502.1 | | Operations Need Date | Date payload operations are needed to meet payload identified business considerations. | PD, POI, OZ, OB, OC, OE, ON | | | | X | X | X | X | X | X | X | X | X | Both | O |
| 503 | Operate Experiment | Operate Experiment | The PD team and POI Real-Time team work together to execute the short-term and daily operating plans. When deviations to operations are needed, the PD works with their Ops Lead and/or PARC to submit an Operations Change Request (OCR) to re-schedule or modify planned payload operations. | PD, POI | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | Both | O |
| 504 | Real-Time Prioritization/Re-Planning | Real-Time Prioritization/Re-Planning | TBD - LIS | OZ, POIC | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | | ISS | O |
| 505 | Build Daily Science Summary | Build Daily Science Summary | TBD - LIS | OZ | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | | ISS | O |
| 506 | Submit Weekly Science Input | Submit Weekly Science Input | When the PD Principal Investigator or Researcher accomplishes significant science and/or operational results, the PD has an opportunity to complete a form and mail it to TBD. The PD input will be rolled in the Weekly Science Summary, which is reviewed by TBD. | PD | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | PD | O |
| 507 | Build Weekly Science Summary | Build Weekly Science Summary | TBD - LIS consolidates all significant science and payload operational results for TBD. Pat Patterson help needed. | OZ | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | | ISS | O |
| 508 | Science tag-up twice a week | Science tag-up twice a week | TBD - LIS. PD Participation is optional. | PD, OZ | | Science Tag Ups are conducted weekly on Tuesdays and TBD date. | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | Both | O |
| 509 | S/W Updates | S/W Updates | TBD (Michael Coats) - Review and approve S/W updates. Include reference to POH Vol II for how S/W is update via OCR. | PD, OD/Manage Interfaces | | | As Required | X | X | X | X | X | X | X | X | X | Both | O |
| 510 | Complete Operations | Complete Operations | The PD team and POI Real-Time team work together to execute the short-term and daily operating plans until all are completed. | PD, POI | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | Both | O |
| | | | **Post Operations** | | | | | | | | | | | | | | | |
| 511 | Submit Flight Safety Certificate | Submit Flt Safety Certificate | PD submits flight safety certification request via IHS (Form 906). This information for each flight includes payload part numbers, hardware description, vehicle applicability, and owner responsibility. | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | PO |
| 512 | Review & Sign Flight Safety Certificate | Review & Sign Flight Safety Certificate | The ISS Safety Review Panel reviews and approves the Form 906, assuming the associated Safety Data Package is complete and all safety related issues have been resolved. | OE | SPE | | TBD | X | X | X | X | X | X | X | X | X | ISS | PO |
| 513 | Safety Data | Safety Data | TBR - Safety data is required for process/approval of payload/sample returns | OE | SPE | | | X | X | X | X | X | X | X | X | X | ISS | PO |
| 514 | Send 30 day reports | Send 30 day reports | TBD - IMT | | | | | X | X | X | X | X | X | X | X | X | PD | PO |
| 515 | Gather/Process 30-day reports | Gather/Process 30-day reports | TBD - IMT | OZ | | | | X | X | X | X | X | X | X | X | | ISS | PO |
| 516 | Create RMDP | Create RMDP | The Return Manifest Disposition Plan (RMDP) provides the requirements and process for returning the ISS manifest items to their respective owners. The RMDP provides ground processing personnel with a complete document to be used to disposition all stowed ISS return items removed from the vehicle after landing. The RMDP is the single ISS source of disposition instructions for ISS hardware being returned in the vehicle. The RMDP Blank Book (SSP 50465) contains the generic instructions that apply to every ISS mission landing and is applicable for every visiting vehicle that returns ISS hardware. The RMDP Blank Book is controlled by the MIOCB. The RMDP mission-specific appendices contain mission-unique information concerning the return items. Inputs to the appendices come from the Mission IDRD Annex 1, the hardware provider, LRODS, and the Cargo Integration point of contact. The initial RMDP data is compiled by OC, tapping into MIDAS and eLRODS inputs.<br><br>OZ Stowage receives the RMDP and distributes to all PIMs with returning PD hardware. The PIM and PD work together to correct and complete all required data fields. Updates are returned to OC for incorporation in the final RMDP. | OZ, PD, OC | SPIM | | Return - 1.5 | X | X | X | | | | | | X | Both | PO |
| 517 | Post Flt BDC | Post BDC | TBD - Baseline Data Collection (BDC) | | | | | X | X | X | | | | | | X | Both | PO |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EF | | | | |
| 518 | Return/Landing meetings (early destow) | Return/Landing meetings (early destow) | A meeting with all the PDs that will travel to NASA designated return area (e.g., Long Beach) to pick up limited life hardware. This meeting covers timeline, text message setup and question & answer from PD. | PD, OC | | As needed prior to Return | Return - 0.25 | X | X | X | | | | | | X | Both | PO |
| 519 | Submit crew debrief questions | Submit crew debrief questions | TBD - LIS | OZ, PD | | | | X | X | X | | | | | | X | PD | PO |
| 520 | Crew Debrief | Crew Debrief | TBD - LIS | OZ, SPE | LIS | | | X | X | X | | | | | | X | Both | PO |
| 521 | Cold Stowage Samples Return | Cold Stowage Samples Return | Requests for early return of conditioned science samples to the PD after SpaceX recovery boat docking will be evaluated based on appropriate scientific rationale documented in the PIA. If approved, real-time ground transportation factors will determine the precise time of PD pickup. Nominal return will be performed at JSC building 7. Cold Stowage representatives would hand over the payload hardware/samples to the PD. | OC | Cold Stowage | Typically early return will occur between R+52 hours and R+72 hours. Nominal return in Houston is later. | Return + 0.15 | X | X | X | | | | | | X | ISS | PO |
| 522 | CMC Early H/W Return | CMC Early H/W Return | Requests for early return of hardware and/or non-cold conditioned science samples to the PD after SpaceX recovery boat docking will be evaluated based on appropriate scientific rationale documented in the PIA. If approved, real-time ground transportation factors will determine the precise time of PD pickup. CMC representatives would hand over the payload hardware/samples to the PD. | OC | CMC | Typically early return will occur between R+52 hours and R+72 hours. | Return + 0.15 | X | X | X | | | | | | X | ISS | PO |
| 523 | CMC Early H/A (Hou) | CMC Early H/W Return (Hou) | Hardware and/or science samples are available for early return pickup by the PD in Houston at the CMC LM16 facility. Appropriate scientific rationale must be documented in the PIA. Real-time air/ground transportation as well as overall CMC workload and prioritization factors will determine the precise time available for pickup. | OC | CMC | Typically as early as R+72 hours | Return + 0.15 | X | X | X | | | | | | X | ISS | PO |
| 524 | Nominal Destow | Nominal Destow | Payloads are de-integrated from the return vehicle. | OC | CMC | | Return + 1 | X | X | X | | | | | | | ISS | PO |
| 525 | Return Cargo | Return Cargo | OC/CMC returns PD hardware as specified in the RMDP. | OC, PD | | Landing + 4 to 10 weeks. | Return + 2.5 | X | X | X | | | | | | X | Both | PO |
| 526 | Receive Samples/H/W | Receive Samples/H/W | PD receives samples/hardware from ISS Program | OC, PD | | | | X | X | X | X | X | X | X | X | X | PD | PO |
| 527 | Lessons Learned (integration, launch, ops, CSS) | Lessons Learned (integration, launch, ops, CSS) | Flight and Increment Lessons Learned<br>The Flight Payload Manager (FPM) is responsible for pulling together all ISS Payloads lessons learned for the Increment Payload Manager (IPM) on a particular flight, as required. That includes hardware integration prior to launch, through flight, onboard ISS, and landing.<br><br>Increment Lessons Learned (do we still do these?)<br>The Increment Payload Engineer (IPE) is responsible for pulling together all ISS Payloads lessons learned for the Increment Payload Manager (IPM) on a particular increment. | OZ, PD | | | Completion of Ops and/or Hardware Return + 2 months | X | X | X | X | X | X | X | X | X | Both | PO |
| 528 | Remove Payload from IPL | Remove Payload from IPL | TBD | OZ | Mandy Cady | | Per Direction | X | X | X | X | X | X | X | X | | ISS | PO |
| 529 | Notify PSO of publications | Notify PSO of publications | TBD - PSO | PD | | | As Required | X | X | X | X | X | X | X | X | X | PD | PO |
| 530 | Compile publications | Compile publications | TBD - PSO | OZ | PSO | | As Required | X | X | X | X | X | X | X | X | | ISS | PO |
| 531 | Update Science Toolbox | Update Science Toolbox | The ISS Investigation Research Summary is a collection of data which is housed in the ISS Program Scientist Toolbox (http://iss.science.jsc.nasa.gov/). The purpose of the information is to provide accurate information about each investigation on the ISS and track the investigation from first operation to final publication. | OZ | PSO | | As Required | X | X | X | X | X | X | X | X | | ISS | PO |
| 532 | Data Access Cancellation | Data Access Cancellation | For PDs with an established remote Ground Control Center and command/data connectivity with the HOSC, after the completion of planned operations, the PD should notify the RIM/PIM/RPM that the HOSC interface is no longer required. Additionally, the PD IT Liaison should be contacted to coordinated NDC access termination.<br><br>The HOSC PIE for the payload will coordinate with the PD team to close out all connectivity with the HOSC services.<br><br>The PD IT Liaison office coordinates access termination with the PD team. | PD | | | Completion of PD Post Ops Reporting | X | X | X | X | X | X | X | X | X | PD | PO |

# SPACEDOC-2 NNC14CA02C
# DO-255 SOFIE-MIO
# SOLID FLUID IGNITION & EXTINCTION – MISSION INTEGRATION AND OPERATIONS (SOFIE-MIO)
# CONTRACT PERFORMANCE PERIOD APRIL 15, 2021 THROUGH MARCH 31, 2023
# DO PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH NOVEMBER 30, 2023

## 1 OVERVIEW

The Solid Fuel Ignition and Extinction (SoFIE) investigation is the first solid-materials combustion experiment planned to operate in the Combustion Integrated Rack (CIR). SoFIE is comprised of a suite of five (5) separate investigations. The goal of these investigations is to study the ignitability and flammability of spacecraft materials in practical geometries and within realistic atmospheric conditions. Specific experiments could include ignition studies of materials representing cabin materials and EVA suit designs. Furthermore, the investigations could study the suppression of burning materials by diluents, airflow reductions, and habitat air venting.

Low-gravity testing has shown that current NASA material qualification methods may not be as conservative as they are believed to be. While NASA has a long history of materials controls, they are based on a 1-g understanding of flammable materials and the data from Earth-based tests. SoFIE will improve our understanding of early fire growth behavior and help validate material flammability numerical models for reduced gravity environments.

This statement of work provides a narrative description – in Section 4 – of the tasks to be carried out under the subject delivery order, most of which involve safety, integration, and operation of the SoFIE payload and science samples.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through November 30, 2023.

### 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, Xuan Nguyen, GRC/MSI0
2) Project Scientist, Paul Ferkul, GRC/LTX

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)
4) SoFIE-OFFS Science Requirements Document, SoFIE-SRD-004 (draft dated 13-SEP-2022)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

**Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:**

Task Manager, MSI/Xuan Nguyen, Mail Stop 77-7, xuan.t.nguyen@nasa.gov

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06

3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) SoFIE Ground Integration Unit (GIU)
2) CIR IPSU simulator (coordinated with FCF Project)
3) CIR IOP simulator (coordinated with FCF Project)
4) CIR GIU and PRCU in Building 333 (Coordinated with FCF Project and managed by FCF)
5) PI provided materials for samples

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Telescience Support Center (Bldg. 333)
2) Power Space Facility (Bldg. 333) – High Bay (100E)
3) Combustion Integrated Rack (CIR) Ground Integration Unit (GIU) in Building 333
4) Lab Space in Building 110
5) Zero Gravity Research Facility (drop tower)
6) Calibration lab
7) Instrumentation Department

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# 4 PROJECT SPECIFIC SOW

This statement of work supports several SoFIE tasks to: (1) complete Phase 3 Flight Safety Review leading up to Flight Hardware Availability (FHA) for the core hardware and first five SoFIE science sample assemblies (see Section 4.1), (2) complete the delivery of the core SoFIE flight hardware and first five sample assemblies, in addition to payload integration, system turnover, and pre-launch activities culminating in the launch of the hardware to ISS (see Section 4.2), (3) to support console operations for the five SoFIE investigations (see Section 4.3), and (4) to support sample design, build, test, integration, and operations for a sixth SoFIE investigation (see Section 4.5). These tasks are outlined below.

## 4.1 SOFIE PHASE 3 FLIGHT SAFETY REVIEW

The contractor shall perform work required for the preparation and successful completion of the SoFIE Phase 3 Flight Safety Review (FSR) including completion of the milestones listed in Table 4.1.1. Document deliverables include the Phase 3 Safety Review Package listed in Table 4.1.3.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Integration Verification Testing Complete | October 2021 (was 9, 8/2021) Complete |
| 2 | Verification Submittals | January 2022 (was 10/2021) Complete |
| 3 | Human Factors Implementation Team Inspection Complete | January 2022 (was 10, 9, 8/2021) Complete |
| 4 | Phase 3 Flight Safety Review | August 2021 (was 7/2021) Complete |
| 5 | RTDFS, NCA and SMuRF Samples: Integration Verification Testing (IVT) Complete | December 2022 (Was 10/2022, 12/2021, 11/2021) |
| 6 | RTDFS, NCA and SMuRF Samples: Verification Submittals (VS) | December 2022 (was 10/2022, 3/2022, 12/2021) |
| 7 | RTDFS, NCA and SMuRF Samples: Human Factors Implementation Team (HFIT) Inspection Complete | December 2022 (was 10/2022, 2/2022, 1/2022) |
| 8 | Phase 3 Flight Safety Review (FSR) for NCA and SMuRF Samples | December 2022 (was 10/2022, 1/2022, 12/2021) |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase 3 Safety Review Inputs/Package | 4 |
| Phase 3 Safety Review for RTDFS, NCA and SMuRF Samples Inputs/Package | 8 |

### 4.2 SoFIE Payload Delivery, integration, System Turnover, and Pre-launch activities

The contractor shall perform work required for the delivery of the SoFIE flight hardware and the SoFIE payload integration, system turnover and pre-launch activities. This includes completion of the milestones listed in Table 4.2.1. The contractor shall coordinate with the FCF team during turnover of the SoFIE hardware. The contractor shall assume there will be post-ship activities related to preparation for launch. There should also be some purchases of operations consumables and management of those deliverables.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Bench Review | January 2022 (was 10, 9/2021) Complete |
| 2 | SoFIE Hardware Turnover | January 2022 (was 10, 9/2021) Complete |
| 3 | Bench Review for RTDFS, NCA and SMuRF Samples | December 2022 (was 10/2022, 2/2022, 1/2022) |
| 4 | SoFIE Hardware Turnover for RTDFS, NCA and SMuRF Samples | January 2023 (was 10/2022, 2/2022, 1/2022) |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

### 4.3 SoFIE MI&O

The contractor shall provide a SoFIE Payload Developer (PD) console operator to operate the SoFIE insert during test point operations and participate in the meetings and reviews listed in Table 4.3.1. A Mission Sequence Test (MST) and an Operations Readiness Review (ORR) shall be completed prior to the start of operations for each SoFIE investigation. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations. For planning purposes, the contractor shall assume eight (8) test point operation days per month, each having a duration of eight (8) hours.

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | GEL MST | Prior to GEL ORR |
| 2 | GEL ORR | Prior to GEL Test Point Operations start |
| 3 | GEL Test Point Operations, Beginning | Increment 68, (was 67, 66) |
| 4 | MIST MST | Prior to starting MIST Test Point Operations |
| 5 | MIST ORR | To be completed prior to starting MIST Test Point Operations |
| 6 | MIST Test Point Operations, Beginning | Increment 69, (was 68) |
| 7 | RTDFS MST | To be completed prior to starting RTDFS ORR |

| Milestone Number | Milestone | Date |
|---|---|---|
| 8 | RTDFS ORR | To be completed prior to starting RTDFS Test Point Operations * |
| 9 | RTDFS Test Point Operations, Beginning | Increment 70 |
| 10 | SMuRF MST | To be completed prior to starting SMuRF ORR * |
| 11 | SMuRF ORR | To be completed prior to starting SMuRF Test Point Operations * |
| 12 | SMuRF Test Point Operations, Beginning | Increment 72 * (was 71) |
| 13 | NCA MST | To be completed prior to starting NCA ORR * |
| 14 | NCA ORR | To be completed prior to starting NCA Test Point Operations * |
| 15 | NCA Test Point Operations, Beginning | Increment 73 * (was 72) |
| 16 | OFFS MST | February 2024* (was August 2023*) |
| 17 | OFFS ORR | To be completed prior to starting OFFS Test Point Operations * |
| 18 | OFFS Test Point Operations, Beginning | March 2024* (was October 2023*) |

*** Items are outside DO period of performance end date; dates are through November 30, 2023**

### 4.4 Additional MI&O Activities/tasks required for SoFIE Operations

The contractor shall coordinate with the FCF team during the checkout of the SoFIE hardware on orbit. The contractor shall perform the work required to resolve the anomalies on orbit and complete the additional operational requirements/tasks requested by PI/science team.

The current on-orbit anomalies are as follows:

- Sample rotation error
- Flow sensor offset discrepancies

Additional operational requirements include but not limited to the following:

- Support the change from short flow duct to the long flow duct with GEL experiment.

- Support igniter arm ceramic blackening

The anomaly resolution work and the work supporting additional operational requirements shall be completed prior to the SoFIE science operations start.

### 4.5 DEVELOPMENT OF THE SOFIE-OSCILLATORY FLOW ON FLAME SPREAD (OFFS) SAMPLES

The contractor shall develop sample assemblies for the SoFIE-OFFS investigation. The design will mimic the SMuRF flat samples, BT302MA12055, except that the sample material will be ~3mm thick cast PMMA instead of the SIBAL fuel fabric used for the SMuRF samples.

The contractor shall develop a prototype or series of prototype sample assemblies that culminate in a high-fidelity representation of the planned flight hardware for evaluation by the science team, to demonstrate manufacturability, and to perform fit checks and integration testing in the CIR/SoFIE GIU prior to flight manufacturing. The contractor shall support periodic PI/science team visits to GRC or the contractor's facilities to aid in the PI's familiarization with the SoFIE hardware and the engineering team's familiarization with the OFFS investigation.

The contractor shall modify the SoFIE flight unit software and GIU software to be capable of controlling the flow speed in a sinusoidal oscillatory fashion with the payload developer console input parameters of baseline flow speed (in cm/s), oscillatory amplitude (in cm/s), and oscillatory frequency (in Hz).

Facility-provided hardware (i.e. CIR gas cylinders and adsorber cartridges) and operations labor support will be negotiated separately through Base Task 1 (BT-1). The contractor shall coordinate the hardware development schedule with BT-1 personnel.

The contractor shall support the milestones in Tables 4.5.1, 4.3.1 and described below. The dates should be interpreted as occurring no-later-than what is defined.

- *Project Kick-Off Meeting* – This meeting will mark the start of the SoFIE-OFFS sample development effort. The objective of the meeting is to introduce the science and engineering teams, discuss the big-picture development plan, define roles and responsibilities, and gain a clear understanding of the near-term activities to reach the next major milestone. The meeting will be led by the GRC Project Manager with support from the GRC Project Scientist. The meeting will include at a minimum, the GRC Project Manager, GRC Project Scientist, Principal Investigator, and representatives from the contractor engineering team.

- *Safety TIM* – Given the similarities to the SMuRF sample assembly design and the limited scope of the project, it is anticipated that the safety process will begin at either Phase II or possibly Phase III. The contractor will confer with the ISRP early in the development process via TIM to determine how to proceed with the safety process.

- *Prototype Evaluation* – This milestone will be achieved when the contractor has provided a flight representative sample assembly(ies) for evaluation by the science team. Science requirements are not currently available; therefore, the contractor should assume the requirements that formed the basis for the SMuRF flat sample assembly design are applicable with the exception of the sample material and thickness that is described in the first paragraph of Section 4.5 of this SOW. New or modified science requirements that result in impacts to cost and/or schedule will be treated as scope changes.

- *Critical Design Review* – This design review will be tailored according to the relatively small scope of the project. The review and supporting artifacts will demonstrate that the design is expected to meet applicable science, interface, safety, and mission assurance requirements and has been evaluated by the science team and found to be acceptable. The review demonstrates that the maturity of the design is appropriate to support proceeding with flight fabrication, assembly, integration, and test.

- *Safety Review(s)* – As applicable and based on the outcome of the initial Safety TIM, the contractor will support appropriate safety reviews with the ISRP.

- *System Acceptance Review* – This milestone ensures that the deliverable hardware and data package have sufficient technical maturity to authorize shipment to the launch site.

- *Hardware Delivery* – The requested hardware delivery date is determined based on the required start of flight operations on ISS in October 2023.

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.5.1.1 | Project Kick-Off Meeting | November 2022 Complete |
| 4.5.1.2 | Safety TIM | January 2023 |
| 4.5.1.3 | Prototype Evaluation | February 2023 |
| 4.5.1.4 | Critical Design Review | March 2023 |
| 4.5.1.5 | Safety Review(s) | August 2023 |
| 4.5.1.6 | System Acceptance Review | September 2023 |
| 4.5.1.7 | Hardware Delivery | September 2023 |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| SoFIE-OFFS Flight Sample Assemblies, Qty 30 (quantity includes 5 flight spares) | 4.5.1.7 |
| SoFIE-OFFS Software Modifications for Flow Duct Fan Control | 4.5.1.7 |

### 4.5.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Plan to CDR (baselined with agreed-to review artifacts) | 4.5.1.4 (minus 3 months) |
| Engineering artifacts required to meet the Entrance and Success Criteria for CDR, any modifications must be agreed to by NASA | 4.5.1.4 |
| CDR Presentation Materials | 4.5.1.4 |
| Safety Data Package | 4.5.1.5 |
| Plan to SAR (baselined with agreed-to review artifacts) | 4.5.1.6 (minus 3 months) |
| Engineering artifacts required to meet the Entrance and Success Criteria for SAR, any modifications must be agreed to by NASA | 4.5.1.6 |
| SAR Presentation Materials | 4.5.1.6 |

## 5 ACRONYM LIST

| Acronym | Definition |
|---|---|
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CIR** | **Combustion Integrated Rack** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EDMP** | **Engineering Data Management Plan** |
| **EVA** | **Extravehicular Activity** |
| **FCF** | **Fluids and Combustion Facility** |
| **FHA** | **Flight Hardware Availability** |
| **FSR** | **Flight Safety Review** |
| **GEL** | **Growth and Extinction Limit** |
| **GIU** | **Ground Integration Unit** |
| **GRC** | **Glenn Research Center** |
| **HFIT** | **Human Factors Implementation Team** |
| **ISRP** | **ISS Safety Review Panel** |
| **ISS** | **International Space Station** |
| **MIO** | **Mission Integration and Operations** |
| **MIST** | **Material Ignition and Suppression Test** |
| **MST** | **Mission Sequence Test** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NCA** | **Narrow Channel Apparatus** |

| | |
|---|---|
| **NPR** | **NASA Procedural Requirement** |
| **OFFS** | **Oscillatory Flow on Flame Spread** |
| **ORR** | **Operations Readiness Review** |
| **PD** | **Payload Developer** |
| **PI** | **Principle Investigator** |
| **PRACA** | **Problem Report and Corrective Action** |
| **PRCU** | **Payload Rack Checkout Unit** |
| **RTDFS** | **Residence Time Driven Flame Spread** |
| **SAR** | **Space Assurance Requirements** |
| **SMuRF** | **Spacecraft Materials Microgravity Research on Flammability** |
| **SoFIE** | **Solid Fuel Ignition and Extinction** |
| **SOW** | **Statement of Work** |
| **SRD** | **Science Requirements Document** |
| **TIM** | **Technical Interchange Meeting** |
| **VS** | **Verification Submittals** |

# SPACEDOC-2 NNC14CA02C
# DO-256 SFS DEMO-BLUE ORIGIN
# SPACECRAFT FIRE SAFETY DEMONSTRATION (SFS DEMO) BLUE ORIGIN PROJECT
# FOR CONTRACT PERFORMANCE PERIOD JANUARY 1, 2022 THROUGH MARCH 31, 2023
# FOR DO PERFORMANCE PERIOD AUGUST 1, 2022 THROUGH DECEMBER 31, 2023

## 1 OVERVIEW

NASA's Flight Opportunities Program has procured half of the available payload space on a Blue Origin New Shepard vehicle for a sub-orbital flight. The unique feature of this flight is that the vehicle will be rotated around its vertical centerline such that a partial gravity level will be produced. With a rotation of about 11 rpm, approximately 1/6-g corresponding to Lunar gravity can be produced at the payload location. With this being the first sub-orbital flight of the New Shepard to produce partial gravity, there is some question whether the gravity level will be sufficiently stable and of sufficient duration to conduct additional material flammability experiments. If the initial test shows sufficient promise, the New Shepard vehicle could become a new and valuable tool to obtain partial-g flammability data.

The Spacecraft Fire Safety-Blue Origin payload is being developed by the Spacecraft Fire Safety Demonstration (SFS Demo) Project at NASA-GRC. The purpose of this experiment is to close lunar surface capability and knowledge gaps associated with material flammability, fire detection, fire suppression, and post-fire clean-up. The SFS Demo Project is funded by the Exploration Capability (EC) Program in the Mars Development Campaign (MCD) Division within the Exploration Systems Development Mission Directorate (ESDMD) at NASA Headquarters (HQ).

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from August 1, 2022 through December 31, 2023.

### 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

1) Gary A. Ruff – Spacecraft Fire Safety Demonstration Project Manager
2) Thomas Acquaviva – Spacecraft Fire Safety Demonstration Resource Manager
3) Paul F. Ferkul – LUCI Principal Investigator
4) Anthony Jannette - Spacecraft Fire Safety Demonstration Chief Engineer

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

The documents listed below are specific to the current task. Additional documents may be prepared as the project matures.

1) SFSDPL-PLN-001: Spacecraft Fire Safety Demonstration Lunar-g Combustion Investigation (LUCI) Project Plan

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

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---

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Exploration Systems Project Office (Thomas Acquaviva, Mail Stop 162-7, thomas.h.acquaviva@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Spacecraft Fire Safety Demonstration Configuration Management Lead, (Kelly Hall, Mail Stop 162-7, kelly.l.hall@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, (Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov)

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, kelly.a.bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, Exploration Systems Project Office (Gary A. Ruff, Mail Stop 162-7, gary.a.ruff@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated weekly.
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4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID# PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) SK22001MD020 SN 003, tag 5012292 (qty 1)
2) Camera, Allied Vision, Manta G-235C, NASA tag 2609981, 2609985 (qty 2)
3) lenses for cameras (qty 2)
4) Ethernet cables (qty 2)
5) camera interface cables, PN CB/I/I-3M (qty 2)
6) adapter card, PC104 bus to USB/SATA (qty 1)
7) processor card, PN: CMA34CRQ2100HR-16384/S32GX (qty 1)

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following facilities:

1) Usage Elective: Thermal Environmental Chambers in Bldg. 333A
2) Usage Elective: Structural Dynamics Laboratory, (SDL).
3) Usage Elective: Electromagnetic Interference (EMI) Laboratory.
4) Usage Elective: Instrumentation Shop
5) Usage Elective: Saffire Imaging Lab (Bldg. 77, Room 154)

### 3.3 Government Furnished Software

1) Government Furnished Software for this DO includes the Saffire-IV-VI software builds.

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## 4 STATEMENT OF WORK – GENERAL

The contractor will provide engineering, design, fabrication, and test support to the SFS Demo project for the development and delivery of a payload for a partial-gravity flight on the Blue Origin New Shepard vehicle as well as support for integration and operations. The specific activities are sub-divided into a series of tasks that support hardware and software engineering, systems engineering and integration, configuration management, and safety and mission assurance of the SFS Demo project. These subtasks will be defined, revised, or removed as necessary throughout the different phases of the SFS Demo Blue Origin flight build and preparation. Initially, the contractor shall review and become familiar with the Blue Origin Users Guide that defines the interfaces between the payload and the New Shepard vehicle and the testing/safety requirements for payloads on Blue Origin vehicles. The contractor shall also support the science team's identification and refinement of the engineering/science requirements by designing and developing bench-top hardware (breadboards) and rigs for laboratory and/or low-gravity ground-based testing, if needed. The concept for the initial payload will be a rather "bare-bones" experiment that will address two simple objectives. These are: (1) quantifying the quality and duration of the partial-gravity environment produced by the New Shepard vehicle and (2) identifying the best orientation for flammability samples within the payload. To achieve these objectives, the Contractor will have to define and develop appropriate interfaces with the Blue Origin spacecraft.

Following a successful proof-of-concept flight, a more capable flight system will be developed. This experimental package will be based on the initial flight payload but contain additional diagnostics including radiometers, gas sensors, additional cameras, and lighting, etc. The number and type of samples required would be based on the findings of the initial flight. This experimental package would then be used in a more extensive flight- campaign consisting of up to six partial gravity flights.

Engineering feasibility issues for both the initial and primary experimental packages shall be identified based on the project requirements and include identification of fundamental capabilities required to meet project objectives, assessment of technical viability based on current industry capabilities, and assessment of the engineering and diagnostic methods required for the experiment. Subsystem and component tests will be performed to reduce project risks and inform the final design of flight systems. Later phases of the project will focus on the final design, fabrication, and assembly of the flight hardware followed by environmental and functional tests. The payload will be delivered with all documentation that demonstrates closure of engineering, safety, and Blue Origin requirements.

The fparti-g flight was originally scheduled for March 2023 but has now been delayed until late 2023. Based on previous experiments, delivery of the payloads is on the order of 1-2 weeks prior to the flight. Even though the flight for the primary experiment package has not been scheduled, it is anticipated that the payload would be ready for flight as early as April 2023.

The contractor shall regularly report progress for approval of designs and implementation prior to completion of the tasks.

**Applicable Documents:**

SFSDPL-REQ-002: Spacecraft Fire Safety Demonstration Lunar-g Combustion Investigation Experiment Science Requirements

SFSDPL-PLN-001: Spacecraft Fire Safety Demonstration Lunar-g Combustion Investigation Project Plan

GRC ISS-PLN-001, NASA GRC International Space Station Systems Engineering Management Plan

NSPM-MA0002: New Shepard Payload User's Guide, Revision F, September 2019. NPR 7120.8A, NASA Research and Technology Program and Project Management Requirements

GLPR 7120.8A, Glenn Research Center Research and Technology Project Management Procedure

**Reference Documents:**

NPR 7120.5F, NASA Space Flight Program and Project Management Requirements

NPR 7123.1B, NASA Systems Engineering Processes and Requirements

NPR 7150.2A Software Engineering Requirements

SFSDP2-PLN-004: Configuration and Data Management Plan

## 4.1 SUBTASK A – EXPERIMENT CONCEPT DEVELOPMENT, PRELIMINARY, AND FINAL DESIGN TASK

The primary focus of this subtask will be to design and analyze two sets of hardware for the Blue Origin material flammability experiments. The first unit will be an experiment package to be used to evaluate the usefulness of additional flights on the Blue Origin platform. This proof-of-concept experiment package will be fully functional but with fewer diagnostics and/or minimal complexity than may be desired in a primary experiment. The main driver for this proof-of-concept unit is to meet a potential launch date no earlier than January 2023. Assuming the proof-of-concept flight is successful and funding is obtained from MCD-EC, the contractor will design a more capable experiment, based on the proof-of-concept design, with an expanded set of requirements. This primary experimental package will be used in a series of partial-g suborbital flights on future Blue Origin vehicles. These experiment packages must meet the design features outlined by Blue Origin in NSPM-MA0002: New Shepard Payload User's Guide, Revision F, September 2019 supplied to the Contractor team.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Attend weekly briefings and meetings with the NASA, Flight Opportunities, and/or Blue Origin personnel to become familiar with the operation and requirements imposed by the New Shepard | December 31, 2023 (was 12/2021, 9/2022) |
| 2 | Review the Blue Origin Users Guide (NSPM-MA002: New Shepard Payload User's Guide, revision F, September 2019) and develop a conceptual design for the proof-of-concept experiment that meets the science requirements. | September 15, 2021 (completed) |
| 3 | Prepare a preliminary design for an experiment that meets the science requirements developed for the initial partial-g flight. | November 30, 2021 (completed) |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Conceptual design of the proof-of-concept Blue Origin flammability experiment | 2 (completed) |
| The preliminary design of the Blue Origin partial-g that meets the science requirements developed for these proof-of-concept experiments. | 3 (completed) |

## 4.2 Subtask B – Blue Origin Experiment System

The primary focus of this subtask is to complete an experiment package, both hardware and software, that can meet the science requirements for partial gravity flammability experiments on a Blue Origin New Shepard vehicle. The Contractor will procure materials, fabricate, assemble, and test the experiment hardware. The Contractor will also develop the software to operate the experiment and interface with the New Shepard vehicle. The Contractor shall work with the engineering and science teams to develop the hardware design of an experiment system for the partial gravity experiments. For each system the contractor shall develop engineering requirements and, where necessary, breadboards to increase confidence that the hardware concepts can meet these requirements.

The Contractor shall prepare for and conduct the following reviews by the dates specified in Table 4.2.1 for Items 'a' to 'e' and in Table 4.8.1 for Item 'f', below:

a) System Mission Concept Review

b) Periodic Project Review-1 (loosely related to a PDR)

c) Periodic Project Review-2 (loosely related to a TRR)

d) Periodic Project Review-3 (loosely related to a System Acceptance Review (SAR) and Pre-Ship Review (PSR))

e) System Safety Reviews (TBD)

For the MCR, the Contractor shall base the entrance and success criteria on the criteria in NPR 7120.5 and NPR7123.1B as tailored by GRC SFS Demo Project Management. For the PPRs, the criteria are as defined in the SFSDPL-PLN-001: Lunar-g Combustion Investigation (LUCI) Project Plan. With appropriate GRC Technical Authority approval, tailoring of these reviews is permitted and encouraged.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Conduct a Mission Concept Review | September 31, 2021 (completed) |
| 2 | Conduct a PPR-1 | March 31, 2022 |
| 3 | Conduct a PPR-2 | March 30, 2023 (was 7/30/2022) |
| 4 | Complete fabrication of the Experiment System (Hardware and Software) | April 30, 2023 (was 6/2022, 10/2022) |
| 5 | Conduct a PPR-3 for experiment system | December 31, 2023 |
| ~~6~~ | ~~Conduct a Pre-Ship Review for the experiment system~~ | ~~February 28, 2023*~~ (deleted) |
| 7 | Conduct a Payload Readiness Review with Blue Origin | December 31, 2023 |
| 8 | Update the MCR data package | January 30, 2022 (completed) |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Deliver an experiment system for the initial flight on the Blue Origin New Shepard vehicle | 5 |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Deliver an experiment MCR data package. | 1 |
| Deliver an experiment PPR-1 Data Package | 2 |
| Deliver an experiment PPR-2 Data Package | 3 |
| Deliver an experiment PPR-3 Data Package | 5 |
| ~~Deliver an experiment Pre-Ship Review Data Package~~ | ~~6~~ * |
| Deliver a data package for a Payload Readiness Review of the experiment | 7 |
| Deliver an updated MCR data package | 8 |

## 4.3 Subtask B1 – SFS-Blue Origin Experiment Hardware Environmental Task

The primary focus of this subtask will be to perform verification and environmental tests of the Experiment System. The contractor will perform functional and environmental tests of the experiment hardware.

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Complete a Thermal Cycle test of the experiment system | April 30, 2023 (was 8/31/2022) |
| 2 | Complete an EMI/EMC test of the experiment system | March 30, 2023 (was 9/12/2022) |
| 3 | Complete a Random Vibration test of the experiment system | April 30, 2023 (was 9/21/2022) |
| 4 | Complete Testing and Verification Reports | May 30, 2023 (was 11/2/2022) |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Deliver the Testing and Verification Reports | 4 |

### 4.4 Subtask B2 – SFS-Blue Origin Experiment Ground Tests, Storage, Shipping, Integration, and Sustaining Engineering

After completion of the experiment system, several ground tests are anticipated to obtain data for comparison with the flight data. These tests may be performed prior to or after the flight depending on the launch date. In these tests, the samples should be oriented parallel to earth's gravity vector. Up to six (6) ground tests will be conducted by ZIN and NASA personnel. After each test, the experiment system will be cleaned, the sample cards replaced, and readied for the next test.

After the ground tests are completed, the experiment will enter a storage period if necessary until it is time to prepare the system for shipment. During storage, the experiment will undergo periodic testing to ensure proper operation of the system and sensors. The tests will be conducted by NASA and Contractor personnel and both groups will review the test results. The experiment system shall be delivered to NASA following PPR-3 that will occur just prior to shipping to the launch site.

Integration of the hardware will be conducted by launch vehicle personnel. Functional tests will be conducted by the Contractor-led integration team and supported by NASA as necessary. Following integration into the launch vehicle, the NASA and Contractor Integration Team will stay at the launch site and recover the experiment following the flight. The NASA and Contractor team shall provide sustaining engineering support during mission operations to review data as needed to help interpret data and sensor output.

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Final check-out of experiment system | December 31, 2023 |
| 2 | Ground tests of the experiment system (up to six) | December 31, 2023 |

#### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| As-run procedure of the final experiment check-out. | 1 |
| Test reports and data from the ground tests | 2 |

## 4.5 Subtask C – SFS-Blue Origin Project Management Task

The primary focus of this subtask will be the management of all tasks within this DO. This subtask will also control the project Configuration Management/Data Management (CM/DM), Systems Engineering and Integration (SE&I), and Safety and Mission Assurance (S&MA). Because the partial gravity flight was originally stated by the Flight Opportunities Program as occurring in March 2023, significant schedule pressure was anticipated. Since then, the launch has been delayed from early 2023 to late 2023. One of the initial Project Management tasks will be to develop a schedule having sufficient fidelity that the impact of design, fabrication, and testing decisions can be ascertained. The flight hardware shall be completed as soon as possible so that ground tests can be completed prior to the Lunar-g flight.

This subtask will be ongoing throughout the life of the project and maintain a life cycle schedule to ensure work is being performed as planned. A life-cycle cost estimate will be updated and reported at project interim milestone reviews.

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Schedule for the completion of the proof-of-concept experiment package that allows for a launch no earlier than January 2023 | September 30, 2021 (completed) |
| 2 | Update to Project schedule | Bi-Weekly |
| 3 | Status of Project Budget against plan | Monthly |
| 4 | Update Project Lifecycle cost as outlined in this CCR-420 | September 30, 2021 (completed) |
| 5 | Update Project Lifecycle cost as outlined in this CCR-478 | February 28, 2022 (completed) |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.5.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Schedule for the completion of the proof-of-concept experiment package no earlier than January 2023 | 1 (completed) |
| The Contractor shall develop, maintain, and regularly report on the budget and schedule throughout the execution of the delivery order. | 2, 3 |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR-420 | 4 (completed) |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR-478 | 5 (completed) |

## 4.6 Subtask C1 – Configuration Management/Data Management (CM/DM)

The Contractor shall implement Configuration and Data Management (C&DM) of requirements, documents, data, technical models, drawings, hardware, and ground support equipment associated with the SFS Demo Blue Origin experiment hardware systems. The contractor's CM/DM system shall be compatible with the established SFS Demo GRC Engineering processes and tools (GRC eRoom system and ProE) and shall provide the following: (1) configuration identification, (2) configuration control, (3) configuration status accounting and (4) configuration verification and audit.

The Contractor shall operate and maintain a CM/DM system(s) to ensure that proper controls are implemented to receive, store/archive, reproduce, distribute, and control project-related documentation and SW. The contractor shall deliver, at the conclusion of this DO, the CM/DM operation and maintenance procedures, as well as the documents, products, associated data and SW generated during the execution of the Saffire project.

The Contractor shall provide an SFS Demo CM/DM Manager and necessary staff and will be responsible for the implementation of the CM/DM function. The contractor shall maintain the CM/DM system in an organized logical fashion and provide training and/or training products to project personnel on CM/DM system and product review process. The Contractor data system shall be compliant with export control regulations. Any items considered Controlled Unclassified Information (CUI) must be handled in accordance with NASA Procedural Requirement (NPR) 1600.1, and must be clearly marked as CUI.

### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Delivery of a list of CM documents and drawings created and uploaded to the contractor CM/DM system | Bi-weekly |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| List of CM documents and drawings created and uploaded to contractor CM/DM system | 1 |

## 4.7 Subtask C2 – System Engineering and Integration (SE&I)

The contractor shall be responsible for all SE&I activities for the SFS Demo LUCI experiments with Blue Origin, including:

1) Systems Engineering: The contractor shall provide systems engineering support as required to all SE&I elements including requirement definition, manufacturing, product fabrication, interface definition and management, assembly and integration, verification and validation and test, external integration, and mission operations.
2) Assembly Integration and Test (AI&T): The contractor shall be responsible for the planning, implementation, and completion of all AI&T activities of the Flight System.
3) Verification and Validation (V&V): The contractor shall be responsible for the planning and completion of all V&V activities of the Flight and Ground System, including the development of associated verification documentation to close the open requirements in the ERD, ICD, Flight Safety Hazard Reports (HRs) and Ground & Launch Safety HRs as appropriate
4) Ground System: The contractor shall be responsible for the Development, Calibration, Maintenance, Operation, and Utilization of all Saffire Ground System Equipment (e.g. Ground Development Unit, Test Support Equipment, and Ground Support Equipment, etc.).
5) External Integration: NASA will provide lead personnel for the coordination of activities with Launch Vehicle System Personnel. The contractor shall provide the necessary support for activities needed for the integration of the experiments including the development of tools, documents, and processes. Additionally, contractor personnel will support the Leads during all integration activities, including the preparation of equipment for shipment as well as the coordination with launch vehicle personnel. The contractor will also participate in the development and maintenance of any interface requirements and definitions (Payload Integration Agreement, PIRN, etc.), launch vehicle interface requirements and definitions (IRD, Mechanical and Electrical ICD, and Software ICD), and inputs for launch vehicle deliverables.

6) Specialty Engineering: The contractor shall provide a radiation hardness assessment on all electronics to determine 1) if the hardware is particularly susceptible to single-event effects (SEEs); 2) if SEE sensitive hardware is safety critical hardware associated with hazard controls; 3) the most probable loss in mission science data for SEE sensitive non-safety critical hardware. A cost and schedule estimate for radiation parts testing shall be provided for all safety critical electronics, and high impact components that, if an SEE occurred, could result in a complete or significant loss of science data

#### 4.7.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Delivery of Verification Tracking Log update | Bi-weekly |

#### 4.7.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.7.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Verification Tracking Log | 1 |

### 4.8 Subtask C3 – Safety and Mission Assurance (S&MA)

Safety reviews for Blue Origin flights are outlined in NSPM-MA0002: New Shepard Payload User's Guide, Revision F, September 2019.. The Contractor should review this manual and build the required reviews into the integrated project schedule. The Contractor shall also develop a Safety & Mission Assurance (S&MA) Plan that is consistent with the review requirements and documents the approach for developing, reviewing and reporting required tasks and analyses. The S&MA plan shall identify and describe the activities to be implemented during the development phase to ensure the design will meet the safety requirements. The Contractor will implement and maintain a Continuous Risk Management process for the project and at a minimum include the NASA Project Manager, Chief Safety Officer, Chief Engineer, and Lead Systems Engineer on their Risk Review Board.

All processes used in the fabrication of experiment hardware shall be qualified in accordance with NASA workmanship requirements or Contractor equivalent requirements. Personnel performing hands on fabrication, assembly, and inspection of experiment hardware shall be trained and certified in accordance with NASA workmanship requirements or Contractor equivalent requirements. All electronic assemblies shall comply with the design, workmanship, and manufacturing requirements of NASA-STD-8739.1 Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies or Contractor equivalent process documents. Flight hardware shall be maintained in controlled storage areas. Access shall be controlled and limited to those persons involved in fabrication, test, and quality assurance tasks.

#### 4.8.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Safety and Mission Assurance requirements that are consistent with the Blue Origin safety requirements | March 31, 2022 (was 9/2021) (completed) |

#### 4.8.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.8.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Safety and Mission Assurance Requirements (in VTL) | 1 |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AI&T | Assembly Integration and Test |
| CCR | Configuration Change Request |
| CDM | Configuration/Data Management |
| CDRL | Contract Data Requirements List |
| CM | Configuration Management |
| CUI | Controlled Unclassified Information |
| DID | Data Item Description |
| DM | Data Management |
| DO | Delivery Order |
| EC | Exploration Capability |
| eCC | electronic Country Clearance |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| ERD | Engineering Requirements Document |
| ESDMD | Exploration System Development Mission Directorate |
| GRC | Glenn Research Center |
| HQ | Headquarters |
| HR | Hazard Report |
| ICD | Interface Control Document |
| IRD | Interface Requirements Document |
| ISS | International Space Station |
| LUCI | Lunar-g Combustion Investigation |
| MDC | Mars Development Campaign |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| PDR | Preliminary Design Review |
| PIRN | Preliminary Interface Revision Notice |
| PPR | Periodic Project Review |
| PSR | Pre-Ship Review |
| PRACA | Preventive and Corrective Action |
| S&MA | Safety and Mission Assurance |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SDL | Structural Dynamics Laboratory |
| SE&I | Systems Engineering and Integration |
| SEE | Single Event Effects |
| SFS Demo | Spacecraft Fire Safety Demonstration |
| SMA | Safety and Mission Assurance |

| Acronym | Description |
|---|---|
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **TBD** | **To Be Determined** |
| **TRR** | **Test Readiness Review** |
| **V&V** | **Validation and Verification** |
| **VTL** | **Verification Tracking Log** |

# SPACEDOC-2 NNC14CA02C
# DO-257 SFS DEMO-CLPS
# SPACECRAFT FIRE SAFETY DEMONSTRATION (SFS DEMO)-
# COMMERCIAL LUNAR PAYLOAD SERVICES (CLPS) PROJECT
# FOR CONTRACT PERFORMANCE PERIOD AUGUST 1, 2022 THROUGH MARCH 31, 2023
# FOR DO PERFORMANCE PERIOD AUGUST 1, 2022 THROUGH NOVEMBER 30, 2023

## 1 OVERVIEW

NASA’s Commercial Lunar Payload Services (CLPS) initiative allows rapid acquisition of lunar delivery services for payloads that advance capabilities for science, exploration or commercial development of the Moon. Investigations and demonstrations launched on commercial Moon flights will help the agency study Earth’s nearest neighbor under the Artemis program. Early science investigations and technology experiments delivered to the lunar surface as part of the Artemis program will help lay the foundation for human exploration on the Moon.

The Spacecraft Fire Safety-Commercial Lunar Payload Services (SFS-CLPS) payload (Flammability of Materials on the Moon – $FM^2$) is being developed by the Spacecraft Fire Safety Demonstration (SFS Demo) Project at NASA-GRC. The purpose of this experiment is to close lunar surface capability and knowledge gaps associated with material flammability in Lunar-g. The SFS Demo Project is funded by the Exploration Capabilities (EC) Program of the Mars Campaign Development (MCD) Division within the Exploration Systems Development Mission Directorate (ESDMD) at NASA Headquarters (HQ).

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from August 1, 2022 through November 30, 2023.

### 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

1) Gary A. Ruff – Spacecraft Fire Safety Demonstration Project Manager
2) Thomas Acquaviva – Spacecraft Fire Safety Demonstration Resource Manager
3) Paul F. Ferkul – Principal Investigator
4) Anthony Janette - Spacecraft Fire Safety Chief Engineer
5) Joseph Powell – Spacecraft Fire Safety Lead Systems Engineer

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

The documents listed below are specific to the current task. During this SOW, NASA Project Management will assess the need for new documentation and produce them as appropriate.

1) SFSDPF-PLN-001: Spacecraft Fire Safety Demonstration Flammability of Materials on the Moon Project Plan

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

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## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Exploration Systems Project Office (Thomas Acquaviva, Mail Stop 162-7, thomas.h.acquaviva@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Spacecraft Fire Safety Demonstration Configuration Management Lead, (Kelly Hall, Mail Stop 162-7, kelly.l.hall@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer, (Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov)

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, kelly.a.bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, Exploration Systems Project Office (Gary A. Ruff, Mail Stop 162-7, gary.a.ruff@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID# PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) There is no Government Furnished Equipment for this DO.

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: Thermal Environmental Chambers in Bldg. 333A
2) Usage Elective: Structural Dynamics Laboratory, (SDL).
3) Usage Elective: Electromagnetic Interference (EMI) Laboratory.
4) Usage Elective: Instrumentation Shop
5) Usage Elective: Saffire Imaging Lab (Bldg. 77, Room 154)

## 3.3 Government Furnished Software

There is no Government Furnished Software for this DO.

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# 4 STATEMENT OF WORK – GENERAL

The contractor will provide engineering, design, fabrication, and test support to the SFS Demo project for the development and delivery of a CLPS payload as well as supporting integration and operations. This payload is named Flammability of Materials on the Moon ($FM^2$), the specific activities are sub-divided into a series of tasks that support hardware and software engineering, systems engineering and integration, configuration management, and safety and mission assurance of the SFS Demo project. These subtasks will be defined, revised, or removed as necessary throughout the different phases of the SFS Demo $FM^2$ flight build and preparation. Initially, the contractor shall support the science team's identification and refinement of the engineering/science requirements by designing and developing bench-top hardware (breadboards) and rigs for laboratory and/or low-gravity ground-based testing, if needed. The concept developed during the first phase of the project will identify subsystems that address the project objectives and identify the key high-risk development areas. The Lunar environment and processes associated with a CLPS payload are new and unique. The initial phases of this project will be to learn about these features and begin a design that includes the major features of an Engineering Development Unit yet is suitable for Lunar operations. Engineering feasibility issues shall be identified based on the project requirements and include; identification of fundamental capabilities required to meet project objectives, assessment of technical viability based on current industry capabilities, and assessment of the engineering and diagnostic methods required for the experiment. Subsystem and component tests will be performed to reduce project risks and inform the final design of flight systems. Later phases of the project will focus on the final design, fabrication, and assembly of the flight hardware followed by environmental and functional tests. The payload will be delivered with all documentation that demonstrates closure of engineering, safety, CLPS launch vehicle and lunar surface requirements.

The $FM^2$ experiment has been manifested on CP-21 and is scheduled to launch in June 2026.. However, integration of the hardware with the lander is generally 9 - 12 months prior to launch making hardware availability no later than May 2025.

The contractor shall regularly report progress for approval of designs and implementation prior to completion of the tasks.

**Applicable Documents:**

SFSDPF-REQ-002: Spacecraft Fire Safety Demonstration Flammability of Materials on the Moon Experiment Science Requirements

SFSDPF-PLN-001: Spacecraft Fire Safety Demonstration Flammability of Materials on the Moon Project Plan

NPR 7120.5F, NASA Space Flight Program and Project Management Requirements

NPR 7123.1B, NASA Systems Engineering Processes and Requirements

GRC ISS-PLN-001, NASA GRC International Space Station Systems Engineering Management Plan (SEMP)

**Reference Documents:**

NPR 7150.2A Software Engineering Requirements

SFSDP2-PLN-004: Configuration and Data Management Plan

### 4.1 SUBTASK A – EXPERIMENT CONCEPT DEVELOPMENT, PRELIMINARY, AND FINAL DESIGN TASK

The primary focus of this subtask will be to design and analyze the hardware for the SFS Demo $FM^2$ material flammability experiment. The contractor shall work with the engineering and science teams to develop the final design for the experiments.

The MCD – EC Office has authorized the Spacecraft Fire Safety Demonstration project team to finalize the concept development, preliminary design, and final design for an experiment that will be transported to and be conducted on the Lunar Surface. This experiment will quantify material flammability in a true Lunar environment. During this period of performance, the Contractor, ZIN Technologies, Inc., and NASA Science Teams will be finalizing requirements for this experiment and developing the conceptual and final designs.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Attend briefings and meetings with the CLPS personnel to become familiar with the requirements imposed by the Lunar surface and the CLPS program | July 30, 2022 (was 12/2021) (completed) |
| 2 | Develop a conceptual design of the CLPS Lunar flammability experiment based on the drawings and operation of the Engineering Development Unit designed and fabricated by NASA-GRC | December 31, 2021 (completed) |
| 3 | Prepare a preliminary design for the $FM^2$ experiment that meets the science requirements. | January 30, 2022 (completed) |
| 4 | Attend briefings and meetings with CLPS and Lander personnel to understand of requirements imposed by the Lander vendor | November 30, 2023 (was 9/30/2023) |
| 5 | Prepare data package for the Payload Workshop to be held after the RFTOP is released | April 30, 2023 |
| 6 | Prepare data and attend the Task Order Kick-off Meeting | August 31, 2023 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Conceptual design of the SFS Demo $FM^2$ Lunar flammability experiment | 2 (completed) |
| The preliminary design of the $FM^2$ experiment that will meet the science requirements. | 3 (completed) |
| Data package for the Payload Workshop | 5 |

| Document Deliverables | Milestone Number |
|---|---|
| Data package and presentation for the Task Order Kick-off Meeting | 6 |

## 4.2 Subtask B – Lunar Surface Experiment System

The primary focus of this subtask is to finalize the design of a Lunar Surface experiment and then procure materials, fabricate, assemble, and test the experiment hardware. The contractor shall work with the engineering and science teams to develop the hardware design of an experiment system for the lunar surface experiments. For each system the contractor shall develop engineering requirements and, where necessary, breadboards to increase confidence that the hardware concepts can meet these requirements.

The Lunar flammability experiment is manifested on CP-21) with a launch planned for June 2026. Integration of the payload with the lander is expected to occur 9 - 12 months prior to launch.

The Contractor shall prepare for and conduct the following reviews by the dates specified in Table 4.2.1 for Items 'a' to 'e' and in Table 4.8.1 for Item 'f', below:

a) System Mission Concept Review

b) System PDR

c) System CDR

d) System Acceptance Review (SAR)

e) System Pre-Ship Review

f) System Safety Reviews (TBD)

For all reviews the Contractor shall use the entrance and success criteria set in the NPR 7120.5 and NPR7123.1B as tailored by GRC SFS Demo Project Management. With appropriate GRC Technical Authority approval, tailoring of these reviews is permitted and encouraged. Processes outlined in ZIN Internal Technical Review and Programmatic Meeting Procedure (P04011) may be implemented with concurrence of the NASA PM and Technical Authorities.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Prepare data package to support a Mission Concept Review | January 30, 2022 (was 12/31/2021) (completed) |
| 2 | Prepare data package to support a PDR | June 30, 2022 (completed) |
| 3 | Prepare data package to support a CDR | March 31, 2024* (was 10/2022, 5/2024) |

| Milestone Number | Milestone | Date |
|---|---|---|
| 4 | Complete fabrication of the experiment hardware and software | December 1, 2024* |
| 5 | Conduct a System Acceptance Review for the experiment system | May 1, 2025* |
| 6 | Conduct a Pre-Ship Review (PSR) for the experiment system | June 1, 2025* |
| 7 | Complete breadboard testing of the sample ignition system | November 30, 2022 (completed) |
| 8 | Complete electronic design of breadboard avionics (sensor, DC/DC converter, and controller boards) | January 31, 2023 |
| 9 | Complete vacuum environmental testing of breadboard electronics | April 30, 2023 (was 3/30/2023) |
| 10 | Complete functional and performance testing of the Engineering Model | December 31, 2023* (was 9/2023) |

*** Items are outside DO period of performance end date.**

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Deliver SFS-CLPS FM$^2$ experiment system | 5* |

*** Items are outside DO period of performance end date.**

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Data package to support an MCR | 1 (completed) |
| Data package to support a PDR | 2 (completed) |
| Data package to support a CDR | 3* |
| Data package to support a System Acceptance Review | 5* |
| Data package to support a Pre-Ship Review | 6* |
| Data package from breadboard testing of the sample ignition system | 7 (completed) |

| Document Deliverables | Milestone Number |
|---|---|
| Test reports from the testing of the Engineering Model that demonstrates adequate performance | 10 |

*** Items are outside DO period of performance end date.**

### 4.3 Subtask B1 – SFS-CLPS Experiment Flight Hardware Environmental Task

**THERE IS NO WORK UNDER THIS SUBTASK AT THIS TIME**

The primary focus of this subtask will be to perform verification and environmental tests of the Experiment Flight System. The contractor will perform functional and environmental tests of the experiment hardware.

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| N/A | | |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

### 4.4 Subtask B2 – SFS-CLPS Flight Experiment Storage, Shipping, Integration, and Sustaining Engineering

**THERE IS NO WORK UNDER THIS SUBTASK AT THIS TIME**

The experiment systems are planned to be delivered to NASA following the System Acceptance Review. If applicable, the experiment will enter a storage period until it is time to prepare the system for shipment. During storage, the experiment will undergo periodic testing to ensure proper operation of the system and sensors. The tests will be conducted by NASA and Contractor personnel and both groups will review the test results.

Following the storage period (if necessary) the hardware will be shipped to the CLPS Lander vendor for integration of the experiment onto the lander. Integration of the hardware will be conducted by launch vehicle personnel. Functional tests during and after integration will be conducted by the Contractor engineering team with support from NASA personnel as necessary. Following integration into the launch vehicle, the Contractor shall provide sustaining engineering support during mission operations to review data as needed to help interpret data and sensor output.

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Final check-out of experiment system | April 30, 2025* |

*** Items are outside DO period of performance end date**

#### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| As-run procedure of the final experiment check-out | 1 * |

*** Items are outside DO period of performance end date.**

### 4.5 Subtask C – Project Management Task

The primary focus of this subtask will be the management of all tasks within this DO. This subtask will also control the project Configuration Management/Data Management (CM/DM), Systems Engineering and Integration (SE&I), and Safety and Mission Assurance (S&MA). This subtask will be ongoing throughout the life of the project and maintain a life cycle schedule to ensure work is being performed as planned. A life-cycle cost estimate will be updated and reported at project interim milestone reviews.

#### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Update to Project schedule | Bi-Weekly |
| 2 | Status of Project Budget against plan | Monthly |
| 3 | Update Project Lifecycle cost as outlined in this CCR-448 | January 30, 2022 (was 9/2021) (completed) |

| Milestone Number | Milestone | Date |
|---|---|---|
| 4 | Update Project Lifecycle cost and schedule as outlined in this CCR-494 | September 30, 2022 (completed) |
| 5 | Update Project Lifecycle cost and schedule to support CDR | March 31, 2024* (was 5/31/2024) |

*** Items are outside DO period of performance end date**

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.5.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| The contractor shall develop, maintain, and regularly report on the budget and schedule throughout the execution of the delivery order. | 1, 2 |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR-448 | 3 (completed) |
| Spreadsheet of Project Lifecycle cost and schedule as outlined in this CCR-494 | 4 (completed) |
| Spreadsheet of Project Lifecycle cost and schedule to support CDR | 5* |

*** Items are outside DO period of performance end date**

## 4.6 Subtask C1 – Configuration Management/Data Management (CM/DM)

The Contractor shall implement Configuration and Data Management (C&DM) of requirements, documents, data, technical models, drawings, hardware, and ground support equipment associated with the SFS Demo $FM^2$ experiment hardware systems. The contractor's CM/DM system shall be compatible with the established SFS Demo GRC Engineering processes and tools (GRC eRoom system and ProE) and shall provide the following: (1) configuration identification, (2) configuration control, (3) configuration status accounting and (4) configuration verification and audit.

The Contractor shall operate and maintain a CM/DM system(s) to ensure that proper controls are implemented to receive, store/archive, reproduce, distribute, and control project-related documentation and SW. The contractor shall deliver, at the conclusion of this DO, the CM/DM operation and maintenance procedures, as well as the documents, products, associated data and SW generated during the execution of the Saffire project.

The Contractor shall provide an SFS Demo CM/DM Manager and necessary staff and will be responsible for the implementation of the CM/DM function. The contractor shall maintain the CM/DM system in an organized logical fashion and provide training and/or training products to project personnel on CM/DM system and product review process. The Contractor data system shall be compliant with export control regulations. Any items considered Controlled Unclassified Information (CUI) must be handled in accordance with NASA Procedural Requirement (NPR) 1600.1, and must be clearly marked as CUI.

#### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Delivery of a list of CM documents and drawings created and uploaded to the contractor CM/DM system | Bi-weekly |

#### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.6.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| List of CM documents and drawings created and uploaded to contractor CM/DM system | 1 |

### 4.7 Subtask C2 – System Engineering and Integration (SE&I)

The contractor shall be responsible for all SE&I activities for the SFS Demo FM[2] experiment, including:

1) Systems Engineering: The contractor shall provide systems engineering support as required to all SE&I elements including requirement definition, manufacturing, product fabrication, interface definition and management, assembly and integration, verification and validation and test, external integration, and mission operations.

2) Assembly Integration and Test (AI&T): The contractor shall be responsible for the planning, implementation, and completion of all AI&T activities of the Flight System.

3) Verification and Validation (V&V): The contractor shall be responsible for the planning and completion of all V&V activities of the Flight and Ground System, including the development of associated verification documentation to close the open requirements in the ERD, ICD, Flight Safety Hazard Reports (HRs) and Ground & Launch Safety HRs.

4) Ground System: The contractor shall be responsible for the Development, Calibration, Maintenance, Operation, and Utilization of all Saffire Ground System Equipment (e.g.

Ground Development Unit, Test Support Equipment, and Ground Support Equipment, etc.).

5) External Integration: NASA will provide personnel for the coordination of activities with Launch Vehicle System Personnel. The contractor shall provide the support for activities needed for the integration of the experiments including the development of tools, documents, and processes. Additionally, contractor personnel will support the Leads during all integration activities, including the preparation of equipment for shipment as well as the coordination with launch vehicle personnel. The contractor will also participate in the development and maintenance of any interface requirements and definitions (Payload Integration Agreement, PIRN, etc.), launch vehicle interface requirements and definitions (IRD, Mechanical and Electrical ICD, and Software ICD), and inputs for launch vehicle deliverables.

6) Specialty Engineering: The contractor shall provide a radiation hardness assessment on all electronics to determine 1) if the hardware is particularly susceptible to single-event effects (SEEs); 2) if SEE sensitive hardware is safety critical hardware associated with hazard controls; 3) the most probable loss in mission science data for SEE sensitive non-safety critical hardware. A cost and schedule estimate for radiation parts testing shall be provided for all safety critical electronics, and high impact components that, if an SEE occurred, could result in a complete or significant loss of science data

### 4.7.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Delivery of JAMA Verification Tracking Log | Bi-weekly (starting 10/1/2023) |
| 2 | Complete initial Payload Verification Plan | 12/15/2022 (completed) |

*** Items are outside DO period of performance end date**

### 4.7.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.7.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Verification Tracking Log from JAMA (starting 10/1/2023) | 1* |

| Document Deliverables | Milestone Number |
|---|---|
| Payload Verification Plan | 2 (completed) |

*** Items are outside DO period of performance end date**

### 4.8 SUBTASK C3 – SAFETY AND MISSION ASSURANCE (S&MA)

For Safety and Mission Assurance Management, the Contractor shall develop a Safety & Mission Assurance (S&MA) Plan that documents the approach for developing, reviewing and reporting required tasks and analyses. The S&MA plan shall identify and describe the activities to be implemented during the development phase to ensure the design will meet the safety requirements. The Safety Reviews required for CLPS payloads are TBD.

The Contractor will implement and maintain a Continuous Risk Management process for the project and at a minimum include the NASA Project Manager, Chief Safety Officer, Chief Engineer, and Lead Systems Engineer on their Risk Review Board.

All processes used in the fabrication of experiment hardware shall be qualified in accordance with NASA workmanship requirements or Contractor equivalent requirements. Personnel performing hands on fabrication, assembly, and inspection of experiment hardware shall be trained and certified in accordance with NASA workmanship requirements or Contractor equivalent requirements. All electronic assemblies shall comply with the design, workmanship, and manufacturing requirements of NASA-STD-8739.1 Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies or Contractor equivalent process documents. Flight hardware shall be maintained in controlled storage areas. Access shall be controlled and limited to those persons involved in fabrication, test, and quality assurance tasks.

#### 4.8.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Safety and Mission Assurance requirements that are consistent with the CLPS safety requirements | January 30. 2022 (was 11/21) (completed) |

#### 4.8.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.8.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Safety and Mission Assurance Requirements (in JAMA) | 1 (completed) |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **AI&T** | **Assembly Integration and Test** |
| **CCR** | **Configuration Change Request** |
| **C&DM** | **Configuration & Data Management** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CLPS** | **Commercial Lunar Payload Services** |
| **CM** | **Configuration Management** |
| **CUI** | **Controlled Unclassified Information** |
| **DID** | **Data Item Description** |
| **DM** | **Data Management** |
| **DO** | **Delivery Order** |
| **EC** | **Exploration Capabilities** |
| **eCC** | **electronic Country Clearance** |
| **EMI** | **Electromagnetic Interference** |
| **ERD** | **Engineering Requirements Document** |
| **ESDMD** | **Exploration Systems Development Mission Directorate** |
| **GRC** | **Glenn Research Center** |
| **HQ** | **Headquarters** |
| **HR** | **Hazard Report** |
| **HW** | **Hardware** |
| **ICD** | **Interface Control Document** |
| **IRD** | **Interface Requirements Document** |
| **ISS** | **International Space Station** |
| **MCD-EC** | **Mars Campaign Development - Exploration Capability** |
| **MCR** | **Mission Concept Review** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PDR** | **Preliminary Design Review** |
| **PIRN** | **Preliminary Interface Revision Notice** |
| **PRACA** | **Preventive and Corrective Action** |
| **PSR** | **Pre-Ship Review** |

| Acronym | Description |
|---|---|
| **RFTOP** | **Request for Task Order Proposal** |
| **S&MA** | **Safety and Mission Assurance** |
| **SAR** | **System Acceptance Review** |
| **SDL** | **Structural Dynamics Laboratory** |
| **SE&I** | **Systems Engineering and Integration** |
| **SEE** | **Single Event Effects** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SFS Demo** | **Spacecraft Fire Safety Demonstration** |
| **S&MA** | **Safety and Mission Assurance** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **TBD** | **To Be Determined** |
| **TO** | **Task Order** |
| **V&V** | **Validation and Verification** |

# SPACEDOC-2 NNC14CA02C
# DO-265 ADVNEXT
# ADVANCED NEXT SYSTEM DEVELOPMENT (ADVNEXT)
**FOR CONTRACT PERFORMANCE PERIOD APRIL 25, 2022 THROUGH MARCH 31, 2023**
**FOR DO PERFORMANCE PERIOD AUGUST 8, 2022 THROUGH SEPTEMBER 8, 2023**

## 1 OVERVIEW

The National Aeronautics and Space Administration ("NASA"), Glenn Research Center (GRC) and the Space Systems Command Space Systems Architect have entered into an effort to mature the Advanced Capability NASA's Evolutionary Xenon Thruster (NEXT) Thruster system for military and commercial earth and lunar orbit applications. The goal of the efforts performed under a Reimbursable Agreement activity is to facilitate the transition of the optimized NEXT thruster technology into a high power and high thrust-to-power variant of the NASA NEXT-C ('Advanced NEXT') flight propulsion system. NEXT-C is classified as Class B hardware.

This Advanced NEXT design will be configured for Medium Power (throttle level AF 1B, 7 kW input power) necessary to support DoD and/or Commercial missions with a design architecture that is compatible with future DoD operations at High Power (throttle level AF 1B HP, 14 kW input power) missions.

Advanced NEXT development performed by NASA, and the contracted efforts, are intended to ensure ZIN Technologies Inc. (heretofore identified as 'Contractor') is sufficiently positioned to manufacture Block 1 (throttle level AF 1B, 7 kW input power) and/or Block 2 (Advanced NEXT at 7-14 kW) flight thruster and Power Processor Units (PPUs) after having successfully completed the contract technical objectives under the NASA / USSF effort.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this order is from August 8, 2022 through September 8, 2023.

### 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, Eric Pencil, Code MT
2) Project Lead Engineer, Robert Thomas, Code LTS

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Draft Task Order Objectives Document (Version 4, dated 2021-10-19)
2) AdvNEXT SpaceDoc DO Data Requirements (Version 1, dated 2022-03-07)
3) USSF AdvNEXT Peer Review presentation (dated 2021-03-02)

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager: Robert Thomas, Code LTS, MS 301-3, Robert.E.Thomas@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Project Manager (Eric Pencil, Mail Stop 301-3, eric.pencil@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Krystal LaMarca, Mail Stop 60-1, krystal.a.lamarca@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
5) Lessons Learned Report per DID PA-17
6) Documentation as described in AdvNEXT SpaceDoc DO Data Requirements (Version 1, dated 2022-03-07)

7) Bi-weekly technical status reports (Powerpoint format)

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-1)

Note: TOO = Task Order Objectives

| Hardware | Schedule of Availability |
|---|---|
| EM6 Thruster / NEXT-C Pathfinder Ion Optics | At Conclusion of NASA "Annex 02" In-house Thruster Work |
| DEV-C Thruster | |
| Prototype Thruster spare parts and assemblies | Per TOO Item 2.2.A |
| NEXT EM PPU | Per TOO Item 3.1.B |
| NEXT Breadboard Beam Modules | Per TOO Item 3.1.A |
| NEXT PPU Test Rack | Per TOO Item 3.1.B |
| NEXT-C PPU spare parts and assemblies | Per TOO Item 3.1.A |

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: Vacuum Facility 16 – Electric Propulsion Research Building
2) Usage Elective: Vacuum Facility 14 – Electric Propulsion Research Building
3) Usage Elective: Structural Dynamics Laboratory

The contractor shall indicate the usage of any government furnished facilities in the work plan, including test description, test layout, and estimate of test duration.

# 4 PROJECT SPECIFIC SOW

## 4.1 REPORTING AND MEETINGS

- The contractor shall provide technical status on a bi-weekly basis, financial reports to NASA on a monthly basis, and all other reports required by the base contract.
- The contractor shall attend every-other-week status meetings with NASA and USSF.
- The contractor shall participate in TIMs with NASA as identified elsewhere in this document and/or in the Task Order Objectives documentation.

- The contractor will support reviews with US Space Force stakeholders for Advanced NEXT system transition into future military prototype demonstrations and space system acquisitions.

### 4.1.1 Document Deliverables

| Document Deliverables | Date |
|---|---|
| Financial Reports | Monthly |
| Bi-weekly technical status reports | Bi-weekly |

## 4.2 ADVANCED NEXT THRUSTER TECHNOLOGY DEVELOPMENT REQUIRED ELEMENTS

- The Contractor shall perform required analysis, design, manufacturing, and assembly process upgrades to support development and flight implementation of a NEXT-C thruster variant compatible with operation at AF 1B throttle levels (7 kW input at approximately 40% higher thrust level as compared to NEXT-C).
- The contractor shall perform required analysis, design, manufacturing, and assembly process upgrades to support development and flight implementation of a NEXT-C thruster variant compatible with operation at AF 1B HP throttle levels (14 kW input at approximately 2X higher thrust level as compared to NEXT-C).

### 4.2.1 Milestones

| Milestone Number | Milestone(s) | Date |
|---|---|---|
| 001 | Thruster Design Compatible with Operation at AF 1B | CFI |
| 002 | Thruster Design Compatible with Operation at AF 1B HP | CFI |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | DRD Number |
|---|---|
| Computational Models | DRD 006 |

#### 4.2.3 Document Deliverables

| Document Deliverables | DRD Number |
|---|---|
| Document and Drawing Trees | DRD 001 |
| Analysis Reports | DRD 007 |
| Engineering Drawings | DRD 011 |
| Interface Control Drawings | DRD 013 |

### 4.3 ADDITIONAL THRUSTER ELEMENTS – EACH OF THESE ADDITIONAL ELEMENTS SHOULD BE PLANNED, PROPOSED, AND PRICED INDEPENDENTLY:

- The contractor shall manufacture an Advanced NEXT Engineering Model (EM) thruster compatible with operation at AF 1B throttle levels.
- The contractor shall performance test the Advanced NEXT EM thruster to establish baseline performance, and operating and thermal margins at AF 1B.
- The contractor shall conduct environmental qualification testing of the Advanced NEXT EM thruster.

#### 4.3.1 Milestones

| Milestone Number | Milestone(s) | Date |
|---|---|---|
| 003 | EM Thruster Fabrication | CFI |
| 004 | Thruster Baseline Performance Test | CFI |
| 005 | Thruster Environmental Qualification-level Test(s) | CFI |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | DRD Number |
|---|---|
| EM thruster | |

### 4.3.3 Document Deliverables

| Document Deliverables | DRD Number |
|---|---|
| Development Hardware Fabrication Plan | DRD 008 |
| Test Plans and Test Readiness Reviews | DRD 009 |
| Test Reports | DRD 010 |
| Engineering Drawings | DRD 011 |

## 4.4 ADVANCED NEXT PPU TECHNOLOGY DEVELOPMENT REQUIRED ELEMENTS

- The contractor shall perform required analysis, design, manufacturing, and assembly process upgrades to support development and flight implementation of a NEXT-C PPU variant compatible with operation at AF 1B throttle level. These activities shall include, but not be limited to: redesign and repackaging of the PPU for higher discharge and beam current operation; and analysis updates including stress, structural, thermal, worst-case (i.e. most stressing conditions), and radiation.
- The contractor shall conduct risk reduction thermal-vacuum testing of the NEXT-C Prototype PPU up to qualification-equivalent levels, as verification of the thermal design.

### 4.4.1 Milestones

| Milestone Number | Milestone(s) | Date |
|---|---|---|
| 006 | PPU Design Compatible with Operation at AF 1B | CFI |
| 007 | PPU Functional Test(s) | CFI |
| 008 | PPU Thermal-Vacuum Test(s) | CFI |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | DRD Number |
|---|---|
| Computational Models | DRD 006 |

#### 4.4.3 Document Deliverables

| Document Deliverables | DRD Number |
|---|---|
| Document and Drawing Trees | DRD 001 |
| Worst Case Analysis | DRD 005 |
| Analysis Reports | DRD 007 |
| Test Plans and Test Readiness Reviews | DRD 009 |
| Test Reports | DRD 010 |
| Engineering Drawings | DRD 011 |
| Interface Control Drawings | DRD 013 |

### 4.5 ADDITIONAL PPU ELEMENTS – EACH OF THESE ADDITIONAL ELEMENTS SHOULD BE PLANNED, PROPOSED, AND PRICED INDEPENDENTLY:

- The contractor shall manufacture an Advanced NEXT Engineering Model (EM) PPU compatible with operation at AF 1B throttle levels.
- The contractor shall conduct integration tests of the Advanced NEXT EM PPU with an appropriate thruster load to establish baseline performance, and operating and thermal margins at AF 1B.
- The contractor shall conduct environmental testing at qualification-equivalent levels of the Advanced NEXT EM PPU.

#### 4.5.1 Milestones

| Milestone Number | Milestone(s) | Date |
|---|---|---|
| 009 | EM PPU Functional Test(s) | CFI |
| 010 | Thruster / PPU – Integration Test | CFI |
| 011 | PPU Environmental Qualification-Level Test(s) | CFI |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Date |
|---|---|
| EM PPU Fabrication | CFI |

### 4.5.3 Document Deliverables

| Document Deliverables | DRD Number |
|---|---|
| Document and Drawing Trees | DRD 001 |
| Development Hardware Fabrication Plan | DRD 008 |
| Test Plans and Test Readiness Reviews | DRD 009 |
| Test Reports | DRD 010 |
| Engineering Drawings | DRD 011 |
| Interface Control Drawings | DRD 013 |

## 4.6 REVIEWS

- The contractor shall conduct the following reviews according to the identified schedules: Systems Requirement Review (SRR), Conceptual Design Review (CoDR), Preliminary Design Review (PDR), and Detailed Design Review (DDR) for both the thruster and PPU. Based on contract resources and the conclusion of negotiations with the contractor, deliver contractor provided hardware.

### 4.6.1 Milestones

| Milestone Number | Milestone(s) | Date |
|---|---|---|
| 012 | SRR | ATP + 6 months |
| 013 | CoDR | ATP + 9 months |

| Milestone Number | Milestone(s) | Date |
|---|---|---|
| 014 | PDR | ATP + 12 months |
| 015 | DDR | ATP + 24* months |

*Items are outside DO period of performance end date

### 4.6.2 Document Deliverables

| Document Deliverables | Date |
|---|---|
| See AdvNEXT SpaceDoc Data Requirements for documentation required at each review. | See Data Req. Document |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AdvNEXT | Advanced NASA's Evolutionary Xenon Thruster |
| AF | Air Force |
| ATP | Authority to Proceed |
| CDRL | Contract Data Requirements List |
| CFI | Contractor Fill In |
| CoDR | Conceptual Design Review |
| DDR | Detailed Design Review |
| DID | Data Item Description |
| DO | Delivery Order |
| DoD | Department of Defense |
| DRD | Data Requirements Description |
| eCC | electronic Country Clearance |
| EM | Engineering Model |
| GRC | Glenn Research Center |
| HP | High Power |
| NA | Not Applicable |
| NEXT | NASA's Evolutionary Xenon Thruster |
| NEXT-C | NASA’s Evolutionary Xenon Thruster - Commercial |
| NPR | NASA Procedural Requirement |
| PDR | Preliminary Design Review |
| PPU | Power Processing Unit |
| PRACA | Preventive and Corrective Action |
| SRR | System Requirements Review |
| TIM | Technical Interchange Meeting |
| TOO | Task Order Objectives |
| US | United States |
| USSF | United States Space Force |

# SpaceDOC-2

# Active Base Tasks and Delivery Orders

# Will NOT Transition to SpaceDOC-3

BT-3: Combustion Integrated Rack (CIR) Payload Inserts - Solid Fuel Ignition and Extinction (SoFIE)
DO-210: HRP Cross-cutting Computational Modeling Projects (CCMP)
DO-220: Spacecraft Fire Safety Demonstration (SFS Demo) Project
DO-224: ElectroHydroDynamics (EHD)
DO-229: Advanced Combustion via Microgravity Experiments (ACME) Mission Integration and Operations
DO-251: Flow Boiling and Condensation Experiment (FBCE) - Ground Interface Unit (GIU) and Test Modules Assemblies (TMAs)
DO-254: Microgravity Acceleration Measurement System (MAMS) Re-Flight (RF)
DO-261: 2020 Lockheed Martin Tipping Point Radio Frequency Mass Gauge (LMTP RFMG)
DO-263: Electro Hydro Dynamics (EHD) - Mission Integration and Operations (MIO)
DO-264: Isolation Amplifier Project (IAP)

**SpaceDOC-2 Base Task #3**
**Combustion Integrated Rack (CIR) Payload Inserts**
**Solid Fuel Ignition and Extinction (SoFIE)**
**Contract Period of Performance 1/1/2014 to 3/31/2023**
**Period of Performance 10/1/2021 to 3/31/2023**

# 1. Introduction

The Combustion Integrated Rack (CIR) located on the International Space Station (ISS) is dedicated to performing experiments focused on combustion research. Combustion research consists of gaseous, liquid and solid flame research. Each area of investigation requires a unique insert into CIR. The liquid flame investigations utilize the Multi-user Droplet Combustion Apparatus and on-orbit operations are complete. The gaseous flame investigations utilize the Advanced Combustion via Microgravity Experiments (ACME) insert and on-orbit operations are in progress. The solid fuel investigations will utilize the Solid Fuel Ignition and Extinction (SoFIE) insert, and on-orbit operations will start when ACME operations are complete.

## 1.1. Solid Fuel Ignition and Extinction (SoFIE) Overview

The Solid Fuel Ignition and Extinction (SoFIE) investigation is the first solid-materials combustion experiment planned to operate in the CIR. SoFIE is comprised of a suite of five separate investigations. The types of specific experiments that can be accommodated range from material ignitability, fire growth and spread, and fire suppression. The experiments under the SoFIE umbrella will study the ignitability and flammability of spacecraft materials in practical geometries and within realistic atmospheric conditions. Experiments could include ignition studies of materials representing cabin materials and EVA suit designs. Furthermore, the investigations could study the suppression of burning materials by diluents, airflow reductions, and habitat air venting.

Low-gravity testing has shown that current NASA material qualification methods may not be as conservative as they are believed to be. While NASA has a long history of materials controls, they are based on a 1-g understanding of flammable materials and the data from Earth-based tests. SoFIE will improve our understanding of early fire growth behavior and help validate material flammability numerical models for reduced gravity environments.

This statement of work will be for the development of the SoFIE hardware and software to meet the science requirements for solid combustion experiments. The scope of the SoFIE Project for the SpaceDOC II contract during this period of performance covers the work to be accomplished that will complete the flight hardware assembly, integration, and test leading up to Flight Hardware Availability (FHA) and also includes system turnover and pre-launch activities culminating in the launch of the hardware to the ISS. The contractor should assume that there will be post-ship activities related to preparation for launch. There should also be some purchases of operations consumables and management of those deliverables.

# 2. Background

The CIR's insert for solid fuels, the SoFIE insert, will be based on the SoFIE Integrated Science Requirements Document (ISRD), which consolidates the requirements of five separate investigations under the SoFIE umbrella. The Science Concept Review (SCR) occurred in July 2013, and Requirements Definition Review was held in December 2014, wherein the final science requirements were approved by a peer review board. An Authority to Proceed (ATP) review was held in April 2015 that gave approval for the experiment to proceed to the Preliminary Design Review (PDR). The PDR was held in July 2016. A second Authority to Proceed (ATP) review was held in October 2016 that gave SoFIE approval to proceed from PDR to FHA. The Critical Design Review (CDR) was held on July 17-18, 2018, and the Phase 2 Flight Safety Review was held in August 2018.

The SoFIE investigation consists to five unique experiments described below:

Growth and Extinction Limit (GEL), James T'ien, Case Western Reserve University
The goal of this experiment is to determine the flame growth and extinction characteristics of a burning solid fuel as a function of flow velocity, oxygen percentage, pressure and degree of internal heating. A high-fidelity numerical model will serve as a tool connecting normal gravity and microgravity performance.

Material Ignition and Suppression Test (MIST), Carlos Fernandez-Pello, University of California, Berkeley
The goal is to conduct microgravity ignition and suppression experiments for materials burning in low-speed forced flow with externally applied heat flux in Space Exploration Atmospheres. Time to ignition and the time between introduction of suppression agent and extinction are measured as a function of environmental conditions. A comprehensive numerical model will support the experiment.

Residence Time Driven Flame Spread (RTDFS), Subrata Bhattacharjee, San Diego State University
Theory and modeling results suggest that an important difference between normal gravity and microgravity material flammability is caused by the influence of the flow field on the relative overlap of the thermal and species fields in the flame zone. The goal of this experiment is to determine how thermal and species fields can diverge and lead to flame extinguishment by varying the thickness of the fuel.

Spacecraft Materials Microgravity Research on Flammability (SMuRF), Sandra Olson, NASA Glenn Research Center
The goal is to develop a fundamental understanding of how NASA's material flammability test (NASA-STD-6001.A Test 1) relates to the actual flammability of materials in reduced gravity. Material flammability aspects as a function of concurrent flow, oxygen, and pressure are sought.

Narrow Channel Apparatus (NCA), Fletcher Miller, San Diego State University
This study will determine fundamental flame spread and extinction over solid fuel slabs in microgravity. The goal of this experiment is to develop earth-based tests in a narrow channel as a fire safety test of materials that are to be used in microgravity.

# 3. Applicable Documents

The contractor shall perform this task in accordance with all applicable contract documents with the additional of the following documents for performing specific CIR Insert activities (note: the contractor shall update any plans to conform to approved changes in procedures/processes implemented):

a) NPR 7120, NASA Space Flight Program and Project Management Requirements
b) NPR 7123, NASA Systems Engineering Processes and Requirements
c) NPR 7150.2 NASA Software Engineering Requirements
d) SSP 51700, Payload Safety Policy and Requirements for the International Space Station
e) NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements for Payloads Using the STS/ISS
f) SSP 51700, Payload Safety Policy and Requirements for the International Space Station

g) NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements for Payloads Using the STS/ISS
h) SoFIE-ISR-001, Integrated Science Requirements Document, latest version
i) CIR Payload Interface Definition Document, FCF-CIR-IDD
j) CIR Phase III Flight Safety Data Package, CIR-DOC-3850
k) CIR Payload Accommodations Handbook, CIR-DOC-4064

# 4. Performance Work Statements

In these performance work statements, the contractor shall maintain and control all applicable records, data, hardware, software, and documents.

## 4.1. Solid Fuel Ignition and Extinction (SoFIE)

The contractor will continue the Implementation phase for SoFIE to develop the Chamber Insert Assembly (CIA), the Avionics Package (AVP), CIA and AVP Ground Integration Units (GIU's) Software, and spares. The insert will allow experimenters to use various solid fuels in flow or quiescent environments and at various pressures, oxidizer compositions, and oxygen concentrations. The SoFIE flight hardware includes the insert assembly, avionics, and diagnostic instruments including cameras, software, and replacement components. The flight hardware also will include the Principal Investigator specific flight hardware, which typically includes solid fuel samples and ancillary igniter tips and sensor rakes. Additional information on the flight hardware can be found in the SoFIE Baseline Concept Description (BCD), SOFIE-CONOPS-001. The latest status can be found in the SoFIE ATP Presentation Package. The FCF CIR hardware interfaces with SoFIE will be documented in the FCF-ICD-CIR-SOFIE, Solid Fuel Ignition and Extinction (SoFIE) Interface Control Document. Table 4-2 and Table 4-3 provide a top-level listing of the SoFIE hardware and software, respectively. The associated delivery dates reflect the contractor's development plan.

The approach for the SoFIE hardware build is changed from building an engineering/qualification model and a flight model to building a protoflight unit and a ground integration unit (GIU). This is necessary to complete the flight unit within the schedule available for ISS experimentation.

The approach for the hardware build and verification of SoFIE sample assemblies is changed as follows:

1. The contractor shall procure all hardware for the SoFIE sample assemblies (GEL, MIST, RTDFS, SMuRF, and NCA) under this SOW.
2. The contractor shall build and verify all GEL sample assemblies. (See table 4-2 for delivery date).
3. The contractor shall build all MIST sample assemblies (verifications are deferred). (See table 4-2 for delivery date).
4. The contractor shall assume the deferment of the build and verifications for RTDFS, SMuRF, and NCA sample assemblies.
5. The contractor shall update the RTDFS sample assembly drawings to include the fuel thicknesses as required in the Integrated Science Requirements document, SoFIE-ISR-001.

The contractor shall use a separate WBS to track the activities that were listed above as deferred work. These activities are no longer deferred and shall be completed in this SOW. These activities include:

1. The contractor shall verify all MIST sample assemblies (See Table 4-2 for delivery date).
2. The contractor shall build and verify RTDFS, SMuRF, and NCA sample assemblies (See Table 4-2 for delivery date.)

a. The contractor shall perform annealing tests on the SMuRF samples as recommended in the ZIN MRB for SoFIE-NCR-189
b. The contractor shall mitigate reflections from the fasteners and radiometer can on the NCA samples.

The SoFIE trainer shall include all components of the SoFIE CIA represented as either a spare flight part, or a 3-D printed component.

Table 4-2 SoFIE Hardware

| **Hardware** | **Qty** | **Delivery Date** |
|---|---|---|
| **SoFIE Insert** | | |
| Flight Unit (tested and verified) | 1 | January 2022 (was 11/2021,10/2021, 7/2021, 2/2021, 7/2020, 2/2020, 7/2019, 2/2019) Complete |
| GIU Model | 1 | July 2022 (was 6/2022, 01/2022 11/2021, 7/2021, 7/2020, 2/2020, 9/2019) Complete |
| GIU Duct Fan Assembly (Rev B) | 1 | October 2022 (was 9/2022) Complete |
| **SoFIE Avionics Package** | | |
| Flight Unit | 1 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020, 2/2020, 7/2019, 2/2019) Complete |
| GIU Model | 1 | July 2022 (was 6/2022, 1/2022, 11/2021, 7/2021, 2/2021, 7/2020, 2/2020, 9/2019) Complete |
| SoFIE Trainer | 1 | April 2021 (was 8/2020, 2/2020) Complete |
| **SoFIE Sample Assemblies** | **Qty** | **Delivery Date** |
| GEL Sample Assembly (build and verify) | 21 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| MIST Sample Assembly (build only) | 34 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| MIST Sample Assembly (verifications) | 34 | July 2022 (was 5/2022, 4/2022, 3/2022, 1/2022) Complete |
| RTDFS Sample Assembly | | January 2023 (was 10/2022, 7/2022, 4/2022, 3/2022, 1/2022) |
| SMuRF Sample Assembly | | January 2023 (was 10/2022, 9/2022, 4/2022, 3/2022, 1/2022) |
| NCA Sample Assembly | | January 2023 (was 10/2022, 7/2022, 4/2022, 3/2022, 1/2022) |
| | | |
| **SoFIE Spares** | **Qty** | **Delivery Date** |
| Internal Camera and Electronics Assembly | 1 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| ~~Soot Catch Assembly~~ (Removed) | | NA |

| | | |
|---|---|---|
| Duct Fan Assembly (Rev B) | 1 | October 2022 (was 9/2022, 1/2022, 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| GEL Sample Assembly | 1 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| 4mm-B Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| 6mm-A Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| 8mm-A Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| 10mm-A Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| 10mm-B Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| NCA Sawtooth Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| NCA Straight Igniter | 2 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| Gas Sensor Module | 1 | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |

Table 4-3 SoFIE Software

| **Software** | **Delivery Date** |
|---|---|
| Software Version Description Document (VDD) | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| Updated Software Management Plan | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| Final Software Development Plan | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| Final Software Requirement Spec | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| Final SW CM Plan | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |
| Final SW Design Document | January 2022 (was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020) Complete |

### 4.1.1. SoFIE Final Design and Fabrication

The contractor shall develop a final design and begin fabrication of the SoFIE test and flight components, assemblies, and subsystems to demonstrate compliance to the system and project requirements with acceptable risk in accordance with section 4.6, Final Design and Fabrication in the SpaceDOC II SOW. The key review for this phase of development is the Critical Design Review (CDR) and the Phase 2 Safety Review. (Completed, CDR was held in July 2018)

The contractor shall assume:

- The contractor shall assume all document deliverables/analysis identified in section 4.6 in the SpaceDOC II SOW are to be provided by the CDR (September 2017). (CDR was completed in July 2018.)
- The contractor shall assume that an informal review of the system integration will be held but no formal System Integration Review as defined in Section 4.6 in the SpaceDOC II SOW.

### 4.1.2. SoFIE Flight System Assembly, Integration and Test

The contractor shall complete the assembly, test, verification, and delivery of the SoFIE hardware, software, and associated integration documentation required for launch in accordance with section 4.7, System Assembly, Integration & Test, Launch in the SpaceDOC II SOW. The key review for this phase of development is the Pre-Ship Review (PSR) and the Phase 3 Safety Review. (Phase 3 Safety Review was held in August 2021).

The contractor shall assume:

- The contractor shall assume that all safety verification activities, all preparation for SoFIE Phase 3 FSR, integration, system turnover, and pre-launch activities are not covered under this SOW. These activities are covered under DO-255.
- The contractor shall assume all document deliverables/analysis identified in section 4.7 in the SpaceDOC II SOW are to be provided by the PSR (1/2022, was 11/2021, 10/2021, 7/2021, 2/2021, 7/2020, 7/2019) except for the Integrated Logistics Plan, Launch Site Operations & Test Plan, ORR Presentation Package, and the Training & Certification Plan. The FCF Project team develops this documentation and information.
- The contractor shall assume the ORR will be an integrated review with the FCF Project Team for the CIR/SoFIE operational readiness. The FCF Project team is responsible for the ORR.

### 4.1.3. SoFIE GIU Igniter Rework

The contractor shall investigate cause of Igniter Arm failure in GIU and develop plan to rework. The contractor shall perform any necessary rework to GIU Igniter Arm according to plan. Updates to deliverable dates associated with this effort are reflected in Table 4-2.

### 4.1.4. SoFIE GIU/Flight Spare Flow Plenum Rebuild and Test

The contractor shall rebuild the flow plenum in the GIU and Flight Spare to match the configuration of the flight unit (Rev B). The contractor shall perform the same benchtop flow plenum characterization testing as was performed on the flight unit. The contractor shall provide engineering support, not to exceed 40 hours, to the science team in testing the revised flow plenum/s in controlled-pressure environments. Updates to deliverable dates associated with this effort are reflected in Table 4-2.

# 5. Milestones and Reviews

The contractor shall provide regularly scheduled meetings/reporting with the NASA Project Manager for the following:

a) Weekly technical status meetings with the NASA Project Manager.
b) Monthly budget and schedule reporting that will include:
   i. Top Level Technical Performance/Accomplishments
   ii. Near Term Activities
   iii. WBS Comments (Problems/Issues/Risks and Mitigation Strategies)
   iv. Schedules (to include a Critical Path Schedule)
   v. Status and planned completion dates for the milestones listed in table 5-1.
c) Technical status meetings with the NASA Project Manager and the NASA Project Scientists, as needed.
d) Monthly Risk Status meetings.

The contractor shall support the major SoFIE Project Design Reviews to include:

a) Provide draft review packages a minimum of two weeks prior to the review, along with supporting documentation, unless otherwise specified under technical direction of the NASA PM. (carried forward)

Table 5-1. SoFIE Milestones

| Milestone Number | Milestone |
|---|---|
| 1 | Complete unit assembly of the Protoflight EMS Subsystem |
| 2 | Complete unit assembly of the Protoflight Chamber Camera |
| 3 | Complete unit assembly of the Protoflight Flow Duct Subsystem |
| 4 | Complete unit assembly of the Protoflight Ignition Subsystem |
| 5 | Complete unit assembly of the Protoflight Measurement Subsystem |
| 6 | Complete unit assembly of the Protoflight Samples (GEL and MIST only) |
| 7 | Complete unit assembly of the Protoflight Heater Subsystem |
| 8 | Complete the top-level unit assembly of the CIA |
| 9 | Complete the top-level unit assembly of the AVP |
| 10 | Complete unit assembly of the GIU CIA |
| 10A | Complete re-work of the SOFIE GIU Igniter Arm Assembly |
| 11 | Complete unit assembly of the GIU AVP |
| 12 | Complete Environmental (EMI, Vibration, and Thermal) Testing |
| 12A | Complete re-execution of NASA directed EMI testing, Run #3 |
| 12B | Complete re-execution of NASA directed SOFIE Impedance Tests, Run #2 |
| 13 | Complete SoFIE flight software build |
| 14 | Complete SoFIE software testing, verification, and validation |
| 15 | Manage and update a SoFIE software version repository (on-going) |
| 16 | Phase 3 Flight Safety Review |
| 17 | Preship Review 1 (SAR-1) |
| 18 | GEL Mission Sequence Test (MST) |
| 19 | Complete unit assembly of the Recirculation Subsystem |
| 20 | Complete assembly of the CIA Support Subsystem |
| 21 | Complete Acoustic Testing |

| Milestone Number | Milestone |
|---|---|
| 22 | Complete Offgas Testing |
| 23 | Start GIU Integration Testing |
| 24 | Complete GIU Integration Testing |
| 25 | Complete CIA Trainer |
| 26 | Complete Spare Hardware |
| 27 | Preship Review 2 (SAR-2) |
| 28 | Complete shipment of SOFIE low risk hardware |
| 28A | Complete final shipment of SOFIE hardware not identified as low risk |

## 6. Travel Required

No travel is required.

## 7. Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**

Task Manager, MSI/Daniel F. Brown, Mail Stop 77-7, NASA Glenn Research Center, Cleveland, OH 44135, daniel.f.brown@nasa.gov

Configuration Management Office, Donna J. Clements, Mail Stop 54-1, Donna.J.Clements@nasa.gov

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Krystal A. LaMarca, Mail Stop 60-1, krystal.a.lamarca@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7 nancy.r.hall@nasa.gov)

Program Manager, (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

A Contracting Officer letter may accomplish changes to the personnel mentioned above.

The contractor shall deliver the following hardware, software, and documentation items to the Government in accordance with the contract requirements.

## 7.1. Hardware Deliverables

The contractor shall deliver the following hardware items to the Government with supporting documentation (specifications, drawings, test procedures, analysis/test reports, and operating/maintenance manuals as applicable):

1. SoFIE Hardware per contractor development plan (per tables 4-2 and 5-1) (carried forward )
2. SoFIE Insert (per table 4-2)
3. SoFIE Avionics Package (per table 4-2)
4. SoFIE GIUs (per table 4-2)
5. SoFIE Trainer Carried Forward (per table 4-2)
6. SoFIE Sample Assemblies (per table 4-2)
7. SoFIE Spare Hardware (per table 4-2)

## 7.2. Software Deliverables

The contractor shall deliver the following software items to the Government with supporting documentation (specifications, drawings, test procedures, analysis/test reports, and operating/maintenance manuals as applicable):

1. SoFIE flight software build (per table 5-1) (carried forward)
2. Test, verify, and validate the SoFIE software (per table 5-1) (carried forward)
3. The contractor shall manage and update an on-going SoFIE software version repository (per table 5-1) (carried forward from)
4. SoFIE software documentation list per table 4-3.

## 7.3. Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with the Contract Data Requirements List (CDRL), if applicable.

The contractor shall provide the following documents:

1. Contractor Work Plan, per DID PM-06 within 30 days of contract start
2. Submit a Monthly Task Report in accordance with DID CD-03
3. Lessons Learned Report per DID PA-17 (yearly)
4. Supporting documentation (specifications, drawings, test procedures, analysis/test reports, and operating/maintenance manuals, as applicable) for the hardware deliverables identified in Hardware Deliverables. (Non-deliverable; available for surveillance) (carried forward)
5. Verification Reports on Manifested Hardware (NASA Concurrence required, by Pre-Ship Review except for packaging) (carried forward)
6. Non-Conformance Report action plans (as required, non-deliverable; available for surveillance) (carried forward)
7. GSE supporting documentation (as required) (carried forward)
8. Acceptance Data Packages for delivered flight hardware to NASA (carried forward)
9. Schedule status, including percent complete for all tasks, shall be reported to the NASA Project Manager in weekly meetings; the NASA project manager shall maintain a current version of the schedule (carried forward)
10. SoFIE Documentation per SpaceDOC II SOW 4.7.3 for the SAR (PSR) is to be completed by 10/2021 (was 07/2021, 02/2021, 07/2020) (carried forward)

## 8. Reporting Requirements

a) Contractor Financial Management Reporting per DID CD-01 with the following reporting structure (or similar, approved by NASA) ON-GOING:

a. Project Management/Support
b. Product Assurance
c. SoFIE
  i. Systems Engineering
  ii. Concept Development
  iii. Engineering Model
  iv. Flight Unit Assembly, Integration and Test
  v. Operations Planning, Trainer, Spares

b) Monthly reporting per DID CD-03 ON-GOING

## 9. Government Furnished Equipment

In assessing the contractor budget and schedule, the following hardware and software shall be made available by the Government to the contractor:

a) CIR IPSU simulator (coordinated with FCF Project)

b) CIR IOP simulator (coordinated with FCF Project)

c) CIR GIU and PRCU in Building 333 (Coordinated with FCF Project and managed by FCF)

d) PI provided materials for samples

## 10. Government Furnished Facilities

The following Government facilities shall be available to the contractor, as needed:

a) Power Space Facility (Bldg. 333) – High Bay (100E)

b) Structural Dynamics Laboratory (Bldg. 54)

c) Thermal Environmental Chambers in Building 333A

d) EMI Laboratory in Building 333A

e) 2.2 Second Drop Tower facility

f) Zero Gravity Research (drop) Facility

g) Calibration lab

h) Instrumentation Department

i) Lab Space in Building 110

## 11. Government Contacts

The contractor shall have access to the following for consultation:

a) FCF CIR Manager for interface reference

b) MDCA Project Team personnel for prior insert consultation

c) ACME Project Team personnel for prior insert consultation

d) GRC SoFIE Project Manager

e) Project Scientist for SoFIE

## 12. Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## Acronym List:

| Acronym | Description |
|---|---|
| ACME | Advanced Combustion via Microgravity Experiments |
| ATP | Authority to Proceed |
| AVP | Avionics Package |
| BCD | Baseline Concept Document |
| BT | Base Task |
| CCR | Configuration Change Request |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CIA | Chamber Insert Assembly |
| ConOps | Concept of Operations |
| DID | Data Item Description |
| EC-AES | Exploration Capability - Advanced Exploration System |
| EMI | Electromagnetic Interference |
| EMS | Experiment Mounting Structure |
| EVA | Extravehicular Activity |
| FCF | Fluids and Combustion Facility |
| FHA | Flight Hardware Available |
| GEL | Growth and Extinction Limit |
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| GSE | Ground Support Equipment |
| ICD | Interface Control Document |
| IDD | Interface Definition Documents |
| IOP | Input/Output Processor |
| IPSU | Image Processing and Storage Unit |
| ISRD | Integrated Science Requirements Document |
| ISS | International Space Station |
| MDCA | Multi-User droplet Combustion Apparatus |
| MIST | Material Ignition and Suppression Test |
| MRB | Materials Review Board |
| MST | Mission Sequence Test |
| NASA | National Aeronautics and Space Administration |
| NCA | Narrow Channel Apparatus |
| NPR | NASA Procedural Requirement |
| NSTS | National Space Transportation System |
| ORR | Operations Readiness Review |
| PDR | Preliminary Design Review |

| Acronym | Description |
|---|---|
| PI | Principal Investigator |
| PM | Project Manager |
| PRCU | Payload Rack Checkout Unit |
| PSR | Pre-Ship Review |
| RTDFS | Residence Time Driven Flame Spread |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SCR | Science Concept Review |
| SMuRF | Spacecraft Materials Microgravity Research on Flammability |
| SoFIE | Solid Fluid Ignition and Extinction |
| SOW | Statement of Work |
| SpaceDOC-II (2) | Space Flight Systems Development and Operations Contract-II (2) |
| SSP | Space Station Program |
| STS | Space Transportation System |
| SW | Software |
| VDD | Version Description Document |
| WBS | Work Breakdown Structure |

**SpaceDOC-2 NNC14CA02C**
**DO-210 CCMP**
**HRP Cross-cutting Computational Modeling Projects (CCMP)**
**FOR DO JANUARY 1, 2014 THROUGH MARCH 31, 2023**
**FOR THE PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH MARCH 31, 2023**

# 1 OVERVIEW

The HRP Cross-cutting Computational Modeling Project (CCMP) implements well-vetted computational models to predict and assess spaceflight health and performance risks and enhance countermeasure development. This DO includes support to the HRP CCMP through the development of Probabilistic Risk Assessment (PRA) tools, multi-parameter, multi-scale performance risk tools, exercise device models, biomechanical models and analysis tools, data analyses and whole body fluid models and ocular models which are used to perform deterministic and probabilistic simulations of human physiology to support research and mission concept decisions for the human exploration of space.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through March 31, 2023.

## 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

1) HRP CCMP Manager
2) HRP CCMP Scientist
3) HRP CCMP Team
4) MEDPRAT Manager
5) MEDPRAT Scientist
6) MEDPRAT Modeling Team

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)

## 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have

successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Kelly M. Gilkey, Mail Stop 77-7, kelly.m.gilkey@nasa.gov #

Configuration Management Office, Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov

Deliver courtesy copies of cover letter only to:

Program Manager, GRC Human Research Program, Kelly Gilkey, Mail Stop 77-7, kelly.m.gilkey@nasa.gov

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office, Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17, ON-GOING

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

The following are GFE for this delivery order:

1) All HRP Computational Modeling (CM) data collected during exercise device testing.
2) All hardware in the GRC Exercise Countermeasure Laboratory (ECL).

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) ECL in GRC Building 110, Room 126.

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# 4 PROJECT SPECIFIC SOW

## 4.1 SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS) MODEL SUPPORT

Many astronauts returning from long duration missions on the ISS present with pathologic changes to the anatomy of their eye. The current hypothesis is that the persistent increase in intracranial pressure due to the cephalad fluid shift distends ocular structures past their elastic limit, producing permanent deformation. To provide the ability to simulate data that would be too invasive and damaging to obtain from a person and to provide evidence to support or contradict the hypothesis, the HRP CCMP team has developed lumped computational models of the eye, Central Nervous System (CNS) flow, and the Cardio Vascular System (CVS). The contractor shall support development, testing and use of these lumped parameter models. There are several updated formulations that have been created for the lumped parameter CVS model, the contractor shall implement these formulations into the model and perform V&V testing. The contractor shall also provide computational support in order to allow the lumped parameter models to be integrated with the FEM of the optic nerve head developed by collaborators from Georgia Tech. The contractor shall also support efforts to use the lumped parameter models to perform analyses which are in support of the Human Health and Countermeasures element's (HHC) cardiovascular, vision and artificial gravity research. Additionally, the contractor will support data analyses utilizing existing HRP data to identify possible correlations and causal links of different etiologies The contractor shall provide support for the milestone deliverables listed in Section 4.2.1, along with quarterly demonstrations of the software as this code is being developed an agile-like methodology and requires frequent customer feedback. The contractor shall contribute to SANS content and participate in HRP investigator workshops as an author, presenter, and/or attendee as determined by the CCMP PM and PS. In addition, the contractor may provide consultation services in the areas of biofluid dynamics, biostatistics, epidemiology, and a graphical artist or illustrator to develop communication products.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Implement tissue weight formulation in SANS WBM and provide a brief report on the implementation tests. | August 31, 2021 COMPLETE |

### 4.1.2 Hardware/Software Deliverables

| HM/SW Deliverable | Milestone Number |
|---|---|
| Deliver updated code and code comments associated with SANS analysis work. | 1 COMPLETE |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Contribute to SANS WBM documentation in preparation for vaulting of all models in the Computational Model Repository (CMR).[1] | 1 September 24, 2021 COMPLETE |

[1]Report should be detailed enough that the implementation, testing, and validation procedures could be reproduced by a computational modeling scientist.

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## 4.2 MEDICAL EXTENSIBLE DYNAMIC PROBABILISTIC RISK ASSESSMENT TOOL (MEDPRAT)

GRC is developing a dynamic Probabilistic Risk Assessment (dPRA) tool to allow research managers to better decide which technologies yield the best risk reduction. It will also allow for mission planners to understand risk associated with differing mission scenarios and hardware selection. In June 2017, GRC began work on an enhanced capability known as the Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT), which will develop a new code from a zero baseline. This tool will be delivered to HRP in September 2020, after going through an appropriate level of review as the CCMP management team will negotiate with the program. In parallel with this delivery of MEDPRAT, work will also begin on a new instance of the tool that will provide an integrated architecture across multiple HRP elements and not be limited to medical conditions but may pull in data on nutrition, exercise, and the like. The contractor shall provide support for the milestone deliverables listed in Section 4.3.1, along with quarterly demonstrations of the software as this code is being developed an agile-like methodology and requires frequent customer feedback. These milestones will require personnel with strong software engineering skills who has written and architected coding projects, beyond the scope of scripting who has solid experience in an object-oriented language, or experience in something like Java or C++. Experience writing mathematical or scientific code would also be very helpful since there is a large, existing code base. In addition, the contractor may provide consultation services in the areas of Bayesian networks, artificial intelligence, neural networks, biostatistics, epidemiology, strategic planning for GRC support of HRP, and a graphical artist or illustrator to develop communication products. The contractor shall contribute to MEDPRAT content and participate in HRP investigator workshops as an author, presenter, and/or attendee as determined by the CCMP PM and PS.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Documentation updates for MEDPRAT Version 1.1 features | August 31, 2021 (was 7/2021) COMPLETE |
| 2 | Call for 2022 IWS – submission of abstract by TBD date from HRP (expected October 2021) | October 18, 2021 (was 11/2021) COMPLETE |
| 3 | MEDPRAT Version 2.0 beta available for use | March 1, 2022 Carried Forward COMPLETE |
| 4 | V&V of integrated architecture complete – MEDPRAT V2.0 ready for Acceptance Review | Carried Forward September 9, 2022 (was 7/2022) COMPLETE |
| 5 | MEDPRAT Version 2.0 Release – Transition to use | Carried Forward November 4, 2022 (was 9/2022) COMPLETE |
| ~~6~~ | ~~Support integration of MEDPRAT into CHP PRA Models and resolution of any anomalies related to IMPACT testing~~ | ~~March 31, 2023~~ DELETE |
| 7 | Transition of ZIN technical expertise of the MEDPRAT architecture to existing computational modeling team members. This transition plan includes the following activities:<br>• In recorded meeting(s), walkthrough MEDPRAT for a single trial/test, explain information flow and function calls and their purpose.<br>• Recorded code review of complex features/sections that would benefit from a live walkthrough/explanation at a level higher than line-by-line, 'purpose by purpose'.<br>• Overview of SDD to give info on how everything is knitted together.<br>• Support bug fixes alongside the MEDPRAT team to transfer knowledge. | March 31, 2023 |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Deliver integrated architecture Version 2.0 production software code | 3<br>Carried Forward<br>COMPLETE |
| Deliver production software code changes needed to support V2.0 review | 4<br>COMPLETE |
| ~~Deliver MEPRAT V2.x software code (incorporating any changes as a result of an IMPACT testing anomalies)~~ | ~~6~~<br>DELETE |
| Add comments to code that help explain class relationships | 7 |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Deliver updates to Software User's Manual for production software code of integrated architecture Version 1.1. | 1<br>COMPLETE |
| Deliver updates to Software Design Description and Software User's Manual for production software code of integrated architecture Version 2.0. | 3<br>April 1, 2022<br>(was 9/2021)<br>Carried Forward<br>COMPLETE |
| Deliver updates to MEDPRAT Testing document & SDD in preparation for MEDPRAT V2.0 Acceptance review, | 4<br>(was 9/2021)<br>Carried Forward<br>COMPLETE |
| Deliver updates to documentation in support of integrated architecture Version 2.0 transition to use activities.<br>(Revisions & updates that are the result from feedback of the acceptance review) | 5<br>Carried Forward<br>COMPLETE |
| ~~Deliver new feature implementation concept document next version of MEDPRAT~~ | ~~6~~<br>DELETE |
| • A write up in general terms that explains the purpose or theme of each object and the objects important relationships.<br>• More detailed class diagrams or explanation detailing the relationships between various classes/objects, hoping to capture more information on the 'why', conceptual meaning.<br>• Share any helpful set up info or other existing documentation on a dedicated area within NASA Box | 7 |

## 4.3 Model Repository

The contractor shall establish a model repository and develop a base of information on the data and models that currently exist within HRP. Possible solutions to meet these objectives are through an intuitive, user experience designed web application or by utilizing the HRP high performance computer cluster, or some combination of the two. The contractor will develop a mechanism for capturing what computational modeling and analysis applications are currently available from program development efforts, understanding the status of verification, validation, and credibility (VV&C) of models and simulation, creating a workflow for processing models and simulations through the NASA standard on models and simulation, creating a workflow for requesting access to models, simulations, and associated documentation for verification, validation, and credibility, and managing the models, simulations, associated input and output data pedigree and processes. The contractor will employ an agile development methodology that incorporates user feedback on a regular basis and encourages flexibility within the solution provided. The contractor will research and select cloud support services, if appropriate, to host the HRP computational model repository and procure and manage these services. Version 2.0 of this tool will be delivered to HRP in September 2021, after going through an appropriate level of review as the CCMP management team will negotiate with the program. ~~and will include public access features for members of the research and development community (non-NASA badge individuals).~~ The contractor shall contribute to CMR content and participate in HRP investigator workshops as an author, presenter, and/or attendee as determined by the CCMP PM and PS. In addition, the contractor may provide consultation services for a graphical artist or illustrator to develop communication products.

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Deliver next generation production model repository. (V2.0) | September 30, 2021<br>COMPLETE |
| ~~2~~ | ~~Deliver next generation production model repository (V3.0)~~<br>~~Deleted~~ | ~~September 30, 2022~~<br>~~Carried Forward~~<br>DELETE |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Deliver next generation production web-based software application. | 1<br>COMPLETE |
| ~~Deliver next generation production web-based software application.~~<br>~~Deleted~~ | ~~2~~<br>~~Carried Forward~~<br>DELETE |

### 4.3.3 Document Deliverables

| Documentation Deliverables | Milestone Number |
|---|---|
| Deliver final software compliance matrix (NPR 7150.2B) | 1<br>COMPLETE |
| Deliver final software test plan and procedure | 1<br>COMPLETE |
| Deliver final software test reports | 1<br>COMPLETE |
| Deliver final software user manual | 1<br>COMPLETE |
| ~~Deliver final software compliance matrix (NPR 7150.2B)~~<br>~~Deleted~~ | ~~2~~<br>~~Carried Forward~~<br>DELETE |
| ~~Deliver final software test plan and procedure~~<br>~~Deleted~~ | ~~2~~<br>~~Carried Forward~~<br>DELETE |
| ~~Deliver final software test reports~~<br>~~Deleted~~ | ~~2~~<br>~~Carried Forward~~<br>DELETE |
| ~~Deliver final software user manual~~<br>~~Deleted~~ | ~~2~~<br>~~Carried Forward~~<br>DELETE |

## 4.4 EVA Injury Credibility Assessment

The Human Health and Countermeasures (HHC) element has tasked the CCMP team to complete a 6-month biomechanics model credibility assessment for quantifying injury risk in a suited astronaut extravehicular activity (EVA) scenario under altered-gravity conditions. The contractor shall provide support in evaluation of Commercial off the shelf (COTS) biomechanics FE and MS-rigid body models, such as global human body model consortium (GHBMC) simplified models, total human model for safety (THuMS), and OpenSIM. The contractor will support credibility evaluations for the models identified based on NASA-STD-7009A , and contribute to the milestone deliverables listed in Section 4.9.1. These milestones will require personnel with strong mechanical, biomedical, or computational modeling skills who has experience with LS-DYNA/Abaqus, OpenSim/ADAMS and/or Python. The contractor shall contribute to EVA injury credibility assessment documentation and participate in HRP investigator workshops as an author, presenter, and/or attendee as determined by the CCMP PM and PS.

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Credibility Metrics defined for selected injury scenarios | July 16, 2021<br>COMPLETE |

| Milestone Number | Milestone | Date |
|---|---|---|
| 2 | Demonstration to HHC of preliminary credibility evaluations | August 13, 2021 COMPLETE |
| 3 | Presentation of final results of credibility assessment | October 15, 2021 Complete |
| ~~4~~ | ~~Contribute to technical memorandum for publication documenting the methodology used to assess credibility of the COTS models~~ | ~~March 31, 2022~~ DELETE |
| 5 | Presentation of results to HRP Element Stakeholders | November 30, 2021 COMPLETE |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Documentation Deliverables | Milestone Number |
|---|---|
| Contribute to the summary reports for a minimum of three credibility evaluations for the scenarios, models, or body regions prioritized | 2 Carried Forward |
| Contribute to a final report that describes the COTS model credibility assessment | 3 Carried Forward |
| ~~Contribute to technical memorandum for publication documenting the methodology used to assess credibility of the COTS models~~ | ~~4~~ DELETE |
| Contribute to a presentation to Element stakeholders that describes the COTS model credibility assessment | 5 COMPLETE |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CCMP** | **Cross-cutting Computational Modeling Project** |
| **CCR** | **Configuration Change Request** |
| **CDRL** | **Contract Data Requirements List** |
| **CM** | **Computational Modeling** |
| **CNS** | **Central Nervous System** |
| **COTS** | **Commercial Off The Shelf** |
| **CVS** | **Cardio Vascular System** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **dPRA** | **dynamic Probabilistic Risk Assessment** |
| **eCC** | **electronic Country Clearance** |
| **ECL** | **Exercise Countermeasures Laboratory** |
| **EDMP** | **Experiment Data Management Plan** |
| **EVA** | **Extravehicular Activity** |
| **FEM** | **Finite Element Model** |
| **GFE** | **Government Furnished Equipment** |
| **GHBMC** | **Global Human Body Model Consortium** |
| **GRC** | **Glenn Research Center** |
| **HHC** | **Human Health Countermeasures** |
| **HRP** | **Human Research Program** |
| **HW** | **Hardware** |
| **ISS** | **International Space Station** |
| **IWS** | **Investigator's Work Shop** |
| **MEDPRAT** | **Medical Extensible Dynamic Probabilistic Risk Assessment Tool** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PM** | **Program Manager** |
| **PRA** | **Probabilistic Risk Assessments** |
| **PRACA** | **Preventive and Corrective Action** |
| **PS** | **Project Scientist** |
| **SANS** | **Spaceflight Adaptation and Neuro-Ocular Syndrome** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **SRD** | **Science Requirements Document** |
| **STD** | **Standard** |
| **SW** | **Software** |
| **THuMS** | **Total Human Model for Safety** |
| **TBD** | **To Be Determined** |

| | |
|---|---|
| **V&V** | **Validation and Verification** |
| **VV&C** | **Verification, Validation and Credibility** |
| **WBM** | **Whole Body Model** |

**SpaceDOC-2 NNC15JZ20D**
**DO-220 Saffire**
**Spacecraft Fire Safety Demonstration (SFS Demo) Project**
**For DO Period July 1, 2015 through March 31, 2023**
**For the Performance Period October 1, 2021 through March 31, 2023**

# 1 OVERVIEW

The Spacecraft Fire Experiment (Saffire) is being developed by the Spacecraft Fire Safety Demonstration (SFS Demo) Project at NASA-GRC. The purpose of this experiment is to close spacecraft fire safety capability and knowledge gaps associated with material flammability, fire detection, fire suppression, and post-fire clean-up for NASA's exploration vehicles. Saffire-I, II, and III were developed to investigate large-scale flame spread and material flammability limits in long duration low-gravity. Saffire-IV, V, and VI will continue to investigate these phenomena as well as address additional objectives such as flame growth/dynamics, fire detection, fire suppression, post-fire cleanup, post-fire monitoring and fire behavior modeling. Saffire VII and VIII will investigate these same phenomena but burning a different medium, anticipated to be laptops and battery cartridges. The SFS Demo Project is funded by the Advanced Exploration Systems (AES) Division within the Human Exploration and Operations Mission Directorate (HEOMD) at NASA Headquarters (HQ). These experiments will be conducted onboard the Northrop Grumman Innovation System (NGIS)'s Cygnus vehicle after it un-berths from the International Space Station (ISS) and before it begins destructive re-entry. The experiment is operated from the NGIS Mission Control Center in Dulles, VA by a team of GRC and NGIS personnel.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through March 31, 2023.

## 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

1) Gary A. Ruff – Spacecraft Fire Safety Demonstration Project Manager
2) Thomas Acquaviva – Spacecraft Fire Safety Demonstration Resource Manager
3) David L. Urban – Saffire Principal Investigator
4) David Carek, - Spacecraft Fire Safety Chief Engineer
5) George Santosuosso – Spacecraft Fire Safety Lead Systems Engineer

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) SFSDP2-PLN-003: Spacecraft Fire Safety Demonstration Project Plan
2) SFSDP2-REQ-001: Experiment Science Requirements Document (ESRD)
3) SFSDP2-PLN-005: System Engineering Management Plan (SEMP)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

> Task Manager, Exploration Systems Project Office (Thomas Acquaviva, Mail Stop 162-7, thomas.h.acquaviva@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)
>
> Spacecraft Fire Safety Demonstration Configuration Management Lead, (Kelly Hall, Mail Stop 162-7, kelly.l.hall@nasa.gov)
>
> Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

> Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1, **elizabeth.a.morales@nasa.gov**
> Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
> Program Manager, Exploration Systems Project Office (Gary A. Ruff, Mail Stop 162-7, gary.a.ruff@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)
>
> Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, Monthly
4) Monthly reporting, per DID# CD-02, Monthly
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, Quarterly
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

Will include the following:

1) Saffire-I, II, and III Ground Support Equipment (as needed). Potentially includes but not limited to:
   a. Cygnus PXI chassis (emulator) with laptop
   b. Cygnus Simulator
   c. Lift fixture
2) JPL CPM (Updated Flight Unit)

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: Thermal Environmental Chambers in Bldg. 333A
2) Usage Elective: Structural Dynamics Laboratory, (SDL).
3) Usage Elective: Electromagnetic Interference (EMI) Laboratory.
4) Usage Elective: Instrumentation Shop
5) Usage Elective: Saffire Imaging Lab (Bldg. 77, Room 154)

## 3.3 GOVERNMENT FURNISHED SOFTWARE

The Government shall make available the ground and flight software in the time frame documented and agreed to in the Integrated Master Schedule. This includes specialized flight-like software for performing the environmental tests.

# 4 STATEMENT OF WORK – GENERAL

The contractor will provide engineering, design, fabrication and test support to the SFS Demo project for the development and delivery of Saffire-IV, V, and VI as well as flight operations. The specific activities are sub-divided into a series of tasks that support hardware and software engineering, systems engineering and integration, configuration management, and safety and mission assurance of the SFS Demo project. These subtasks will be defined, revised, or removed as necessary throughout the different phases of the SFS Demo project. Initially, the contractor shall support the science team's identification and refinement of the engineering/science requirements by designing and developing bench-top hardware (breadboards) and rigs for laboratory and/or low-gravity ground-based testing. The concept developed during the first phase of the project will identify subsystems that address the project objectives and identify the key high-risk development areas. Engineering feasibility issues shall be identified based on the project requirements and include: identification of fundamental capabilities required to meet project objectives, assessment of technical viability based on current industry capabilities, and assessment of the engineering and diagnostic methods utilized in Saffire I, II, and III. Subsystem and component tests will be performed to reduce project risks and inform the final design of flight systems. Later phases of the project will focus on the final design, fabrication, and assembly of the Saffire flight hardware followed by environmental and functional tests. The flight system will be delivered with all documentation that demonstrates closure of engineering, safety, ISS, and NGIS requirements, except those that can only be closed during integration with the NGIS Cygnus vehicle. The Spacecraft Fire Safety Demonstration Project has been instructed by AES that Saffire IV, V, and VI experiments should launch on NG-13, NG-14, and NG-19 currently planned for February 2020, August 2020, and April 2023, respectively. The timing of these launches is heavily dependent on the readiness and launch of the commercial crew vehicles to the ISS and the increased trash that must be removed from ISS as a result of the larger number of crew onboard. To increase the flexibility of the Saffire experiments to respond to anticipated changes in the launch schedule, the Saffire-V and VI hardware are to be completed in parallel to the greatest extent possible. A single System Acceptance Review should be planned for these two units with an initial Phase 3 Flight Safety Review for Saffire-IV and separate series/re-flight Phase 3 Flight Safety Reviews for Saffire-V and Saffire-IV at the appropriate intervals prior to flight.

The contractor shall regularly report progress for approval of designs and implementation prior to completion of the tasks.

**Applicable Documents:**

SFSDP2-REQ-001: Spacecraft Fire Safety Demonstration Flight IV, V, VI Experiment Science Requirements

SFSDP2-PLN-003: Spacecraft Fire Safety Demonstration Project Plan

SFSDP2-PLN-005: Systems Engineering Management Plan

GRC ISS-PLN-001, NASA GRC International Space Station Systems Engineering Management Plan

NASA-STD-8739.1 Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies

**Reference Documents:**

NPR 7120.5E, NASA Space Flight Program and Project Management Requirements

NPR 7123.1B, NASA Systems Engineering Processes and Requirements

NPR 7150.2A Software Engineering Requirements

SFSDP2-PLN-004: Configuration and Data Management Plan

SFSDP2-PLN-006: Safety and Mission Assurance Plan

SFSDP2-PLN-008: Software Management and Development Plan

SFSDP2-PLN-009: Software Configuration Management Plan

SFSDP2-PLN-010: Software Requirements Management Plan

SFSDP2-PLN-011: Software Assurance Plan

SFSDP2-PLN-013: Software Test Plan

## 4.1 Subtask A – Saffire Concept Development, Preliminary, and Final Design Task

During FY18, the AES Office authorized the Spacecraft Fire Safety Demonstration project team to begin planning for two additional flights after Saffire-VI was completed. These experiments would be complete demonstrations of a spacecraft fire scenario including ignition, fire growth, detection, suppression, and cleanup. The hardware for these experiments is planned to be similar to Saffire-IV-VI with as few modifications as possible. During this period of performance, the NASA Science Team will be developing requirements for Saffire-VII and VIII. The Contractor is requested to address capabilities of the current flight system relative to its ability to perform tests required in Saffire-VII and VIII.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Prepare an assessment report about implementing preliminary Saffire-VII and VIII requirements into the Saffire-IV-VI design | 9/30/2020 (completed) |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Assessment report of implementing preliminary Saffire VII and VIII requirements into Saffire IV-VI hardware with minimal changes. | 1 |

## 4.2 Subtask B – Saffire Flight System

The primary focus of this subtask is to finalize the design of the Saffire IV, V, and VI Flight Systems and then procure materials, fabricate, assemble, and test the flight hardware. The contractor shall work with the engineering and science teams to develop a flight system hardware design for the Saffire experiments. For each flight system the contractor shall develop engineering requirements and, where necessary, breadboards to increase confidence that the hardware concepts can meet these requirements.

Each Saffire Flight System will be composed of the following:

1) The Saffire Flow Unit containing the following components:
   a) A primary structure supporting the Flow Duct and Avionics Bay.
   b) The Flow Duct made up of the Sample Card System; the Flow system (e.g., flow control, combustion gas mixing and $O_2$ introduction); the Post-fire gas generation/delivery system; and Instrumentation (including internal sensors).
   c) The Avionics Bay containing the Power Management System; the Avionics System (including processor, signal conditioning, DAQ cube); and the Vision system (including front and side view imaging).
2) The Far-field Diagnostics (FFD) Unit that will have several instruments for monitoring particulate and combustion products in the Cygnus PCM. It will also contain a module for post-fire cleanup.
3) Remote Sensor suite to sample the atmosphere at specified locations within the Cygnus volume.

All Saffire Flight System hardware must work as an integrated system that will be housed within the Cygnus Pressurized Cargo Module (PCM) during the Saffire flight experiment execution.

Following data analysis from Saffire-IV and V, it was clear that the SFU outlet gas sampling location was not ideal to obtain a gas sample representative of the outlet conditions. The Contractor should review the design and, with the proper documentation of the schedule and costs, relocate the sampling location on the Saffire-VI SFU to obtain a gas sample more representative of the conditions at the SFU outlet.

The Far-Field Diagnostic and Saffire Flow Unit (SFU) can be integrated at either L-60 or L-20 days. However, the time for integration at L-20 is just over 1 day with practically no time to address issues if they arise. Integration of the Remote Sensors and SFU-to-RS and SFU-to-FFD cables is to occur at L-60 days even if the FFD and SFU is integrated at L-20 days. Travel for one or more Contractor personnel to the integration site and/or the launch site should be included in the estimate.

The Contractor shall prepare for and conduct the following reviews by the dates specified in Section 4.2.1 below:

1) Saffire V & VI System Acceptance Review (SAR)
2) Saffire V Series/Re-flight Phase 3 Flight Safety Review
3) Saffire V Flight System Pre-Ship Review
4) Saffire VI Series/Re-flight Phase 3 Flight Safety Review
5) Saffire VI Flight System Pre-Ship Review

For all reviews the Contractor shall use the entrance and success criteria set in the NPR 7120.5 and NPR7123.1B. With appropriate GRC Technical Authority approval, tailoring of these reviews, similar to that for Saffire-I, II, and III, is permitted and encouraged. Hardware turnover from ZIN to NASA is planned to occur following the appropriate Pre-Ship review.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Deliver Saffire-IV Flight System (SFU and FFD) | 11/30/2019 (completed) |
| 2 | Conduct a System Acceptance Review for Saffire IV flight system | 11/30/2019 (completed) |
| 3 | Conduct a Pre-Ship Review for the Saffire IV flight system | 11/30/2019 (completed) |
| 4 | Complete Saffire V Flight Hardware - Remote Sensors (RS) and SFU-to-RS cable | 12/31/2019 (completed) |
| 5 | Complete fabrication of the Saffire-V Structured PMMA Sample (two). Delivery will be split to allow the second sample to be used as a flight spare if necessary. | **1st** : 12/31/2019 (completed) **2nd** : 9/30/2021 (was 4/2020) (completed) |
| 6 | Complete Saffire-V Flight Hardware – Far-Field Diagnostic and SFU-to-FFD cable | 4/1/2020 (was 2/2020) (completed) |
| 7 | Complete Saffire V Flight Hardware – Saffire Flow Unit | 3/27/2020 (was 2/2020) (completed) |
| 8 | Conduct a System Acceptance Review for Saffire V flight system | 5/29/2020 (completed) |
| 9 | Conduct a Pre-Ship Review for the Saffire V flight system | 6/5/2020 (was 4/2020) (completed) |
| 10 | Complete Saffire VI Flight Hardware – Remote Sensors and SFU-to-RS Cable | 12/31/2019 (completed) |
| 11 | Complete Saffire VI Flight Hardware – Far-Field Diagnostic and SFU-to-FFD cable | 4/1/2020 (was 2/2020) (completed) |
| 13 | Complete Saffire VI Flight Hardware – Saffire Flow Unit | 4/30/2020 (was 3/2020) |

| Milestone Number | Milestone | Date |
|---|---|---|
| | | (completed) |
| 14 | Conduct a System Acceptance Review for Saffire VI flight system | 7/31/2020 (was 5/2020) (completed) |
| 15 | Conduct a Pre-Ship Review for the Saffire VI flight system | 03/2023 (was 3/2023; 1/2021) |
| 16 | Conduct a delta-System Acceptance Review for the Saffire-VI flight system | 01/2023 (was 1/2023) |
| 17 | Close verifications for the SFU outlet gas sampling port modification | 09/30/2021 |
| 18 | Post-Storage Review | 03/2023 (was 3/2023) |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| Saffire-IV Flight System (SFU and FFD) | 1 (delivered) |
| ~~Saffire V Flight System – Remote Sensors and SFU to RS cable~~ | ~~4 (deleted)~~ |
| Saffire-V Structured PMMA Sample (two) | 5 (delivered) |
| Saffire V Flight System (SFU, RS, FFD, and all cables) | 9 (delivered) |
| ~~Saffire VI Flight System – Remote Sensors and SFU to RS cable~~ | ~~10 (deleted)~~ |
| Saffire VI Flight System (SFU, RS, FFD) | 15 (was 16) |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Acceptance Data Package for Saffire-IV flight system (SFU and FFD) | 2 (delivered) |
| Document products and supporting materials for the Pre-Ship Review for Saffire-IV flight system | 3 (delivered) |

| Document Deliverables | Milestone |
|---|---|
| Completed End Item Audit for the Saffire-V remote Sensors (RS) and SFU-to-RS cable | 4 (delivered) |
| Document products and supporting materials to successfully complete a System Acceptance Review for Saffire-V flight system (RS, FFD, and SFU) | 8 (delivered) |
| Document products and supporting material to successfully complete the Pre-Ship Review for Saffire-V flight system | 9 (delivered) |
| Completed End Item Audit for the Saffire VI Remote Sensors and SFU-to-RS Cable | 10 (delivered) |
| Completed End Item Audit for the Saffire VI Far-Field Diagnostic and SFU-to-FFD cable | 11 (delivered) |
| Document products and supporting materials to successfully complete a System Acceptance Review for Saffire-VI flight system (RS, FFD, and SFU) | 14 (delivered) |
| Document products and supporting materials for the successful completion of the Pre-Ship Review for Saffire-VI flight system | 15 |
| Complete End Item Audit for the Saffire-V Flight Hardware – Far-Field Diagnostic and SFU-to-FFD cable | 6 (delivered) |
| Document products and supporting materials to successfully complete a delta-System Acceptance Review for Saffire-VI flight system (RS, FFD, and SFU) | 16 |
| Verification Tracking Log showing closure of the Saffire-VI verifications resulting from the relocation of the SFU outlet gas sampling port | 17 |
| Document products and supporting materials for the successful completion of the Post-Storage Review for Saffire-VI flight system | 18 |

### 4.3 Subtask B1 – Saffire Flight Hardware Environmental Test Task

The primary focus of this subtask will be to perform verification and environmental tests of the Saffire IV, V, and VI Flight Systems. The Saffire Flow Unit, Far-Field Diagnostics, and Remote Sensors may be tested individually or as an integrated system.

The contractor will perform functional and environmental tests of the Saffire IV-V-VI flight hardware. These will include the tests for the Saffire SFU, Far-Field Diagnostics and Remote Sensors for all three Saffire flight systems. Beginning with the Saffire IV and then proceeding to Saffire V and IV. The functional and environmental tests will be performed on each unit.

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Complete system-level thermal cycle test for Saffire V | 4/10/2020 (was 1/20) (completed) |
| 2 | Complete system level EMI/EMC test for Saffire V | 4/24/2020 (was 2/2020) (completed) |
| 3 | Complete Saffire V SFU random vibration test | 5/11/2020 (completed) (was 2/2020) |
| 4 | Modify foam for Saffire-V and VI in preparation for vibe tests | 4/1/2020 (completed) |
| 5 | Complete system-level thermal cycle test for Saffire-VI | 5/31/2020 (was 5/14/20) (completed) |
| 6 | Complete system level EMI/EMC test for Saffire-VI | 6/30/2020 (was 5/2020) (completed) |
| 7 | Complete Saffire-VI SFU random vibration test | 6/30/2020 (was 6/15/2020) (completed) |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Copy of the As-Run Test Procedure for the System-level thermal test report for Saffire-V | 1 (delivered) |
| Copy of the As-Run Test Procedure for the System-level EMI/EMC test report for Saffire-V | 2 (delivered) |
| Copy of the As-Run Test Procedure for the Saffire-V SFU random vibration test report | 3 (delivered) |
| Copy of the As-Run Test Procedure for the system-level thermal test for Saffire-VI | 5 (delivered) |

| Document Deliverables | Milestone |
|---|---|
| Copy of the As-Run Test Procedure for the system-level EMI/EMC test for Saffire-VI | 6 (delivered) |
| Copy of the As-Run Test Procedure for Saffire-VI SFU random vibration test | 7 (delivered) |

### 4.4 Subtask B2 – Acid Gas Aging Tests

The conceptual design for the Saffire units includes two bottles of acid gas, either HF or HCl. The ConOps timeline has approximately 3 months between shipment and launch with up to three months between launch and departure from ISS. Acid gas bottles for calibration are known to have a finite lifetime because these gases are known to react with the bottle material. The Contractor shall perform gas bottle aging tests to determine the rate of decay of the concentration of acid gas in flight-like bottles. Also, a control set of bottles should be prepared and filled at the same time as the flight bottles. The concentrations of these control bottles will be measured when the experiment operates.

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Refine the test plan for the Flight Control Acid Gas Aging Test | 3/13/2020 (was 10/2019) (completed) |
| 2 | Initiate Flight Control Acid Gas Aging Test for Saffire-IV | 5/22/2020 (was 11/2019) (completed) |
| 3 | Initiate Flight Control Acid Gas Aging Test for Saffire-V ~~Test Flight Control Acid Gas Cylinder~~ | 1/15/2021 (was 11/2020; 6, 5/2019) (completed) |
| 4 | Initiate Flight Control Acid Gas Aging Test for Saffire-VI | 03/2023 (was 3/2023; 06//2021) |

#### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone/Date |
|---|---|
| Test plan for the Flight Control Acid Gas Aging Test | 1 (delivered) |
| Report describing results from the flight control acid gas bottle for Saffire-IV | 2 (delivered) |
| Report describing results from the flight control acid gas bottle for Saffire-V ~~Report of the initial and final Flight Control Acid Gas Tests~~ | 3 (delivered) |
| Document the status and results of the bottle fill for the Flight Control Acid Gas Aging Test samples used in the Saffire-VI. | 4 |

## 4.5 Subtask B3 – Saffire Storage, Shipping, Integration, and Sustaining Engineering

The Saffire-IV, V, and VI flight systems (SFU, FFD, and Remote Sensors) are planned to be delivered to NASA following the System Acceptance Review. However, Saffire-VI was de-manifested from NG-15 shortly after the System Acceptance Review. Therefore, storage for an undetermined duration must be planned. The flight system will remain in storage until it is time to prepare the flight system for shipment. A storage plan must be developed to specify the current state of the flight system, identify any open work remaining on Saffire-VI, the frequency and scope of any periodic testing, and the tasks to be completed and schedule following storage to prepare the Saffire-VI for shipping to the launch site. The storage plan should also identify a mitigation plan for any limited life items in the flight system. Also, the Cygnus simulators at NASA and Contractor facilities require periodic re-certification. The re-certification can be performed by either NASA or Contractor personnel. The Contractor should plan to provide personnel to perform this re-certification at the required intervals.

Following the storage period, the hardware will be shipped from NASA to the Contractor site to fill the oxygen and reference gas bottles and then shipped directly to the launch site for integration. Integration of the hardware will be conducted by NGIS. Functional tests will be conducted by the NASA-led integration team and supported by the Contractor as necessary. Contractor personnel will be available to travel to the integration/launch site as necessary to support the activity. Following integration into the Cygnus vehicle, the Contractor shall provide sustaining engineering support during mission operations to review data as needed to help interpret data and sensor output.

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Fill oxygen and reference gas bottles for Saffire-IV | 11/30/2019 |

| Milestone Number | Milestone | Date |
|---|---|---|
| | | (completed) |
| 2 | Fill oxygen and reference gas bottles for Saffire-V | 6/4/2020 (was 3/2020) (completed) |
| 3 | Fill oxygen and reference gas bottles for Saffire-VI | 03/2023 (11/2021) |
| 4 | Perform re-certification of the Cygnus simulators | As required (was 3/2023) |
| 5 | Develop storage plan for Saffire-VI | 5/1/2021 (completed) |
| 6 | Conduct periodic testing as defined in storage plan | As required (was 8/2021) |
| 7 | Initiate Post-Storage activities per schedule | 01/2023 (was 12/2022) |
| 8 | Initiate Storage activities per schedule | 09/30/2021 |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.5.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Completed verifications of Saffire-IV oxygen and reference gas bottles | 1 (completed) |
| Completed verifications of Saffire-V oxygen and reference gas bottle filling | 2 (completed) |
| Completed verifications of Saffire-VI oxygen and reference gas bottle filling | 3 |
| Report documenting successful completion of the Cygnus Simulator re-certification procedure | 4 |
| Data report of periodic testing | 6 |

## 4.6 Subtask C – Saffire Project Management Task

The primary focus of this subtask will be the management of all tasks within this DO. This subtask will also control the project Configuration Management/Data Management (CM/DM), Systems Engineering and Integration (SE&I), and Safety and Mission Assurance (S&MA). This subtask will be ongoing throughout the life of the project and maintain a life cycle schedule to ensure work is being performed as planned. A life-cycle cost estimate will be updated and reported at project interim milestone reviews.

### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Update to Project schedule | Bi-Weekly |
| 2 | Status of Project Budget against plan | Monthly |
| 3 | Update Project Lifecycle cost as outlined in this CCR | 3/31/2020 (was 10/2019) (completed) |
| 4 | Update Project Lifecycle cost as outlined in this CCR | 3/31/2021 (completed) |
| 5 | Update Project Lifecycle cost as outlined in this CCR | 09/30/2021 |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| The contractor shall develop, maintain, and regularly report on the budget and schedule throughout the execution of the delivery order. | 1, 2 |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR | 3 (delivered) |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR | 4 (delivered) |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR | 5 |

## 4.7 Subtask C1 - Configuration Management/Data Management (CM/DM)

The Contractor shall implement Configuration and Data Management (C&DM) of requirements, documents, data, technical models, drawings, hardware, and ground support equipment associated with the Saffire IV, V, and VI flight hardware systems. The contractor's CM/DM system shall be compatible with the established Saffire GRC Engineering processes and tools

(GRC eRoom system and ProE) and shall provide the following: (1) configuration identification, (2) configuration control, (3) configuration status accounting and (4) configuration verification and audit.

The Contractor shall operate and maintain a CM/DM system(s) to ensure that proper controls are implemented to receive, store/archive, reproduce, distribute, and control project-related documentation and SW. The contractor shall deliver, at the conclusion of this DO, the CM/DM operation and maintenance procedures, as well as the documents, products, associated data and SW generated during the execution of the Saffire project.

The Contractor shall provide a Saffire CM/DM Manager and necessary staff and will be responsible for the implementation of the CM/DM function. The contractor shall maintain the CM/DM system in an organized logical fashion and provide training and/or training products to project personnel on CM/DM system and product review process. The Contractor data system shall be compliant with export control regulations. Any items considered Sensitive-But-Unclassified (SBU) must be handled in accordance with NASA Procedural Requirement (NPR) 1600.1, and must be clearly marked as SBU.

### 4.7.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Delivery of a list of CM documents and drawings created and uploaded to the contractor CM/DM system | Bi-weekly |

### 4.7.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.7.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| List of CM documents and drawings created and uploaded to contractor CM/DM system | 1 |

## 4.8 SUBTASK C2 - SYSTEMS ENGINEERING AND INTEGRATION (SE&I)

The contractor shall be responsible for all SE&I activities for the Saffire IV, V, and VI, including:

1) Systems Engineering: The contractor shall provide systems engineering support as required to all SE&I elements including requirement definition, manufacturing, product fabrication, interface definition and management, assembly and integration, verification and validation and test, external integration, and mission operations.
2) Assembly Integration and Test (AI&T): The contractor shall be responsible for the planning, implementation, and completion of all AI&T activities of the Flight System.

3) Verification and Validation (V&V): The contractor shall be responsible for the planning and completion of all V&V activities of the Flight and Ground System, including the development of associated verification documentation to close the open requirements in the ERD, ICD, Flight Safety Hazard Reports (HRs) and Ground & Launch Safety HRs.
4) Ground System: The contractor shall be responsible for the Development, Calibration, Maintenance, Operation, and Utilization of all Saffire Ground System Equipment (e.g. Ground Development Unit, Test Support Equipment, and Ground Support Equipment, etc.).
5) External Integration: NASA will provide lead personnel for the coordination of activities with NGIS and ISS. The contractor shall provide the necessary support for activities needed for the integration of Saffire IV, V, and VI flight systems including the development of tools, documents, and processes. Additionally, contractor personnel will support the Leads during all Saffire IV, V, and VI integration activities, including the preparation of equipment for shipment as well as the coordination with ISS and NGIS on all ISS and Cygnus-related issues for the Saffire flight units. The contractor will also participate in the development and maintenance of ISS interface requirements and definitions (Payload Integration Agreement, PIRN, etc.), Cygnus interface requirements and definitions (IRD, Mechanical and Electrical ICD, and Software ICD), and inputs for ISS and NGIS deliverables.
6) Specialty Engineering: The contractor shall provide a radiation hardness assessment on all electronics to determine 1) if the hardware is particularly susceptible to single-event effects (SEEs); 2) if SEE sensitive hardware is safety critical hardware associated with hazard controls; 3) the most probable loss in mission science data for SEE sensitive non-safety critical hardware. A cost and schedule estimate for radiation parts testing shall be provided for all safety critical electronics, and high impact components that, if an SEE occurred, could result in a complete or significant loss of science data

### 4.8.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Delivery of Verification Tracking Log update | Bi-weekly |

### 4.8.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.8.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Verification Tracking Log | 1 |

## 4.9 Subtask C3 - Safety and Mission Assurance (S&MA)

For Safety and Mission Assurance Management, the Contractor shall develop a Safety & Mission

Assurance (S&MA) Plan that documents the approach for developing, reviewing and reporting required tasks and analyses. The S&MA plan shall identify and describe the activities to be implemented during the development phase to ensure the design will meet flight requirements. The Contractor will implement and maintain a Continuous Risk Management process for the project and at a minimum include the NASA Project Manager, Chief Safety Officer, Chief Engineer, and Lead Systems Engineer on their Risk Review Board.

All processes used in the fabrication of flight hardware shall be qualified in accordance with NASA workmanship requirements or Contractor equivalent requirements. Personnel performing hands on fabrication, assembly, and inspection of flight hardware shall be trained and certified in accordance with NASA workmanship requirements or Contractor equivalent requirements. All electronic assemblies shall comply with the design, workmanship, and manufacturing requirements of NASA-STD-8739.1 Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies or Contractor equivalent process documents. Flight hardware shall be maintained in controlled storage areas. Access shall be controlled and limited to those persons involved in fabrication, test, and quality assurance tasks.

### 4.9.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Complete the Phase 3 Series/Reflight Flight Safety Review for Saffire V | 5/15/2020 (was 3/2020) (completed) |
| 2 | Complete the Ground Safety Data Package for Saffire-V | 6/5/2020 (was 3/2020) (completed) |
| 3 | Complete the Phase 3 Series/Reflight Flight Safety Review for Saffire VI | 6/30/2020 (10/2020) (completed) |
| 4 | Complete the Ground Safety Data Package for Saffire-VI | 1/30/2021 (10/2020) (completed) |

### 4.9.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

### 4.9.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Series/Reflight Flight Safety Data Package/Phase 3 Presentation for Saffire V | 1 (delivered) |
| Ground Safety Data Package for Saffire-V | 2 (delivered) |

| Document Deliverables | Milestone |
|---|---|
| Series/Reflight Flight Safety Data Package/Phase 3 Presentation for Saffire VI | 3 (delivered) |
| Ground Safety Data Package for Saffire-VI | 4 (delivered) |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AES | Advanced Exploration System |
| AI&T | Assembly Integration and Test |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| CM | Configuration Management |
| CO2 | Carbon Dioxide |
| ConOps | Concept of Operations |
| CPM | Combustion Product Monitor |
| DAQ | Data Acquisition System |
| DID | Data Item Description |
| DM | Data Management |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| ERD | Engineering Requirements Document |
| ESRD | Experiment SRD |
| FFD | Far-Field Diagnostic |
| FY | Fiscal Year |
| GRC | Glenn Research Center |
| HCL | Hydrochloric Acid |
| HEOMD | Human Exploration and Operations Mission Directorate |
| HF | Hardware Fabrication |
| HQ | Headquarters |
| HR | Hazard Report |
| HW | Hardware |
| ICD | Interface Control Document |
| IRD | Interface Requirements Document |
| ISS | International Space Station |
| JPL | Jet Propulsion Laboratory |
| NASA | National Aeronautics and Space Administration |

| Acronym | Description |
|---|---|
| **NGIS** | **Northrop Grumman Innovation System** |
| **NPR** | **NASA Procedural Requirement** |
| **O2** | **Oxygen** |
| **PCM** | **Pressurized Cargo Module** |
| **PIRN** | **Preliminary Interface Revision Notice** |
| **PRACA** | **Preventive and Corrective Action** |
| **Q** | **Quarter** |
| **RS** | **Remote Sensor** |
| **Saffire** | **Spacecraft Fire Experiment** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SBU** | **Sensitive But Unclassified** |
| **SDL** | **Structural Dynamics Laboratory** |
| **SE&I** | **Systems Engineering and Integration** |
| **SEE** | **Single Event Effects** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SFS Demo** | **Spacecraft Fire Safety Demonstration** |
| **SFU** | **Space Flyer Unit** |
| **SMA** | **Safety and Mission Assurance** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRR** | **System Requirements Review** |
| **V&V** | **Validation and Verification** |

**SPACEDOC-2 NNC14CA02C**
**DO-224 EHD**
**ElectroHydroDynamics (EHD)**
**For DO Period December 15, 2016 through March 31, 2023**
**For the Performance Period October 1, 2021 through February 28, 2023**

# 1 OVERVIEW

The "Electrically Driven Liquid Film Boiling in the Absence of Gravity," science experiment commonly called "Electrohydrodynamics" or "EHD," is an International Space Station Fluids Physics Research project. The project will be designed for use in the Microgravity Science Glovebox (MSG) of the ISS.

The experiment seeks to provide experimentally validated fundamental understanding of the electrically driven liquid film flow in the microgravity environment, and experimentally validated phenomenological foundation for the development of electric field based two-phase thermal management systems. This will be completed by demonstration that EHD conduction pumping can sustain liquid film boiling in the microgravity environment and that a material's critical heat flux is enhanced through EHD conduction pump. In addition, the dielectricphoretic (DEP) force in the presence of phase change and the absence of gravity will be investigated by demonstrating bubble departure effects with an applied DEP force during thin film boiling. Detailed experimental constraints and requirements are located in the Science Requirement Document (SRD).

NASA, specifically GSFC Thermal Engineering Branch, will provide technical parameters and design associated with the test chamber including the condenser, fluid supply, EHD electrode and DEP electrode. The Test Chamber will be provided as Government Furnished Equipment. The contractor shall work with the GSFC team to design and integrate the test chamber into the EHD system hardware. NASA will provide all verifications for the Test Chamber certification.

Assume there will be dry run presentations in preparation for major reviews.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through February 28, 2023.

## 1.2 GOVERNMENT CONTACTS

1) Project Manager, Cody Farinacci /GRC
2) Project Scientist, Mohammed M. Hasan /GRC
3) Co-Investigator, Jeffery Didion/GSFC

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) EHD Project Plan
2) EHD Science Requirements Document (SRD)
3) EHD Experiment Data Management Plan (EDMP)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

DO Manager, ISS and Human Health Projects Office, (Cody W. Farinacci, MS 77-7, NASA Glenn Research Center, Cleveland, OH 44135 cody.w.farinacci@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated bi-weekly.

2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) EHD Drop Tower Rig and associated hardware (as needed)
2) EHD Prototype Heaters (Qty3)
3) EHD Test Chamber (EM Unit, Qty 1)
4) EHD Test Chamber (Flight Unit, Qty 2)
   a. 2mm fluid fill level
   b. 3mm fluid fill level
5) CABLE, special purpose, Part number NDBC-TFE-22-2SJ-100, (Qty 32 ft.)

## 3.2 GOVERNMENT FURNISHED FACILITIES

The government shall make available on an as-needed basis for this period of performance:

1) Zero Gravity Research Facility
2) GRC Instrumentation Shop
3) GRC Building 333 rooms as requested
4) Bldg. 45, 2.2 Second Drop Tower
5) EHD Lab in Bldg. 110, Rm 220

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# 4 PROJECT SPECIFIC SOW

## 4.1 EHD REQUIREMENTS DEFINITION REVIEW (RDR)

A successful Science Concept Review (SCR) was held in July 2014 and this section of the Delivery Order will cover work toward a Requirements Definition Review.

The contractor shall:

Develop the EHD RDR products for an EHD system concept for a RDR review.

a) Provide the engineering artifacts required to meet the Entrance and Success Criteria for the RDR as specified in the ISS research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B.
b) Provide the EHD project with the EHD Product Breakdown Structure for the system development.

1) Review latest version of the EHD Science Requirements Document (SRD); NASA will provide.
2) Develop an EHD Engineering Requirements Document (ERD).

3) Develop concepts for imaging, thermoelectric cooler, voltage supply control unit and Data Acquisition and Control Unit (DACU).
4) Prepare an EHD Requirements Definition Review (RDR) presentation package.
5) Travel to PI and Co-I site.
6) Develop an Engineering Concept Design to layout the design concept details, identify any issues with meeting the science requirements, and present a plan and schedule to complete the design definition.
7) Develop preliminary software documents containing elements required for the Software Management Plan and the Software Development Plan.
8) Develop a preliminary Concept of Operations document to include the overall system including the experiment test chamber, measurement, imaging, software, avionics, support hardware and operations.
9) Act as systems integrator of the EHD system including the test section that is being developed by GSFC. This includes being the project interface to MSG.

#### 4.1.1 Milestones

The contractor shall meet the following milestones and participate in the following meetings and reviews. Dates with asterisks are provided for contractor long term planning and are not covered by the period of performance of this delivery order.

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Biweekly EHD team meetings and other meetings as needed. | On-going |

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

### 4.2 EHD PRELIMINARY DESIGN REVIEW (PDR)

The contractor shall:

1) Develop the Phase 0/1 Safety Data Package (Draft – 2 weeks prior to PDR) (carried forward A) Carried forward B

2) Act as system integrator of the EHD system including the Test Chamber that is being developed and verified by GSFC, this includes project interface to MSG (carried forward A) Carried forward B
3) PDR review Request for Action (RFA's) generated from the PDR meeting will be addressed (carried forward A) Carried forward B
4) Utilize the EHD drop tower rig at the 2.2 second drop tower as needed to develop the visualization of the Test Chamber initial fill level imaging.

The contractor shall meet the following milestones and participate in the following meetings and reviews.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | EHD Phase 0/1 Safety Data Package | December 2021 (was September 2021) Completed |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| EHD Phase 0/1 Safety Data Package | 1<br>December 2021<br>Completed |

#### 4.2.4 Travel

| Travel | Milestone Number |
|---|---|
| | |

### 4.3 EHD Critical Design Review (CDR)

The contractor shall:

1) Develop EHD system schedule to CDR. Carried forward B

2) Develop electrical design and drawings for the Engineering Model (EM) build hardware. Carried forward B

3) Develop mechanical design and drawings for the Engineering Model build hardware. Carried forward B

4) Develop test procedures to test the EHD Engineering Model system. Carried forward B

5) Build the EHD system Engineering Model hardware. Carried forward B

6) Test the EHD system Engineering Model hardware. Carried forward B

7) Integrate the Government Furnished Equipment (GFE) Test Chamber supplied by GSFC into the EHD system Engineering Model hardware. Carried forward B

8) Test the integrated EHD system with the Engineering Model hardware. Include the Test Chamber, Thermal Electric Cooler (TEC) and the EHD system hardware. Carried forward B

9) Conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the CDR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.

10) Support EHD Critical Design Review (CDR) (Conducted and Chaired by GRC). Carried forward B

11) Prepare documents for the EHD Phase 2 Flight Safety Review (FSR). Carried forward B

12) Conduct the Phase 2 Flight Safety Review (FSR). Carried forward B

13) Provide support to GSFC in their development of the EHD test chamber in the following capacities:

    a. Mechanical Engineering

    b. Electrical Engineering

    c. Safety Engineering

    d. Systems Engineering

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Critical Design Review (CDR) (Conducted and Chaired by GRC) | ~~No Later than February 2023 (Carried forward B)~~ Deleted |

### 4.3.2 H/W and S/W Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | Deleted |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| EHD Engineering Requirements Document (Released) | ~~1 2 weeks prior to CDR~~ Deleted |
| EHD Phase 2 Safety Data Package (Draft) | ~~1 2 weeks prior to CDR~~ Deleted |
| Interface Control Document (Released) | ~~1~~ Deleted |
| EHD Systems Drawings (80% Released)<br><br>Pro-E models of system and each subsystem (Released) | ~~1~~ Deleted |
| Verification Plan (Released) | ~~1~~ Deleted |
| Software Requirements Specification (Released)<br><br>Software Test Plan (Released)<br><br>Software Management and Development Plan (Released)<br><br>Software Design Description (Released)<br><br>Software Interface Design Document (Released) | ~~1~~ Deleted |
| CDR Artifacts to Meet the Entrance and Success Criteria | ~~1~~ Deleted |

| Document Deliverables | Milestone Number |
|---|---|
| CDR Presentation Materials | ~~1~~ Deleted |
| Phase 2 Flight Safety Review (FSR) data package | ~~1 +6 weeks~~ Deleted |
| Phase 2 Flight Safety Review Presentation | ~~1 +6 weeks~~ Deleted |

#### 4.3.4 Travel

| Travel | Milestone Number |
|---|---|
| N/A | Deleted |

### 4.4 EHD System Acceptance Review (SAR)

The contractor shall:

1) Develop EHD system schedule to SAR.
2) Develop electrical design and drawings for the Flight build hardware.
3) Develop mechanical design and drawings for the Flight build hardware.
4) Develop test procedures to test the EHD Flight system.
5) Build the EHD system Flight hardware.
6) Test the EHD system Flight hardware.
7) Integrate the Government Furnished Equipment (GFE) Test Chamber supplied by GSFC into the EHD system Flight hardware.
8) Test the integrated EHD system with the Flight hardware. Include the Test Chamber, Thermal Electric Cooler (TEC) and the EHD system hardware. Tests to include
   a. Functional
   b. Environmental
   c. MSG integration test (at MSFC)
9) Report progress against verification plan activities.
10) Prepare documents for the EHD Phase 3 Flight Safety Review (FSR).

11) Conduct the Phase 3 Flight Safety Review (FSR).

12) Conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the SAR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest. Any tailoring of the review criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.

13) Support the EHD System Acceptance Review (SAR) (Conducted and Chaired by GRC).

14) Provide support to GSFC in their development of the EHD test chamber in the following capacities:

a. Mechanical Engineering

b. Electrical Engineering

c. Safety Engineering

d. Systems Engineering

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | System Acceptance Review (SAR) (Held and Chaired by GRC) | ~~February 2025 *~~ ~~(was January 2024*)~~ Deleted |

*** Items are outside DO period of performance end date; dates are through March 31, 2023.**

#### 4.4.2 H/W and S/W Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| EHD Full Experiment (incl. SW) | ~~1~~ Deleted |

#### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase 3 Flight Safety Review (FSR) data package | ~~3 – 4 weeks Prior to 1~~ Deleted |

| Document Deliverables | Milestone Number |
|---|---|
| Phase 3 Flight Safety Review Presentation | ~~3 – 4 weeks Prior to 1~~ Deleted |
| SAR Artifacts to Meet the Entrance and Success Criteria | ~~1~~ Deleted |
| SAR Presentation Package | ~~1~~ Deleted |

### 4.4.4 Travel

| Travel | Milestone Number |
|---|---|
| Travel to Principal Investigator, Co-Investigator and MSFC | ~~Prior to 1~~ Deleted |

## 4.5 EHD Project Closeout Tasks

With the addition of section 4.5, all SOW items and deliverables in Sections 4.1 to 4.4 have been deleted. Section 4.5 describes tasks required for Project Closeout.

The contractor shall:

1) Close out in-process Manufacturing Work Orders.
2) Transfer documents to GRC for archiving.
    a. Completed documents - send as-is
    b. In-process documents – label as incomplete, then send
3) Transfer drawings to GRC for archiving.
    a. Completed drawings - send as-is
    b. In-process drawings – label as incomplete, then send
4) Disposition open Purchase Orders and Purchase requests.
5) Perform inventory and equipment reconciliation activities. These activities may include transfer of materials to GRC, transfer of materials to other ZIN projects, and the excess of materials
6) Support Project Lessons Learned solicitation and disposition

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **Co-I** | **Co-Investigator** |
| **COR** | **Contracting Officer Representative** |
| **DACU** | **Data Acquisition and Control Unit** |
| **DEP** | **Dielectricphoretic** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EDMP** | **Experiment Data Management Plan** |
| **EHD** | **ElectroHydroDynamics** |
| **EM** | **Engineering Model** |
| **ERD** | **Engineering Requirements Document** |
| **FSR** | **Flight Safety Review** |
| **GFE** | **Government Furnished Equipment** |
| **GRC** | **Glenn Research Center** |
| **GSFC** | **Goddard Space Flight Center** |
| **ISS** | **International Space Station** |
| **MSG** | **Microgravity Science Glovebox** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PDR** | **Preliminary Design Review** |
| **PI** | **Principal Investigator** |
| **RDR** | **Requirements Definition Review** |
| **RFA** | **Request for Action** |
| **SCR** | **Science Concept Review** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SLPSRA** | **Space Life and Physical Sciences Research and Application** |
| **SMAP** | **Safety and Mission Assurance Plan** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **TEC** | **Thermal Electric Cooler** |

**SpaceDOC-2 NNC14CA02C**
**DO-229 ACME MI&O**
**Advanced Combustion via Microgravity Experiments**
**Mission Integration and Operations**
**For Contract Performance Period May 1, 2017 through March 31, 2023**
**For the Performance Period October 1, 2021 through June 30, 2023**

# 1 OVERVIEW

Advanced Combustion via Microgravity Experiment (ACME) is a Chamber Insert Assembly (CIA) designed to operate as a sub-rack payload in the NASA International Space Station (ISS) Combustion Integrated Rack (CIR) from September 2017 (ISS Increment 53) through July 2020 (ISS Increment 64). The insert will function as an experiment platform for 5 gaseous flow combustion experiments (CLD Flame, E-FIELD Flames, BRE, s-Flame, and Flame Design).

The purpose of this work effort is to support console operations for the five (5) ACME investigations. Specifically, this effort will provide an ACME Payload Developer (PD) console operator to operate the insert during test point operations. The effort will involve periodic meetings with the ACME science team in order to understand near term science objectives and to develop a plan for optimizing the system configuration to meet those objectives.

This Statement of Work (SOW) also includes the delivery of flight hardware that has been identified as critical flight spares for science. The effort includes building two (2) 14-micron Thin Fiber Pyrometry Arrays and two sets of ten (10) Igniter Tip Assemblies, two (2) Igniter Tip Holders, and three (3) flight Spherical Burners. The igniter tip geometry will be of a new design but the mounting and insulator will reaming the same. The flight hardware as described above was completed and delivered.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through June 30, 2023.

## 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

1) GRC DO Manager
2) ACME Project Scientist
3) Principal Investigators for ACME experiments

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Experiment Data Management Plan (EDMP)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

DO Manager, ISS and Human Health Office (Xuan Nguyen, Mail Stop 77-7, xuan.t.nguyen@nasa.gov, Research Center, Cleveland, OH 44135)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office, Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) ACME Ground Integration Unit (GIU) hardware

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) Telescience Support Center in Building 333
2) Combustion Integrated Rack (CIR) Ground Integration Unit (GIU) in Building 333

---

# 4 PROJECT SPECIFIC SOW

## 4.1 ACME MIO

The contractor shall (1) provide an ACME Payload Developer (PD) console operator to operate the ACME insert during test point operations and (2) participate in the meetings and reviews listed in Section 4.1.1. A Mission Sequence Test (MST) and an Operations Readiness Review (ORR) shall be completed prior to the start of operations for each ACME investigation. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations. For planning purposes, the contractor shall assume eight (8) test point operation days per month, each having a duration of eight (8) hours.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | ACME Science Team Meeting, Bi-Weekly | Complete |
| 2 | s-Flame MST | Complete<br>(To be completed prior to starting s-Flame Part 1 Test Point Operations (carried forward A)) |
| 3 | s-Flame ORR | Complete |

| Milestone Number | Milestone | Date |
|---|---|---|
| | | (To be completed prior to starting s-Flame Part 1 Test Point Operations (carried forward A)) |
| 4 | s-Flame Part 1 Test Point Operations, Beginning | Complete<br>(8/2019 (carried forward A)) |
| 5 | BRE Part 2 Test Point Operations, Beginning | Increment 63<br>(was 9/2019)<br>Complete |
| 6 | s-Flame Part 2 Test Point Operations, Beginning | Complete<br>(11/2019) |
| 7 | Flame Design Part 2 Test Point Operations, Beginning | Increment 66 , 11/2021<br>(was Increment 63,1/2020) |
| 8 | CLD Flame Part 3 Test Point Operations, Beginning | Increment 64<br>(was 4/2020)<br>Complete |
| 9 | CFIG MST | (To be completed prior to starting CFIG Test Point Operations)<br>Complete |
| 10 | CFIG ORR | (To be completed prior to starting CFIG Test Point Operations)<br>Complete |
| 11 | CFIG Test Point Operations, Beginning | Increment 64<br>Complete |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| N/A | |

## 4.2 ACME PROJECT CLOSEOUT REVIEW

The contractor shall participate and contribute to the Project Closeout Review (PCR) for ACME investigations listed in sections 4.2.1 (Milestones and Reviews)

The contractor shall prepare and provide all the project deliverables and documentation including project lifecycle costs, schedules, problem reports, anomalies, corrective action requests, lessons learned, and other documents as identified in the PCR Entrance and Success Criteria (E&SC).

The contactor shall support NASA PM, prepare, and conduct PCRs per NASA/GRC/Code M PCR Guide. The PCR for each ACME investigation will be conducted using the NASA/GRC PCR presentation template and PCR E&SC.

The contractor shall complete and deliver the post-flight reports/plans including Report on overall post -recovery condition, Post -flight anomalies reports, Hardware Retention plans, and Post flight hardware data assessment plan to NASA after the flight hardware is returned.

Reference attachments: Project Closeout Review Guide (PCRG).pdf, PCR Presentation Template.pptx, and PCR Entrance and Success Criteria.docx.

### 4.2.1 Milestones and Reviews

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | E-Field Flames PCR | March 31, 2022<br>Complete |
| 2 | s-Flames PCR | May 3, 2022<br>(was 4/2022)<br>Complete |
| 3 | BRE PCR | May 31, 2022<br>Complete |
| 4 | CDL Flame PCR | July 7, 2022<br>(was 6/2022)<br>Complete |
| 5 | Flame Design PCR | August 4, 2022<br>(was 7/2022)<br>Complete |

### 4.2.2 Document Deliverables

| Document Deliverables | Milestone/Date |
|---|---|
| All project documentation required to complete E-Field Flames PCR | 1 |
| All project documentation required to complete s-Flames PCR | 2 |
| All project documentation required to complete BRE PCR | 3 |
| All project documentation required to complete CDL PCR | 4 |

| Document Deliverables | Milestone/Date |
|---|---|
| All project documentation required to complete Flame Design PCR | 5 |
| ACME Post-Flight Hardware Assessment Report | May 31, 2023<br>(was 2/28/23) |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **ACME** | **Advanced Combustion via Microgravity Experiments** |
| **BRE** | **Burning Rate Emulator** |
| **CCR** | **Configuration Change Request** |
| **CDRL** | **Contract Data Requirements List** |
| **CFIG** | **Cool Flame Investigation with Gases** |
| **CIA** | **Chamber Insert Assembly** |
| **CIR** | **Combustion Integration Rack** |
| **CLD** | **Co-flow Laminar Diffusion** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EDMP** | **Experiment Data Management Plan** |
| **E-FIELD** | **Electric-Field Effects on Laminar Diffusion** |
| **GIU** | **Ground Integration Unit** |
| **GRC** | **Glenn Research Center** |
| **ISS** | **International Space Station** |
| **MIO (MI&O)** | **Mission Integration and Operations** |
| **MST** | **Mission Sequence Test** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **ORR** | **Operations Readiness Review** |
| **PCR** | **Project Closeout Review** |
| **PD** | **Payload Developers** |
| **PRACA** | **Preventive and Corrective Action** |
| **S-FLAME** | **Spherical Flame** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **SRD** | **Science Requirement Definition** |

**SpaceDOC-2 NNC14CA02C**
**DO-251(FBCE - GIU and TMAs)**
**Flow Boiling and Condensation Experiment (FBCE) – Ground Interface Unit (GIU) and Test Modules Assemblies (TMAs)**
**Contract Performance Period September 15, 2020 through March 31, 2023**
**DO Performance Period October 1, 2021 through March 31, 2023**

# 1 OVERVIEW

The Flow Boiling and Condensation Experiment is a sub-rack payload operating in the NASA International Space Station (ISS) Fluids Integrated Rack (FIR) since December 2021. The insert will function as an experiment platform for various flow boiling and condensation experiments. The current flight hardware for FBCE was developed, built, and tested by a team at NASA Glenn Research Center. They did not build a duplicate Ground Integration Unit (GIU) that will assist in future experiment module testing, along with on-orbit anomaly resolution.

The purpose of this work effort is to build equivalent units for use in the FIR GIU located at NASA GRC. The effort will involve build to print development and test of the duplicate units, along with identifying any build or potential design issues that may need to be resolved. The build and delivery of GIU hardware that can be developed at the "Qualification level 2", flight support hardware process. The effort includes building FBCE Fluid Module 1 (FSML), FBCE Fluid Module 2 (FSMU), FBCE Heater (BHM) and associated cabling, hoses and accumulator assemblies. All NASA drawings will be provided for the performance of this effort.

This Statement of Work (SOW) also includes the completion the Condensation Test Module currently being build by NASA GRC. NASA will provide the Condensation Test Module as Government Furnished Equipment (GFE) and this effort will be to complete the verification and testing required for launch and operation on ISS. Additionally, the Avionics 1 and Avionics 2 modules encountered issues during FBCE EMI testing, and the fix was the built up of a Power Filter Module (PFM). This work effort will include assessment of the feasibility of correcting the EMI issue that resulted in the Power Filter Module and build two new the Avionics 1 and Avionics 2 modules (and Power Filter module, if required) to Qual Period of Performance.

Due to budget issues in FY22, the contractor was given a stop work on the GIU task. However, several activities were in process and the following is intended to clarify how the contractor is to proceed with the open work to get it to an appropriate stopping point. Specifically, the contractor shall:

- Have QA mark as incomplete the 6 GIU cables that are built but require HIPOT testing to become qualified for use. Document the assembly and return items to stores.
- Complete the redlines and QA inspection for the Power Filter Module process plan in order to close out the Power Filter Module assembly.
- For FBCE2-ECO-069 to modify BHM, complete the review and leave as approved but "not incorporated"
- Cancel the workflow for the weld procedures in support of drawings in initial COMET review that was needed to close out 11 mechanical drawings.

- Cancel the workflow for the 11 mechanical drawings that require updates to the weld procedure
- Complete the signature cycle for the 8 electrical drawings
- Receive parts as normal and resolve issues (but note issues for anything that will require significant work) for incoming parts for the approximately $29K of parts for the GIU that have been ordered by not yet received and are non-cancelable.
- Mechanical and electrical drawings not yet in the review cycle are to be stopped immediately.
- ECO's that have been approved but not incorporated will remain in that state.
  - Process plans and assembly procedures not currently in the review cycle have been stopped. The document numbers will remain in place as "draft".

Upon completion of the above, all effort with the FBCE GIU will end.

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2021 through March 31, 2023.

### 1.2 Government Contacts

1) GRC DO Manager (FBCE Project Manager), Nancy R. Hall
2) GRC BPS Program Manager, Kelly Bailey
3) GRC FBCE Condensation Test Module Product Lead Engineer, Jeff Mackey
4) GRC FBCE Software Lead, Rochelle May

### 1.3 Available Project Specific Documentation

1) FBCE Project Plan, FBCE-DOC-004
2) FBCE SRD (Flow Boiling Module and Condensation Test Module)
3) FBCE Design Description Document, FBCE-DOC-025
4) FBCE Mission Operations Document, Rev A, FBCE-DOC-074
5) Access to the FBCE Sharepoint site with all FBCE documentation
6) FBCE Drawing Package (~543 drawings)
7) FBCE Build Books
8) FBCE Process Plans

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

# 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/N. Hall, Mail Stop 77-7, Nancy.R.Hall@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

SpaceDOC-2 COR (Kelly Bailey, Mail Stop 77-7, kelly.a.bailey@nasa.gov)

Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule, load and leveled for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated monthly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1. FBCE Residual Hardware residing in NASA Bonded Storage (listing to be provided)

### 3.2 Government Furnished Facilities

The Government shall make available, on an as needed basis, the following Government facilities:

1. Thermal Environmental Chamber in Building 332
2. Structural Dynamics Laboratory in Building 55
3. EMI Laboratory in Building 332
4. GRC Telescience Support Center (TSC)
5. FBCE Integrated Requirements & Software Test Environment (FIRSTE) Lab, Bldg 110, Rm 220 (New Location of the FBCE Brassboard)

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## 4 PROJECT SPECIFIC SOW

### 4.1 FBCE Ground Integration Unit – All this effort has been deleted

~~The contractor shall build to print the FBCE GIU assembly and then test, verify, and delivery the following hardware and TADS specific software: FBCE Fluid Module 1 (FSML), FBCE Fluid Module 2 (FSMU), FBCE Heater (BHM), Avionics 1 (RDAQM-1), Avionics 2 (RDAQM-2) and associated cabling, hoses, accumulator assemblies and support hardware per provided NASA Drawings. The hardware shall be developed at a Qualification 2 level except for Avionics 1 (RDAQM-1) which shall be built to Qualification 1 level. The key review for this phase of development is a Validation/Verification Review/ to show the GIU will function as a ground unit for FBCE Operations during subsystem checkout and in the FIR GIU.~~

~~Specifically, the contractor shall:~~

- ~~Review all NASA provided drawings and redlines. Disposition all ECO's and redlines. Incorporate all changes and release new drawings with all changes incorporated. All unresolved issues or obsolete parts will require new design. Archive and control all documents, artifacts, and hardware of the GIU via internal configuration and bonded storage management and controls.~~
- ~~Assemble, test, verify, and validate the FBCE GIU hardware including necessary software and any required ground support equipment, functions as intended via Mission Simulation Testing (MST) and Functional Testing.~~
- ~~Archive and control all documents, artifacts, and hardware of the GIU via internal configuration and bonded storage management and controls.~~
- ~~*The NASA FBCE Flight Software team will lead all the flight software activities with the contractor providing software support (i.e. TADS) for all flight and ground activities*~~

~~Develop The Avionics 1 (RDAQM1) as QUAL 1 and Avionics 2 (RDAQM2) as Qual 2 GIU modules to replicate the design per section 4.2 of the DO. Provide schedule milestones by module (FBCE Fluid Module 1 (FSML), FBCE Fluid Module 2 (FSMU), FBCE Heater (BHM), Avionics 1 (RDAQM-1), Avionics 2 (RDAQM-2).~~

~~Provide two distinct schedules, one schedule with only the flight Avionics (RDAQM) -1, -2 and Condensation Test Module effort and a second schedule with only the notional FBCE GIU effort.~~

~~A Final Design review will be held to discuss any changes to NASA provided drawings to address obsolete parts and any new design changes.~~

~~Coordinate with NASA software team to load software on the GIU and support the verification and validation testing.~~

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~FBCE Verification/Validation Review~~ | ~~August 31, 2022 (was 10/2021)~~ DELETED |
| ~~2~~ | ~~FBCE GIU Acceptance Test~~ | ~~September 30, 2022 (was 3/2022)~~ DELETED |
| ~~3~~ | ~~FBCE GIU Hardware Build Complete~~ | ~~September 30, 2022 (was 1/2023)~~ DELETED |
| ~~4~~ | ~~Final Design Review~~ | ~~February 28, 2022~~ DELETED |
| ~~5~~ | ~~FBCE GIU MST/TC Characterization TRR~~ | ~~September 30, 2022~~ DELETED |
| ~~6~~ | ~~FBCE GIU MST/TC Characterization Testing~~ | ~~October 1, 2022~~ DELETED |
| ~~7~~ | ~~Hardware Turnover of GIU~~ | ~~October 15, 2022~~ DELETED |
| ~~1~~ | ~~FBCE GIU Hardware Build Continuance Review~~ | ~~February 17, 2023~~ DELETED |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number or Date |
|---|---|
| ~~FBCE Verification/Validation Review Charts~~ | ~~1 week before review~~ DELETED |

| HW/SW Deliverable | Milestone Number or Date |
|---|---|
| ~~FBCE GIU hardware~~ | ~~7~~ DELETED |
| ~~FBCE GIU Hardware Build Notional Schedule~~ | ~~1~~ DELETED |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| ~~Any revised Drawings~~ | ~~1~~ DELETED |
| ~~Final Design Review Chart Package~~ | ~~4~~ DELETED |
| ~~FBCE GIU MST TRR Chart Package~~ | ~~5~~ DELETED |
| ~~Completed MST As-Run Report (Test Log)~~ | ~~6~~ DELETED |
| ~~FBCE GIU Hardware Build Continuance Review package~~ | ~~2 weeks before review~~ DELETED |

## 4.2 FBCE Avionics 1 and Avionics 2 Modules Qual 1 units

The Avionics 1 (RDAQM1) and Avionics 2 (RDAQM2) modules encountered issues during FBCE EMI testing, and the fix was the built up of a Power Filter Module (PFM). The contractor shall assess the feasibility of correcting the EMI issue that resulted in the Power Filter module. The government will provide a summary of the Engineering Review Board (ERB) on the EMI issues as well as access to key NASA and contractor personnel involved with this activity.

The contractor shall build the Avionics 1 and Avionics 2 modules (and Power Filter module if required) to Qual level 1. Avionics 1 is needed for thermocouple characterization and final flight verifications with the Condensation Test Module flight unit. Test boxes will be needed for the Avionics modules in order to complete verification testing. It is expected that the Avionics 1 Module will be launched with the Condensation Test Module. Due to the schedule associated with test boxes, only the test box for Avionics 1 will continue on schedule. Avionics 2 and the test box for Avionics 2 will continue with its build but is a lower priority schedule-wise. Avionics 2 will not launch with Avionics 1 and CMHT. No environmental testing is required for Avionics 2. The key review for this phase of development is a Critical Design Review with Phase III Safety Review and SAR (Systems Acceptance Review) for the Avionics Modules and Condensation Test Module. The contractor shall hold a Requirements and Verification review to present the plan for requirement closure and obtain concurrence from NASA. This will include ERD, ICD, SAR and SVTL and shall describe which items are closed by similarity and which will require new closure documentation.

Provide two distinct schedules, one schedule with only the flight Avionics (RDAQM) -1, -2 and Condensation Test Module effort and a second schedule with only the notional FBCE GIU effort.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Avionics Redesign CDR (Internal ZIN) | January 26, 2021 (was 12/2020) COMPLETED |
| 2 | Phase III Safety Review for Avionics 1,2 (to be conducted with Condensation Test Module Phase III Review) | December 1, 2022 (was 11/2022, 8/2022) COMPLETED |
| 3 | System Acceptance Review | January 13, 2023 (was 12/2022, 11/2022, 9/2022) |
| 4 | Requirements and Verification Summit (Avionics) | May 31, 2022 COMPLETED |
| 5 | Avionics 1 Hardware Assembly Complete | January 6, 2023 (was 11/2022, 5/2022) |
| 6 | Avionics 2 Hardware Assembly Complete | January 6, 2023 (was 10/2022) |
| ~~7~~ | ~~System Acceptance Review~~ | ~~December 12, 2022~~ DELETED |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Avionics 1 | 3 |
| Avionics 2 | 3 |
| ~~New Cables, if required~~ | ~~7~~ DELETED |
| ~~Revised Avionics Software, if required~~ | ~~5~~ DELETED |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number or Date |
|---|---|
| Revised Drawings and Process Plans | 3 |

| Document Deliverables | Milestone Number or Date |
|---|---|
| Phase III Safety Data Package | 2<br>COMPLETED |
| System Acceptance Review Package | 1 week before SAR |
| Verification Tracking Log | 4 |

### 4.3 FBCE Condensation Test (CM-HT) Module

NASA GRC manufacturing is working on completing the Condensation Test Module test section fabrication and assembly of the thermocouple probes, brazed tube assembly, wiring and instrumentation. Upon completion of this work, the contractor shall support the Condensation Test Module test section thermocouple characterizations with the Avionics Modules. Then NASA GRC will complete the assemble the Condensation Test Module.

The key review for the Condensation Test Module is the Phase III Safety Review and the combined SAR (Systems Acceptance Review) for the Avionics Modules and Condensation Test Module Assembly.

Specifically, the contractor shall:

- Develop a verification and validation plan, distinguishing between NASA and ZIN closure responsibility. Present this at a verification review to obtain concurrence from NASA.
- Integrate, test, verify and validate the Avionics hardware with the Condensation Test Module, including necessary software and any required ground support equipment.
- Provide load data, based on launch vehicle, to NASA to support the updated structural and load analysis being done to add the Condensation tube with standoff to NASA's structural analysis model.
- Archive and control all documents, artifacts, and hardware via internal configuration and bonded storage management and controls.
- Coordinate with the ZIN FBCE MI&O tasks as well as FCF Ops team for activities needed to be performed on the hardware prior to shipping the hardware or to get it ready for Operations. Integration and hardware turn over shall be performed on DO-234 FBCE MIO task.
- Provide two distinct schedules, one schedule with only the flight Avionics (RDAQM) -1, -2 and Condensation Test Module effort and a second schedule with only the notional FBCE GIU effort.

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~Condensation Test Module /Avionics Test Readiness Review (ZIN Internal)~~ | ~~March 31, 2022 (was 12/2020)~~ DELETED |
| 2 | Condensation Test Module Phase III Safety Review (to be conducted with Avionics -1 Safety Review) | December 1, 2023 (was 11/2022, 5/2022) COMPLETED |
| 3 | Condensation Test Module SAR | January 13, 2023 (was 12/2022, 11/2022, 6/2022) |
| 4 | ~~Condensation Test Module Launch~~ | ~~September 30, 2022*~~ DELETED |
| ~~5~~ | ~~Condensation Test Module Operational Readiness Review~~ | ~~December 2022*~~ DELETED |
| 6 | Condensation Test Module Requirements and Verification Summit | June 14, 2022 COMPLETED |
| 7 | Thermocouple Characterization Test Readiness Review | May 15, 2022 COMPLETED |
| ~~8~~ | ~~Condensation Test Module SAR~~ | ~~December 12, 2022~~ DELETED |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number or Date |
|---|---|
| ~~Process Documentation~~ | ~~2~~ DELETED |
| ~~Environmental Verification Documentation~~ | ~~March 30, 2022~~ DELETED |
| Phase III Safety Data Package | 2 |

| Document Deliverables | Milestone Number or Date |
|---|---|
| System Acceptance Review Package | One week before review |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **BHM** | **FBCE Heater** |
| **BPS** | **Biological and Physical Sciences** |
| **CCR** | **Configuration Change Request** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **COR** | **Contracting Officer Representative** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EMI** | **Electromagnetic Interference** |
| **ERB** | **Engineering Review Board** |
| **ERD** | **Engineering Requirements Document** |
| **FBCE** | **Flow Boiling Condensation Experiment** |
| **FCF** | **Fluids and Combustion Facility** |
| **FIR** | **Fluids Integration Rack** |
| **FSML** | **FBCE Fluid Module 1** |
| **FSMU** | **FBCE Fluid Module 2** |
| **GFE** | **Government Furnished Equipment** |
| **GIU** | **Ground Integration Unit** |
| **GRC** | **Glenn Research Center** |
| **HIPOT** | **High Potential** |
| **ICD** | **Interface Control Document** |
| **ISS** | **International Space Station** |
| **MST** | **Mission Simulation Testing** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PFM** | **Power Filter Module** |
| **PRACA** | **Preventive and Corrective Action** |
| **QA** | **Quality Assurance** |
| **RDAQM** | **Remote Data Acquisition Module** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SOW** | **Statement of Work** |

| Acronym | Description |
|---|---|
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **SVTL** | **Safety Verification Tracking Log** |
| **TMA** | **Test Module Assembly** |
| **TSC** | **Telescience Support Center** |

**SPACEDOC-II NNC14CA2C**
**DO-254 MAMS Re-Flight**
**Microgravity Acceleration Measurement System (MAMS) Re-Flight (RF)**
**Contract Period November 15, 2020 through March 31, 2023**
**DO PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH SEPTEMBER 30, 2023**

# 1 OVERVIEW

The Acceleration Measurement Project at the Glenn Research Center (GRC) is comprised of three closely related projects: the Microgravity Acceleration Measurement System (MAMS) project, the Space Acceleration Measurement System (SAMS) project, and the Principal Investigator Microgravity Services (PIMS) project. The MAMS and SAMS projects complement each other relative to the frequency spectra they are responsible for measuring on the International Space Station (ISS). The PIMS project provides real-time and offline analysis of the acceleration data received from these unique instruments. The acceleration measurement sustaining engineering support task for SAMS and MAMS is covered under SpaceDocII BaseTask 2, but this work for refurbishment and re-qualification of the MAMS unit needs to be managed under a separate Delivery Order.

The SAMS and MAMS payloads were launched on Space Shuttle Flight 6A (April 2001) and the SAMS system continues operating on board the International Space Station (ISS). The MAMS unit sustained a failure in April 2017 and has been returned for repair and re-flight.

The results from the MAMS system Post Flight Assessment Report (PFAR) indicated a failure in the Central Processing Unit (CPU) board, thus rendering MAMS non-functional. ZIN has isolated the problem to a memory card and has been able to demonstrate the OSS sensor remains functional. This DO will focus on development of supporting electronics and software to return the MAMS to its original functionality.

The new MAMS instrument will be located in a double ISS locker. Unlike its predecessor, the new MAMS unit will only contain the OARE Sensor Subsystem (OSS); it will not include the High-Resolution Accelerometer Package (HiRAP). The OSS quasi-steady acceleration data are routed to the ground by the MAMS computer, located within the MAMS ISIS drawer volume. The OSS and its bias calibration table will be located in a double ISS locker location.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2021 through September 30, 2023.

## 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

a) GRC Project Manager, Kevin McPherson (MSI)

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

a) NPR 7120, NASA Space Flight Program and Project Management Requirements
b) NPR 7123, NASA Systems Engineering Processes and Requirements

c) PIMS-ISS-001revB, PIMS Software Requirements for Processing Acceleration Data from the International Space Station
d) PIMS-ISS-100_revBaseline, PIMS International Space Station System Reference Document
e) SP401010 MAMS Software Requirements Document
f) SP401011 MAMS Processing and Control Systems Programmer's Interface Manual
g) Canopus Systems MAMS TR008 MAMS Maintenance and Operations Manual

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/Kevin McPherson, MS 77-7, Kevin.M.McPherson@nasa.gov

Configuration Management Office, Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

Standard document deliverables shall be as follows:

a) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated weekly.
b) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
d) Monthly reporting, per DID# CD-02, ON-GOING
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
f) Lessons Learned Report per DID PA-17, Draft due at the end of the PoP

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

a) MAMS OSS Sensor, all associated GSE, and all available documentation
b) Additional hardware from MAMS flight system at GRC
c) EXPRESS double locker hardware from the original MAMS flight unit and ProE model of EXPRESS double locker.

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

a) NASA Glenn Telescience Support Center
b) NASA Glenn EMI Lab (Building 332)
c) NASA Glenn Thermal Lab (Building 332)
d) JSC Joint Station LAN
e) MSFC EXPRESS Test Facilities

Usage shall be agreed upon by and coordinated with the NASA Project Manager.

# 4 PROJECT SPECIFIC SOW

## 4.1 GENERAL DEVELOPMENT APPROACH

Since the electronics from the original MAMS flight are 20+ years old, the MAMS Re-Flight Engineering Requirements Document will be used to generate a detailed design for the updated MAMS electronics and mechanical housing. The MAMS re-flight design will utilize the existing MAMS OSS sensor, its associated Bias Calibration Table Assembly (BCTA), the MAMS OARE Interface Sub-system (MOIS), and the custom Driver/Receiver card within the original MAMS Processor Control Sub-system (MPCS). All sub-assemblies shall be housed in an ISS EXPRESS double locker. Any new supporting electronics will also be house in the EXPRESS double locker.

Flight software and ground software development should leverage existing MAMS flight code as well as ground infrastructure code available for capturing, processing, and archiving all MAMS acceleration data and MAMS housekeeping data. This code re-use should not be limited to code specific to the MAMS OSS sensor operations and bias calibration, but also any code associated with interfacing to the host EXPRESS rack.

ZIN will generate all necessary integration paperwork for launch and integration on the ISS. This includes all verification paperwork and any crew training processes and procedures, including any On-Board Training materials for the use by the ISS crew. ZIN is responsible for transportation of the MAMS system to JSC and/or MSFC for any integrated training, as well as final delivery to JSC for launch preparation.

## 4.2 System Requirements Review (SRR) - COMPLETED

The primary focus of this subtask will be to finalize the engineering requirements for the re-packaged MAMS flight unit (double ISS locker) and the operations approach.

The contractor shall conduct an SRR after completion of the MAMS requirements and the concept of operations documents are complete:

1) Prepare the updated MAMS requirements document and updated Concept of Operations document
2) Conduct the SRR with the participation of appropriate NASA personnel
3) Success criteria for the SRR are:
    a. Disposition of comments from the Systems Requirements Review Board, as agreed by the ZIN and NASA project managers
    b. Concept of Operations document is approved
    c. All requirements for the updated MAMS design are properly documented in an Engineering Requirements Document (ERD)

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Conduct the SRR | Delivery Order Initialization + 60 days |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | 1 |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| SRR Artifacts to Meet the Entrance and Success Criteria | 1 |
| SRR Presentation Materials | 1 |

## 4.3 Critical Design Review - COMPLETED

The primary focus of this subtask will be to design and analyze the hardware for the repackaged MAMS flight unit (double ISS locker). The contractor shall develop the final design for the MAMS that meets the requirements of the MAMS Engineering Requirements Document.

The contractor shall convene a CDR Board with NASA PM participation for the Critical Design Review. The contractor shall conduct a design prior to the start of fabrication and assembly:

1) Prepare the final update for the updated Concept of Operations document
2) Conduct the CDR with the participation of appropriate NASA personnel
3) Success criteria for the CDR are:
   a. Disposition of comments from the Critical Design Review Board, as agreed by the ZIN and NASA project managers
   b. Design information documented, test and verification approach documented, and/or actions addressed and closed at CDR to clarify/correct design information
   c. Final release of Concept of Operations document is approved

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Conduct the CDR | January 28, 2022<br>Complete |
| 2 | Disposition/Close engineering related actions, agreements or Requests for Action (RFAs) resulting from the CDR | February 11, 2022<br>Complete |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| CDR Artifacts to Meet the Entrance and Success Criteria | 1 |
| CDR Presentation Materials | 1 |

## 4.4 MAMS Flight System Acceptance Review

The primary focus of this subtask is to finalize the design of the MAMS unit and then procure materials, fabricate, assemble, and test the flight hardware. The contractor shall build and deliver the hardware according to Table 4.4.2. All hardware and software shall be verified to meet the requirements defined in the ERD. The contractor shall provide appropriate evidence as part of a System Acceptance Review with NASA.

The Contractor shall prepare for and conduct the following reviews by the dates specified in Section 4.4.1 below:

1) MAMS System Acceptance Review (SAR)
2) MAMS Phase 3 Flight Safety Review

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | MAMS Phase 3 Safety Review | July 15, 2023 (was 9/2022, 11/2022 and 3/2023) |
| 2 | Conduct the SAR | July 31, 2023 (was 10/2022, 12/2022 and 3/2023) |
| 3 | Disposition/Close engineering related actions, agreements or Constraints defined for shipment/launch resulting from the SAR | August 31, 2023 (was 10/2022 and 4/2023) |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| All support and flight hardware and software or acquired and/or created in the completion of this DO, including tools, spares and equipment purchased supplied as Government Furnished Equipment (GFE). These items shall be delivered to the NASA PM or transfer to BT-2 for operations and sustainment:<br>a. MAMS Double Locker for the OSS Sensor<br>b. Flight Software<br>c. Ground Software | 2 |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| SAR Artifacts to Meet the Entrance and Success Criteria | 2 |
| SAR Presentation Materials | 2 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **BCTA** | **Bias Calibration Table Assembly** |
| **CCR** | **Configuration Change Request** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **COR** | **Contracting Officer Representative** |
| **CPU** | **Central Processing Unit** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EMI** | **Electromagnetic Interference** |
| **ERD** | **Engineering Requirements Document** |
| **ExPRESS** | **Expedite the Process of Experiments to the Space Station Rack** |
| **GFE** | **Government Furnished Equipment** |
| **GRC** | **Glenn Research Center** |
| **GSE** | **Ground Support Equipment** |
| **HiRAP** | **High Resolution Accelerometer Package** |
| **ISIS** | **International Subrack Interface Standard** |
| **ISS** | **International Space Station** |
| **JSC** | **Johnson Space Center** |
| **MAMS** | **Microgravity Acceleration Measurement System** |
| **MSFC** | **Marshall Space Flight Center** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **OSS** | **OARE Sensor System** |
| **PFAR** | **Post-Flight Assessment Review** |
| **PIMS** | **Principal Investigator Microgravity Services** |
| **PM** | **Project Manager** |
| **PoP** | **Period of Performance** |
| **RF** | **Re-Flight** |
| **RFA** | **Request for Action** |
| **SAMS** | **Space Acceleration Measurement System** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-2** |
| **SRR** | **System Requirements Review** |

# SPACEDOC-2 NNC14CA02C
# DO-261 LMTP RFMG
# 2020 LOCKHEED MARTIN TIPPING POINT RADIO FREQUENCY MASS GAUGE (LMTP RFMG)
## CONTRACT PERFORMANCE PERIOD JANUARY 15, 2022 THROUGH MARCH 31, 2023
## DO PERFORMANCE PERIOD JANUARY 15, 2022 THROUGH JUNE 30, 2023

## 1 OVERVIEW

NASA Glenn Research Center (GRC) is supporting a Lockheed Martin Cryogenic Demonstration Mission (CDM) Tipping Point demonstrating several key Cryogenic Fluid Management (CFM) technologies. For the Tipping Point, NASA GRC is initiating this DO with Zin Technologies to build the Radio Frequency Mass Gauge (RFMG) Avionics Unit. NASA GRC will provide the drawings and process plans to Zin Technologies to build the RFMG Avionics Unit to print and conduct functional checkout tests. The RFMG Software Lead (currently under GEARS contract) will load the operating system and RFMG software onto the single board computer. The RFMG Avionics Unit will then be delivered to NASA GRC. NASA GRC will be responsible for functional, environmental, and software testing, and delivery to Lockheed Martin.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from January 15, 2022 through June 30, 2023.

### 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, Erin Pisciotta (MT)
2) RFMG Product Lead Engineer, Greg Zimmerli (LTF)

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Mechanical and Electrical Drawings
2) Step file CAD Models
3) Schematics
4) Bill of Materials
5) Assembly Process Plans
6) Functional Test Plans
7) Any other documentation, as needed, to build the flight avionics.

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have

successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MT/Erin Pisciotta, MS 162-7, erin.s.neiss@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office (Robert R. Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Program Manager, Timothy D. Smith, Mail Stop 162-7, timothy.d.smith@nasa.gov

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) NASA is offering to provide long lead avionics electronic parts, if available, from existing NASA stores to Zin Technologies provided Zin Technologies replenishes the NASA equipment with an equivalent part. The following items may be provided from existing NASA stores:

    a) Flight Model T-Switch (Part Number: R587472601)
    b) Reflectometer (Part Number: R54)
    c) PC Board 1A (Part Number: 150304EEP01/200202EFP001)
    d) Single Board Computer (Part Number: NASA06CME136686LX500HR-W512F)
    e) RF Connector (Part Number: 95006)
    f) Heatspreader (Part Number: 230000297)
    g) 28DC EMI Filter (Part Number: DVMH28F)
    h) 5VDC Converter (Part Number: DVHF2805SF)
    i) DC Converters (Part Number DVHF2828SF)

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) B333 High-bay RFMG Flight Hardware Test Area

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# 4 PROJECT SPECIFIC SOW

## 4.1 Build to print

NASA GRC shall:

1) Provide Zin Technologies the configuration-controlled RFMG Avionics Unit drawings and process plans in addition to functional test plans for the RFMG Avionics Unit no later than 10 business days after DO initiation
2) Provide RFMG subject matter expertise during the RFMG Avionics Unit build, including in-person support, as needed
3) Provide Zin Technologies the software and personnel to load the operating system and RFMG software onto the single board computer of the RFMG Avionics Unit
4) Perform software and environmental testing on the RFMG Avionics Unit upon receipt from Zin Technologies

The contractor shall:

1) Perform manufacturing review of GRC supplied drawings and process plans
2) Procure all hardware in BOM

3) Build RFMG Avionics Unit according to drawings and process plans provided by NASA GRC with updates as documented in RFMG-DEV-001, RFMG-DEV-002, RFMG-DEV-003, RFMG-DEV-004, RFMG-DEV-005, RFMG-DEV-006, RFMG-DEV-007, RFMG-DEV-008, and RFMG-DEV-009.
4) Perform functional test for RFMG Avionics Unit
5) Author Power Card functional test with inputs from NASA GRC subject matter experts and perform functional test for the Power Card
6) Notify NASA GRC of any functional test failures and identify resolution plan
7) Deliver RFMG Avionics Unit to NASA GRC

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Schedule, Long-lead Item Review | June 7, 2022 Complete |
| 2 | Mid-point Schedule and Hardware Readiness Review | July 21, 2022 Complete |
| 3 | Pre-Ship Review | March 1, 2023 (was December 2022) |
| 4 | Deliver the RFMG Avionics Unit to NASA GRC | March 2, 2023 (was December 2022) |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| RFMG Avionics Unit | 4 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| As-built/Red-lined Drawings | 4 |
| As-run Process Plans and Build-up Photos | 4 |
| Functional Test Reports | A/R |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **A/R** | **As Required** |
| **CCR** | **Configuration Change Request** |
| **CDM** | **Cryogenic Demonstration Mission** |
| **CDRL** | **Contract Data Requirements List** |
| **CFM** | **Cryogenic Fluid Management** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **GRC** | **Glenn Research Center** |
| **LMTP** | **Lockheed Martin Tipping Point** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PRACA** | **Preventive and Corrective Action** |
| **RF** | **Radio Frequency** |
| **RFMG** | **Radio Frequency Mass Gauge** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |

**SPACEDOC-2 NNC14CA02C**
**DO-263 EHD-MIO**
**Electro Hydro Dynamics (EHD)-**
**Mission Integration and Operations (MIO)**
**For Contract Period February 15, 2022 through March 31, 2023**
**For the DO Performance Period February 15, 2022 through March 31, 2023**

# 1 OVERVIEW

The "Electrically Driven Liquid Film Boiling in the Absence of Gravity," science experiment commonly called "Electrohydrodynamics" or "EHD," is an International Space Station Fluids Physics Research project. The project will be designed for use in the Microgravity Science Glovebox (MSG) of the ISS.

The design and development of the EHD experimental hardware is performed under Delivery Order 224 of the SpaceDOC II contract. This delivery order (DO-263) includes the mission integration and operations (MIO) activities that support the EHD investigation.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from February 15, 2022 through March 31, 2023. Some of the milestones and deliverables for this delivery order occur beyond the stated period of performance; however, necessary integration and safety tasks/support will take place during this period of performance.

## 1.2 GOVERNMENT CONTACTS

1) Project Manager, Cody Farinacci /GRC
2) Project Scientist, Mohammed M. Hasan /GRC

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) EHD Project Plan
2) EHD Science Requirements Document (SRD)
3) EHD Experiment Data Management Plan (EDMP)

## 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

DO Manager, ISS and Human Health Projects Office, (Cody W. Farinacci, MS 77-7, NASA Glenn Research Center, Cleveland, OH 44135 cody.w.farinacci@nasa.gov)

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, Eric T. Hartman, Mail Stop 60-1, eric.t.hartman@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77-7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall, Mail Stop 77-7, nancy.r.hall@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) [1]Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated [1]weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) [1]Monthly reporting, per DID# CD-02, ON-GOING
5) [1]Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) [1]Lessons Learned Report per DID PA-17

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[1] Deliverable can be provided as a part of DO-224 standard document deliverables for as long as DO-224 is active.

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

N/A

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) GRC Tele-Science Center (TSC)

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# 4 PROJECT SPECIFIC SOW

## 4.1 ISS/Carrier Integration – Design and Analyze Phase

The Design and Analyze Phase is the third phase of the ST&E Integration Flow as defined in SSP 57057. The first two phases consisted of low-level activities that were completed as part of DO-222. During the Design and Analyze Phase, the PD may conduct a Preliminary Design Review (PDR) and/or Critical Design Review (CDR) to assess the fidelity of the payload design. These design reviews are conducted as part of the hardware development delivery order, DO-222, but are mentioned here because the integration timeline is relative to the payload design maturity. Additionally, a Phase II Safety Review is conducted where any safety non-compliances identified are defined and discussed. Major events occurring during the Design and Analyze Phase include the PD receiving training on operations processes and documentation, crew training needs assessment, and initial procedures and planning product development. A key milestone in this phase is the assignment of a flight for the payload.

At the end of the Phase, the ISS Program conducts Sync Point 2. The purpose of Sync Point 2 is to ensure the ISS Program process owners/supporting organizations understand the maturity of the payload/experiment design as well as any risks as the payload proceeds to fabrication and verification.

The detailed task and milestone definitions for each activity in the Design & Analyze Phase are found on the ST&E Integration Flow Website under ST&E Integration Flow Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration tasks is also provided in Appendix A of this Delivery Order.

***All SOW items and deliverables descoped due to cancellation of EHD Flight development Delivery Order (DO-224)**

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.1.1.1 | Phase II Safety Review | ~~no later than 6/31/22~~<br>Delete |

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase II Safety Review Inputs/Package - Delete | 4.1.1.1 |

### 4.2 ISS/CARRIER INTEGRATION – VERIFY PHASE

It is important and crucial for the ISS Program to understand the payload readiness for: a) final delivery, b) launch/return c) on-orbit ISS integration, and d) operations. The ISS Program is informed of the payload readiness during the Verify Phase of the ST&E Integration Flow. This Phase includes verification submittals and a Phase III Safety Review with the associated approvals. The ISS Program conducts its final Sync Point, Sync Point 3, at the end of the Verify Phase to ensure all ISS Program's process owners/supporting organizations understand the payload readiness for shipment and launch vehicle integration.

The detailed task and milestone definitions for each activity in the Verify Phase is found on the ST&E Integration Flow Website under ISS Program Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration activities is also provided in Appendix B of this Delivery Order.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.2.1.1 | Integrated Verification Testing Complete | ~~no later than 12/1/2023*~~ Delete |
| 4.2.1.2 | Verification Submittals | ~~no later than 12/1/2023*~~ Delete |
| 4.2.1.3 | Human Factors Implementation Team Inspection Complete | ~~no later than 12/1/2023*~~ Delete |
| 4.2.1.4 | Phase III Safety Review | ~~no later than 12/1/2023*~~ Delete |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase III Safety Review Inputs/Package – Delete | 4.2.1.4 |

## 4.3 ISS/Carrier Integration – Deliver Phase

Launch vehicle integration and delivery to ISS occurs during the Deliver Phase, phase five of ST&E Integration Flow. All late load and other launch site activities are included in this phase as well as coordination of the flight's launch campaign requirements. Additionally, the ISS Program conducts its Certification of Flight Readiness (CoFR) in this Phase. PDs provide input into CoFR through the Open Work Tracking Log (OWTL). The Deliver Phase concludes with launch of the payload to ISS.

Note: *Readiness for delivery and launch is reviewed/tracked as a part of the CoFR process/plan. The PDs review payload readiness at the Open Work Tracking Log (OWTL) meeting. If necessary, the ISS Program will conduct the payload readiness review at Stage Operations Readiness Review (SORR).*

The detailed task and milestone definitions for each activity in the Deliver Phase are found on the ST&E Integration Flow website under ISS Program Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration activities is also provided in Appendix C of this Delivery Order.

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.3.1.1 | Bench Review | ~~no later than 1/17/2024*~~ Delete |
| 4.3.1.2 | EHD Hardware Turnover | ~~no later than 1/17/2024*~~ Delete |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

## 4.4 ISS/Carrier Integration – Operations and Post-Operations Phase

The final Phase of the ST&E Integration Flow is the Operate and Post Operations Phase where the payload is operated on ISS and where post operations integration activities occur once the Operations Phase has ended. The Operations portion of the Phase includes verifying the ISS Program and PD teams are ready for operations, conducting experiment operations, and implementing real-time changes if necessary. The Post Operations portion of the Phase includes removing the payload from the ISS, communicating the science results, and removing the payload from the IPL.

The detailed task and milestone definitions for each activity in the Operate and Post Operations Phase are found on the ST&E Integration Flow Website under ISS Program Task and Milestone Definitions & Chronology Tables Section. A current snapshot of the integration activities is also provided in Appendix D of this Delivery Order.

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 4.4.1.1 | Operations Readiness Review | ~~Outside of Period of Performance~~ Delete |
| 4.4.1.2 | Flight Operations Begin | ~~Outside of Period of Performance~~ Delete |
| 4.4.1.3 | Science Data Delivery | ~~Outside of Period of Performance~~ Delete |
| 4.4.1.4 | Project Closeout Review | ~~Outside of Period of Performance~~ Delete |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CCR** | **Configuration Change Request** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CoFR** | **Certification of Flight Readiness** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **DPIV** | **Digital Particle Image Velocimetry** |
| **eCC** | **electronic Country Clearance** |
| **EDMP** | **Experiment Data Management Plan** |
| **EHD** | **ElectroHydroDynamics** |
| **GRC** | **Glenn Research Center** |
| **GSFC** | **Goddard Space Flight Center** |
| **IPL** | **Integrated Payload List** |
| **ISS** | **International Space Station** |
| **MIO (MI&O)** | **Mission Integration and Operations** |
| **MSG** | **Microgravity Science Glovebox** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **OWTL** | **Open Work Tracking Log** |
| **PD** | **Payload Developers** |
| **PDR** | **Preliminary Design Review** |
| **PRACA** | **Preventive and Corrective Action** |
| **SORR** | **Stage Operations Readiness Review** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **SRD** | **Science Requirements Document** |
| **ST&E** | **Science, Technology & Exploration** |
| **TSC** | **Telescience Support Center** |

## APPENDIX A – GUIDANCE ON MI&O SCOPE

Mission Integration and Operations scope consists of three categories of activities: integration activities, operations activities, and safety activities.

### A.1 INTEGRATION ACTIVITIES

The Integration activities include the planning and execution of activities addressing requirements levied on the payload to ensure successful integration of the payload with the carrier (facility, launch vehicle).

Payload-to-Carrier Integration Requirement Categories:

- Structural/Mechanical Interfaces
- Electrical Interfaces
- Command and Data Handling
- Thermal Control Interfaces
- Vacuum System
- Pressurized Gas
- Environment Interfaces
- Fire Protection Interfaces
- Materials and Parts Interfaces
- Human Factors Interfaces

### A.2 OPERATIONS ACTIVITIES

All flight operations-related activities fall within the scope of MIO.

### A.3 SAFETY ACTIVITIES

The safety activities include all payload safety related activities.

- Safety Review Document preparation
- Safety Review support
- Safety Verifications

# APPENDIX B – INTEGRATION ACTIVITIES

## B.1 SUMMARY OF TASKS BY PHASE

| CONCEPTION PHASE | PLAN & PREPARE PHASE | DESIGN & ANALYZE PHASE | VERIFY PHASE | DELIVER PHASE | OPERATE & POST OPS PHASE |
|---|---|---|---|---|---|
| Understand what the PD needs from the ISS Program | ISSP collaborates with the PD to provide items required to design the experiment or payload | Understand maturity of design and forward risk as integration process moves into fabrication & verification | Fabricate & complete verification in prep for shipment and launch vehicle integration | Perform launch vehicle integration, & deliver to ISS | Operate the experiment and complete post ops integration |
| DRIVEN BY PAYLOAD DEVELOPMENT SCHEDULE | | | | | |
| PD receives NASA IT access<br><br>PD provides Initial Data set<br>• Initial Ops Concept<br>• Initial assessment of Interfaces and services needed from ISS<br>• Project schedule<br><br>PIA created<br><br>PIM Schedule developed<br><br>Kickoff | Complete Phase 0 Safety TIM<br><br>Complete Phase I Safety Review<br><br>ISSP develops baseline requirements (ISS and VV)<br><br>C&DH/GDS Coordination Meeting<br><br>Identify NASA Test Facility Needs<br><br>ISSP provides operational constraints<br><br>PD provides payload readiness date | ISSP/PD define NCR approach (if required)<br><br>Complete Phase II Safety Review<br><br>ISSP/PD identifies crew training needs<br><br>PD completes PDR/CDR (ISSP support as requested by PD)<br><br>PD submits C&DH inputs<br><br>PD receives training ops integration products, tools, and documents<br><br>PD provides inputs to initial ops and planning products<br><br>PD delivers cargo analytical products | Complete Phase III Safety Review<br><br>PD conducts verification testing and submit verification data to NASA<br>• Hardware<br>• Software<br>• Science<br>• Operations<br><br>PD/ISSP updates ops & planning products, pld regs, flight rules, and conducts review<br><br>C&DH inputs finalized<br><br>PD identifies part level flight manifest data<br><br>ISSP approves interface verification data and NCRs (if required)<br><br>PD receives operations console training<br><br>PD conducts training for crew and visiting vehicle team<br><br>PD provides ground facility requirements<br><br>ISSP hosts Science Symposium | PD defines Time-critical Ground Handling Requirements and launch campaign constraints<br><br>PD delivers hardware and processes at launch site<br><br>PD provides final inputs to ops and planning products<br><br>ISS communicates Launch campaign information<br><br>PD participates in OWTL meeting to report non-standard open work<br><br>ISSP provides CoFR | PD operates experiment<br><br>Sample and data return<br><br>Collect and Evaluate Lessons Learned<br><br>Crew debrief<br><br>ISSP ends HOSC services<br><br>PI publications<br><br>ISSP shares science with the world |
| FUTURE STATE: ONE ST&E INTEGRATION FLOW DATA ENTRY POINT (I.E., EMBARK) FOR PAYLOAD DEVELOPER | | | | | |

## B.2 Integration Activities – Design and Analyze Phase

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal: F | Internal: S | Internal: Sub | External: ELC | External: Truss | External: JEM-EF | External: COL-EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | Provide D&A Data Set | Provide D&A Data Set | Provide data that is needed by the program. Data deliveries may be spread throughout the phase. For specific details on data deliveries in this phase, refer to Provide Research Planning Data, Provide Revised Topology Data, and Provide Imagery Activity Data. | | | | | | | | | | | | | | PD | D/A |
| 200.1 | | Provide Research Planning Data | Provide data needed by the ISS Program to begin planning for increment and flight activities. Data provided will include estimated transportation (mass, volume, etc.) and on-orbit (crew time, power, data, etc.) resource needs. | PD | | Provide inputs after the Ops Concept has been assessed and updated if necessary. | Assess Ops Concept + 1 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 200.2 | | Provide Revised Topology Data | If revisions to the initial topology data is identified during the design phase (e.g., CDR), the PD submits revised data needed by Payload Topology Forum to update and finalize the on-orbit placement study. | PD | | Updates are provided as soon as they are known (typically after CDR). | CDR + 0.5 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 200.3 | | Provide Imagery Activity Data | If Imagery is requested, the PD provides activity level data to the ISS Program identifying the requested imagery activities (what, when, where, how, etc.). The inputs are used to produce IDRD Annex 3. | PD, OC/Imagery team | Rebecca Difard | Initial inputs provided after design and ops concept are firm. | Provide Inputs to Ops Products + 0.25 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 201 | Ops Considerations Discussion | Ops Considerations Discussion | The Ops Lead will discuss the definitions of Payload Regs, Flight Rules, and Planning Constraints (Gr&Cs), how they affect/impact operations, who is the responsible party, and how they are developed. This will include a preliminary discussion on foreseen payload operational constraints. | POI | Ops Lead, PARC, POIC OC | | PDR - 0.5 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 202 | Add to Research Plan | Add to Research Plan | The Multilateral Research Planning Working Group (MRPWG) consolidates and integrates research requirements and objectives from NASA and International Partners/Participants into a continuous Research Plan based on partner allocations, payload readiness, on-orbit required date(s), science priority, crew time availability/phasing, and constrained resources (facility throughput, power, launch vehicle big bags, etc.). The Research Plan portrays these requirements at the increment level. The Science Resource Tracking Database (SRTD) breaks down these requirements to the weekly level and includes specific information regarding investigation start/stop dates, flexibility in execution, crew member assignments, crew time requirements per investigation activity, and constraints on the investigation activities. | OZ5 | T. C. Judd | | Provide Research Planning Data + 1 | X | X | X | X | X | X | X | X | | ISS | D/A |
| 203 | PD Trng TST | PD Trng TST | POI Trainers will provide an overview of PD Training milestones, including an overview of the train-the-trainer concept, and will establish a PD Team training plan for the PD Team Trainer based upon Ground Data Services requests. The PD Team training plan will outline training requirements for the PD team. The TST is conducted by telecom and web conference. Required participants are PD Team Trainers, Payload Integration Engineer (PIE), and POI Trainers. | PD, HP26 | POI PD Trainers | This could occur any time in Design & Analyze or Verify phase. | Flight Assignment + 0.75 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 204 | Provide PDR data package | Provide PDR data package | The PD provides access to their Preliminary Design Review (PDR) data package, if they request ISS Program review support. | PD | | PDR data packs should be submitted to the ISS Program 1 week before PDR to allow sufficient time for review and comment development. | PDR - 0.25 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 205 | PDR Prep | PDR Prep | The PIM coordinates ISS Program support to the PDR, and the PIRE coordinates support among the Systems Engineering and Integration (SE&I) Subject Matter Experts (SMEs). The applicable ISS Program representatives review the Provide PDR data package from the PD for compliance to the interface requirements and implications to ISS operations, and provide development guidance to the PD. A checklist is used to help organize the ISS Program review. Comments are coordinated back with the PD during the PDR. | ISS Program | | | Provide PDR data package + 0.25 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 206 | PDR | PDR | Payload Project conducts a Preliminary Design Review (PDR). Some Payload projects, as part of their design effort, may conduct a PDR (or other equivalent review) when their design reaches 10% maturity. A PDR may not be held by all PDs. The PDR is the completion activity of the Classical Project Development Cycle Phase B (reference NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook). The PDR demonstrates and baselines a feasible and credible design that will accomplish the stated goals within the constraints imposed by the fiscal and operating environment. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | D/A |
| 207 | Approve VV ICD | Approve VV ICD | Following the iterative process for the development and review of the VV ICD, the Launch Vehicle Provider releases the approved ICD. This milestone is only required to document non-standard interfaces (usually for external or powered pressurized payloads only). | PD, ON | Launch Vehicle Provider | | TBD - VV ICD Inputs + 4.0 (Jason Smith / ON) | X | | X | X | X | X | X | X | X | Both | D/A |
| 208 | Identify Exceptions | Identify Exceptions | PD identifies known ISS and vehicle interface requirement Exceptions. Not all payloads will have Exceptions. When identified, Exceptions are communicated to the ISS Program to assess and document approval. This milestone can be repeated as necessary. | PD | | Exceptions are identified after the IRB is approved and the payload design requires deviations. | Approve IRB + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 209 | Disposition Exceptions | Disposition Exceptions | ISS Program supports the PD in Identify Exceptions, by proactively identifying known Exceptions. Additionally, the ISS Program assesses and coordinates recommendations and/or risk assessment for each Exception. The PIRE enlists support from Subject Matter Experts in the review of Exceptions via the PIRN review process. Disposition of the Exception (acceptance or rejection) is documented and communicated to the PD. | OB6 | PIRE, SME | Duration of the Exception review is dependent on the technical complexity, with nominal duration being 1 month. | Identify Exception + 1.0 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 210 | Final Topology Assessment | Final Topology Assessment | For payload located in ISS facilities or deployed in the aisle, the Payload Topology Forum reviews the Provide Revised Topology Data from the PD and performs a final Placement Study. The study identifies specific operational on-orbit location(s) and potential issues or exceptions. The results are used by the PD and ISS Program for product development (e.g., procedures). Results for payloads commanding using 1553 are used for Software development. | OM2, OB / Facility Project Manager | Craig Gordon | After Research Plan and PDR. Desire to have completed in time for PD to incorporate inputs into CDR. | Add to Research Plan + 1.0 | X | X | X | | | | | | X | ISS | D/A |
| 211 | Flight Assignment Assessment | Flight Assignment Assessment | After the PD provides a minimum set of cargo data (Provide Research Planning Data) the ISS Program will identify (and update as the Flight Program changes) a set of candidate flights that meet PD defined on-orbit need dates. As detailed cargo data matures and research requirements are baselined in the ISS Research Plan a target flight assignment can be made. Note that the number and type of constraints identified for launching / returning cargo will drive the timeframe in which flight assignment is finalized. | OC, OZ5/RPWG | | Candidate Flights are identified when a minimum cargo data set and on-orbit need dates are defined. Target flight assignment occurs only after Research Plan assignment and cargo data reaches sufficient maturity and may differ for each cargo item based on defined constraints. | Add to Research Plan + TBD | X | X | X | X | X | X | X | X | | ISS | D/A |
| 212 | Flight Assignment | Flight Assignment | The ISS Program assigns specific flights for the delivery and return/removal of the payload from ISS and communicates the flight assignment to the PD. Flight assignment in the Design and Analyze phase is necessary for certain powered locker, cold stowage and/or late load cargo as part of the Research Plan process of optimizing limited resources. A Flight Assignment change after initial assignment can occur due to PD or ISS Program changes (e.g., change in Hardware Readiness date, revision to flight schedule), and will be communicated to all impacted organizations. | OC | | Flight assignment occurs after payload has been included in the Research Plan (which defined the on-orbit need date) and kit-level manifest data has been provided. | Flight Assignment Assessment + TBD | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 213 | Dev. Testing | Dev. Testing | PD performs development testing to verify the payload design. If ISS Program facilities or resources are needed, they are identified in the PIA, and tracked in the schedule. | | | | | | | | | | | | | | Both | D/A |
| 213.1 | | JSC Dexterous Manipulator Trainer (DMT) | The JSC DMT provides an SPDM trainer which can be used for payload robotic interface engineering unit testing and training. | OM, OB, ER | Michael Wright | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | PDR + 1.0 | | | | X | X | X | X | X | X | ISS | D/A |
| 213.2 | | C&DH Development Testing | ECFs, PCFs, HPEG Configuration, and Command and Telemetry database are made available to the PD by the ISS Program. These products can be used by the PD for development testing.<br><br>**Add statement about coordination.** | PD, OD, POI | | Each product listed has its own schedule, and could have multiple dependencies, or none at all. Check PSCP website/agendas for Flight Product Schedules which has readiness date for many of these products. PSCP website/agenda also has dates for HOSC Database availability. | Build HOSC Databases for Test + 1 | X | X | X | X | X | X | X | | X | PD | D/A |
| 213.3 | | DCLA | TBD - If needed by the PD, the PD provides models to support the development of a Visiting Vehicle Design Coupled Loads Analysis (DCLA). | PD, ON | | | TBD | | | | X | X | X | X | | X | PD | D/A |
| 214 | Phase II Safety Review Inputs | Phase II Safety Review Inputs | The PD requests the ISS Program schedule a Phase II Safety Review with the ISS Safety Review Panel (ISRP). The PD performs a safety assessment based on the guidelines in SSP 30599 and safety requirements in SSP 51700 submits the Phase II Safety Data Package (including Hazard Reports (HRs)) for review via the ISS Hazard System (IHS) tool. If support is required during input development, the SPE can coordinate Working Group meetings with Subject Matter Experts to discuss any questions. | PD | | Tie to design maturity close to CDR, but complete enough to support inputs for CDR. Inputs should be provided 20 working days before the Phase II Safety Review to allow Safety Panel members time to review and provide comments. | PDR + 1.0 | X | X | X | X | X | X | X | X | X | PD | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 215 | Phase II Safety Review Prep | Phase II Safety Review Prep | The SPE coordinates the scheduling of the Phase II Safety Review meeting, reviews the Phase II Safety Inputs from the PD, and distributes to the Safety Subject Matter Experts for review and comment. Comments are coordinated back with the PD to allow the PD to prepare responses prior to the Phase II Safety Review. If necessary, the SPE coordinates Working Group meetings with Subject Matter Experts to discuss comments and pre-coordinate responses.<br><br>During the review of the Phase II Safety Data Package, the PD will receive and review comments from Subject Matter Experts provided by the SPE and prepare responses. Responses will be discussed either during working groups in preparation for the review or during the formal Phase II Safety Review. Working Groups will be coordinated by the SPE with Subject Matter Experts. | PD, OE | SPE | | Phase II Safety Inputs + 0.75 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 216 | Phase II Safety Review | Phase II Safety Review | If requested, a Phase II Safety Review is held with the PD and ISS Safety Review Panel (ISRP). The PD presents their Phase II Safety Inputs to the ISRP, and the ISRP provide concurrence and/or recommendations. The objectives of the Phase II Safety Review are to:<br>• Obtain safety review panel approval of updated safety analysis that reflect the critical design and concept of operations of the payload and its interfaces,<br>• Update hazard causes defined at Phase I<br>• Assure all appropriate hazard controls have been implemented,<br>• Assure all verification methods are documented,<br>• Identify potential safety non-compliances in detail,<br>• Document newly identified hazards in existing or additional Hrs. | PD, OE | SPE | | Phase II Safety Inputs + 1.0 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 217 | Define NCR Approach | Define NCR Approach | The ISS Program / OE will review the results of the Phase II Safety Review and, <u>if required</u>, develop a strategy for each Non Compliance Report (NCR). | PD, OE | SPE | Identify a strategy as each NCR is identified, typically beginning after Phase II Safety Review. | Phase II Safety Review + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 218 | Initial Operability Review | Initial Operability Review | If requested by the PD, the ISS Program reviews the payload design (prototype, engineering unit, etc.) for engineering and operations considerations (Human Factors Integration Team (HFIT) requirements compliance, crew operability, procedure realism, label application, etc.). This is nominally accomplished by a review of a payload hardware prototype or engineering unit either at the PD site or in an ISS mockup.<br><br>Participation from the ISS Program nominally includes the Ops Lead, PARC, HFIT rep., crew office rep., IPLAT rep., POI OC and PIM, but other folks could be added if appropriate (e.g., Topology rep., ISS Plug in Plan rep, JSC/PLUTO, EVA, etc.). Lessons and results from the evaluation are incorporated into various products including the procedures, HFIT verification CoC (and identification of potential exceptions), and Label Plan. | SF, OB, POIF | PD, Ops Lead, PARC, HFIT rep., crew office rep., IPLAT rep., POI OC and PIM | After payload hardware design is mature. | PDR + 0.75 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 219 | Cargo Processing Rqmts | Cargo Processing Rqmts | The PD working with the ISS Program / OC review the standard cargo processing capabilities for the assigned flight, and identify if there are any anticipated unique cargo processing requirements for the cold stowage or Cargo Mission Contract teams. Unique requirements will be documented in the appropriate request form: Cold Stowage Form (Cold Stowage team) or Request for Services (RFS) (Cargo Mission Contract). | OC, PD | | After flight assignment, the cargo processing capabilities are reviewed, and special needs identified and coordinated with the appropriate provider. | Flight Assignment + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 220 | Vehicle Processing Rqmts | Vehicle Processing Rqmts | The PD working with the ISS Program / ON review the standard vehicle processing capabilities for the assigned flight, and identify if there are any unique vehicle processing requirements for the Vehicle Provider teams. Requirements will be documented in the appropriate document: Space-X ICD, Orbital-ATK Interface Control Agreement (ICA), etc.. | ON, PD | | After flight assignment, the transportation interfaces are reviewed, and special needs identified and coordinated with the appropriate provider. | Flight Assignment + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 221 | PAS Tag up | PAS Tag up | This tag with the PD outlines the process to deliver EXPRESS/WORF Laptop Payload Application Software (PAS) to the PSIVF for integrated laptop verification testing. | PD, OD | | | PDR + 0.5 | X | X | X | | | | | X | X | Both | D/A |
| 222 | Initial C&DH Inputs | Initial C&DH Inputs | The Command and Data Handling (C&DH) Data Set is a collection of data input by the Payload Developers into the Payload Data Library. This data defines the flight unique software interface requirements (including command and telemetry definitions) between Integrated Payload Systems and ISS flight data handling elements. Data from the C&DH data set is used to build the Payload Multiplexer/Demultiplexer (MDM) Configuration Files, EXPRESS Logistics Carrier Configuration Files, the Portable Computer System (PCS) Payload Displays, the POIC Command and Telemetry Databases, and the Software Interface Control Documents (ICDs). C&DH data set requirements are documented in SSP 57000 (pressurized) or 57003 (unpressurized / ELC). | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EF | | | | |
| 223 | Generate SIM/ENG HOSC Export | Generate SIM/ENG HOSC Export | Date the data from the Payload Data Library is exported and sent to the HOSC for incorporation into engineering telemetry and commanding databases. Database can be used for payload testing. | OD | | Data is currently included in an increment product. Dates are coordinated at the PSCP. | Initial C&DH Inputs + TBD | X | X | X | X | X | X | X | | | ISS | D/A |
| 224 | Review Interim SW ICD | Review Interim S/W ICD | A documentation review for the Interim Software (SW) ICD. The data in the Interim Software ICD is expected to be used in the implementation of the payload software. The MSFC Payload Rack Officer (PRO) is the POI position that leads this task. | MSFC PRO, PD, OD, SPE | | | TBD | X | X | X | X | X | X | X | | X | Both | D/A |
| 225 | Generate & Complete Interim S/W ICD | Generate & Complete Interim S/W ICD | The Generate & Complete Interim S/W ICD process synthesis the inputs from multiple sources into an easily assimilate textual format used to develop and test payload software and configure ground systems for test. Sources include the payload developer (payload commands and telemetry), Plan OPS (payload topology) and the Payload Data Library (PDL) (other integration data). As comments and redlines are found during the review process, changes are made in the master dataset that produces the software ICD and the interim ICD is corrected for release as the final software ICD. | SE&I PSI, OD | PSIE | | Review Interim S/W ICD + 0.5 | X | X | X | X | X | X | X | | X | Both | D/A |
| 226 | Deliver ISS Configuration Files for Test | Deliver ISS Configuration Files for Test | After the creation of the increment-based Engineering Payload Configuration Files (PCFs) and the EXPRESS Logistics Carrier Configuration Files (ECFs) but before they are tested, these files are placed into Payload Data Management Tool (PDMT) and the MBF for use by the payloads in development testing without flight hardware. | OD | | | Initial C&DH Inputs + TBD | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 227 | Submit Interim EXPRESS/WORF Laptop PAS | Submit Interim EXPRESS/WORF Laptop PAS | The Payload Developer is required to submit the EXPRESS or WORF payload application software (PAS) to the PSIV Team for testing and step-up to flight maturity. An interim version of the EXPRESS or WORF Laptop Payload Application Software (PAS) is required to be provided to the PSIVF before the final PAS is submitted. This interim delivery allows the PSIVF to check out many of the characteristics of the PAS in order to get familiar with the software before the final version of the PAS is submitted by the PD. | PD, OD | | | CDR + 0.5 | X | X | X | | | | | | X | Both | D/A |
| 228 | Generate KuIP Export | Generate KuIP Export | The task Generate Ku Band Internet Protocol (KuIP) Export provides KuIP configuration and attribute information used to build a ground HOSC Payload Ethernet Gateway (HPEG) Configuration File. The export ensures that on-board and ground systems are configured in concert. The export is available to the Ops Integration swim lane and made available to the POIC (Configure HOSC Systems for Test). Exports are accomplished whenever new data is available and therefore these exports may occur in any phase of the Manage Interfaces (Software) ST&E Flow. For simplicity, we elected to show this export just one time in the phase we most expected the new KuIP configuration to be defined. | OD | | Ku IP exports/reports are generated when new information is provided by OD to POI. POI uses this information to configure systems for test and flight. NET completion C&DH/GDS coordination meeting. | PDL + TBD | X | X | X | X | X | X | X | | | ISS | D/A |
| 229 | Build HOSC Databases for Test | Build HOSC Databases for Test | HOSC command and telemetry databases incorporate PDL inputs provided by PDs as well as ISS system data definitions. These databases are built for each increment and include any payloads that have worked with the PSCP/PDL to be included for testing during that increment/timeframe as well as payloads that will be onboard ISS during that increment. These databases can be used for various tests that include the HOSC as part of the data flow path (ODTE, ORTs, simulations) or they can be used to pull definitions that will be included in a TReK database for other localized testing. | POIC | | It takes approximately one month to build and checkout command & telemetry databases. | Generate SIM/ENG HOSC Export + 1 | X | X | X | X | X | X | X | | X | ISS | D/A |
| 230 | Configure HOSC Systems for Test | Configure HOSC Systems for Test | HOSC systems must be configured with the proper command and telemetry databases and HPEG configurations, as well as voice, video, and telemetry routing prior to tests so that the services needed during that test are available to the user. | POIC | | | Build HOSC Databases for Test + 0.1 | X | X | X | | | | | | | ISS | D/A |
| 231 | Deliver Initial Crew Displays | Deliver Initial Crew Displays | Deliver initial crew displays to Payload Displays Review Team (PDRT). Initial displays are subject to review and usability verification by the PDRT, the IDAGS Team and the JSC Astronaut Office. Initial displays should provide a static depiction (screenshots) of the crew graphical user interface (crew GUI) that will support the payload nominal operational tasks. Initial displays should begin to outline the basic GUI architecture, the essential software monitoring/control functions and the operational sequence required to service the payload. | HP26, PD | PDRT | | CDR - 0.25 | X | X | X | X | X | X | X | | X | ISS | D/A |
| 232 | Provide CDR data package | Provide CDR data package | The PD provides access to their Critical Design Review (CDR) data package, if they request ISS Program review support. | PD | | CDR data packs should be submitted to the ISS Program 1 week before CDR to allow sufficient time for review and comment development. | CDR - 0.25 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 233 | CDR Prep | CDR Prep | The PIM and PIRE coordinates ISS Program support to the CDR. The applicable ISS Program representatives review the Provide CDR data package from the PD for compliance to the interface requirements and implications to ISS operations, and provide development guidance to the PD. Comments are coordinated back with the PD during the CDR. The ISS Research Integration Office also reviews the CDR data package for implications to ISS payload integration, and to provide verification guidance to the PD. A checklist is used to help organize the ISS Program review. | ISS Program | | | Provide CDR data package + 0.25 | X | X | X | X | X | X | X | X | X | ISS | D/A |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal: F | Internal: S | Internal: Sub | External: ELC | External: Truss | External: JEM-EF | External: COL-EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 234 | CDR | CDR | Payload Project conducts a Critical Design Review (CDR). Most Payload projects, as part of their design effort, may conduct a CDR (or other equivalent review) when their design reaches 90% maturity. CDR may not be held by all PDs, i.e., re-flight or serial hardware. The CDR represents completion of the classical Project Development Cycle Phase C (reference NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook). The CDR demonstrates a "build-to" detailed design baseline to fabricate, integrate and verify. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | D/A |
| 235 | Deliver Cargo Analytical Products | Deliver Cargo Analytical Products | TBD - The PD provides inputs to the launch vehicle provider to support development of the Mission Resource Allocation Document (MRAD). The initial MRAD shall contain current analytical data related to: electrical power and energy, command and data requirements, orbital vehicle dynamics and mass properties, robotics and berthing requirements, orbital vehicle Computer-Aided Design (CAD) models, orbital vehicle structural math model, plume history, thruster firing history, propellant types, launch to activation (LTA) analysis for external cargo.<br><br>Check with Jason Smith. | PD | | After CDR (design is mature). | CDR + 0.5 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 235.1 | | HF Mockup | If a payload requires cold stowage, the PD ships a High fidelity (HF) mockup to Cold Stowage (CS) team to allow that team to perform an integrated fit check. Alternatively, the PD can ship flight hardware or provides a CAD model suitable for 3D printing. | PD, OC/CS team | | CS performs integrated fit check at L-7.5 months. | CDR + 0.5 | X | X | X | | | | | | X | PD | D/A |
| 236 | MRAD | MRAD | Mission Requirements and Allocations Document (MRAD) captures extensive mission and cargo unique data and analyses, including vehicle and cargo physical configuration, electrical power budgets, communication and data budgets, coupled loads analysis results, crew utilization, flight operation support, vehicle design changes, a mission training plan, and other specific information. | ON | | MRAD data provided to needed teams at L-13. | Deliver Cargo Analytical Products + 10.5 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 237 | Crew Training TST | Crew Training TST | The Training Strategy Team (TST) is a structured planning and decision-making group who determine crew training requirements for each payload. The required TST participants are the CTC, Ops Lead, User, FOD Rep (Crew Office Rep), and if there are displays, the Payload Displays Review Team (PDRT). A TST may be held for either a new payload, an increment payload complement, or for any update that warrants a change to existing crew training strategy. | PD, POIF, FOD | | | Flight Assignment + 0.25 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 238 | EIR | EIR | TBD - External Integration Review (EIR).<br><br>Get with Jason Smith | ON | | | Deliver Cargo Analytical Products + 3.0 | | | | X | X | X | X | X | X | Both | D/A |
| 239 | PV Assessment | PV Assessment | The Procedure Validation (PV) Assessment is a structured meeting to determine the procedure validation plan for each payload. The plan will include the validation method, hardware fidelity, location, timing, and participants. The participants can include Ops Lead, PARC, FOD Rep, PD, and POI OC. | Ops Lead | Ops Lead | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 240 | Provide Inputs to Ops Products | Provide Inputs to Ops Products | PD provides inputs to the PARC/Ops Lead to develop draft crew procedures and planning products (Payload Activity Requirements Document (PARD), Payload Planning Overview (PPO), and planning Ground rules and Constraints (Gr&C)). This begins an iterative process between the Ops Lead, PARC, POI OC, and PD to fully mature the ops products. | PD | | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | PD | D/A |
| 241 | Begin Ops Products Coordination | Begin Ops Products Coordination | PARC/Ops Lead begin coordination with PD to develop draft crew procedures and planning products (PPO, PARD and planning Gr&C). This begins an iterative process between the Ops Lead, PARC, POI OC, and PD to fully mature the ops products. | POIF | PARC, Ops Lead | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 242 | Build Timeliner | Build Timeliner | POIF and PD work together on Timeliner bundles for a payload for testing | PD, POIF | Timeliner Lead on the MSFC PRO team | | CDR + 0.5 | X | X | X | X | X | X | X | X | X | Both | D/A |
| 243 | Approve Exceptions | Approve Exceptions | An Exception to a requirement may be submitted when a requirement cannot be met but sufficient rationale exists for the condition to be accepted. | OB | | | CDR + 1.0 | X | X | X | X | X | X | X | X | X | ISS | D/A |
| 244 | CSS Inputs | CSS Inputs | PSO contacts the PD teams to assess their customer satisfaction. | PD, ISS Program | PSO Rep | Prior to Sync Point Reviews | | X | X | X | X | X | X | X | X | X | Both | D/A |
| 245 | Sync Pt 2 | Sync Pt 2 | Internal ISS Program review intended to sync up NASA organizations and review issues coming out of payload design efforts and before verification. Specific topics include reviewing PIM Schedule, approving PIA updates, and communicating risks among the ISS Program management. More information is included in the Sync Point 2 Charter. | OZ6 | PIM | Schedule after PD completes their design efforts. | CDR + 1.0 | X | X | X | X | X | X | X | X | | ISS | D/A |

## B.3 INTEGRATION ACTIVITIES – VERIFY PHASE

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL EP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 | Provide Verify Data Set | Provide Verify Data Set | Provide data that is needed by the program. Data deliveries may be spread throughout the phase. For specific details on data deliveries in this phase, refer to FCC License. | PD | | | | | | | | | | | | | PD | V |
| 300.1 | | FCC License | PD receives approval for their FCC license. | PD | | | Apply for FCC License + 6 | | | | X | X | X | X | X | X | PD | V |
| 301 | Complete H/W Fabrication | Complete H/W Fabrication | PD completes their fabrication of hardware for testing and flight. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | V |
| 302 | Develop Ground Command Procedures | Develop Ground Command Procedures | Ground Command Procedures (GCPs) developed by POIF Payload Rack Officers (PRO) are used to send commands for managing resources to payloads and/or take action if necessary to save Payload science and/or hardware. Inputs are provided from OD (Final PCFs and ECFs into PDMT, and Build HOSC Databases). This begins an iterative process between the PRO and PD to fully mature/baseline the GCPs. | POIF, PD | MSFC PRO | L-6 months for nominal payloads L-12 months for complex payloads. | Launch - 6 | X | X | X | X | X | X | X | | X | Both | V |
| 303 | Submit Cargo Processing RFS | Submit Cargo Processing RFS | If necessary, the PD completes a Request for Services (RFS) to identify any requested part-specific standard cargo processing services from the Program. This could include unique packing materials (foam, zip locks, bags, etc.) or special cargo processing services. | PD | | Request should be provided 30 days before the Service need date. | TBD | X | X | X | | | | | X | X | PD | V |
| 304 | Submit Manifest Rqmts | Submit Manifest Rqmts | The PD completes a Manifest Request (MR) itemizing part names, numbers, mass and dimensions for each requested piece of hardware to be transported to or from ISS.<br><br>**Talk with Christian, Brad on relationship with Research Plan.** | PD, Payload Manifest Lead | | | CDR + 2.0 | X | X | X | X | X | X | X | X | X | PD | V |
| 304.1 | | Hardware OpNom | TBD - PD provides recommended Operations Nomenclature (OpNom) name to be used by the ISS Program for each hardware item that will be delivered to ISS or used on-orbit. Naming guidelines and official approval are administered by the Operations Data File Control Board (ODFCB). | PD, FOD, OC/CMC | | All hardware OpNoms should be approved before Final Operability Review. | TBD | X | X | X | X | X | X | X | X | X | Both | V |
| 305 | Integrate Manifest Rqmts | Integrate Manifest Rqmts | The ISS Program integrates all Manifest Request (MR) received. As the requests are approved, the MR data is transitioned from the ORBIT/MR database to the MIDAS database.<br><br>**Talk with Christian, Brad on relationship with Research Plan.** | OC | | | Submit MR + 0.05 | X | X | X | X | X | X | X | X | | ISS | V |
| 306 | Submit Stowage Rqmts | Submit Stowage Requirements | The PD, with help from the ISS Program/Payload Stowage Coordinator, completes an electronic Launch, Return, On-orbit Data Set (eLRODS) to identify packing / stowage requirements for each payload hardware item. | PD, Payload Stowage Coordinator | OZ/Virginia Spaniel | | Submit MR + 1.0 | X | X | X | | | | | X | X | Both | V |
| 307 | Develop Stowage Layouts | Develop Stowage Layouts | The ISS Program Cargo Processing team produces integrated stowage layouts for all hardware on a per flight basis using the data provided in the eLRODS submissions. | OC, CMC | | | Submit eLRODS + 1.0 | X | X | X | | | | | X | X | ISS | V |
| 308 | Complete Final C&DH Updates | Complete Final C&DH Updates | This is the last opportunity for the PD to update any previously entered C&DH data prior to the programs formal build and test process. After this update process completes the data is locked down and placed under configuration management. Additional changes must be accompanied by a Data Set Change Request (DSCR) and approved by the PSCP. PSCP approval is governed by the balance between the risk to operations of non-incorporation and the resulting schedule impacts to other payload customers and the program caused by incorporating the late data entry.<br><br>The Command and Data Handling (C&DH) Data Set is a collection of data input by the Payload Developers into the Payload Data Library. This data defines the flight unique software interface requirements (including command and telemetry definitions) between Integrated Payload Systems and ISS flight data handling elements. Data from the C&DH Data Set is used to build the Payload Multiplexer/Demultiplexer (MDM) Configuration Files, the Portable Computer System (PCS) Displays, the POIC Command and Telemetry Databases, and the Software Interface Control Documents (ICDs). C&DH Data Set requirements are defined in SSP 57002, Payload Software Interface Control Document Template. | PD, OD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 309 | Generate Final HOSC Export | Generate Final HOSC Export | Date the data from the Payload Data Library is exported and sent to the HOSC for incorporation into flight telemetry and commanding databases. These HOSC databases are used to decommutate the data received from the payload systems on-orbit before the data is viewed on the ground. | OD | | Final C&DH inputs must be complete 1 to 2 weeks prior to a planned export. Data is currently included in an increment product. Dates are coordinated at the PSCP. | Complete Final C&DH Updates + 0.5 | X | X | X | X | X | X | X | X | | ISS | V |
| 310 | Build HOSC Databases for Flight | Build HOSC Databases for Flight | HOSC command and telemetry databases incorporate PDL inputs provided by PDs as well as ISS system data definitions. These databases are built for each increment and include any payloads that have worked with the PSCP/PDL to be included for testing during that increment/timeframe as well as payloads that will be onboard ISS during that increment. These databases will be used for flight operations during the increment. | POIC | | | Generate Final HOSC Export + 1.0 | X | X | X | X | X | X | X | X | | ISS | V |
| 311 | Deliver Final PCFs and ECFs | Deliver Final PCFs and ECFs | The date PSIVF delivers the Engineering mature versions of the Payload Configuration Files (PCFs) and the EXPRESS Logistics Carriers Configuration Files (ECFs) to the MBF and PDMT. These products have been integration tested but no formal testing has been performed. Only after formal verification testing the Payload Configuration Files (PCFs) and EXPRESS Logistics Carrier Configuration Files (EFCs) are moved to FQT and Flight Mature. | OD | | | TBD | X | X | X | X | X | X | X | | X | ISS | V |
| 313 | Submit Final EXPRESS/WORF Laptop PAS | Submit Final EXPRESS/WORF Laptop PAS | The PD submits the final version of their EXPRESS or WORF Laptop Payload Application Software (PAS) to PSIVF. | PD | | | TBD | X | X | X | | | | | | X | PD | V |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EPF | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 314 | Flight Test & Deliver Final EXPRESS/WORF Laptop PAS | Flight Test & Deliver Final EXPRESS/WORF Laptop PAS | The date the EXPRESS/WORF Payload Application Software (PAS) (i.e., payload laptop applications) is moved to flight mature status and can be manifested, uplinked, installed, and used on-orbit. EXPRESS and WORF laptop applications are tested by the PSIV Team to ensure that: (1) the payload application software can close open verification, (2) integrates and works nominally with the entire payload complement of payload laptop applications, and (3) identifies and documents any constraints for operating the payload laptop. The final version of the laptop software will configuration managed by the ISS Program, given a unique part number and provided to payload operations. | OD | | | TBD | X | X | X | | | | | | X | ISS | V |
| 315 | Complete Test PPIL Inputs | Complete Test PPIL Inputs | | OD | | | | | | | | | | | | | | |
| 316 | Baseline Test PPIL | Baseline Test PPIL | The date the PD must complete their input to their Test Payload Product Integrated List (PPIL) to document the complete C&DH payload software configuration for the verification test.<br><br>Test PPIL is a managed list of software products to be used with the Payload Rack Checkout Unit (PRCU) or other functional checkout units during formal C&DH payload verification testing prior to a specific increment. Includes the same basic information categories as the Flight PPIL. | PD, OD | | | TBD | X | X | X | X | | | | | X | PD | V |
| 317 | Identify Media Manifesting Rqmts | Identify Media Manifesting Rqmts | PD submits request to ISS Program/OD to build and transport software media to ISS. Media can include CDs/DVDs, thumb drives, SD/microSD cards. | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 318 | Flt Media Manifesting Process | Flt Media Manifesting Process | ISS Program / OD builds and verifies software media for flight. Media can include CDs/DVDs, thumb drives, SD/microSD cards. | OD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 319 | Order / receive labels | Order / Receive Labels | | | | | | | | | | | | | | | | V |
| 319.1 | | Order Labels | PD submits request for hardware labels to the ISS Payload Label Analysis Team (IPLAT). | PD | | Labels should be ordered to arrive after hardware is fabricated. | Submit Manifest Requirements + 1.0 | X | X | X | | | | | X | X | PD | V |
| 319.2 | | Receive Labels | ISS Payload Label Analysis Team (IPLAT) fabricates the hardware labels and delivers them to the PD for application on the PD hardware. | SF | IPLAT rep. | Nominal order takes 30 days from request to delivery. | Order labels +1.0 | X | X | X | | | | | X | X | ISS | V |
| 320 | Final Operability Review | Final Operability Review | Pressurized and External description. | | | | | | | | | | | | | | | V |
| 320.1 | | Final Operability Review | For pressurized payloads, the ISS Program reviews the payload for engineering and operations requirements compliance (Human Factors Integration Team (HFIT) requirements, crew operability, procedure validation, label application, etc.). This is nominally accomplished by a review of the as-built payload hardware, displays and draft procedures either at the PD site or in an ISS mockup.<br><br>During the procedure validation every procedure is checked for technical accuracy, that it executes as written, that it achieves its desired objectives, and that it assures crew safety. Also, the overall operability is checked to ensure that the procedures are in sync with the layout of the planned activities. The procedure validation method/plan is outlined and agreed to during the PV Assessment.<br><br>Participation from the ISS Program nominally includes the Ops Lead, PARC, HFIT rep., crew office rep., IPLAT rep., and PIM, but other folks could be added if appropriate (e.g., Topology rep., ISS Plug in Plan rep, JSC/PLUTO, etc.). Results from the review are used to close HFIT and labeling requirements, identify necessary exceptions, and validate flight crew procedures.<br><br>If displays are included, a Usability Review is incorporated and PDRT is also invited. Usability Verification advances both the displays and the procedures to NASA acceptance as flight and training products. PDRT conducts integrated usability verification tests (or trials) on mature graphical user interfaces (GUIs) that are compliant with the payload display design standards/guidelines. Usability testing is supported by the Payload Developer and the JSC Astronaut Office. Separate time will need to be set aside to complete the specific Usability objectives during the Final Operability Review. | SF, OB, POIF | PD, Ops Lead, PARC, HFIT or VITT rep., crew office rep., IPLAT rep., PIM and PDRT (if displays) | After payload hardware design and displays are mature, procedures are drafted, and labels have been received. Must be done before verifications are due and hardware turnover. | Complete Payload Fabrication + 1.0 | X | X | X | | | | | X | X | ISS | V |
| 320.2 | | VITT Review | For external payloads, the ISS Program reviews the payload for engineering and operations requirements compliance (applicable EVA interface requirements (bolt gauging, tool fit checks and sharp edge inspections), crew operability, procedure validation, etc.). This is nominally accomplished by coordinating with PD and can be performed at the PD site or after delivery for launch. Results are documented and reported through the CoFR process.<br><br>Participation from the ISS Program nominally includes the Crew Office rep., EVA Office rep., Ops Lead, PARC, and PIM, but other folks could be added if appropriate (e.g., Robotics rep., etc.). Results from the review are used to close requirements, identify necessary exceptions, and validate flight crew procedures. | CA, XX, OB, POIF | PD, Crew Office rep., EVA Office rep., Ops Lead, PARC, and PIM | After payload hardware design is mature. Must be done before verifications are due. | Complete Payload Fabrication + 1.0 | | | | X | X | X | X | | X | ISS | V |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 321 | Verification Testing | | The specific tests that the PD requests ISS Program facility or support will be itemized below and tracked individually in the payload unique schedules. | PD | | | | | | | | | | | | | | V |
| 321.1 | | 1553 RT Validation Test | Each payload requiring 1553 commanding needs to perform a MIL SPEC 1553 Remote Terminal (RT) Validation Test to ensure that the payload hardware is compliant with the 1553 protocols. The ISS Program offers this test capability at the SCTF RT Validation lab. | OD | Kevin Calvin | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.2 | | JSL Testing | Payloads can perform a functional demonstration test of their payload Ethernet interface at the Joint Station LAN (JSL) laboratory located at the SCTF or via connection to JSL Lab via the Space Station Integration and Test Facility (SSITF). Payloads using external wireless Ethernet for communications can request to perform a functional demonstration test of their payload Ethernet interface at the JSL lab located at the SCTF. In addition, JEM-EF installed payloads are required to perform a functional demonstration test that their payload Ethernet interface can communicate with the LEHX hardware found on the JEM.<br>Note 1: All testing will be coordinated utilizing the current SDIL test process which identifies all testing and necessary resources via a SIF.<br><br>**TBD: Need to identify how the PD can test Ethernet interoperability without using the JSL Lab. Incorporate Ethernet Test Suite and RAPTR.** | OD | Margaret Sterling | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.3 | | Frequency Management Analysis | Ensures that payloads with Radio Frequency transmissions do not interfere with ISS frequencies. The PD is required to provide data into the JSC Frequency Management database. | OD/EV | Cathy Sham | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.4 | | Power Quality Testing | This testing can help ensure the PD is collecting power data in a manner that satisfies the electrical interface verification requirements. The ISS Program offers power testing support to payloads using various electrical interfaces on ISS. This test service is available at JSC in the SCTF Integrated Power Lab (IPL), at KSC in the SSPF, or it can be performed at the payload's development site with the proper coordination. The JSC Energy System Test Area (ESTA) Power Testing Lab also can support power quality testing to verify a payload works properly with the various electrical power supplied by ISS. This testing includes 120Volt (V) Direct Current (DC), 28VDC, 120V Alternating Current (AC), and various DC load testing. The ESTA lab can also test compliance with turn on/off current, AC and DC impedance, and voltage excursions. Since JSC ESTA lab services are independent of the ISS Program, there typically is cost associated with use of this lab. | OD/EA | Casey Adams | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.5 | | PRCU Testing | Utilized to test payload hardware interfaces to the ISS and conduct end-to-end development or functional testing. In this capacity the Payload Rack Checkout Unit (PRCU) serves as a high fidelity emulator of on-orbit ISS interfaces (C&DH, laptop, power, cooling, vacuum, etc.) and allows experiment developers to ensure that their payload will interact properly once connected on-orbit. PRCUs are located at NASA JSC, KSC, MSFC, and GRC. | OD | MSFC/Rob West KSC/Rob Kuczajda JSC/ GRC/Terry O'Malley | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.6 | | RITF Testing | JSC Receiving, Inspection, and Testing Facility (RITF) is available to perform a variety of mechanical testing, such as fastener testing. | OB | Raani Francis/OB, Cheryl Corbin/NT4 | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.7 | | KSC Testing | Kennedy Space Center (KSC) is available to perform a variety of testing prior to vehicle integration (e.g., EXPRESS Logistics Carrier (ELC) testing). | KSC/UB-A | Robert Kuczajda | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.8 | | WFF Testing | Wallops Flight Facility (WFF) is available to perform a variety of testing prior to vehicle integration. | KSC/UB-A | Robert Kuczajda | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | X | X | ISS | V |
| 321.9 | | Flight Media Production/Testing | The PSIVF can be utilized to create and test flight certified media (Compact Discs [CDs] or Digital Video Discs [DVDs]) containing payload software for launch to ISS. The ISS CD Library Process owned by JSC/ISS Avionics & Software Office (OD) is the ISS Program's preferred method for manifesting media for use onboard ISS. The Payload Software Control Panel (PSCP) allows PDs to simply turnover their payload media and supporting documentation to the PSIVF for all ISS CD Library processing. The PSIVF and the Software Configuration Management team will then build, verify, and deliver flight media which meets the requirements in SSP 50613, ISS CD Library Requirements Document. Using a PSCP-owned and managed media duplicator and the process described in the Payload CD Library Process flow diagram, the PSCP will ensure a consistent, timely, repeatable, and highly successful flight media delivery process for the PD. | OD/PSIVF | Jill Travers | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | | X | ISS | V |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 321.1 | | SSC Software / Integration Testing | Testing of PD provided software can occur in the SCTF along with integration into ISS Service Packs. | OD | Keith Chuvala | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | | X | ISS | V |
| 321.11 | | Freezer Verification Testing | The Cold Stowage team can provide freezer verification testing for payload containers if negotiated and coordinated in advance. | OB | Larry Cotton | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | X | X | X | | | | | | X | ISS | V |
| 321.12 | | Coordinated External Contamination Analysis | The standard service provided by the Boeing External Contamination Group becomes a coordinated service if out-gassing and venting properties for materials used by the PD are not readily available.<br>Note: This service will not be available for Payloads that integrate to the JEM-EF or the COL EPF. | OB | Ron Mikatarian | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | | | | X | X | | | X | X | ISS | V |
| 321.13 | | EVA Worksite Analysis | For payloads robotically installed on to a USOS payload site, with the exception of JEM element sites, NASA via Boeing EVA and Systems Engineering and Integration will be responsible for payload contingency EVA data products and requirements definition. This includes an EVA Analysis Report (EAR) for each payload and an EVA Verification Report for each payload's integrated EVA requirements. These reports will be provided to the PD and will include all documentation required to support verification closure of the payload's integrated EVA requirements.<br>For payloads robotically installed on to JEM elements, EVA verification NASA and JAXA, with input from the PD, shall jointly determine if the payload has unique EVA requirements not enveloped by existing JEM-EF verification work. If an agreement is not reached, the discussion shall be brought to the EVA Analysis Integration Team (AIT) for resolution. When required, EVA verification shall be performed by JAXA. JAXA shall develop the Integrated EVA verification analysis report (worksite and translation path) and provide it to the NASA Vehicle Office. NASA Vehicle Office representatives shall be responsible for producing any necessary exceptions paperwork, which shall be reviewed by JAXA and presented to the EVA AIT for approval. The JAXA report of the Integrated EVA verification analysis shall be archived as part of the payload verification records. | OM, OB, XX | Linda Thomas | Need to be bounded by when payload is mature enough for testing and early enough to meet verification submittal needs. | Sync Point 2 + 1.0 | | | | X | X | X | X | X | X | ISS | V |
| 321.14 | | Glint/Obstruction Analysis | The JSC Graphics Research and Analysis Facility Lab is used for glint analysis of an ISS external payload and can also be used for truss site Payload Attach System (PAS) obstruction analysis. | OM, OB | | | | | | | X | X | X | X | X | X | ISS | V |
| 321.15 | | HOSC Verification Test | Test with HOSC to verify PDs can receive Telemetry and send commands and/or data via HOSC services. | POIC | PIE/Marshall Ops | | | X | X | X | X | X | X | X | X | X | ISS | V |
| 321.16 | | Conduct Timeliner Testing | POIF Timeliner leads works with PD to test Timeliner sequences and bundles. | POIF | | | | X | X | X | X | X | X | X | | X | ISS | V |
| 321.17 | | Dragon Force Test | For new powered lockers flying on SpX, a Dragon Force test is available to verify power interfaces with the SpX Dragon. It is an avionics test bed in Hawthorne, CA, but a reduced fidelity unit is available to be transported to the PD location if shipping to Hawthorne is not practical. | PD, ON | | | | | X | X | | | | | | X | ISS | V |
| 321.18 | | Cygnus Test | Powered payloads flying on Cygnus for the first time may be required to be power tested at Dulles with the spacecraft. In addition, a fit check of the unit is required to ensure any needed shimming or installation procedure development can be in place. | PD, ON | | This testing should take place at or before L-12 months. | | | X | X | | | | | | X | ISS | V |
| 322 | Submit I/F Verification Data | Submit I/F Verification Data | PD submits verification data to demonstrate adherence to the ISS Program requirements for Hardware and Software Interfaces. This line item does not account for planned late load related verifications (provided in the Deliver phase). | PD | | Verification data should be submitted as soon as each type of data is available. Verification dependent on testing typically takes longer than Certificate of Compliance (CoC) or Analysis. | Perform payload testing + 0.5 | X | X | X | X | X | X | X | X | X | PD | V |
| 323 | Accept and Close I/F Verifications | Accept and Close I/F Verifications | ISS Program reviews verification inputs provided by PD for adherence to ISS requirements.<br><br>**Add description of OB L-2 ops constraint process if verifications are not closed.** | OB, OD, OM, SF | | | Submit Interface Verification Data + 0.5 | X | X | X | X | X | X | X | X | X | ISS | V |
| 324 | Submit Unique VV Verification Data | Submit Unique VV Verification Data | If there are unique Visiting Vehicle (VV) requirements, the PD submits verification data to demonstrate adherence to the ISS Program requirements for Visiting Vehicle Interfaces. | PD | | Verification data should be submitted as soon as each type of data is available. Verification dependent on testing typically takes longer than Certificate of Compliance (CoC) or Analysis. | Perform payload testing + 0.5 | X | | X | X | X | X | X | X | X | PD | V |
| 325 | Accept and Close Unique VV Verifications | Accept and Close Unique VV Verifications | If there are unique Visiting Vehicle (VV) requirements, the ISS Program and Visiting Vehicle provider reviews verification inputs provided by PD for adherence to Visiting Vehicle requirements. | ON | | | Submit VV Verification Data + 0.5 | X | | X | X | X | X | X | X | X | ISS | V |
| 326 | Review Final Software ICD | Review Final Software ICD | The ISS Program / OD documentation review of the Final Software ICD for completeness and verification of compliance with Program requirements. The data in the Final Software ICD is expected to be a review of the final as-built data used in the implementation of the payload software. | PD, OD, MSFC PRO | Michael Coats | | TBD | X | X | X | X | X | X | X | | X | Both | V |

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| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EP | | | | |
| 327 | Configure HOSC systems for Flight | Configure HOSC systems for Flight | HOSC systems must be configured with the proper command and telemetry databases and HPEG configurations, as well as voice, video, and telemetry routing for a particular increment so that the services needed during the increment are available to all the payload users. | POIC | | HOSC systems are configured prior to increment transitions - generally 2 weeks prior to the start of the onboard increment. | Increment - 0.5 | X | X | X | X | X | X | X | | | ISS | V |
| 328 | Phase III Safety Review Inputs | Phase III Safety Review Inputs | The PD requests the ISS Program schedule a Phase III Safety Review with the Safety Panel. The PD performs a safety assessment based on the guidelines in SSP 30599 and submits the Phase III Safety Data Package to the SPE via the ISS Hazard System (IHS) tool. The PD then reviews comments from the Safety Subject Matter Experts provided by the SPE, and prepares responses to be discussed during the Phase III Safety Review. If necessary, the SPE can coordinate Working Group meetings with Subject Matter Experts to discuss comments and pre-coordinate responses. | PD | | Inputs should be provided 20 working days before the Phase III Safety Review to allow Safety Panel members time to review and provide comments. | PD Driven | X | X | X | X | X | X | X | X | X | PD | V |
| 329 | Phase III Safety Review Prep | Phase III Safety Review Prep | The SPE coordinates the scheduling of the <u>Phase III Safety Review</u> meeting, reviews the <u>Phase III Safety Review Inputs</u> from the PD, and distributes to the Safety Subject Matter Experts for review and comment. Comments are coordinated back with the PD to allow the PD to prepare responses prior to the <u>Phase III Safety Review</u>. If necessary, the SPE coordinates Working Group meetings with Subject Matter Experts to discuss comments and pre-coordinate responses. | PD, OE | SPE | | Phase III Safety Review Inputs + 0.75 | X | X | X | X | X | X | X | X | X | Both | V |
| 330 | Phase III Safety Review | Phase III Safety Review | Phase III Safety Review is held with the PD and ISS Safety Review Panel (ISRP). The PD presents their Phase III Safety Inputs to the ISRP, and the ISRP provide concurrence and/or recommendations. The objectives of the Phase III Safety Review are to:<br>• Obtain safety review panel final approval of the safety analysis that reflects the design and concept of operations of the payload and its interfaces.<br>• Present the final safety analysis that identifies all hazards and hazard causes, resolves any safety non-compliances, and identifies all safety verification methods, status of verification closures, and status of remaining open items transferred to Safety Verification Tracking Log (SVTL) and status.<br><br>For hardware that is considered to be series or reflown hardware, a Series/Reflown Hardware Safety Assessment should be performed. It is typically reviewed around the time when a Phase III review would occur. | PD, OE | SPE | | Phase III Safety Review Inputs + 1.0 | X | X | X | X | X | X | X | X | X | Both | V |
| 331 | Science Symposium | Science Symposium | A multi-day event for Principal Investigators to present their science objectives, testing approach, and measurement methods to agency scientists, managers, and other investigators. Participation is encouraged (but not required) to gather a global picture of the science planned to be performed on ISS during a specified timeframe (usually increment pair). | PD, Steward Discovery | PSO | | TBD | X | X | X | X | X | X | X | X | X | Both | V |
| 332 | Approve NCRs | Approve NCRs | The ISS Program must review, assess risk to ISS, and approve each Non Compliance Report (NCR) prior to the payload deviating from established safety requirements. The ISS Safety Review Panel will identify the appropriate approval authority for each Non Compliance Report (NCR). The PD is responsible to provide the necessary information to the approval authority to allow sufficient review and understanding of the risk to ISS prior to approval. | OE | | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |
| 333 | Provide Phase III SDP for VV internal safety review | Provide Phase III SDP for VV internal safety review | If payloads have any Safety Hazards that could impact the transportation vehicle, the transportation vehicle will be responsible for presenting integrated vehicle hazards to the ISS Safety Review Panel for review and approval. These integrated hazards must be closed to consider the payload certified for flight. | VV int. | | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |
| 334 | Ground Crew Training | Ground Crew Training | PD team conducts ground crew training for their experiment. This can also be done by a POI representative on behalf of the PD team if agreed to at the Crew Training TST. POI facilitates the crew training session. Other POI members, such as Ops Leads and OCs, may attend to gain better ops understanding. | PD, POIF | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 335 | Submit Flight Safety Certificate | Submit Flt Safety Certificate | PD submits flight safety certification request via IHS (Form 906). This information for each flight includes payload part numbers, hardware description, vehicle applicability, and owner responsibility. | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 336 | Review & Sign Flight Safety Certificate | Review & Sign Flight Safety Certificate | The ISS Safety Review Panel reviews and approves the Form 906, assuming the associated Safety Data Package is complete and all safety related issues have been resolved. | OE | SPE | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |
| 337 | PD Training | PD Training | PD is provided training on POI ground systems and interfacing with the POIC cadre. This training will prepare the PD to support ISS real time operations for their payload. At their request, PDs may also participate in voice loop exercises and simulations. | PD, POI | | Will not train until ISS Program knows when they will operate. | Submit Inputs to CoFR Checklist – 0.25 | X | X | X | X | X | X | X | X | X | ISS | V |
| 338 | Submit Ground Safety Checklist / Hazard Reports | Submit Ground Safety Checklist / Hazard Reports | TBD | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | V |
| 339 | Coordinate Ground Safety Checklist/Hazard Reports | Coordinate Ground Safety Checklist/Hazard Reports | TBD | Plan and Process Cargo | | | TBD | X | X | X | X | X | X | X | X | | ISS | V |
| 340 | Review and approve Ground Safety Checklist / Hazard Reports | Review and approve Ground Safety Checklist / Hazard Reports | TBD | OE, Launch site | | | TBD | X | X | X | X | X | X | X | X | X | ISS | V |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 342 | Provide Inputs to PL Regs & FRs | Develop PL Regs and FR's | Ops Lead works with PD to develop any necessary Payload Regs and/or Flight Rules based on ops constraints. Ops Lead normally submits constraints on behalf of the PD team; however, the PD may make the inputs directly to the Book Managers. | PD, HP26 | Ops Lead | Normally occurs after Final Operability Review; however, results from Phase III Safety Review may lead to additional constraints being submitted. | Final Operability Review + 1.0 | X | X | X | X | X | X | X | X | X | Both | V |
| 343 | Submit Ground Processing Requirements (PSRD/PRD) & Technical Requirements | Submit Ground Processing Requirements (PSRD/PRD) & Technical Requirements | The PD submits inputs to the Payload Support Requirements Document (PSRD). The PSRD documents the advanced planning for ground processing support requirements necessary to process ISS payloads at KSC or Wallops. Payload support provided by KSC or Wallops may comprise some or all of the following phases of the payload life cycle: simulations, preflight, in-flight, and post-flight phases. This includes both hardware and science items to be processed at KSC or Wallops. | PD | | | | X | X | X | X | X | X | X | X | X | PD | V |
| 344 | Assess & Implement Ground Processing Requirements (PSRD/PRD) | Assess & Implement Ground Processing Requirements (PSRD/PRD) | KSC assesses PD requests, documents ground processing support requests in the PSRD, and provides the support as agreed. | Plan and Process Cargo | KSC/Jennifer Wahlberg | | | X | X | X | X | X | X | X | X | | ISS | V |
| 345 | Hold Cargo Integration Review (CIR) | Hold CIR | Cargo Integration Review (CIR): | ON | | | | | | | | | | | | | ISS | V |
| 345.1 | | Hold Cargo Integration Review (CIR) | Cargo Integration Review (CIR):<br>HTV<br>Confirms that the manifested cargo complement can be integrated in the HTV.<br>Approves the final layout of the cargo in the HTV and confirms the availability of all the related procedures and application of the related procurement plans. Confirms the cargo integration schedule. Authorizes the start of the cargo physical integration. | HTV | | | | X | X | X | X | X | X | X | X | | ISS | V |
| 345.2 | | Hold Cargo Integration Review (CIR) | Cargo Integration Review (CIR):<br>SpaceX<br>Verify that ground processing facilities are ready to receive NASA cargo and the Dragon Spacecraft is on-track for cargo integration activities. Verify that cargo staging facilities are in place, cargo is under environmental control and monitoring, stowage planning and procedures are completed and released including the readiness level to allow timely cargo integration and launch of the Dragon Spacecraft, Falcon 9 launch vehicle and pad systems. | SpX | | | Launch - 4 | X | X | X | X | X | X | X | X | | ISS | V |
| 345.3 | | Hold Cargo Integration Review (CIR) | Cargo Integration Review (CIR):<br>Orbital-ATK<br>CIR is an in-process review of on-going mission-specific cargo integration activities. Orbital provides confirmation that ground processing facilities are ready to receive NASA cargo and that the Cygnus spacecraft is on-track for cargo integration activities. This includes reporting results of all analytical assessments (e.g., integrated loads, launch-to-activation thermal assessments) showing cargo compatibility with the Antares launch vehicle and Cygnus spacecraft. | Orbital-ATK | | | | X | X | X | X | X | X | X | X | | ISS | V |
| 346 | Review KSC Technical Requirements & Baseline OMRS | Review KSC Technical Rqmts & B/L OMRS | TBD | KSC | Jennifer Wahlberg | | | X | X | X | X | X | X | X | X | | ISS | V |
| 347 | Payload handling training for VV. Deliver Ground Handling/IVT documentation | | TBD | PD, KSC | | | | X | X | X | X | X | X | X | X | X | Both | V |
| 348 | Return PFE | Return PFE | The PD returns Program Furnished Equipment (PFE) provided by the ISS Program, per the agreements documented in the PIA. The unique schedules will track each item/group of items per owner and return date. | PD | | | PD Driven | X | X | X | X | X | X | X | X | X | PD | V |
| 349 | CoFR Checklist | CoFR Checklist | The PD provides inputs to the Certification of Flight Readiness (CoFR) Endorsement Checklist and Open Work Tracking Log (OWTL) per requirements referenced in SSP 52054.<br>All OZ certifying organizations are required to submit a CoFR Endorsement checklist and OWTL. | PD, OZ | | | | X | X | X | X | X | X | X | X | X | Both | V |
| 350 | Hold VV Preship Review (externals) | | TBD | PD, ON | | | | | | | X | X | X | X | | X | Both | V |
| 351 | CSS Inputs | CSS Inputs | PSO contacts the PD teams to assess their customer satisfaction. | PD, ISS Program | PSO Rep | Prior to Sync Point Reviews | | X | X | X | X | X | X | X | X | X | Both | V |
| 352 | Sync Point 3 | | Internal ISS Program review intended to sync up NASA organizations and review issues coming out of payload verification efforts. Specific topics include reviewing PIM Schedule, approving PIA updates, and communicating risks among the ISS Program management. More information is included in the Sync Point 3 Charter. | OZ6 | PIM | Schedule after PD completes their verification efforts, and before hardware delivery for integration. | Deliver Payload - 0.25 | X | X | X | X | X | X | X | X | | ISS | V |

## B.4 Integration Activities – Deliver Phase

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL-EFP | | | | |
| 400 | Provider Deliver Data Set | Provider Deliver Data Set | Provide data that is needed by the program. Data deliveries may be spread throughout the phase. For specific details on data deliveries in this phase, refer to FCC License. | PD | | | | | | | | | | | | X | PD | D |
| 402 | Launch Site Badging & Import Permits | Launch Site Badging & Import Permits | For Payload Developer personnel that will require access to Launch Site to support payload/sample hardware ground processing, Visitor Requests must be submitted so that the Launch Site can issue Temporary Badges. US PD personnel can obtain a non-escort badge; International PD personnel must obtain escort badges a Foreign Visitor Information Sheet must be provided for each person with a copy of passport. Need words import permits. Jennifer Wahlberg.<br><br>If PD team members will require access to Launch Site (e.g., KSC) for payload hardware/sample processing prior to turnover, coordination with the badging office is required. The PIM will contact the badging office to obtain the list of attributes required for processing and will coordinate with the PD team for submittal. Processing for IP PD teams is lengthy. The Launch Site will determine the PD training required after badge receipt (standard safety training for handling, etc.) | PD, OZ, KSC | | Amanda emailed Sharon Lozado on 11/10/16 to request timing info. | | X | X | X | X | X | X | X | X | X | Both | D |
| 403 | Deliver RCF Inputs | Deliver RCF Inputs | Process Owner: Manage Interfaces (Software)<br><br>The delivery of the EXPRESS Rack RIC Configuration Files to OPS Integration. These files are used to configure the EXPRESS Racks for the increment by payload. Milestones does not require data defined in ATTG from PD | OD | | | | | | | | | | | | | ISS | D |
| 405 | Complete Flight PPIL Inputs | Complete Flight PPIL Inputs | Process Owner: Manage Interfaces (Software)<br><br>The date the PD must complete their input to the Increment Flight PPIL to document the complete C&DH payload software configuration.<br><br>The Payload Product Integrated List (PPIL) is a managed list of software products to be used on-orbit or on the ground to support payload operations during a specific increment. Includes Product Type (rack, subrack, pallet, sub-pallet, core element, and ground), Part Number/Version, Version Description Document Number, Maturity Level, Provider Name and Compatibility/Known References. | OD | | | | | | | | | | | | | | D |
| 406 | Build & Test EXPRESS Config | | TBD - Pat Patterson. Milestones does not require data defined in ATTG from PD | POI | | | | | | | | | | | | | ISS | D |
| 407 | Baseline Flight PPIL | Baseline Flight PPIL | Process Owner: Manage Interfaces (Software)<br><br>The date the Flight PPIL is approved and baselined for the Increment. This baseline is a required dependency to load the payload software flight products on-orbit.<br><br>The Payload Product Integrated List (PPIL) is a managed list of software products to be used on-orbit or on the ground to support payload operations during a specific increment. Includes Product Type (rack, subrack, pallet, sub-pallet, core element, and ground), Part Number/Version, Version Description Document Number, Maturity Level, Provider Name and Compatibility/Known References. | OD | | | | | | | | | | | | | | D |
| 408 | Deliver Media Transfer Case | Deliver Media Transfer Case | Process Owner: Manage Interfaces (Software)<br><br>The date the CD Transfer Case is delivered to the Cargo Mission Contract for packing in the launch vehicle. | OD | | | | | | | | | | | | | | D |
| 409 | Complete P1, P2, and Cadre Training | Cadre Training Products | Cadre training consists of payload specific products deemed necessary to prepare the cadre for upcoming operations. The intent of these training products is to educate flight controllers on the concepts, constraints, and technical data associated with a payload required for it to operate. The PD is a courtesy reviewer for the product. | POI, PD | Ops Lead | | L- 1.25 | X | X | X | X | X | X | X | X | X | Both | D |
| 410 | OWTL | OWTL | The PD provides Certification of Flight Readiness Endorsement Checklist and Open Work Tracking Log (OWTL) inputs to the ISS Program per requirements referenced in SSP 52054. OZ6 conducts a review of all PD CoFR open work to focus and identify any potential issues/threats and CoFR exceptions. Emphasis is made to prioritize work to close open endorsements prior to OZ Stage Operations Readiness Review (SORR). | PD, OZ | | | L- 1.4 | X | X | X | X | X | X | X | X | X | Both | D |
| 411 | Cargo Layouts | Cargo Layouts | The Cargo Mission Contractor (CMC) develops Cargo Layouts for the planned launch configuration based on approved Manifest Request (MR) Loaders. The Stowage PIM distributes CMC Cargo Layouts for review by the PDs. The PD/PIM review the information with respect to the payload volume, and relevant orientation and/or placement constraints if they exist for the payload. | PD, OC/CMC | SPIM | On Dock minus 6 to 8 weeks. Needed to support Packing Readiness Review. | Hardware Readiness - 2 | X | X | X | | | | | X | X | Both | D |
| 412 | TGHR | TGHR | PDs provide input to the ISS Program/OC-KSC to develop the Time-Critical Ground Handling Requirements (TGHR) table if their hardware or samples have time-critical requirements. Time-critical requirements include prelaunch late turnover, launch delay, power interrupt constraints, and payload orientation requirements. The TGHR may also include time-critical requirements for non-payload items. OC distributes the draft Time-Critical Ground Handling Requirements (TGHR) input and will review the captured constraints for time-critical PD hardware and/or sample turnover. | KSC, OC, OZ | | OC distributes the draft TGHR input and will review the captured constraints for time-critical PD hardware and/or sample turnover and will provide input. | As required prior to Launch | X | X | X | X | X | X | X | X | X | Both | D |
| 413 | Hardware Readiness | Hardware Readiness | Date the hardware is ready to ship to either the Cargo Integrator (e.g., Cold Stowage or Cargo Mission Contract (CMC)) or Launch Vehicle Provider, and Launch related Safety and Verifications have been approved by the ISS Program and/or Launch Vehicle Provider. | PD, OZ, OB, OC, OE, ON | PIM | | | X | X | X | X | X | X | X | X | X | PD | D |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EFP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 414 | Deliver Payload to ISS Program | Deliver Payload to ISS Program | The PD delivers the external payload to the appropriate Visiting Vehicle integration team. For payloads requiring ground processing, On-Dock (O/D) dates are based on the payload's unique processing schedule of activities which occur prior to turnover (T/O). At T/O, the payload hardware custodianship is passed from/to the hardware owner to/from the ISS program integration organization. T/O may or may not coincide with O/D dates, depending on the payload's unique processing schedule of activities.<br><br>The PD delivers the pressurized payload hardware to the Cargo Mission Contractor. At delivery, the payload hardware custodianship is passed from/to the hardware owner to/from the ISS program integration organization.<br><br>**TBD - Describe Form 1149.** | PD | | | Hardware Readiness + 0 | | | | X | X | X | X | | X | PD | D |
| 415 | Integrate External Payload | Integrate External Payload | The Visiting Vehicle team integrates the external payload hardware based on Ground Processing Requirements coordinated and agreed to within the Verify Phase. | VV | | | Hardware Readiness + 0 | | | | X | X | X | X | | | ISS | D |
| 416 | Nominal cargo delivery | Nominal cargo delivery | The Cargo Mission Contractor (OC) takes ownership of payload delivered hardware and packages the payload hardware based on approved Cargo Layouts and eLRODS requirements. The Cargo Mission Contractor ships fully packaged payload hardware to the Visiting Vehicle. | OC, VV | | | | X | X | X | | | | | | | ISS | D |
| 416.1 | | Pre-Turnover Review | If needed for late load payloads, Stowage PIM works with the PIM/PD to schedule a pre turnover review of the hardware at late load processing facility prior to turnover to CMC. CMC does shadow in this meeting to capture barcodes, serial numbers for population in manifest to support MITR deliverables. | OZ, PD | SPIM | On Dock minus ~7-3 days for Dragon and ~14-4 days for Cygnus | Nominal cargo delivery - 0.5 | X | X | X | | | | | | | | |
| 417 | Internal CoFR | Internal CoFR | OZ consolidates all payload CoFR inputs for presentation at the Stage Operations Readiness Review (SORR). Reference SSP 57054, CoFR Plan, for more definition. | OZ | | | TBD | X | X | X | X | X | X | X | X | | ISS | D |
| 420 | Final Ops Products Reviewed | Final Ops Products Reviewed | PD team participates in Pre-ECR check, ECR Review, and ECR Meeting to baseline procedures and planning products (Payload Activity Requirements Document (PARD), Payload Planning Overview (PPO), and planning Ground rules and Constraints (Gr&C)). | POI, PD | | | L - 2 | X | X | X | X | X | X | X | X | X | Both | D |
| 422 | Launch Campaign Constraints | Launch Campaign Constraints | For payload hardware or samples with critical pre-launch processing timing requirements, the PD will provide input to the Experiment Constraint Questionnaire. The ISS program evaluates this to understand the impact to PDs when launch go/no go decisions are to be made. Data is collected regarding long lead decision points, pre-processing timeline, lifetime of hardware/sample on the launch vehicle prior to launch, multiple sets of payload hardware/samples to be processed for multiple launch opportunities, critical activation/operations points in time. The ISS program evaluates this to understand the impact to PDs when launch go/no go decisions are to be made.<br><br>The ISS program evaluates Experiment Constraint Questionnaire input from all PDs to understand the impact to PDs when launch go/no go decisions are to be made.<br><br>**Add sentence about "Prepare launch Related communication package".** | PD, OZ | | | L - TBD Ask Mary Walsh | X | X | X | | | | | | X | Both | D |
| 423 | SORR | SORR | The Stage Operations Readiness Review (SORR) certifies that the Visiting Vehicle/Cargo Element ground support facilities and personnel are ready to support the flight, stage, and/or increment. Additionally, it certifies the readiness of the on-orbit stage configuration to accept the Visiting Vehicle/Cargo Element and readiness for on-orbit increment operations.<br>This review applies to the cargo elements and on-orbit stage, as well as payloads and logistics items, consumables, and facilities and personnel associated with launch and on-orbit operations. The NASA CoFR endorsement is signed at the SORR. Each IP/P presents its CoFR at the SORR. | OZ | | | L minus 3.5 wks | X | X | X | X | X | X | X | X | | ISS | D |
| 424 | Develop Real-Time Team Contact List | Develop Real-Time Team Contact List | TBD - LIS/Brad Files needs to provide definition. POI is the user of this list. This should be compiled from each PD Team, GDSBB Input, team members. | LIS | | | | X | X | X | X | X | X | X | X | X | Both | D |
| 425 | Accept and Close Late Load Verifications | Accept and Close Late Load Verifications | SE&I Discipline Experts review Late Load Verification submittals made by the PD. | OB | | | | X | X | X | X | X | X | X | X | | ISS | D |
| 425.1 | | Conduct Late Load Burr Inspection and Label Check | An inspection of Burrs on late load payload hardware is required per the IRB. The SE&I HFIT organization can close relevant Burrs verification based on either PD Quality or CMC Quality physical inspection. The Stowage PIM will check all hardware labels for conformance to documented expectations. | PD, OZ, OC | | | Prior to Turnover | X | X | X | | | | | | | ISS | D |
| 425.2 | | Closeout of open work (HMST) | If the payload contains Hazardous Materials, JSC Toxicology will issue a Verification (V-2) form to the PD team to verify that the materials loaded are exactly as listed in the verified HMST for the payload. The PD will complete and sign the form, and will return it to JSC Toxicology. | PD, Tox | | Just following the completion of HMST loading in the payload hardware. | | X | X | X | X | X | X | X | X | X | Both | D |
| 426 | Preflight BDC | Preflight BDC | This is refers to completion of preflight BDC, if applicable. If the BDC isn't completed per requirements, the payload may not be ready for on-orbit operations (might still launch the hardware, but payload readiness will be a question at SORR). | PD, CB, SA | | BDC is generally completed around 6 to 8 weeks prior to crewmember launch. | Increment - 2.0 | X | X | X | | | | | | X | Both | D |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal | | | External | | | | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | S | Sub | ELC | Truss | JEM-EF | COL EP | | | | |
| 427 | Late Load cargo delivery to next level integrator | Late Load cargo delivery to next level integrator | Hardware received from the PD, and packaged by CMC or the Cold Stowage Team is turned over to the Launch Provider for final loading. | PD | | | | X | X | X | | | | | | X | PD | D |
| 427.1 | | Pre-Turnover Review | If needed for late load payloads, Stowage PIM works with the PIM/PD to schedule a pre turnover review of the hardware at late load processing facility prior to turnover to CMC. CMC does shadow in this meeting to capture barcodes, serial numbers for population in manifest to support MITR deliverables. | OZ, PD | SPIM | On Dock minus ~7-3 days for Dragon and ~14-4 days for Cygnus | Pack & deliver late load cargo - 0.5 | X | X | X | | | | | | X | Both | D |
| 428 | Cold Stowage Late Load Launch Services | Cold Stowage Late Load Launch Services | The Cold Stowage team can perform late Cold bag and GLACIER integration of PD hardware later than L-48hrs, if appropriate scientific rationale is documented in the PIA. | OC | | | L - 48 hrs. | X | X | X | | | | | | X | ISS | D |
| 429 | Pack & deliver late load cargo | Pack & deliver late load cargo | Hardware received from the PD is packaged by CMC or the Cold Stowage Team per eLRODS input. | OC, CMC | | | | X | X | X | | | | | | | ISS | D |
| 430 | Install Cargo | Install Cargo | Hardware received from the PD (nominal or late load), and packaged by CMC or the Cold Stowage Team is turned over to the Launch Provider for final loading. | VV | | | | X | X | X | | | | | | | ISS | D |
| 431 | CSS Inputs | CSS Inputs | PSO contacts the PD teams to assess their customer satisfaction. | PD, ISS Program | PSO Rep | Prior to Sync Point Reviews | | X | X | X | X | X | X | X | X | X | Both | |
| 432 | Launch | Launch | We have liftoff! | VV | | | L :) | X | X | X | X | X | X | X | X | | | D |

## B.5 INTEGRATION ACTIVITIES – OPERATIONS AND POST OPERATIONS PHASE

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | Internal ELC | External Truss | External JEM-EF | External COL-EP | Jettison | PD View of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 500 | Submit Console Support Plan | Submit Console Support Plan | TBD - Pat Patterson | POI | | | | X | X | X | X | X | X | X | X | | ISS | O |
| 501 | Document Console Support Plan | Document Console Support Plan | TBD - Pat Patterson | POI | | | | X | X | X | X | X | X | X | X | | ISS | O |
| 502 | Operations Readiness | Operations Readiness | All operations products have been verified for first time use by the POI Readiness Check process defined in POH Vol 2 SOP 7.14/Readiness Check for Payload Operations. All Operational Constraints have been lifted. | PD, POI, OZ, OB, OC, OE, ON | | | | X | X | X | X | X | X | X | X | X | Both | O |
| 502.1 | | Operations Need Date | Date payload operations are needed to meet payload identified business considerations. | PD, POI, OZ, OB, OC, OE, ON | | | | X | X | X | X | X | X | X | X | X | Both | O |
| 503 | Operate Experiment | Operate Experiment | The PD team and POI Real-Time team work together to execute the short-term and daily operating plans. When deviations to operations are needed, the PD works with their Ops Lead and/or PARC to submit an Operations Change Request (OCR) to re-schedule or modify planned payload operations. | PD, POI | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | Both | O |
| 504 | Real-Time Prioritization/Re-Planning | Real-Time Prioritization/Re-Planning | TBD - UIS | OZ, POIC | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | | ISS | O |
| 505 | Build Daily Science Summary | Build Daily Science Summary | TBD - UIS | OZ | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | | ISS | O |
| 506 | Submit Weekly Science Input | Submit Weekly Science Input | When the PD Principal Investigator or Researcher accomplishes significant science and/or operational results, the PD has an opportunity to complete a form and mail it to TBD. The PD input will be rolled in the Weekly Science Summary, which is reviewed by TBD. | PD | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | PD | O |
| 507 | Build Weekly Science Summary | Build Weekly Science Summary | TBD - UIS consolidates all significant science and payload operational results for TBD.<br>Pat Patterson help needed. | OZ | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | | ISS | O |
| 508 | Science tag-up twice a week | Science tag-up twice a week | TBD - UIS. PD Participation is optional. | PD, OZ | | Science Tag Ups are conducted weekly on Tuesdays and TBD date. | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | Both | O |
| 509 | S/W Updates | S/W Updates | TBD (Michael Coats) - Review and approve S/W updates. Include reference to POH Vol II for how S/W is update via OCR. | PD, OD/Manage Interfaces | | | As Required | X | X | X | X | X | X | X | X | X | Both | O |
| 510 | Complete Operations | Complete Operations | The PD team and POI Real-Time team work together to execute the short-term and daily operating plans until all are completed. | PD, POI | | | On-Orbit Duration of Science Ops | X | X | X | X | X | X | X | X | X | Both | O |
| | | | **Post Operations** | | | | | | | | | | | | | | | |
| 511 | Submit Flight Safety Certificate | Submit Flt Safety Certificate | PD submits flight safety certification request via IHS (Form 906). This information for each flight includes payload part numbers, hardware description, vehicle applicability, and owner responsibility. | PD | | | TBD | X | X | X | X | X | X | X | X | X | PD | PO |
| 512 | Review & Sign Flight Safety Certificate | Review & Sign Flight Safety Certificate | The ISS Safety Review Panel reviews and approves the Form 906, assuming the associated Safety Data Package is complete and all safety related issues have been resolved. | OE | SPE | | TBD | X | X | X | X | X | X | X | X | X | ISS | PO |
| 513 | Safety Data | Safety Data | TBR - Safety data is required for process/approval of payload/sample returns | OE | SPE | | | X | X | X | X | X | X | X | X | X | ISS | PO |
| 514 | Send 30 day reports | Send 30 day reports | TBD - IMT | | | | | X | X | X | X | X | X | X | X | X | PD | PO |
| 515 | Gather/Process 30-day reports | Gather/Process 30-day reports | TBD - IMT | OZ | | | | X | X | X | X | X | X | X | X | | ISS | PO |
| 516 | Create RMDP | Create RMDP | The Return Manifest Disposition Plan (RMDP) provides the requirements and process for returning the ISS manifest items to their respective owners. The RMDP provides ground processing personnel with a complete document to be used to disposition all stowed ISS return items removed from the vehicle after landing. The RMDP is the single ISS source of disposition instructions for ISS hardware being returned in the vehicle. The RMDP Blank Book (SSP 50465) contains the generic instructions that apply to every ISS mission landing and is applicable for every visiting vehicle that returns ISS hardware. The RMDP Blank Book is controlled by the MIOCB. The RMDP mission-specific appendices contain mission-unique information concerning the return items. Inputs to the appendices come from the Mission IDRD Annex 1, the hardware provider, LRODS, and the Cargo Integration point of contact. The initial RMDP data is compiled by OC, tapping into MIDAS and eLRODS inputs.<br><br>OZ Stowage receives the RMDP and distributes to all PIMs with returning PD hardware. The PIM and PD work together to correct and complete all required data fields. Updates are returned to OC for incorporation in the final RMDP. | OZ, PD, OC | SPIM | | Return - 1.5 | X | X | X | | | | | | X | Both | PO |
| 517 | Post Flt BDC | Post BDC | TBD - Baseline Data Collection (BDC) | | | | | X | X | X | | | | | | X | Both | PO |

| Flow Reference # | Flow Task / Milestone | Schedule Task / Milestone | Definition | Owner | Person | Timing Information | Date (Months) | Internal F | Internal S | Internal Sub | External ELC | External Truss | External JEM-EF | External COL-EFP | Jettison | PD view of PIM Schedule | PD / Program | ST&E Phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 518 | Return/Landing meetings (early destow) | Return/Landing meetings (early destow) | A meeting with all the PDs that will travel to NASA designated return area (e.g., Long Beach) to pick up limited life hardware. This meeting covers timeline, text message setup and question & answer from PD. | PD, OC | | As needed prior to Return | Return - 0.25 | X | X | X | | | | | | X | Both | PO |
| 519 | Submit crew debrief questions | Submit crew debrief questions | TBD - LIS | OZ, PD | | | | X | X | X | | | | | | X | PD | PO |
| 520 | Crew Debrief | Crew Debrief | TBD - LIS | OZ, SPE | LIS | | | X | X | X | | | | | | X | Both | PO |
| 521 | Cold Stowage Samples Return | Cold Stowage Samples Return | Requests for early return of conditioned science samples to the PD after SpaceX recovery boat docking will be evaluated based on appropriate scientific rationale documented in the PIA. If approved, real-time ground transportation factors will determine the precise time of PD pickup. Nominal return will be performed at JSC building 7. Cold Stowage representatives would hand over the payload hardware/samples to the PD. | OC | Cold Stowage | Typically early return will occur between R+52 hours and R+72 hours. Nominal return in Houston is later. | Return + 0.15 | X | X | X | | | | | | X | ISS | PO |
| 522 | CMC Early H/W Return | CMC Early H/W Return | Requests for early return of hardware and/or non-cold conditioned science samples to the PD after SpaceX recovery boat docking will be evaluated based on appropriate scientific rationale documented in the PIA. If approved, real-time ground transportation factors will determine the precise time of PD pickup. CMC representatives would hand over the payload hardware/samples to the PD. | OC | CMC | Typically early return will occur between R+52 hours and R+72 hours. | Return + 0.15 | X | X | X | | | | | | X | ISS | PO |
| 523 | CMC Early H/A (Hou) | CMC Early H/W Return (Hou) | Hardware and/or science samples are available for early return pickup by the PD in Houston at the CMC LM16 facility. Appropriate scientific rationale must be documented in the PIA. Real-time air/ground transportation as well as overall CMC workload and prioritization factors will determine the precise time available for pickup. | OC | CMC | Typically as early as R+72 hours | Return + 0.15 | X | X | X | | | | | | X | ISS | PO |
| 524 | Nominal Destow | Nominal Destow | Payloads are de-integrated from the return vehicle. | OC | CMC | | Return + 1 | X | X | X | | | | | | | ISS | PO |
| 525 | Return Cargo | Return Cargo | OC/CMC returns PD hardware as specified in the RMDP. | OC, PD | | Landing + 4 to 10 weeks. | Return + 2.5 | X | X | X | | | | | | X | Both | PO |
| 526 | Receive Samples/H/W | Receive Samples/H/W | PD receives samples/hardware from ISS Program | OC, PD | | | | X | X | X | X | X | X | X | X | X | PD | PO |
| 527 | Lessons Learned (integration, launch, ops, CSS) | Lessons Learned (integration, launch, ops, CSS) | Flight and Increment Lessons Learned<br>The Flight Payload Manager (FPM) is responsible for pulling together all ISS Payloads lessons learned for the Increment Payload Manager (IPM) on a particular flight, as required. That includes hardware integration prior to launch, through flight, onboard ISS, and landing.<br><br>Increment Lessons Learned (do we still do these?)<br>The Increment Payload Engineer (IPE) is responsible for pulling together all ISS Payloads lessons learned for the Increment Payload Manager (IPM) on a particular increment. | OZ, PD | | | Completion of Ops and/or Hardware Return + 2 months | X | X | X | X | X | X | X | X | X | Both | PO |
| 528 | Remove Payload from IPL | Remove Payload from IPL | TBD | OZ | Mandy Cady | | Per Direction | X | X | X | X | X | X | X | X | | ISS | PO |
| 529 | Notify PSO of publications | Notify PSO of publications | TBD - PSO | PD | | | As Required | X | X | X | X | X | X | X | X | X | PD | PO |
| 530 | Compile publications | Compile publications | TBD - PSO | OZ | PSO | | As Required | X | X | X | X | X | X | X | X | | ISS | PO |
| 531 | Update Science Toolbox | Update Science Toolbox | The ISS Investigation Research Summary is a collection of data which is housed in the ISS Program Scientist Toolbox (http://iss.science.jsc.nasa.gov/). The purpose of the information is to provide accurate information about each investigation on the ISS and track the investigation from first operation to final publication. | OZ | PSO | | As Required | X | X | X | X | X | X | X | X | | ISS | PO |
| 532 | Data Access Cancellation | Data Access Cancellation | For PDs with an established remote Ground Control Center and command/data connectivity with the HOSC, after the completion of planned operations, the PD should notify the RIM/PIM/RPM that the HOSC interface is no longer required. Additionally, the PD IT Liaison should be contacted to coordinated NDC access termination.<br><br>The HOSC PIE for the payload will coordinate with the PD team to close out all connectivity with the HOSC services.<br><br>The PD IT Liaison office coordinates access termination with the PD team. | PD | | | Completion of PD Post Ops Reporting | X | X | X | X | X | X | X | X | X | PD | PO |

# SPACEDOC-2 NNC14CA02C
# DO-264 IAP
# ISOLATION AMPLIFIER PROJECT (IAP)
# CONTRACT PERFORMANCE PERIOD MARCH 30, 2022 THROUGH MARCH 31, 2023
# DO PERFORMANCE PERIOD MARCH 30, 2022 THROUGH JUNE 30, 2023

## 1 OVERVIEW

Preston 8300 XWB-A amplifiers have been utilized to isolate and buffer instrumentation signals between multiple Data Acquisition (DAQ) and control systems utilized in GRC ground test facilities. The 50-year-old Preston amplifiers have long exceeded their serviceable life and require costly repairs by a sole vendor. A project was created to search for a COTS replacement in (2014-2015). Commercial projects were vetted at this time and after no viable options were found, the design of in-house replacement was pursued.

A plan was formulated to design the units in-house at GRC. These amplifiers would utilize contemporary, common, commercial-off-the-shelf parts and provide equivalent "Preston Amplifier" functions with improved operation. There have been 3 design revisions, with 8 units of design Revs. 1 and 2 currently being used in the field. The Rev. 3 design is not complete.

This delivery order is divided into 2 main tasks:

Perform a trade study of existing COTS instrumentation amplifiers to determine if a viable replacement for the Preston amplifiers is available for purchase, and procure the two most viable COTS amplifiers, identified in this market survey, which meet the needs of the GRC testing enterprise.

- Review the whatever incomplete Rev 3 amplifier design documentation existing to date.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from March 30, 2022 through June 30, 2023.

Government Contacts:

1) GRC Program Manager, Scott Williamson
2) GRC Project Manager, Dean Kocan
3) Project Engineer, Matt Laun

### 1.2 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Master Amplifier Comparison (E-Team Reduction based on Rev 8)(minor Rev A).xls
2) Amplifier Replacement Recommendation Update 11-30-2014.doc
3) Amplifier Specifications Comparison for submittal 2022-02-07.xls
4) 8300_XWB.PDF
5) Preston_Amplifier_U-Spec.PDF

6) Rev 3 design documents. **These documents are not available currently**. They will be delivered upon completion.

### 1.3 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Project Manager, Dean Kocan, MS 6-8, Dean.A.Kocan@nasa.gov

Configuration Management Office, (Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Eric Hartman, Mail Stop 60-1, Eric.T.Hartman@nasa.gov

Program Manager, Scott Williamson, MS 6-7, Gary.S.Williamson@nasa.gov

Chief, GRC Testing Division (James A. Doglio, Mail Stop 6-8, james.a.doglio@nasa.gov)

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) Laboratory hardware located in Building 5 Room CW4G
2) Previously purchased electronic components may be utilized as needed.

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Building 5 Room CW4G – amplifier development area
2) Propulsion Systems Lab (Building 125)-Existing amplifiers are deployed here.

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# 4 PROJECT SPECIFIC SOW

## 4.1 PERFORM A TRADE STUDY AND ANALYSIS OF EXISTING COTS INSTRUMENTATION AMPLIFIERS TO DETERMINE IF A VIABLE REPLACEMENT FOR THE PRESTON AMPLIFIERS (MODEL 8300XWB-A) IS AVAILABLE FOR PURCHASE.

This analysis shall include all candidates considered, their respective specifications, a recommendation of suitable replacements (if any) and the criteria used to determine their feasibility as replacements.

The attached "Preston equivalent" specifications (Amplifier Specifications Comparison for submittal 2022-02-07.xls) shall be used as a baseline for the technical requirements comparison and analysis. For each candidate, all manufacturer specifications shall be documented and considered for this analysis, and the specifications listed below (contained in Amplifier Specifications Comparison for submittal 2022-02-07.xls) should be considered of higher importance when performing the analysis and recommendations.

8-Isolation between input and output

9-Isolation between input and power

10-Isolation between output and power

27-Accuracy

45-Linearity

82-Common Mode Rejection Ratio (CMRR)

The study should include standalone amplifier systems as well as combination signal conditioner/amplifier systems.

A hardware only (i.e., no external computer required for configuration and/or operation) solution would be preferred, but computer-controlled systems should be considered as well.

The analysis shall include present and future costs of hardware as well as software and licensing, if applicable. Instrument calibration cycles shall also be considered. These costs should be based on a 20-year life cycle.

The results of the previous trade study (Master Amplifier Comparison (E-Team Reduction based on Rev 8)(minor Rev A).xls and Amplifier Replacement Recommendation Update 11-30.2014.doc) will be made available for reference.

Upon delivery of the market survey, the two most viable COTS amplifiers (summarized in the figure below) will be procured and delivered to GRC for testing:

| Item | Part number | Description |
|---|---|---|
| | **Dewtron system parts** | |
| 1 | DEWE3-RM4 | Rack mount data acquisition system, 4 slots |
| 2 | TRION3-1820-MULTI-AOUT-8 | 8 channel Trion 3 module |
| 3 | TRION-CBL-L0B9-OE-05-02 | Cable from Lemo 0B 309 plug to open end, 5m |
| 4 | CAL-TRION-8CH-US-NEW | Calibration for the 8x inputs of the TRION3-1820-MULTI-AOUT-8 board |
| 5 | CAL-TRION-AOUT-8C-US | Calibration for the 8x outputs of the TRION3-1820-MULTI-AOUT-8 board |
| | | |
| | **Pacific Instruments** | |
| 6 | 6000E | Enclosure, 16 slot, Ethernet interface |
| 7 | 6165HF-PF4-BE6 | 2 channel instrumentation amplifier, 100KHz, 4 Frequency, 6 Pole Bessel with +/- 10V Input option. Filter: 10Hz, 100Hz,1kHz, and wideband. |
| 8 | PI660 | Software |

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Kickoff meeting and initial requirements review. | June 1, 2022 (was 4/2022) COMPLETE |
| 2 | Presentation of market survey report covering the analysis of available COTS replacement amplifiers as described by the task in Section 4. This analysis shall include all candidates considered and the criteria used to determine their feasibility as replacements. | August 1, 2022 (was 5/2022) COMPLETE |

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~3~~ | ~~Design Review Presentation~~ | ~~November 14, 2022~~ DELETE |
| 4 | Delivery of the COTS amplifiers identified in the figure above | June 30, 2023 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Dewetron Amplifier | 4 |
| Pacific Amplifier | 4 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| A trade study containing the analysis of available COTS replacement amplifiers as described by the task in Section 4. | 2 COMPLETE |

## 4.2 Design Analysis

Perform a technical review of the NASA Facilities Testing (FT) Rev. 3 amplifier component drawings (Schematics, Printed Circuit Board (PCB) artwork and mechanical drawings) as listed in the table below. Items with an "NA" don't exist and thereby do not require review.

Review the design and verify that it is safe and uses good standard design practice. These amplifiers will be used in ground test facilities. They are not flight hardware.

Review the design specifications for accuracy and determine how closely they meet the Preston Model 8300XWB-A specifications (Amplifier Specifications Comparison for submittal 2022-02-07.xls and 8300_XWB.PDF). Document any specification discrepancies.

Audit the PCB traces and vias for accuracy and verify that there are no collisions.

Reconcile the Bills of Materials (BOM's) for accuracy vs. the drawings.

Verify component availability and identify any long lead time components.

Perform a worst-case circuit error analysis and determine the impact on the amplifier performance specifications.

Review the chassis assembly (2U + 1U) for accuracy, fit and completeness. Investigate utilizing a 3U chassis in place of the 2U + 1U configuration.

Note: The PCB boards were designed utilizing PCB123 software

The front and rear panels were designed and fabricated by Front Panel Express using their software.

| No. | Description | Schematic | PCB Artwork | Mech. Drawing | BOM |
|---|---|---|---|---|---|
| 1 | Main PCB | X | X | NA | X |
| 2 | Input PCB | X | X | NA | X |
| 3 | Front PCB | X | X | NA | X |
| 4 | Expansion Main PCB | X | X | NA | X |
| 5 | Expansion Front PCB | X | X | NA | X |
| 6 | Front Main Panel | NA | NA | X | X |
| 7 | Front Expansion Panel | NA | NA | X | X |
| 8 | Chassis Mechanical | NA | NA | X | X |
| 10 | Wiring Harness | X | NA | NA | X |

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Kickoff meeting and initial requirements review. | July 18, 2022 (was 4/2022) COMPLETE |
| 2 | Technical Design Review -This should include drawing design review, BOM reconciliation, PCB audit, component availability review, and circuit error analysis. | September 19, 2022 (was 6/2022) COMPLETE |
| 3 | Determine and provide a cost to build and verify the system | September 30, 2022 (was 7/2022) COMPLETE |
| 4 | Final document delivery | October 18, 2022 (was 7/2022) COMPLETE |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| NA | |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Report containing the initial results of the drawing design review, BOM reconciliation, PCB audit, component availability review, and circuit error analysis. | 2<br>COMPLETE |
| Cost estimate to build and verify the system. This should list the criteria used and assumptions made to determine the cost. | 3<br>COMPLETE |
| Report containing the final results of drawing design review, review of BOM's, component availability review and circuit error analysis. | 4<br>COMPLETE |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| BOM | Bill of Materials |
| COTS | Commercial Off The Shelf |
| CMRR | Common Mode Rejection Ratio |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| DAQ | Data Acquisition System |
| DID | Data Item Description |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| FT | Facilities Testing |
| GRC | Glenn Research Center |
| ISS | International Space Station |
| IAP | Isolation Amplifier Project |
| NPR | NASA Procedural Requirement |
| NASA | National Aeronautics and Space Administration |
| NA | Not Applicable |
| PRACA | Preventive and Corrective Action |
| PCB | Printed Circuit Board |
| SpaceDOC-II (2) | Space Flight Systems Development and Operations Contract-II (2) |

# SpaceDOC-2
# Archived Base Tasks and Delivery Orders

BT-4: Space Communications and Navigation (SCaN) Testbed
BT-5: Exploration Technology & Flight Development (ETFD) - Space Launch System (SLS)
DO-201: Flame Extinguishment Experiment (FLEX)
DO-202: Constrained Vapor Bubble (CVB-2)
DO-203: Capillary Flow Experiment-2 (CFE-2)
DO-204: Zero Boil-Off Tank Project (ZBOT)
DO-205: Observation & Analysis of Smectic Island in Space (OASIS)
DO-206: Burning and Suppression of Solids-2 (BASS-2)
DO-207: Coarsening in Solid-Liquid Mixtures (CSLM-4)
DO-208: Packed Bed Reactor Experiment (PBRE)
DO-209: Advanced Colloids Experiment (ACE)
DO-211: Binary Colloidal Alloy Test (BCAT3-6)
DO-212: Cool Flame Investigation (CFI)
DO-214: Solid Fluid Ignition & Extinction (SoFIE) Science
DO-215: Human Health Countermeasures (HHC)
DO-216: Macromolecular Biophysics - Manual Base 1, 2, 3
DO-218: Unique Payload Development (UPD)
DO-219: Mission Integration and Operations (MIO)
DO-221: Two-Phase Flow Separator Experiment (TPFSE)
DO-223: Liquid Crystal Facility (LCF)
DO-225: Portable Unit for Metabolic Analysis (PUMA)
DO-227: Advanced Colloids Experiment (ACE)
DO-228: SCaN Center for Engineering, Networking, Integration, and Communications (SCENIC)
DO-231: CASIS Mission Integration and Operations (MIO)
DO-232: Additive Manufacturing Support (AMS)
DO-233: Zero Boil-Off Tank (ZBOT) - Mission Integration and Operations (MIO)
DO-235: Mini-Stirling Flight Technology Experiment (MISFTE)
DO-236: Flow Boiling and Condensation Experience (FBCE) - Hardware Fabrication
DO-237: Advanced Colloids Experiment (ACE) - Mission Integration and Operations (MIO)
DO-238: Solar Array Electrical Simulator (SAES)
DO-239: Sub-Kilowatt Electric Propulsion (SKEP)
DO-240: Plant Water Management (PWM)
DO-241: Microgravity Wind Tunnel (MWT)
DO-243: SCAN Program Strategic Plan Development (SCAN-PSPD)
DO-245: Lunar Solar Cell Demonstration Platform (LSCDP)
DO-246: Microgravity Wind Tunnel-2 (MWT-2)
DO-247: Electro-Motive Drop Tower (EMDT)
DO-249: Translating HRP Research and Evidence Into Actionable Deliverables (THREAD)
DO-253: Spacecraft Fire Safety Demonstration (SFS DEMO) Project VII and VIII

**Base Task 4**
**Space Communications and Navigation (SCaN) Testbed**
**For Contract Period of Performance 10/1/2014 through 9/30/2019**
**For the Performance Period 10/1/2017 to 9/30/2019**

## 1. Introduction

The SCaN Testbed project is a communications, networking, and navigation technology demonstration project funded by the Space Communications and Navigation (SCaN) Program within the Human Exploration and Operations Mission Directorate (HEOMD) at NASA Headquarters (HQ). The project was formerly called CoNNeCT. It includes both a Flight System, also referred to as the SCaN Testbed, and a Ground System known as the Ground Integration Unit (GIU). The Flight System is installed in the inboard, ram, and zenith location on the Express Logistics Carrier (ELC-3) located on the exterior truss of the International Space Station. The Flight System is remotely operated from the SCaN Testbed Control Center (STCC) located in the Telescience Support Center (TSC) at Glenn Research Center (GRC).

The payload is comprised of the following major subsystems: three Software Defined Radios (SDRs) developed by General Dynamics (GD), Harris Corporation, and Jet Propulsion Lab (JPL); a Radiation Frequency (RF) subsystem consisting of antennas, waveguides, switches and a Traveling Wave Tube Amplified (TWTA); the Avionics subsystem consisting of hardware to perform the Power and Command and Data Handling (C&DH) functions of the payload; the Antenna Point System (APS) consisting of the Integrated Gimbal Assembly and the Gimbal Control Electronics; the Mechanical/Thermal subsystem, consisting of the Flight Enclosure and Heaters; and the ExPRESS Pallet Adapter (ExPA) which provides the structural and mechanical interface to the ELC-3. Additionally, the payload consists of Software (SW) that resides in the Avionics subsystem and the SDRs, including Safety Critical SW in Avionics that is used to control hazards, as documented in the Flight Safety Review Process.

The project is responsible for the operations, sustaining engineering and utilization of the Flight and Ground System throughout the life of the project, currently planned through FY2024. Unique experiments are developed throughout the life of the project to accomplish the technology development goals of the SCaN Testbed project. It is expected that the Flight and Ground System shall be uploaded with new communications, networking, and navigation software experiments to advance the technology readiness level (TRL) of critical SCaN technology and standards required to support future NASA missions.

The Flight System interfaces directly with the ELC-3 on ISS, which provides mechanical, power, and C&DH interfaces to the payload. The Flight System also communicates directly with the Space Network (SN) and Near Earth Network (NEN) provided by SCaN's Network Services Division, as well as Global Positioning Satellites (GPS). The SN and NEN utilize the NASA Integrated Services Network (NISN) to distribute data from various ground stations to the GRC TSC.

Decommissioning of SCaN Testbed is expected to occur NET May 2019. The exact decommissioning date is linked to the launch of the SpaceX CRS-17 vehicle. SCaN Testbed will be decommissioned via robotic removal from ISS, placed in the CRS-17 trunk, and will burn up as CRS-17 re-enters Earth's atmosphere.

After the completion of SCaN Testbed, the project will focus entirely on Cognitive Communication, which is a research and development program to create the next generation of space communication platforms. These platforms are intelligent across the communication stack, from physical layer to application layer, allowing real-time decision-making and seamless connectivity. The project intends to complete a flight demonstration of this technology in the next 3-5 years.

## 2. Background

The contractor shall perform the long-term Sustaining Engineering and Operations of the Flight and Ground System.
The contractor shall be responsible for integration and interface management with the Payload Operations Integration Center (POIC) at Marshall Spaceflight Center, the ISS Program at Johnson Spaceflight Center, SCaN-provided Network Services (SN and NEN), and NISN.

The contractor shall provide appropriate Safety and Mission Assurance to support the tasks outlined in this delivery order and shall develop a Safety and Mission Assurance Plan (SMAP) in compliance with GLPR 7120.5.30, GRC Space Assurance Requirements.

## 3. Reference Documents

NPR 7120.5, NASA Space Flight Program and Project Management Requirements
NPR 7123.1, NASA Systems Engineering Processes and Requirements
NPR 7150.2, NASA Software Engineering Requirements
NASA-STD-8719.13B, Software Safety Standard
NASA-STD-8739.8, Software Assurance Standard
GLPR 8739.1, Software Assurance Procedure
GLPR 7120.5.30, GRC Space Assurance Requirements
GRC-CONN-PLAN-0001, CoNNeCT Software Configuration Management Plan
GRC-CONN-PLAN-0002, CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-004, CoNNeCT Project Plan (Rev B)
GRC-CONN-PLAN-0006, CoNNeCT Product Assurance Plan
GRC-CONN-PLAN-0005, CoNNeCT Systems Engineering Management Plan
GRC-CONN-PLAN-0923 - GIU Operational Guidelines
GRC-CONN-PLAN-0085, CoNNeCT Software Assurance Plan
GRC-CONN-REQ-0084, CoNNeCT Software Requirements Specification
GRC-CONN-REQ-0156, CoNNeCT Ground Software Requirements Specification
GRC-CONN-PLAN-0024, CoNNeCT Software Development and Management Plan
GRC-CONN-PLAN-0133, Mission Operations Plan
GRC-CONN-OPS-0429, Mission Operations Scenario Timelines
450-PSLA-SCaN Testbed, Payload Service Level Agreement
GRC-CONN-PLAN-0900, SCaN Testbed SN-NEN Planning Guide
GRC-CONN-OPS-0911, Payload Operations Handbook
GRC-CONN-OPS-0176 Volume 1, SCAN Testbed Console Handbook Volume 1 ISS Interfaces
GRC-CONN-PLAN-0130, Science Data Management Plan Update
GRC-CONN-PLAN-0089, CoNNeCT Project Decommissioning/Disposal Plan

## 4. Performance Work Statements

Overview: The contractor shall be responsible for the CM/DM activities for the entire SCaN Testbed Project including the Configuration Management of all SW developed by and/or delivered to the SCaN Testbed Project. The contractor shall be responsible for all SE&I activities for the entire SCaN Testbed Project, including SW Sustaining Engineering, Ground Systems, and product integration (experiment radio and waveforms). The contractor shall also be responsible for development of new capabilities needed to achieve the payload's remaining science objectives and enabling the utilization of the payload by new experimenters. The contractor shall be responsible for the planning, preparation and execution of the on-orbit operations and experiments of the Flight System.

The contractor will be responsible for providing Subject Matter Expertise to develop and deliver project assessment reports and specific deliverable documents for the OPS project formulation to implementation deliverables associated with 7120.5 requirements.

### 4.1. Configuration Management/Data Management (CM/DM)

The contractor shall be responsible for the CM/DM activities for the entire SCaN Testbed Project including the Configuration Management of all SW developed by and/or delivered to the SCaN Testbed Project.

The contractor shall operate and sustain the Configuration Management and Tracking System (CMTS), or equivalent, to ensure that proper controls are implemented to receive, store/archive, reproduce and distribute project-related documentation and SW. The contractor shall perform daily backups of the CMTS data. The contractor shall deliver to the project at the conclusion of this Base Task the following: data and SW generated during the execution of the SCaN Testbed project. If the data and SW is generated in a format requiring special CMTS software, the contractor shall deliver the CMTS software and CMTS operation and maintenance manuals at the conclusion of this Base Task.

CMTS shall reside physically at the contractor site with remote access from the NASA GRC network.

The contractor shall provide support for data and access management of SCAN data located in eRoom including SBU items. The contractor shall facilitate eRoom access, maintain documentation in eRoom, monitor the size and use of the SCaN eRoom, and work with the Knowledge Worker Infrastructure (KWI) Support Team to help resolve any eRoom issues.

The contractor shall update and maintain the CM plan (GRC-CONN-PLAN-0002, CoNNeCT Configuration Management Plan) and the SW CM plan (GRC-CONN-PLAN-0001, CoNNeCT Software Configuration Management Plan) as necessary. Any items considered Sensitive But Unclassified (SBU) shall be handled in accordance with NASA Procedural Requirement (NPR) 1600.1, shall be clearly marked as SBU, and shall reside in NASA eRoom.

SCaN Testbed SW includes, but is not limited to, the Payload Avionics Software (PAS), the SCaN Testbed Ground SW, Operating Environments (OEs) and Waveforms for each Software Defined Radio (SDR), experiment-unique SW that shall reside in the Avionics Subsystem, experiment-unique Ground SW, and supporting artifacts for the above (documentation, configuration files, models, etc.).

The contractor shall update and maintain a server-based version of Subversion to configuration manage the STB SW, including the Payload Avionics Software (PAS), the STB Ground SW, Operating Environments (OEs) and Waveforms for each Software Defined Radio (SDR), experiment-unique SW that shall reside in the Avionics Subsystem, and experiment-unique Ground SW. The contractor's SW CM responsibilities include: making and merging branches; creating, documenting, and implementing procedures related to builds and deployments; and maintaining the SW CM plan. The contractor shall provide SW CM training products and training sessions to STB Project personnel as necessary.

The contractor shall provide the necessary staff and shall be responsible for the implementation of these CM/DM functions. The contractor shall maintain the CM/DM system in an organized, logical fashion, and shall provide training and/or training products to project personnel on CM/DM system and product review process as necessary.

### 4.2. Avionics and Radio Software (SW)

No Payload Avionics Software (PAS) updates will occur in the remaining life of SCaN Testbed. The contractor shall maintain appropriate subject matter expertise for operation and routine maintenance of PAS until decommissioning. All PAS software (source code, documentation, libraries and include files, test bench code, stubs), both beta and baselined, is the property of NASA.

The contractor shall document, report, and disposition major anomalies with the Flight and Ground Systems, consistent with the contractor's Safety and Mission Assurance Plan (SMAP).

The contractor shall be responsible for the operation and maintenance of the SCaN Testbed commanding and telemetry capabilities.

### 4.3. Ground Systems

The contractor shall be responsible for the Development, Sustaining Engineering, Logistics (scheduling utilization of Ground Systems), interfacing to experimenters (liaison role), Maintenance (e.g. installation and interfacing of equipment), Operations, and Utilization of all SCaN Testbed Ground System Equipment. Such Ground System Equipment includes the Ground Integration Unit (GIU), SCaN Testbed Front End Processor (SFEP), Test Support Equipment (e.g. TDRSS Simulators/TSIMs), Experimenter Development System (EDS), and Ground Support Equipment.

The contractor shall develop a plan for decommissioning, disposal, and/or reuse of the GIU equipment at the conclusion of the SCaN Testbed flight program. The contractor shall assist in the decommissioning of the GIU, including coordinating building moves and dismantling racks as required.

This does not include the STB Control Center equipment located within the TSC or White Sands Complex (WSC), which is covered under the Mission Operations subtask. For GIU sparing, the three SDR engineering models already have one spare of each, and there are no plans to further spare the Avionics.

The contractor shall perform the sustaining engineering efforts – including system administration, IT security audits including generating documents and reports in support of the audit, troubleshooting, anomaly resolution/testing support, operator training, and on-site support as needed - for the four SCaN Front End Processors (SFEP) systems already delivered to the STB project, located at WSGT, STGT and GRC and the backup system located at GSFC, building 25.

The contractor shall use a Manufacturing Work Order (MWO) process and form to manage, track, and perform SW changes on ground equipment, including the GIU. The MWO shall also be used to manufacture or assemble new hardware items or repair existing hardware items. The MWO form/process requires the approval (signature) of the STB customer for all items physically located at NASA GRC whose accountability resides with the contractor. Log books or electronic logs shall be used to track the configuration of ground equipment. For example, if the engineering avionics package is replaced by the flight spare avionics package, this change shall be documented in a log book/electronic log.

All contractor sustaining engineering responsibility for ground systems, above, with the exception of the SFEP systems, will cease upon decommissioning of the SCaN Testbed flight system. The SFEP sustaining engineering shall continue beyond SCaN Testbed decommissioning.

### 4.4. Product Integration and Mission Operations

The contractor shall develop the tools, documents, and processes necessary for the integration of experiments and capabilities. Additionally, the contractor shall be responsible for the execution of all Experiment Integration activities and guiding all experimenters through the experiment processes. The contractor shall partner directly with experimenters on experiment radio and waveform integration and testing activities, serving as the contact point to experimenters and holding action item lists and tracking external interfaces. The contractor shall lead development of the flight test matrix, sometimes based on limited input from the experimenter (especially external-to-GRC) i.e. which SDR(s), data rates, coded or uncoded. The contractor shall lead script development (with necessary input from the experimenter). The contractor shall lead procedure development, and shall lead dry runs (as necessary). The contractor shall lead flight operations planning and execution.

The contractor shall be responsible for the planning, preparation and execution of the on-orbit operations and experiments of the Flight System. This includes, but is not limited to, the development and execution of all procedures, training, mission simulations and testing, and control center equipment, operations processes, user's guides, tools, and IT security concerns. Control Center equipment includes, but is not limited to, hardware and tools used for Data Storage, Management, and Distribution to remote authorized users.

The contractor shall estimate approximately 20 hours/week on average of on-orbit payload operations.

The contractor shall be responsible for designing, implementing, testing, and maintaining data storage and distribution solutions, based on the needs of entire Project, including the Principal Investigator Team, the Experiment Team and the Mission Operations Team. This includes the capability to process, route, store, backup, restore, and distribute payload telemetry and science data from SCaN Testbed experiments, including distribution to remote PIs.

The Contractor shall also be responsible for daily status reports on operational days summarizing the performance and utilization of the SCaN Testbed flight system.

The contractor shall also be responsible for the interface management with HOSC/POIC personnel at MSFC and ISS operations personnel at JSC. This includes updating ISS flight rules, creating operational interface procedures, increment planning, and activities required for Certification of Flight Readiness on all future increments.

The contractor shall track and archive all documentation, software, and analytical models per the above CM/DM subtask – reference section 4.1 above. The STB eRoom tools shall be used to manage and disseminate information and data products among NASA and contractor STB team members. Data transfers to NASA shall be accomplished by whatever method is most convenient for NASA, including the NASA GRC eRoom.

The contractor shall be responsible for decommissioning, disposal, and final documentation/archiving of SCaN Testbed, upon direction of the SCaN Testbed Project Manager. The SCaN Testbed Project Manager's authority to decommission and dispose of SCaN Testbed flows from the SCaN Program's direction to decommission and dispose of SCaN Testbed. The contractor shall decommission and dispose of SCaN Testbed as outlined in the CoNNeCT Disposal Plan GRC-CONN-PLAN-0089, which includes archiving all documentation, software, and analytical models performed by or for the project. The contractor shall provide verification documents as necessary for decommissioning, including mass properties, CAD models, and related data from SCaN Testbed launch.

All contractor responsibilities, above, in this section shall cease upon decommissioning and disposal of SCaN Testbed.

The contractor shall be responsible for interface management with the SN and NEN, including their ground stations at White Sands and Wallops. This responsibility includes implementation, preparation, and usage of all flight operations ground systems with the SN and NEN, including the SCaN Testbed Front End Processors (SFEPs) at GRC and White Sands, and completing the NISN connection from GRC to Wallops. This includes obtaining baseline functionality as well as any updates required due to experiments. The contractor shall maintain a Demand Access Service (DAS) ground data connection with the Space Network, and also establish a TDRSS Augmentation Service for Satellite (TASS) ground data connection when it becomes possible to do so. Responsibilities in this paragraph shall continue beyond decommissioning of SCaN Testbed.

### 4.5. Experiment RF Technician Support

No further support is required in this section at this time.

### 4.6. Logistics; Safety and Product Assurance

The contractor shall furnish necessary computer network services, procurement services, financial and schedule reporting, and property management of project hardware. The contractor shall provide all desktop computer hardware and software for general use by the SpaceDOC team members assigned to the STB project. Hardware needed to perform unique elements shall be purchased under the appropriate base task work item. Specific technical training may need to be taken to support base task work items.

The contractor shall assume:
Annual nominal Material ODC budget of $5,000 to support software license renewals, purchases to support sparing other GIU assemblies, the data storage/archive system, upgrades, and other miscellaneous costs (unanticipated hardware failures on the GIU).

The STB project has successfully met the Flight Safety Review process requirements. The contractor shall follow practices and processes currently utilized by the STB Project and in accordance with the CoNNeCT Product Assurance Plan GRC-CONN-PLAN-006 and the CoNNeCT Software Assurance Plan GRC-CONN-PLAN-0085.

### 4.7. LEO-T Support

No further support is required in this section at this time.

**4.8. User Initiated Service Request**

The contractor shall develop the software and perform the integration necessary to implement User Initiated Service Request (UISR) demonstration using SCaN Testbed, including automated (autonomous) antenna pointing, link selection, and link scheduling capability. Previously developed LynxCAT software may be utilized as appropriate. New software shall be developed in coordination with the government Cognitive Systems Lead or designee. Following decommissioning of SCaN Testbed, software shall be developed to target platforms as directed by the Cognitive Systems Lead or designee.

This work shall build upon UISR software already developed in previous years, including the autonomous antenna pointing component, the event manager, service manager, and scheduling system interface (i.e., Tempus). This builds upon previous software developed for SCaN Testbed operations as well as the successful 2017 SCaN Testbed experiment demonstrating UIS requests through the Space Network (Phase I). UIS capability will be expanded with additional ability to schedule NEN assets using UIS requests sent direct-to-Earth (Phase II).

The contractor shall:
- Maintain existing UISR capability and related User Initiated Service (UIS) code developed previously.
- Develop and deliver UIS software including documentation per NPR 7150.2 as Class C, Non-Safety Critical software. Includes AutoCAT Suite – Phase II and LynxCAT Toolbox Plus.
- Support remaining SCaN Testbed experiments demonstrating components of the direct-to-Earth UIS request process, as possible before SCaN Testbed decommissioning.
- Lead the development and execution of a demonstration proving the expanded capability of the UIS software. Demonstration should include several simulated flight nodes and several simulated ground stations running the AutoCAT Suite – Phase II software. Demonstration should show simulated flight nodes sending UIS requests, being granted ground station allocations after deconfliction, and receiving UIS responses during a simulated low-Earth orbit pass.
- Complete additional tests to verify Phase II software functionality as directed by the Cognitive Systems Lead or designee.
- Support GSFC in implementation of released software (including beta release). Provide assistance with GSFC's efforts to integrate software into operational network and flight missions as necessary.
- Assist with upgrading the GRC S-band ground station to the latest version of LynxCAT Toolbox Plus.
- Support integration of current version of AutoCAT Suite (beta release) UIS client software into the core Flight System (cFS) framework. Develop a cFS application integrating the full capabilities of AutoCAT Suite Phase II software, once completed. This element shall be conducted in collaboration with a contractors on other contracts, under direction of the Cognitive Systems Lead or designee.
- As applicable, integrate cognitive engines developed by government personnel into the Event Manager (part of the AutoCAT Suite) for deconfliction and other optimization activities.

**4.9. Delay Tolerant Networking Software Development Support**

No further support is required in this section at this time.

**4.10. Cognitive and Adaptive Systems Engineering**

No further support is required in this section at this time.

**4.11. Optical Pathfinder Satellite (OPS)**

No further support is required in this section at this time.

**5. Milestones & Reviews**

The contractor shall participate in the following:

a) Government-led Experiment Reviews, such as Experiment Requirements Review, Verification Test Reviews, and Experiment Operations Reviews. (Carried Forward from B)
b) Bi-weekly STB Team Meetings. (Carried Forward from B)

## 6. Travel

Travel may be required throughout the period of performance. The contractor shall contact the task manager for travel approval. The contractor may use contract funding as necessary to fund approved travel.

## 7. Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**All Deliverables excluding Optical Pathfinder Satellite deliverables:**
Task Manager, MSC0, David Chelmins, Mail Stop 142-3, dchelmins@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Melissa A. Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov
Contracting Officer's Representative, ISS & Human Health Office (William Foster Mail Stop 77/7, william.m.foster@nasa.gov )
Program Manager, MT00, Elias Naffah, Mail Stop 142-2, elias.t.naffah@nasa.gov
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### 7.1. Hardware

Not applicable.

### 7.2. Software

The following are the expected software deliverables identified in the Performance Work Statements:

a) CM/DM System(s), if required to read project CM/DM data and SW, by Sept. 30, 2021, or at the conclusion of the Base Task. (Carried forward from B, A)
b) Final PAS and CTADS software release (including source code, documentation, libraries and include files, test bench code, stubs), due by Sept. 30, 2021, or at the conclusion of the Base Task. (Carried forward from B, A)
c) User Initiated Service Request software (including source code, documentation, libraries and include files, test bench code, and stubs), with annual deliveries throughout the POP and a final delivery due by Sept. 30, 2021, or at the conclusion of the Base Task. (Carried forward from B, A)

### 7.3. Documentation

The contractor shall provide the following documents:

Task 4.1 – CM/DM

The contractor shall provide:

a) Configuration Managed SCaN Testbed Project Data and SW, by Sept. 30, 2021, or at the conclusion of the Base Task. (Carried forward from B, A)

b) CMTS operation and maintenance manuals, if delivery of the CM/DM system software is required to read project CM/DM data and software, by Sept. 30, 2021, or at the conclusion of the Base Task (Carried forward from B, A)

Task 4.2 – Avionics and Radio SW (was 4.2. SE)

The contractor shall provide:

c) Supporting files for any software necessary to operate the Flight System or CTADS, due upon SCaN Testbed decommissioning, or at the conclusion of the Base Task. (Carried forward from B, A)

Task 4.4 – Product Integration and Mission Operations (was 4.3. MO)

The contractor shall provide:

d) POIC Increment Deliverables, per increment template (Carried forward from B, A)
e) Updated SCaN Testbed SN-NEN Planning Guide Update, GRC-CONN-PLAN-0900, as necessary.
f) Final Payload Operations Handbook, GRC-CONN-OPS-0911, due upon SCaN Testbed decommissioning.
g) Final SCAN Testbed Console Handbook Volume 1 ISS Interfaces, GRC-CONN-OPS-0176 Vol 1, due upon SCaN Testbed decommissioning.
h) Final Science Data Management Plan Update, GRC-CONN-PLAN-0130, due upon SCaN Testbed decommissioning.
i) Final Trajectory, Attitude and Antenna Modeling Plan, GRC-CONN-PLAN-0922, due upon SCaN Testbed decommissioning.
j) Final LynxCAT SK Toolbox User's Guide, GRC-CONN-DOC-0982, due upon SCaN Testbed decommissioning.

Task 4.5 – Experiment RF Technician Support (was 4.4. Experiment Development)

The contractor shall provide: N/A

Task 4.8 – User Initiated Service Request

The contractor shall provide:

k) User's guide(s) and ICDs for all portions of the software development, with a final delivery due by Sept. 30, 2021, or at the conclusion of the Base Task (Carried Forward from B)
l) Demonstration of the User Initiated Service functionality, as needed, but at least yearly throughout the POP. (Carried Forward from B)
m) Presentation material on the UISR capability for relevant SCaN reviews, due as necessary. (Carried Forward from B)

Task 4.9 – Delay Tolerant Networking Software Development Support

The contractor shall provide: N/A

Task 4.10 – Cognitive and Adaptive Systems Engineering

The contractor shall provide: N/A

Task 4.11 – Optical Pathfinder Satellite

The contractor shall provide: N/A

**8. <u>Reporting Requirements</u>**

a) Contractor Work Plan per DID PM-06. ON-GOING
b) Contractor Financial Management Reporting per DID CD-01. Financial Reporting should be reported down to the 4.x level. ON-GOING

c) Monthly reporting per DID CD-03 ON-GOING

**9. Government Furnished Equipment**

a) SCaN Testbed Flight System and associated SW
b) SCaN Testbed Ground System and associated SW, including, but not limited to:
   i. Ground Integration Unit
   ii. ELC Simulators
   iii. Software Development Systems
   iv. TDRSS Simulators
   v. Communication Test Support Equipment
   vi. CCC Control Center Equipment, including TReKs and planning workstations
   vii. SCaN Testbed Front End Processors (SFEPs)
   viii. Experimenter Development System (EDS) and associated equipment
   ix. Ground Station and associated equipment
   x. SCaN Testbed Analysis Tool (STAT), for RF and antenna performance predictions and post-processing
c) GRC Risk Management and Information (RMIT) System
d) Configuration Management Tracking System (CMTS), developed by contractor under Base Task-115
e) Wind River Vx Works SW licenses, up to 10
f) STK SW license, 1
g) Other GRC provided SW CM and DM tools, including but not limited to:
   i. Subversion software repository for source code management
   ii. Cognitive engine software applications to make real-time UISR decisions for integration into the UISR software suite
h) SCaN eRoom

**10. Government Furnished Facilities**

The following Government facilities shall be available to the contractor as needed:
a) GRC Telescience Support Center (TSC)
c) SCaN Testbed High Bay Space, Building 333, Rm 100W
e) Conference Rooms on-site at NASA GRC

**11. Government Contacts**

The contractor shall have access to the following for consultation:
a) GRC Cognitive Communications Project Manager
b) GRC Cognitive Communications Lead Engineers
h) SCaN Testbed Principal Investigator Team
i) GRC QA personnel
j) GRC personnel with SDR, Communications, Networking, Navigation, and RF expertise
k) MSFC POIC Personnel
l) JSC/ISS Payloads Office Personnel
m) JSC/ISS Mission Operations Personnel
n) GRC OPS Managers and Principal Investigator

**12. Acronym List**

| Acronym | Description |
|---|---|
| ACTS | Advanced Communications Technology Satellite |
| AFRL | Air Force Research Lab |
| APS | Antenna Point System |
| BDA | Bermuda |
| BT | Base Task |
| C&DH | Command and Data Handling |
| CCC | CoNNeCT Control Center |
| CM | Configuration Management |
| CMTS | Configuration Management Tracking System |
| Co-I | Co-Investigator |
| CoNNeCT | Communications, Navigation, and Networking Reconfigurable Testbed |
| ConOps | Concept of Operations |
| CTADS | Connect Telemetry Acquisition and Display System |
| DAS | Demand Access Service |
| DID | Data Item Description |
| DM | Data Management |
| DoD | Department of Defense |
| eAuth | Electronic Authentication |
| EDS | Experimenter Development System |
| ELC | EXPRESS Logistics Carrier |
| ExPA | EXPRESS Pallet Adapter |
| ExPRESS | Expedite the Process of Experiments to the Space Station Rack |
| FY | Fiscal Year |
| GD | General Dynamics |
| GFE | Government Furnished Equipment |
| GFF | Government Furnished Facilities |
| GIU | Ground Integration Unit |
| GLPR | GRC Procedural Requirement(s) |
| GPS | Global Positioning System |
| GRC | Glenn Research Center |
| GSFC | Goddard Space Flight Center |
| HEOMD | Human Exploration and Operations Mission Directorate |
| HOSC | Huntsville Operations Support Center |
| HQ | Headquarters |
| ISS | International Space Station |
| IT | Information Technology |
| JPL | Jet Propulsion Laboratory |
| JSC | Johnson Space Center |
| KSC | Kennedy Space Center |
| KUS | Kennedy Uplink |
| LEO-T | Low Earth Orbit - Terminal |
| LTP | LynxCAT Toolbox Plus |
| MOC | Mission Operation Center |
| MSFC | Marshall Space Flight Center |
| MWO | Maintenance Work Order |

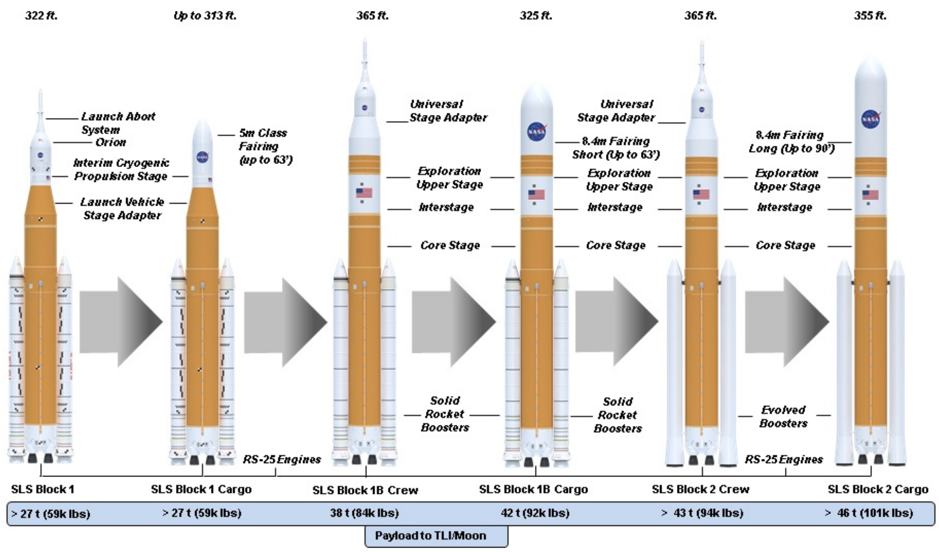
| | |
|---|---|
| **N/A** | **Not Applicable** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NEN** | **Near Earth Network** |
| **NGBS** | **Next Generation Broadcast Service** |
| **NISN** | **NASA Integrated Science Network** |
| **NPR** | **NASA Procedural Requirement** |
| **ODC** | **Other Direct Cost** |
| **OE** | **Operating Environment** |
| **OGA** | **Other Government Agencies** |
| **OPS** | **Optical Pathfinder Satellite** |
| **PAS** | **Payload Avionics Software** |
| **PDL** | **Ponce de Leon** |
| **PI** | **Principal Investigator** |
| **POIC** | **Payload Operations and Integration Center** |
| **POP** | **Period of performance** |
| **PPP** | **Public-Private Partnership** |
| **PSIVF** | **Payload Software Integration and Verification Facility** |
| **QA** | **Quality Assurance** |
| **QoS** | **Quality of Service** |
| **RF** | **Radio Frequency** |
| **RMIT** | **Risk Management and Information** |
| **SBU** | **Sensitive But Unclassified** |
| **SCaN** | **Space Communications and Navigation** |
| **SCI** | **Sensitive Compartmented Information** |
| **SDR** | **System Definition Review** |
| **SE&I** | **Systems Engineering and Integration** |
| **SFEP** | **SCAN Testbed Front End Processor** |
| **SMAP** | **Safety and Mission Assurance Plan** |
| **SMC** | **Space Missile Command** |
| **SN** | **Space Network** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **STAT** | **SCaN Testbed Analysis Tool** |
| **STB** | **SCaN Testbed** |
| **STCC** | **SCaN Testbed Control Center** |
| **STGT** | **Second TDRSS Ground Terminal** |
| **STK** | **Satellite Toolkit** |
| **STRS** | **Space telecommunications Radio Standard** |
| **SW** | **Software** |
| **TASS** | **TDRSS Augmentation Service** |
| **TDRSS** | **Tracking and Data Relay Satellite** |
| **TReK** | **Telescience Resource Kit** |
| **TRL** | **Technology Readiness Level** |
| **TS** | **Top Secret** |
| **TSC** | **Telescience Support Center** |
| **TWTA** | **Traveling Wave Tube Amplifier** |

| | |
|---|---|
| **UISR** | **User Initiated Service Request** |
| **WSC** | **White Sands Complex** |
| **WSGT** | **White Sands Ground Terminal** |

**SpaceDOC II**
**Base Task 5**
**Exploration Technology & Flight Development (ETFD)**
**Space Launch System (SLS)**
**Contract Period of Performance January 1, 2014 through March 30, 2023**
**Task Period of Performance October 1, 2021 through March 31, 2023**

# 1. Introduction

The Space Launch System (SLS) is the new heavy lift launch vehicle that will replace the shuttle's payload delivery capability in support of the Exploration Vision as well as other NASA and DoD missions.




Current substantial Glenn Research Center (GRC) responsibilities include leading the design, development, test and evaluation and production of the Level 4 Universal Stage Adapter (USA) and the Payload Fairing (PLF) sub-elements for the MSFC Spacecraft Payload Integration and Evolution (SPIE) Office. The effort is assisted by the Langley Research Center (LaRC). The USA supports the Orion capsule on the SLS Block 1B vehicle and contains a co-manifested payload.

This Delivery Order is for support of the PLF Element Phase A planning and USA risk mitigation and oversight tasks to support the Design, Development, Test, and Evaluation of the USA .

**Task Description:**

This effort is to provide engineering services in support of the design, analysis, and concept assessment, as well as engineering support for various risk mitigation activities, for the SLS USA and PLF. The disciplines involved for the execution of this task are structural, mechanical, and systems engineering.

# 2. Background

The SLS fairing is planned as a multiple fairing development effort. An 8.4 m diameter fairing for the SLS Block 1B vehicle is baselined in the program, with an evolution to a 10 m diameter fairing as a Block 2 upgrade for the vehicle.

The USA will be the adapter for manned Block 1B missions and provides a co-manifested payload capability for mission augmentation..

## 3. Applicable Documents

| | |
|---|---|
| SLS-SPEC-032 | SLSP System Specification |
| SLS-SPEC-049 | SLSP Integrated Vehicle Outer Mold Line (OML) |
| SLS-SPIE-RQMT-027 | SPIE Block 1B Universal Stage Adapter Requirements Document |
| SLS-SPIE-RQMT-030 | SPIE Block 1B Payload Fairing Requirements Document |

## Performance Work Statements

The effort for the fairings and USA is broken into two categories, structural assessment and separation simulation for concept development and test.

The structural assessment initially involves modeling and performing the requisite structural analyses to insure that the fairing or adapter can perform as designed in the SLS flight environment including global buckling and strength assessments. It also includes analysis to support fracture control requirement evaluation and design insight/oversight.

The separation analysis involves performing a nonlinear transient analysis to simulate the separation event. Additionally, the custom software known as SepTOOL is to be used to evaluate the separation event at various vehicle acceleration levels and at various angles of attack to determine the clearance from the payload and SLS launch vehicle. The SepTOOL is also used to perform dispersion analyses of the separation event by modifying the input fairing petal trace.

These efforts also include providing support for the SLS Block 1B SPIE Cargo PLF Preliminary Design Review (PDR) and support for the USA Critical Design Review (CDR) assessments.

## 4. Milestones & Reviews

Support SLS Block 1B USA CDR structural assessment products delivered by CDR 6/1/2022 (C, D, Carried Forward)

## 5. Travel

Travel to critical meetings and reviews may be necessary but will be determined on an individual basis and will only be required if physical presence is necessary.

## 6. Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**

Task Manager, LSA, Thomas M. Krivanek, Mail Stop 162-7,
Thomas.M.Krivanek@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7,
Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1,
elizabeth.a.morales@nasa.gov
Program Manager, MSX0, Kirk Seablom, Mail Stop 162-6, Kirk.D.Seablom@nasa.gov
Chief, ISS and Human Health Project Office, Robert Corban, Mail Stop 77-7,
Robert.R.Corban@nasa.gov
Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

Design, analysis, and support for the USA structural evaluation is to be completed by 3/31/2023. (B, C, D, Carried Forward)

Design, analysis, and support for the USA separation development to be completed by 3/31/2023 (C, D, Carried Forward)

### 6.1. Hardware
None

### 6.2. Software
SepTOOL program and user manual (A, B, C, D, Carried Forward)

### 6.3. Documentation
The contractor shall provide the following documents:
a) Submit a Monthly Task Report in accordance with DID CD-03 On-going
b) Lessons Learned Report per DID PA-17 (yearly)
c) PLF and USA Analysis summary reports (as required) (A, B, C, D, Carried Forward)

## 7. Reporting Requirements
The contractor shall furnish the following documentation in the implementation of this SOW.
a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC-2 Contract Requirements. (per DID# PM-06 On going)
b) Contractor Financial Management Reporting (per DID# CD-01 On going)
c) Monthly reporting (per DID# CD-03 On going)

## 8. Government Furnished Equipment
No Government Furnished Equipment is required.

## 9. Government Furnished Facilities
No Government facilities required for this work to be performed.

## 10. Government Contacts

The contractor shall have access to the following for consultation:

a) GRC USA Project Manager
b) GRC USA/Payload Fairing Chief Engineer
c) GRC USA/Payload Fairing Lead Engineer
d) SLS USA/Payload Fairing Project Team

## 11. Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

# 12. Acronym List

| Acronym | Description |
|---|---|
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| DID | Data Item Description |
| DoD | Department of Defense |
| eCC | electronic Country Clearance |
| ETFD | Exploration Technology and Flight Development |
| GRC | Glenn Research Center |
| LaRC | Langley Research Center |
| MSFC | Marshall Space Flight Center |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| OML | Outer Mold Line |
| PDR | Preliminary Design Review |
| PLF | Payload Fairing |
| SLS | Space Launch System |
| SLSP | Space Launch System Project |
| SOW | Statement of Work |
| SpaceDOC-II (2) | Space Flight Systems Development and Operations Contract-II (2) |
| SPIE | Spacecraft Payload Integration and Evolution |
| USA | Universal Stage Adapter |

**SpaceDOC-2 NNC14CA02C**
**DO-201 FLEX Projects**
**Flame Extinguishment Experiment (FLEX)**
**For DO Period January 1, 2014 through September 30, 2017**
**For the Performance Period October 1, 2015 through September 30, 2017**

# 1) Introduction

This Statement of Work covers the scope of the final hardware procurement and preparation for the FLEX series of experiments, the remaining FLEX-2 flight hardware and resupply, in particular. The full set of FLEX investigations to date is comprised by the FLEX, FLEX-2, FLEX-ICE-GA, and FLEX-2J experiments. By the time of the start of this Delivery Order's period of performance, the FLEX and FLEX-ICE-GA on-orbit operations will be complete and the FLEX-2 and FLEX-2J set of operations will be partially complete. Most FLEX-2 hardware assets will be pre-positioned on-board the ISS.

The Contractor Proposal shall provide a cost, technical, and schedule estimate for the period of performance from October 1, 2015 through September 30, 2017. The effort during this performance period shall include the completion of the procurements, fabrication, build and test of the specified FLEX-2 flight hardware. Additionally, for the MDCA/FLEX and FLEX-2 projects the scope of work includes the operations phase of the project to support execution of the science test matrices as defined in the MDCA/FLEX Integration Agreement (IA) and the FLEX-2 IA, and additional efforts to acquire the resources (gas bottles, fuel reservoirs, etc.) and support necessary reviews to perform the test points for the FLEX series experiments that are defined in the MDCA/FLEX IA. Moreover, the project team will prepare a final flight hardware assessment that will be included in a later Post-Flight Assessment Review (PFAR) presentation package.

### MDCA/FLEX

The MDCA is the initial payload in the CIR. It contains the hardware and software required to conduct unique droplet combustion experiments in microgravity. The first experiment is the Flame Extinguishment Experiment (FLEX), which involves assessing the effectiveness of flame suppressants in microgravity, quantifying the effect of candidate exploration atmospheres on fire suppression characteristics, and providing data to develop simplified combustion models. MDCA/FLEX consists of a Chamber Insert Assembly (CIA), an Avionics Package, and a set of kits containing experiment consumables and spares. Its modular approach permits on-orbit changes for accommodating different fuels, fuel flow rates, and varying droplet support and translation mechanisms to accommodate multiple investigations.

Single combustible fuel droplets of varying sizes, freely deployed or supported by a tether are planned for study using the MDCA. Such research supports how liquid-fuel-droplets ignite, spread, and extinguish under quiescent microgravity conditions.

The contractor shall:

a) The contractor shall complete any documentation of the remaining flight hardware and provide that documentation to NASA consisting of the ADPs and any associated reports.
b) Support the Post Flight Assessment Review (PFAR) for the FLEX series of experiments.

### Flame Extinguishment Experiment (FLEX-2)

The Flame Extinguishment Experiment (FLEX-2) is a flight experiment that continues the FLEX studies of fuel droplet combustion. This experiment, however, is designed to study single fuel and bi-component fuel droplets at a fundamental level. The overall objectives are to (1) extend single fuel droplet studies of pure fuels as well as introducing bi-component fuels, (2) investigate the influence of sub-buoyant convective flows on fuels, and (3) extend single fuel droplet studies to binary arrays of droplets.

The FLEX-2 flight experiment will use the MDCA in the CIR. The MDCA hardware will provide the platform, power, and communications for conducting the experiment while the CIR will provide the support structure, combustion chamber, diagnostics, and FOMA control system. As such, FLEX-2 will consist of MDCA Orbital Replaceable Units (ORUs) such as fuel dispensing reservoirs, Retractable Indexing Fiber mechanisms, and combustion chamber gas bottles for the new environments. On-orbit operations for FLEX-2 will commence after successful completion of the MDCA/FLEX flight experiment and whenever possible prior to the MDCA being removed and while working around other CIR experiments. The contractor shall:

a) Minimize costs and reduce technical and schedule risk for FLEX-2 by leveraging off all aspects of MDCA/FLEX such as existing drawings, documentation, software, plans and procedures, testing, use of same vendors for procurement, databases (CM, PRACA, Risk Management, ECO process, Product Assurance process, etc.) as is currently in use by the MDCA/FLEX projects..
b) Review on-orbit resource status and projected need based on changes to science matrix and actual usage rates of consumables including gas bottles igniter tips, adsorber cartridges, fiber arms, and fuel reservoirs.

The contractor shall support GRC FLEX-2 project manager and project scientist during the operations phase of the project.

Furthermore, the contractor shall:
a) Develop and maintain a detailed schedule of the activities to be performed on this Delivery Order.
b) Update training materials as required to support continued crew training at NASA JSC per the ISS Integration Template for MDCA/FLEX-2
c) Provide additional on-orbit hardware and resources as required to complete the FLEX-2 science matrix. In particular the contractor shall provide these additional hardware items, including the appropriate labor, material, environmental testing, MIUL/MUA and hazard reporting, addendum to the Safety Data Package, launch manifest submissions, and SAR support
d) Support the Post Flight Assessment Review (PFAR) for the FLEX series of experiments (that is, all the FLEX experiments will perform one PFAR at the close of the MDCA/FLEX series of experiments).
e) Manifest the already assembled and verified needle pairs (2) and fuel reservoirs (2), including the fuel fill and post-fill vibration test.
f) Analyze the failed 80/20 propanol/glycerol fuel mixture as soon as possible after deorbiting to determine the cause of the failed fuel deployment, including a written report and verbal outbrief to GRC.
g) Replace the flight hardware that was lost on the Orbital-3 flight failure, specifically one (1) fiber arm assembly and three (3) fuel reservoirs. The fiber arm assembly shall be a newly fabricated assembly. The fuel reservoirs shall be refurbished MDCA fuel reservoir assemblies from returned flights.
h) Replace the flight hardware that was lost on the SpaceX-7 flight failure, specifically two (2) MDCA fiber arm assembly, six (6) MDCA igniter tip holders, two (2) MDCA Needle 1 Holders, three (3) MDCA Needle 2 Holders, and two (2) fuel reservoirs. The fuel reservoirs shall be refurbished MDCA fuel reservoir assemblies from returned flights.

**Flame Extinguishment Experiment/JAXA (FLEX-2J)**

The Flame Extinguishment Experiment/JAXA (FLEX-2J) is a flight experiment that continues the FLEX and FLEX-2 studies of fuel droplet combustion. This experiment, however, is designed to determine the influence of a flame spreading along a linear array of droplets on the flame spread rate and droplet motion. The research objectives are to measure the burning rate, burning time, the ambient pressure and gas composition, and flame spread and droplet motion as a function of inter-droplet spacing.

The FLEX-2J flight experiment will use the Multi-User Droplet Combustion Apparatus (MDCA) hardware in the Combustion Integrated Rack (CIR). The MDCA hardware will provide the platform, power, and communications for conducting the experiment while the CIR will provide the support structure, combustion chamber, diagnostics, and FOMA control system. FLEX-2J will use as much of the FLEX-2 hardware as practical, consisting of MDCA Orbital Replaceable Units (ORUs) such as fuel dispensing reservoirs, Retractable Indexing Fiber mechanisms, and combustion chamber gas bottles for the new environments. On-orbit operations for FLEX-2J will commence after successful completion of the FLEX-2 flight experiment. The planned duration for on-orbit operations is 3-6 months.

a) FLEX-2J shall leverage off all aspects of MDCA/FLEX/FLEX-2 such as existing drawings, documentation, software, plans and procedures, testing, use of same vendors for procurement, databases (CM, PRACA, Risk Management, ECO process, Product Assurance process, etc.) as is currently in use by the MDCA/FLEX/FLEX-2 projects to minimize costs and reduce technical and schedule risk.

The contractor shall support GRC FLEX-2J project manager and project scientist during the implementation phase of the project leading up to a Systems Acceptance Review for the final hardware manifested for flight.

For FLEX-2J, the contractor shall:

a) Perform safety assessments and hazards analyses, materials compatibility analysis, and safety data packages that will support all required Flight Safety Reviews.
b) Develop the corresponding registry configuration and/or software updates that support the FLEX-2J package, if not already completed. Perform an integrated rack test with the FLEX-2J hardware and registry configuration on the GIU rack to validate the registry files.
c) Test Fiber Arm Assembly kits consisting of 6 beaded fiber structures provided by Nihon University. Hold equipment for verification per manifest schedule to be determined by GRC.
d) Provide crew training materials for training at NASA JSC per the ISS Integration Template.
e) Develop software algorithms to support deployment of fuel droplet arrays per the FLEX-2J science requirements, if not already completed,
f) Support the Post Flight Assessment Review (PFAR) for the FLEX series of experiments (that is, all the FLEX experiments will perform one PFAR at the close of the MDCA/FLEX series of experiments).

**FLEX Italian Combustion Experiment for Green Air (ICE-GA)**

The FLEX Italian Combustion Experiment for Green Air (FLEX-ICE-GA, also referred to here simply as ICE-GA) is a flight experiment sponsored by Agenzia Spaziale Italiana (ASI), the Italian Space Agency. The intent of ICE-GA is to investigate the ignition and combustion of a single droplet of a biologically-derived fuel (bio-fuel) in a quiescent microgravity environment. The research will dispense, deploy and ignite single droplets of bio-fuel and study the droplet and flame regression histories, in a well-controlled (and variable) ambient environment. The results of the research will provide benchmark data that will assist in the development and validation of models of bio-fuel combustion. Phenomena such as finite-rate gas-phase chemistry, multicomponent-species gas- and liquid-phase transport processes, production of soot and other pollutants, phase-change processes, liquid-phase species separation and fluid motion, and radiation and conductive energy transfer, for example, which determine to varying degrees the performance of a practical combustor, are all present in microgravity droplet combustion. The metrics for comparison include burning rate, burning time, soot aggregate size, extinction diameter, flame diameter, and flame luminosity.

The experiment will take place in the Combustion Integrated Rack (CIR) using the Multi-User Droplet Combustion Apparatus (MDCA). NASA will provide fuel and fuel reservoirs for the MDCA that will be filled with surrogate bio-fuel as determined by the Italian Space Agency (ASI). NASA will also supply the gas bottles and other MDCA hardware necessary to successfully complete the experiment. The current plan calls for hardware to be launched in early 2013 and the conduct of the experiments during ISS Increments 35-36. ASI will supply crew time as available to perform the experiments, and NASA will provide the remainder of the crew time. Both NASA and ASI will collaborate on the analysis and reporting of the data from the experiments. The planned duration for on-orbit operations is 3-6 months.

a) ICE-GA shall leverage off all aspects of MDCA/FLEX/FLEX-2 such as existing drawings, documentation, software, plans and procedures, testing, use of same vendors for procurement, databases (CM, PRACA, Risk Management, ECO process, Product Assurance process, etc.) as is currently in use by the MDCA/FLEX/FLEX-2/FLEX-2J projects to minimize costs and reduce technical and schedule risk.

FLEX-ICE-GA on-orbit operations have completed. For FLEX ICE-GA, the contractor shall:

a) Perform post-flight analysis of the flight hardware, as required by the Project Manager.
b) Support the Post Flight Assessment Review (PFAR) for the FLEX series of experiments (that is, all the FLEX experiments will perform one PFAR at the close of the MDCA/FLEX series of experiments).

## 2) Milestones and Reviews

The contractor shall provide regularly scheduled meetings/reporting with the NASA Project Manager for the following:

a) Weekly technical status meetings with the NASA Project Manager. (carried forward A)
b) Monthly budget and schedule reporting that will include:
    i. Top Level Technical Performance/Accomplishments (carried forward A)
    ii. Near Term Activities (carried forward A)
    iii. WBS Comments (Problems/Issues/Risks and Mitigation Strategies) (carried forward A)
    iv. Schedules (to include a Critical Path Schedule) (carried forward A)
c) Technical status meetings with the NASA Project Manager and the NASA Project Scientists, as needed. (carried forward A)

The contractor shall support the FLEX Series Post-Flight Assessment Review (PFAR) presentation package with post flight hardware assessments, a list of MDCA and FLEX specific hardware and software failures and mitigations, ISS caused delays, and lessons learned applicable to future CIR inserts and experiments. The FLEX Series PFAR, including the FLEX-1, FLEX-2, FLEX-ICE-GA, and FLEX-2J experiments, is tentatively scheduled for the end of June 2016. (carried forward A)

## 3) Hardware/Software Design, Test Integration and Operations Deliverables

The contractor shall complete and deliver the following hardware items to accommodate the science test matrix. (Some deliveries may be in a follow-on Delivery Order.)

**FLEX-2**

The contractor shall complete and deliver on-orbit resource analysis showing remaining consumable resource allocation vs. projected needs. The contractor shall also prepare and deliver for flight:

a. Three (2) refurbished fuel reservoirs. Replace hardware lost on SpaceX-7.

**Miscellaneous Flight Hardware**

Miscellaneous TBD spare flight hardware is required that can be applied to any of the FLEX series experiments. (carried forward A)

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/J. Mark Hickman, MS 77-7, J.M.Hickman@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov

Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

A Contracting Officer letter may accomplish changes to the personnel mentioned above.

### Document deliverables shall be as follows:

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06) ON-GOING

b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly. ON-GOING

c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING

d) Monthly reporting, per DID# CD-03, ON-GOING

e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

In assessing the contractor budget and schedule, the following hardware and software shall be made available by the Government to the contractor:
a) MDCA Flight Hardware
b) MDCA Crew Training Hardware (Chamber Insert Assembly and Avionics Package)
c) MDCA/FLEX Drop Tower Rig
d) Spare HiBMS Camera and modules
e) Flight IPSU-Remora

## 6) Government Furnished Facilities

In assessing the contractor budget and schedule, the following Government Facilities shall be available by the Government to the contractor as needed:
a) Controlled Access Flight H/W Buildup Laboratory in Building 333, Room 100W-A and 100W-B and Hi-Bay.
b) Structural Dynamics Laboratory
c) Microgravity Emissions Lab and Acoustics Lab
d) Thermal Environmental Chambers in Building 333A
e) EMI Laboratory in Building 333A
f) 2.2 Second Drop Tower Facility
g) Zero G Drop Tower Facility
h) Inspection Department
i) Instrumentation Department
j) Lab Space in Building 110

## 7) Government Contacts

The contractor shall have access to consultation with:
a) GRC MDCA/FLEX-2/FLEX-2J CIR Project Manager
b) FCF CIR Manager
c) Project Scientists for FLEX-2/FLEX-2J

d) MDCA Project Team personnel

## 8) Period of Performance

The period of performance for this delivery order is from October 1, 2015 through September 30, 2017.

## 9) Acronym List

| Acronym | Description |
|---|---|
| ADP | Acceptance Data Package |
| ASI | Agenzia Spaziale Italiana |
| ATV | Autonomous Transfer Vehicle |
| CDRL | Contract Data Requirements List |
| CIA | Chamber Insert Assembly |
| CIR | Combustion Integration Rack |
| CM | Configuration Management |
| DID | Data Item Description |
| DO | Delivery Order |
| ECO | Engineering Change Order |
| FCF | Fluids and Combustion Facility |
| FLEX | Flame Extinguishment Experiment |
| FLEX-2J | FLEX/JAXA |
| FOMA | Fuel Oxidizer Management Assembly |
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| H/W | Hardware |
| HiBMS | High Bit-Depth/MultiSpectral |
| IA | Integration Agreement |
| ICE-GA | Italian Combustion Experiment for Green Air |
| IPSU | Image Processing & Storage Unit |
| ISS | International Space Station |
| JAXA | Japan Aerospace eXploration Agency |
| JSC | Johnson Space Center |
| MDCA | Multi-User droplet Combustion Apparatus |
| MIUL | Materials Identification & Usage List |
| MUA | Materials Usage Agreement |
| NASA | National Aeronautics & Space Administration |
| ORU | Orbital Replaceable Unit |
| PFAR | Post-Flight Assessment Review |
| PRACA | Preventive and Corrective Action |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| TBD | To Be Determined |
| WBS | Work Breakdown Structure |

**SpaceDOC-2 NNC14CA02C**
**DO-202 CVB-2**
**Constrained Vapor Bubble (CVB-2)**
**For DO Period January 1, 2014 through May 31, 2015**
**For the Performance Period December 1, 2014 through May 31, 2015**

## 1) Introduction

The Constrained Vapor Bubble (CVB) experiment is the first payload scheduled in the Light Microscopy Module (LMM). Being the first payload (and only) payload for several years allowed the LMM/CVB to be developed by a prototype / protoflight approach. With the addition of additional payloads beginning in FY09 a change in development approach was required.

Two CVB science modules were launched on STS-128 (17A). The remaining two science modules were launched on ULF-3. All 4 CVB modules have been successfully operated.

The dry and 30mm pentane modules were returned on 19A (April 2010). The 40mm pentane module was returned on ULF-5 (February 2011). The 30mm and 40mm modules fluid will be analyzed for purity.

The 20mm pentane module was returned on STS-135. It was functionally tested, but, there are no plans for additional ground testing.

Due to resources becoming available a CVB-2 experiment has been funded.

CVB-2 was launched on HTV-4 and will be operated through February 2014.

CVB-2 was returned on SpX-4 and is awaiting ground transportation back to ZIN.

**Statement of Work – General**

The CVB 30mm module was returned on SpX-4 and needs to be ground tested per updated procedures. The fluid in the module will need to be extracted and sent to a vendor for analysis. A final report needs to be prepared and sent to the Co-PI's.

Stowage review (PFAR) will be need to be performed when ground testing is complete (March 2015) Hardware will be returned to GRC while funding decisions are being made.

Limited support of ground testing (at Case, J. Mann, Chair of CVB-2 RDR) to support the advocacy for a CVB-3 experiment with an approximate 50/50% pentane/iso-hexane mixture (note CVB-2 was 93/7%).

**Applicable Documents:**

a) NPR 7120.5, NASA Space Flight Program and Project Management Requirements

**b)** NPR 7123.1A, NASA Systems Engineering Processes and Requirements

## 2) Milestones and Reviews

Return of CVB-2 payload on Spx-4 (estimate December 2014)

Ground testing post flight of CVB-2 (Return plus 3 months)

Storage Review (PFAR, March 2015).

### 2) Hardware/Software Deliverables

Return Hardware/Software to NASA when Project is concluded.

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Ronald Sicker, MS 77-7, Ronald.J.Sicker@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Technical Representative, MA/Terence F. O'Malley, Mail Stop 142-7, TFOMalley@nasa.gov

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### Document deliverables shall be as follows:

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements.

b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.

c) Contractor Financial Management Reporting

d) Monthly reporting

CVB-2 Specific

a) Post Flight Report (Ground testing, Inspection, functional test) CVB-2

b) Post Flight Chemical Analysis Report of fluid

c) Down mass Safety Assessment for SpX-4

d) PFAR Presentation and Final Report

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order.

a) LMM GIU
b) LMM FU
c) CVB Sample modules
d) CVB Fill system

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

a) Laboratory facilities in building 333 and 110
b) GRC Tele-Science Center (TSC)

## 7) Government Contacts

The contractor shall have access to consultation with:

a) Ronald Sicker GRC/MSI0
b) David Chao, CVB
c) Pete Wayner, CVB
d) Joel Plawsky, CVB
e) Brian Motil, CVB

## 8) Period of Performance

The period of performance for this delivery order is from January 1, 2014 through May 31, 2015.

## 9) Acronym List

| Acronym | Description |
|---|---|
| CDRL | Contract Data Requirements List |
| CVB | Constrained Vapor Bubble |
| DO | Delivery Order |
| FU | Flight Unit |
| GFE | Government Furnished Equipment |
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| ISS | International Space Station |
| LMM | Light Microscopy Module |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| PI | Principal Investigator |
| RDR | Requirements Definition Review |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SpX | SpaceX |
| STS | Space Transportation System |
| TSC | Telescience Support Center |
| ULF | Utilization Flight |

**SpaceDOC-2 NNC14CA02C**
**DO-203 CFE-2**
**Capillary Flow Experiment-2 (CFE-2)**
**For DO Period January 1, 2014 through September 30, 2015**
**For the Performance Period January 1, 2014 through September 30, 2015**

# 1) Introduction

This delivery order covers the Capillary Flow Experiment-2 (CFE-2) fluid physics experiment. The CFE-2 experiment has 11 vessels (ICF1, ICF2, VG1, VG2, ICF3, ICF4, ICF5, ICF6, ICF7, ICF8, and ICF9) which are on board the International Space Station. The CFE-2 experiment uses the Maintenance Work Area (MWA) to operate the vessels on board the ISS.

The Capillary Flow Experiments (CFE-2) will consist of eleven test vessels designed to characterize capillary flow in complex containers, critical wetting in discontinuous structures and surfaces, and passive gas-liquid phase separations. Highly quantitative video obtained on-orbit provides the science for data processing. Four of the eleven vessels required adaptations to existing flight qualified hardware. The remaining seven units are new builds using the same basic materials and hardware. All of the experiments contain small volumes of zero hazard fluids (silicone oil), require no electrical interface, minimal crew training, and are conducted in the ISS Maintenance Work Area (MWA). The CFE-2 project is in the operations phase of the project.

The test section geometry of the four test vessels is listed below:

1 CFE VG-1 with a 15% open vane test chamber design.
2 CFE VG-2 with a 30% open vane test chamber design.
3 CFE ICF-1 with a truncated parabolic taper test chamber design.
4 CFE ICF-2 with a linear taper test chamber design.

The test section geometry of the seven test vessels are listed below:

5 Interior Corner Flow-3 (ICF-3) test vessel with a 90 degree stepped snow cone taper.
6 Interior Corner Flow-4 (ICF-4) test vessel with a 50 degree stepped snow cone taper.
7 Interior Corner Flow-5 (ICF-5) test vessel with a 4-pack graded pore.
8 Interior Corner Flow-6 (ICF-6) test vessel with a square tapered vane.
9 Interior Corner Flow-7 (ICF-7) test vessel with a circular tapered vane.
10 Interior Corner Flow-8 (ICF-8) test vessel with a segmented graded pore section.
11 Interior Corner Flow-9 (ICF-9) test vessel with a complete parabolic taper.

The scope of this delivery order for CFE-2 includes the completion of verifications, safety reviews, integration, operations and sustaining engineering of these instruments and their data products. The scope for the payload is defined in this delivery order. Specifically the contractor shall;

Support procedure development and validation
TSC coordination and ground displays
Develop and/or provide review of all products required to accomplish the integration of flight experiment
Ground data services
Payload operations data file and flight displays
Payload planning inputs
Crew training support at JSC
Create/update and maintain a verification tracking log
Operations support at the Glenn Research Center TSC

## Statement of Work – General

The contractor shall provide a schedule and budget to reflect the effort detailed in the delivery order. The contractor shall perform the work per the delivery order. The contractor shall continue to maintain and track Non-Conformances and Limited Life records.

**Applicable Documents:**
NASA SSP 57000, Pressurized Payloads Interface Requirements Document
NASA SSP 50432, Space Station Program Requirements for Payloads
GRC-ISS-PLN-001, GRC ISS System Engineering Management Plan
GLPR 7120.5.30, Glenn Procedural Space Assurance Requirements
NPR 7120, NASA Space Flight Program and Project Management Requirements
NPR 7123, NASA Systems Engineering Processes and Requirements

## 2) Milestones and Reviews

The contactor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with the payloads respective launch dates and/or increment operations.

1. Support NASA management meetings and reviews, as needed
2. Support major reviews
3. PI teleconferences, as needed
4. Support procedural review telecons, for example, Lead Increment Scientist, and Daily Science Tag as needed
5. Integration telecons as required
6. Support crew training sessions
7. Support ground testing
8. Support operations planning
9. Operations support at the GRC Telescience Support Center

## 3) Hardware/Software Deliverables

Not applicable for this period of performance

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Robert W. Hawersaat, MS 77-7, Robert.W.Hawersaat@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, MSI/William M. Foster, Mail Stop 77-7, william.m.foster@nasa.gov

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### Document deliverables shall be as follows:

**General**

1. The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06)

2 Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
3 Contractor Financial Management Reporting, per DID# CD-01
4 Monthly reporting, per DID# CD-03
5 Problem Report and Corrective Action (PRACA) Report, per DID# PA-12
6 Lessons Learned Report, per DID# PA-17

**CFE-2 Specific:**

1 CFE-2 Post Flight Report

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order.

CFE-2 Flight Hardware
CFE-2 Engineering Hardware
CFE-2 Ground Test Vessels (used for testing and training)

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

Structural Dynamics Laboratory (Building 55)
Thermal Environmental Chambers (Building 333A)
EMI Laboratory (Building 333A)
GRC Acoustics Test Facility
Marshall Space Flight Center (MSFC) Off-Gassing Facilities
Usage Elective: GRC Instrumentation Shop
GRC Telescience Support Center (Building 333, room 150)

## 7) Government Contacts

The contractor shall have access to consultation with:

GRC CFE-2 Project Manager
GRC CFE-2 Project Scientists
GRC QA personnel
MSFC ISS Ground Support personnel
MSFC Integration discipline engineers
Maintenance Work Area (MWA) personnel
JSC Crew Training personnel

## 8) Period of Performance

The period of performance for this delivery order is from January 1, 2014 through September 30, 2015.

## 9) Acronym List

**Acronym List:**

| Acronym | Description |
|---|---|
| **CDRL** | **Contract Data Requirements List** |
| **CFE** | **Capillary Flow Experiments** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |

| Acronym | Description |
|---|---|
| EMI | Electromagnetic Interference |
| FDSP | Flight Data Safety Package |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| ICD | Interface Control Document |
| ICF | Interior Corner Flow |
| ISS | International Space Station |
| JSC | Johnson Space Center |
| LIS | Lead Increment Scientist |
| MSFC | Marshall Space Flight Center |
| MWA | Maintenance Work Area |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| PI | Principal Investigator |
| POP | Period of performance |
| PRA | Probabilistic Risk Assessments |
| QA | Quality Assurance |
| RDR | Requirements Definition Review |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SARG | Standard Assurance Requirements and Guidelines |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SSP | Space Station Program |
| TSC | Telescience Support Center |
| VG | Vane Gap |

**SpaceDOC-2 NNC14CA02C**
**DO-204 ZBOT**
**Zero Boil-Off Tank Project (ZBOT)**
**For DO Period April 1, 2014 through January 31, 2017**
**For the Performance Period October 1, 2016 through January 31, 2017**

# 1) Introduction

NASA Glenn Research Center (GRC) is developing the ZBOT experiment for operations in the Microgravity Science Glovebox (MSG) facility aboard the International Space Station (ISS). Engineering work was previously conducted under SpaceDOC DO-109 and that Delivery Order (DO) concluded with the flight hardware build and software development in progress and with the Verification Readiness Review being conducted. The scope of this DO includes post-VRR activities, through system assembly, integration and testing and delivery of the flight system. Per CCR-087, it also includes project closeout. Most Mission Integration and Operations (MIO) content is being performed under SpaceDOC-2 DO-219. This includes Interface Verification Testing (IVT), ISS/carrier integration, payload flight safety, turnover activities and operations planning, preparation and execution, as well as the Post-Flight Assessment Review (PFAR).

CCR-119 adds scope to Flight system development and testing activities.

The contractor shall provide all of the documentation and engineering products, hardware and software as required during the period of performance to develop and conduct the ZBOT investigation. The contractor shall provide a bottoms-up schedule to reflect the effort detailed in the DO. The contractor shall provide a management structure, technical approach, resource requirements (including funding) and a Work Breakdown Structure (WBS). The total price shall include direct labor costs, indirect costs, subcontractor costs (if applicable), materials, supplies, travel, other direct costs, general and administrative costs and fees required to execute plans and schedules, and these proposals shall be broken down to allow the ability to track the progress of these activities versus the scheduled deadlines and milestones.

### Background

ZBOT is a small-scale simulant-fluid experiment that will be used to obtain valuable microgravity empirical data for cryogenic storage tank pressure control design and archival science data for model validation. It will be used to build a science base for future space storage tank engineering efforts by elucidating the roles of the various interacting transport and phase change phenomena that impact tank pressurization and pressure control in variable gravity. The project science team will develop, validate, and verify two-phase CFD models for tank pressure control that can be used to aid the future scale-up tank design. ZBOT will show the feasibility of a Zero-Boil-Off (ZBO) pressure control scheme for microgravity and variable gravity applications by examining the effect of forced mixing of the bulk liquid on destratification and pressure reduction in a ventless Dewar.

## Statement of Work – General

### Management

The contractor shall be responsible for managing resources on a day-to-day basis, executing the DO, documenting and resolving problems and issues that occur and obtaining guidance and other direction, as needed, from the NASA Project Manager (PM).

The contractor shall prepare and forward to the NASA PM a monthly progress report defining the month's technical progress, the future month's planned activities and an updated schedule. In addition, updates of the task's financial status shall be provided monthly to the NASA PM and also upon request.
The contractor shall prepare presentation materials in support of all of the project level and safety reviews and interface with the MSG carrier and ISS Payloads Program as required.

### Product Assurance

The contractor shall implement an effective quality assurance program during all phases of the project development cycle. The contractor shall ensure that product quality requirements are determined and satisfied through all phases of product development. This is documented in the SpaceDOC Safety and Mission Assurance Plan (SMAP), P40020, and the ZBOT Software Quality Assurance Plan, ZBOT-PLN-154. A project specific matrix will be utilized to document applicability of requirements from the Space Assurance Requirements (SAR), GLPR 7120.5.30, as well as any tailoring that is necessary. Since many of the verification documents were created using the SpaceDOC Safety and Mission Assurance Plan 30020, some approaches previously agreed to may be grandfathered. Any changes to this existing approach must be approved by the NASA PM and documented by a formal revision of the matrix and/or plan(s).

### Safety

The contractor shall ensure that the product developed is safe for the intended manned space flight application. Specifically, the contractor must address all applicable requirements of the following documents:

a) SSP 51700, Payload Safety Policy and Requirements for the International Space Station
b) Appendix J of SSP 30599, International Space Station Program Safety Review Process

The contractor shall identify and address all unique ISS and MSG facility safety requirements as appropriate for the period of performance. Under DO-219, the contractor will complete the Flight Safety Data Package (FSDP) and participate in the associated reviews as appropriate for the period or performance.

The contractor shall follow all applicable safety practices, policies and procedures during 1-g lab development and testing.

### Other

a) System Design and Development:

The ZBOT Flight hardware and software shall be designed, developed and verified to meet the science, engineering, software, carrier, safety and assurance required per the latest versions of the source documents and as documented in the ZBOT Verification Plan, ZBOT-PLN-052. The contractor shall implement the microgravity test matrix and the Digital Particle Image Velocimetry (DPIV) imaging times in Appendix A of this document rather than those in the Science Requirements Definition (SRD) document, Version 5.0, Table 3. (Note: This scope is addressed as part of "Revision and testing of the Flight and ground software…" below per CCR-087)

Ground Support Equipment (GSE) activities will include:

i) Development and readiness of GSE as required for Flight system development, testing and operations.

Breadboard and EM activities will include:

ii) Continued breadboard testing to evaluate the suitability of Digital Particle Image Velocimetry (DPIV) particles with respect to signal level, loss of fluorescence, sticking and any other performance related characteristics.
iii) Maintenance of the EM system and continued use as required; includes (but is not limited to)
    1. DPIV performance testing
    2. DPIV, optics, and particle injection verification testing and any other verification testing as specified in the ZBOT Verification Plan; DPIV testing/verification includes analysis of the DPIV images and the provision of data for comparison with predictive models
    3. Software testing
    4. Performance testing to assess design or component changes or issues, including the refurbished water pump
    5. Maintain and ready the EM for any 1-g testing and troubleshooting that may be necessary during ISS operations of the Flight system

The following activities will be performed during the development of the Flight systems:

iv) Revision, completion and archival of designs, drawings, analyses, plans and procedures as required to support the manufacture, assembly and testing of the Flight components and systems.

v) Testing of the components and subassemblies for fit, function, performance and reliability as required to support the higher level Flight build.
vi) Procurement of a spare flight bellows for the Fluid Reservoir Assembly (FRA)
vii) Provision of a sixth Particle Injector to be included for flight
viii) Generation and provision of STEP files to support science modelling
ix) Addressing questions and comments from the science team regarding the Interface Design Description, ZBOT-DOC-105, and data file content
x) Assess protoflight vibration testing performed on ZBOT hardware vs. HTV launch loads; document and review results with NASA
x.1) Determine and provide Test Tank fill levels from thermal science testing using the method that will be utilized during ISS operations

Flight Systems Assembly and Testing shall include the following activities:

xi) Remaining fabrication and assembly of the Flight hardware, including traceability documentation, archival of materials certifications, inspections at required times and conformance to all Flight drawings and assembly procedures.
xii) Revision and testing of the Flight and ground software; includes revision due to changes to the science test matrix and DPIV image sequencing.
xiii) Testing of the individual assemblies and/or the integrated Flight systems to perform the following objectives:
    1. Science requirements verification
    2. Engineering and Software requirements verification
    3. Safety requirements verification
    4. MSG carrier (including vehicle and ISS) requirements verification
    5. Product Assurance requirements compliance/verification
    6. Environmental requirements verifications, including:
        a. Component level and acceptance vibration testing; includes preparation for workmanship vibration testing of replacement solenoid valves (but not vibration testing or post-vibration testing checkout)
        b. Thermal testing
        c. EMI testing
        d. Acoustic testing
        e. Offgas testing
    7. Obtain 1-g science data for ten test points selected by the science team
xiv) Performance of a fit check of the DACU in MSG Engineering Unit (EU) at MSFC
xv) Conduct analysis of the Perfluoro-N-Pentane (PNP) drained from the flight system in order to determine the cause of discoloration and/or the presence of any leachates
xvi) Perform the following activities on Flight fluids system relief valves RV7 and RV8:
    1. Conduct thermal testing of the relief tube assembly to assess valve leakage
    2. Replace faulty valve(s) and conduct proof, leak and functional (cracking) testing of the relief tube assembly
    3. Conduct thermal testing of the reworked relief tube assembly to assess leakage
    4. Install the relief tube assembly and characterize at the system level
    5. Report on results
xvii) Perform Vacuum Exhaust System (VES) verifications with the Payload Rack Checkout Unit (PRCU) in building 333
xviii) Perform testing/analysis to verify SSP 57000, requirement 3.6.1.8, Limit VES Venting Profile
xix) Perform the second round of offgas testing of the flight hardware in two lots; perform a pre-test "bakeout" of each lot

b) Reviews:

The contractor shall address any engineering related Requests for Action (RFA)/Review Item Discrepancies (RID) from the VRR.

The contractor shall conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the System Acceptance Review (SAR) as specified in the ISS

Research Systems Engineering and Management Plan (SEMP), GRC ISS-SEMP-001, Rev A or the latest; any tailoring of the criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review.

The contractor shall prepare presentation materials and participate in the following reviews:

i) DPIV Engineering Review Board (ERB)
ii) SAR
iii) ERB/informal review of inline heater driver circuit changes

The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions and agreements, RFAs and RIDs resulting from these reviews.

c) ZBOT-2 Flow Visualization Development:

The contractor shall perform the following activities in support of ZBOT-2 flow visualization development:

i) Purchase one gallon of Perfluoro-N-Pentane (PNP) and send it to Manoochehr Koochesfahani at Michigan State University (MSU) in one shipment
ii) Participate in a one day site visit to MSU. Transportation to be provided by the government; no lodging required
iii) Participate in six status meetings/telecons and provide technical information about ZBOT as requested

d) Project closeout:
The contractor shall perform the following project closeout activities

i) Transfer of property to the ZBOT-2 SpaceDOC-2 DO or other agreed upon DO
ii) Delivery of remaining hardware/software per section 3) Hardware/Software deliverables
iii) Delivery of "All other documents…" per section 4) Document Deliverables

**Reference Documents:**

a) NPR 7120.5E, NASA Space Flight Program and Project Management Requirements
b) NPR 7123.1B, NASA Systems Engineering Processes and Requirements
c) GRC ISS-SEMP-001, ISS Research Systems Engineering and Management Plan (SEMP)
d) GLPR 7120.5.30, Space Assurance Requirements (SAR)
e) ZBOT Science Requirements Definition (SRD) document, Version 5.0
f) ZBOT Project Plan

## 2) Milestones and Reviews

The contractor shall meet the following milestones and participate in the following meetings and reviews:

a) A weekly technical status meeting with the NASA PM. The Principal Investigator (PI), Co-Investigator (Co-I) and Project Scientist (PS) should be invited to participate. Minutes shall be taken and published by the contractor. Items to be covered:
   i) Top level technical performance/accomplishments (Carried forward from A)
   ii) Near term activities (Carried forward from A)
   iii) Work Breakdown Structure (WBS) comments (problems/issues/risks and mitigation strategies) (Carried forward from A)
   iv) Schedule (include the critical path) (Carried forward from A)
b) Technical, schedule and budget status meetings with the NASA PM, PS, PI, ISS and Human Health Office Chief and the ISS Research Project Manager, as necessary. (Carried forward from A)
c) Complete the assembly, testing and verification activities in support of Flight system turnover for launch. November 9, 2016 (was 9/2016, 4/2016, Carried forward from A)
d) SAR November 16, 2016 (was 9/2016, 4/2016, Carried forward from A)

Estimated completion dates for the milestones and reviews specified in items d) and following shall be included in the detailed schedule provided by the contractor.

## 3) Hardware/Software Deliverables

The contractor shall furnish the following hardware/software in the implementation of the other item(s): All support, Breadboard, EM and Flight hardware and software supplied as Government Furnished Equipment (GFE) or acquired and/or created in the completion of this DO, including tools, spares and equipment purchased; these items shall be delivered to the NASA PM or transferred to a follow-on DO. November 30, 2016 (was 9/2016, 4/2016, Carried forward from A)

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/ William Sheredy, MS 77-7, William.Sheredy@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Technical Representative, MSI/William Foster, Mail Stop 77-7, William.M.Foster@nasa.gov

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### Document deliverables shall be as follows:

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC-2 requirements (per DID# PM-06) ON-GOING
b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
d) Monthly reporting, per DID# CD-02, ON-GOING
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
f) Lessons Learned Report per DID PA-17 ON-GOING November 30, 2016 (was 9/2016, 4/2016)
g) Functional test plans, procedures, analyses and reports November 16, 2016 (was 9/2016, 4/2016, Carried forward from A)
h) Verification test plans, procedure, analyses and reports November 16, 2016 (was 9/2016, 4/2016, Carried forward from A)
i) Documentation products required as artifacts for the project reviews November 16, 2016 (was 9/2016, 4/2016, Carried forward from A)
j) All other documents created or revised in the execution of this DO, including but not limited to, drawings, analyses, plans, procedures and reports, memos, deviations and waivers and nonconformance reports; purchasing orders, Manufacturing Work Orders and process plans, shall not be provided but shall be retained by the contractor November 30, 2016 (was 9/2016, 4/2016, Carried forward from A)
k) Products required to address actions/agreements and/or RFAs/RIDs that may result from the project reviews November 30, 2016 (was 9/2016, 4/2016, Carried forward from A)

Documentation products required for reviews shall be submitted a minimum of 3 weeks prior or later if agreed upon by the NASA PM.

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order:

a) All hardware and software transferred to the contractor during previous Performance Periods
b) MSG Work Volume
c) Sound level meter (as required for periodic acoustic testing)

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

a) Thermal Environmental Chamber in Building 332
b) EMI Laboratory in Building 332
c) GRC Calibration Lab
d) Off Gas Testing Facility at Marshal Space Flight Center
e) PRCU in Building 333

Usage shall be agreed upon by and coordinated with the NASA Project Manager.

## 7) Government Contacts

The contractor shall have access to consultation with:

a) NASA ZBOT PM
b) ZBOT PS
c) ZBOT Co-I
d) ZBOT PS
e) MSG PM
f) MSG Payload Integration Manager
g) ZBOT Investigation Payload Integration Manager (IPIM)
h) MSFC Integration Discipline Engineers
i) GRC PIMS team

## 8) Period of Performance

The period of performance for this delivery order is from October 1, 2015 through January 31, 2017.

## 9) Acronym List

| Acronym | Description |
|---|---|
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CFD** | **Computational Fluid Dynamics** |
| **Co-I** | **Co-Investigator** |
| **DACU** | **Data Acquisition and Control Unit** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **DPIV** | **Digital Particle Image Velocimetry** |
| **EM** | **Engineering Model** |
| **EMI** | **Electromagnetic Interference** |
| **EU** | **Engineering Unit** |
| **FRA** | **Fluid Reservoir Assembly** |
| **FSDP** | **Flight Safety Data Package** |
| **FSR** | **Flight Safety Review** |
| **GFE** | **Government Furnished Equipment** |

| Acronym | Description |
|---|---|
| GLPR | GRC Procedural Requirement(s) |
| GRC | Glenn Research Center |
| GSE | Ground Support Equipment |
| IPIM | Investigation Payload Integration Manager |
| ISS | International Space Station |
| IVT | Interface Verification Testing |
| MI&O (MIO) | Mission Integration & Operations |
| MSFC | Marshall Space Flight Center |
| MSG | Microgravity Science Glovebox |
| MSU | Michigan State University |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| ORR | Operations Readiness Review |
| PFAR | Post-Flight Assessment Review |
| PI | Principal Investigator |
| PIM | Payload Integration Manager |
| PM | Program Manager |
| PNP | Perfluoro-N-Pentane |
| PRCU | Payload Rack Checkout Unit |
| PS | Project Scientist |
| RDR | Requirements Definition Review |
| RFA | Request for Action |
| RID | Review Item Discrepancy |
| SAR | Space Assurance Requirements |
| SDP | Safety Data Package |
| SEMP | Systems Engineering Management Plan |
| SMAP | Safety & Mission Assurance Plan |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SRD | Science Requirements Document |
| TIM | Technical Interchange Meeting |
| VES | Vacuum Exhaust System |
| WBS | Work Breakdown Structure |

**Appendix A: See PDF SOW**

**SpaceDOC-2 NNC14CA02C**
**DO-205 OASIS**
**Observation & Analysis of Smectic Island in Space (OASIS)**
**For DO Period of Performance January 1, 2014 through June 30, 2015**
**For the Performance Period January 1, 2014 through September 30, 2015**

# 1) Introduction

The Observation and Analysis of Smectic Islands In Space (OASIS) experiment is designed to exploit the unique characteristics of freely suspended liquid crystals in a microgravity environment to advance the understanding of fluid state physics. It is designed to operate within the Microgravity Science Glovebox (MSG) on ISS. The OASIS sample module flight hardware will be developed from a functional model of the liquid crystal mixture dispensing system from commercial off-the-shelf (COTS) parts and will be designed to be integrated into MSG.

MSG is located in International Space Station (ISS) Columbus Module and is a multi-user flexible facility with an enclosed 255-liter work area accessible to the crew through sealed glove ports and to ground-based scientists through real-time data links and video. The MSG provides power and data for the OASIS experiment with dedicated video resources for live downlink or video recording, digital photography, sensors for monitoring experiment health and status, a cold plate for removal of heat load of up to 800 Watts at 50 degrees C as required. The MSG laptop computer (MLC) provides server software for experimental control as required.

Due to the budget constraints and Principal Investigator (PI) funding levels, the hardware development approach will be primarily the integration of COTS parts that are upgraded for space flight. The OASIS experiment will be developed through a combination of converting the engineering model into flight hardware (regrade process) as well as built up of individual flight hardware unit for delivery.

OASIS has already successfully completed its Science Concept Review (SCR) in June 2008, the Requirements Definition Review in March 2011 and a Preliminary Design Review in March 2012. A tabletop Critical Design Review (CDR) was held in November 2013 and a CDR/VRR (Verification Readiness Review) was held in March 2014.

The scope for this DO is to support the following reviews: Phase III Safety Review and Pre-Ship Review in preparation for turnover of the flight hardware for the assigned Orbital or SpaceX launch. The scope will also cover a Post Flight Assessment Review to assess the state of the hardware for future OASIS reflight experiments and use of the OASIS hardware. As a result of Russian participation, crew training for a Russian cosmonaut, in addition to a US astronaut, will be required.

Specifically, the contractor shall:

a) Use the Regrade Process for completion of the build-up, fab and assembly of the OASIS Power Enclosure, Optics/Illumination Assembly, Bubble Chamber Inserts and Bubble Chamber Assembly.
b) Complete the buildup of the Flight Bubble Chamber Inserts (4x), Power Enclosure, Avionics, DAQ I/O, Soft Start Assembly and cables flight hardware.
c) Perform integrated flight functional testing, environmental testing and analysis as necessary to satisfy CDR/VRR entrance criteria on OASIS system.
d) Perform Integrated PI testing on the flight hardware and perform additional hardware improvements, specifically improvements to the micro-view and macro view systems as well as additional software effort in order to meet the science requirements.
e) Support engineering and science reviews, and telecons as necessary.
   i. CDR/VRR scheduled for NLT Jan 2014 (COMPLETED)
   ii. Miscellaneous TIMs on the regrade hardware (COMPLETED)
   iii. Phase III Safety Review scheduled for NLT December 2014 (was 7/14)
   iv. Pre-Ship Review scheduled for NLT January 2015 (was 9/14)

   v. Post Flight Assessment Review for NLT June 2015
- f) Support weekly team and science telecon meetings.
- g) Close out open RFAs from VRR and PSR prior to flight.
- h) Create and/or update the appropriate documentation required for CDR/VRR, Phase III Safety Review, PSR and PFAR.
- i) Support operations to include crew training briefing and Payload Training Dry Run (PTDR) at JSC
- j) Support the MSFC Complex Impedance & Large Signal Stability verification test by providing parts and fabricating the EFA3501 board

Delivery Order 219 (DO-219) consolidates all the Mission Integration and Operations scope of work. This includes the consolidated activities, products, and milestones described within the Payload Integration Template (PIT), SSP 57057, in support of OASIS. These activities include:

- a) Interface Verification Testing (IVT)
- b) ISS/Carrier Integration (including flight and ground safety)
- c) Turnover
- d) Operations

These activities have now been removed from this DO.

**Applicable Documents:**
NPR 7120, NASA Space Flight Program and Project Management Requirements
NPR 7123, NASA Systems Engineering Processes and Requirements

## 2) Milestones and Reviews

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

- a) Weekly OASIS team meetings at ZIN
- b) PI teleconferences as needed
- c) Travel to the PI university to resolve engineering/science issues, as needed
- d) NASA management meetings and reviews, as needed
- e) Phase III SDP Submission ~~and Phase III Safety Review~~ Delete/Moved to DO-219 MI&O
- f) CDR/VRR (COMPLETED)Dry run presentations in preparation for major reviews
- g) MSG PIM Integration telecons as required
- h) Pre-Ship Reviews
- i) Post Flight Assessment Review

## 3) Hardware/Software Deliverables

The contractor shall complete the design, assembly, integration, and test of the hardware as required in the implementation of Item 1 of this DO:

**Flight hardware (which includes the hardware utilizing the regrade process) for:**

- a) OASIS Power Enclosure
- b) Optics/Illumination Assembly
- c) Bubble Chamber Inserts (4)
- d) Bubble Chamber Assembly
- e) Avionics
- f) DAQ I/O Miscellaneous flight hardware cables
- g) Soft Start Assembly
- h) EFA3501 board and associated parts

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Nancy R. Hall, MS 77-7, Nancy.R.Hall@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### Document deliverables shall be as follows:

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06)

b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.

c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING

d) Monthly reporting, per DID# CD-03, ON-GOING

e) Operations Documentation

f) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING

g) Lessons Learned Report per DID PA-17

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order:
a) Picoliter-Dispensing System (Returned to GRC)
b) Liquid Crystal Sample Material
c) MSG Flexible Arm
d) MSG Simulator

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:
a) Thermal Environmental Chambers in Building 333A
b) Structural Dynamics Laboratory
c) EMI Laboratory in Building 333A
d) GRC Acoustics Test Facility
e) GRC ISS Payload Operation Center and satellite facilities
f) Marshall Space Flight Center Offgassing Facilities
g) Vibration Test Laboratory in Building 55
h) GRC OASIS Laboratory in Building 110 Room 129
i) GRC Instrumentation Shop

j) Project Scientist: Padetha Tin’s lab, Building 105/Rm 210

## 7) Government Contacts

The contractor shall have access to consultation with:

a) Nancy R. Hall / GRC project manager
b) Padetha Tin / NCSER project scientist
c) Noel Clark / University of Colorado in Boulder Principal Investigator (PI)
d) Co-Investigators and graduate students from the University of Colorado
e) MSFC POIC and MSG personnel
f) Russian Cosmonauts and US Astronauts

## 8) Period of Performance

The period of performance for this delivery order is from January 1, 2014 through September 30, 2015.

## 9) Acronym List

| Acronym | Description |
|---|---|
| C | Centigrade |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| Co-I | Co-Investigator |
| COTS | Commercial Off The Shelf |
| DID | Data Item Description |
| DO | Delivery Order |
| EMI | Electromagnetic Interference |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| ISS | International Space Station |
| MLC | MSG Laptop Computer |
| MSG | Microgravity Science Glovebox |
| NASA | National Aeronautics & Space Administration |
| NLT | No Later Than |
| NPR | NASA Procedural Requirement |
| OASIS | Observation & Analysis of Smectic Island in Space |
| PFAR | Post Flight Assessment Review |
| PI | Principal Investigator |
| PIM | Payload Integration Manager |
| POIC | Payload Operations & Integration Center |
| PSR | Pre-Ship Review |
| RFA | Request for Action |
| SCR | Science Concept Review |
| SDP | Safety Data Package |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| TBD | To Be Determined |
| TIM | Technical Interchange Meeting |
| TSC | Telescience Support Center |
| VRR | Verification Readiness Review |

**SpaceDOC-2 NNC14CA02C**
**DO-206 BASS-2**
**Burning And Suppression of Solids-2 (BASS-2)**
**For DO Period January 1, 2014 through September 30, 2015**
**For the Performance Period January 1, 2014 through September 30, 2015**

# 1) Introduction

This delivery order covers the BASS-2 combustion science experiment. The BASS-2 experiment uses the existing SPICE Experiment Assembly currently on orbit on the International Space Station. The BASS-2 flight hardware samples, igniters and camera micro-drives are scheduled to launch on Orbital-1 in December 2013. The BASS-2 experiment continues the fundamental phenomena related to understanding the mechanisms controlling the stability and extinction of solid fuel flames. The BASS-2 will stabilize an enclosed laminar flame, measure the overall flame shape to validate the theoretical and numerical predictions, measure the flame stabilization heights, and measure the temperature field to verify flame structure predictions.

The scope of this delivery order for BASS-2 includes the completion of verifications, safety reviews, integration, operations and sustaining engineering of these instruments and their data products. The scope for the payload is defined in this delivery order. Specifically the contractor shall:

a) Support procedure development and validation
b) TSC coordination and ground displays
c) Develop and/or provide review of all products required to accomplish the integration of flight experiment
d) Ground data services
e) Payload operations data file and flight displays
f) Payload planning inputs
g) Crew training support at JSC
h) Create/update and maintain a verification tracking log
i) Operations support at the TSC

**Statement of Work – General**

The contractor shall provide a schedule and budget to reflect the effort detailed in the delivery order. The contractor shall perform the work per the delivery order. The contractor shall continue to maintain and track Non-Conformances and Limited Life records.

**Applicable Documents:**

NASA SSP 57000, Pressurized Payloads Interface Requirements Document
NASA SSP 50432, Space Station Program Requirements for Payloads
GRC-ISS-PLN-001, GRC ISS System Engineering Management Plan
GLPR 7120.5.30, Glenn Procedural Space Assurance Requirements
NPR 7120, NASA Space Flight Program and Project Management Requirements
NPR 7123, NASA Systems Engineering Processes and Requirements

## 2) Milestones and Reviews

The contactor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall:

a) Propose the dates for milestones in accordance with the payloads respective launch dates and/or increment operations
b) Support NASA management meetings and reviews, as needed
c) Provide dry run presentations in preparation for major reviews
d) PI teleconferences, as needed
e) Support procedural review telecons, for example, JIT, Lead Increment Scientist, and Daily Science Tag as needed
f) Integration telecons as required
g) Support crew training sessions at JSC
h) Support ground testing
i) Support operations planning
j) Operations support at the GRC Telescience Support Center

## 3) Hardware/Software Deliverables

Not applicable for this period of performance

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Robert W. Hawersaat, MS 77-7, Robert.W.Hawersaat@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, MSI/William M. Foster, Mail Stop 77-7, william.m.foster@nasa.gov

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

## Document deliverables shall be as follows:

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06)
b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
c) Contractor Financial Management Reporting, per DID# CD-01
d) Monthly reporting, per DID# CD-03
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12
f) Lessons Learned Report, per DID# PA-17

**BASS-2 Specific:**

a) BASS-2 Post Flight Report

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order.

BASS Flight Hardware
SPICE Flight Hardware
SPICE Engineering Hardware

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

Structural Dynamics Laboratory (Building 55)
Thermal Environmental Chambers (Building 333A)
EMI Laboratory (Building 333A)
GRC Acoustics Test Facility
Marshall Space Flight Center (MSFC) Off-Gassing Facilities
Usage Elective: GRC Instrumentation Shop
GRC Telescience Support Center (Building 333, room 150)

## 7) Government Contacts

The contractor shall have access to consultation with:

GRC BASS Project Manager
GRC/NCSER Project Scientists
GRC QA personnel
MSFC ISS Ground Support personnel
MSFC Integration discipline engineers
MSFC Microgravity Science Glovebox (MSG) personnel
JSC Crew Training personnel

## 8) Period of Performance

The period of performance for this delivery order is from January 1, 2014 through September 30, 2015.

## 9) Acronym List

**Acronym List:**

| Acronym | Description |
|---|---|
| ATV | Autonomous Transfer Vehicle |
| BASS | Burning And Suppression of Solids |
| CDRL | Contract Data Requirements List |
| DID | Data Item Description |
| DO | Delivery Order |
| EMI | Electromagnetic Interference |
| FDSP | Flight Data Safety Package |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| ICD | Interface Control Document |
| ISS | International Space Station |

| Acronym | Description |
|---|---|
| JIT | Just In Time |
| JSC | Johnson Space Center |
| LIS | Lead Increment Scientist |
| MSFC | Marshall Space Flight Center |
| MSG | Microgravity Science Glovebox |
| NASA | National Aeronautics & Space Administration |
| NCSER | National Center for Space Exploration Research |
| NPR | NASA Procedural Requirement |
| PI | Principal Investigator |
| POP | Period of performance |
| PRACA | Preventive and Corrective Action |
| QA | Quality Assurance |
| RDR | Requirements Definition Review |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SARG | Standard Assurance Requirements and Guidelines |
| SFS | Spacecraft Fire Safety |
| SLICE | Structure and Liftoff In Combustion Experiment |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SPICE | Smoke Point in Coflow Experiment |
| TSC | Telescience Support Center |
| ULF | Utilization Flight |

**SpaceDOC-2 NNC14CA02C**
**DO-207 CSLM-4**
**Coarsening in Solid-Liquid Mixtures (CSLM-4)**
**For DO Period January 1, 2014 through December 31, 2016**
**For the Performance Period October 1, 2015 through December 31, 2016**

# 1) Introduction

This delivery order covers the material science experiment Coarsening in Solid Liquid Mixtures-4 (CSLM-4). The CSLM-4 experiment investigates the kinetics of competitive particle growth within a liquid matrix. The CSLM-4 flight hardware consists of the Sample Processing Unit (SPU), the Electronics Control Unit (ECU) and auxiliary hardware. This hardware has been designed to be operated within the Microgravity Science Glovebox (MSG). Six sample processing units (SPU's) were launched on SpaceX-5 and operated in the MSG on board the International Space Station. During operations on board the ISS the Electronic Control Unit (ECU) did not function for three of the six Sample Processing Units. The plan is to test and repair the ECU. The materials program is considering options if the current ECU is not repairable, investigate the current design of electronics controllers.

The Marshall Space Flight Center (MSFC) materials science team has received a Sample Processing Unit to perform ground test at MSFC materials lab. The CSLM team will work with the MSFC materials team to develop a plan to utilize existing CSLM hardware to perform the ground test.

## Statement of Work – General

The goal of the CSLM-4 experiment is to perform coarsening experiments using dendrite samples. The CSLM-4 specific payload hardware will use new dendrite samples provided by the Principal Investigator. The CSLM-4 experiment operated on board the ISS in January 2015.

The scope of this delivery order includes the completion of testing, repair, verifications and sustaining engineering of these instruments and their data products. The scope for each payload is defined in this delivery order. Specifically the contractor shall:

1 Develop a test plan to check the function of the ECU.
2 Provide testing of the ECU.
3 The contractor shall develop and/or provide review of all of the products required to accomplish the repair of the flight hardware.
4 Repair the ECU to original functionality, if possible.
 a) Create/update and maintain a verification tracking log.
5 Research controller options for possible upgrade to ECU, develop a cost estimate.

**Applicable Documents:**

1 NASA SSP 57000, Pressurized Payloads Interface Requirements Document
2 NASA SSP 50431, Space Station Program Requirements for Payloads
3 GLPR 7120.5.30, Glenn Procedural Space Assurance Requirements
4 NPR 7120, NASA Space Flight Program and Project Management Requirements
5 NPR 7123, NASA Systems Engineering Processed and Requirements
6 GRC-ISS-PLN-001, GRC ISS System Engineering Management Plan
7 CSLM, Microgravity Science Glovebox Interface Control Document (MSG ICD)
8 CSLM, Flight Data Safety Package (FDSP)

## 2) Milestones and Reviews

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with the payloads respective launch dates and/or increment operations.

1 PI Teleconferences, as needed (Carries forward from A)
2 NASA management meetings and reviews, as needed (Carries forward from A)
3 Dry run presentations in preparation for major reviews, RDR and SAR (Carries forward from A)
4 Support procedural review telecons, ie, JIT,LIS, and Daily Science Tag as needed (Carries forward from A)
5 Integration telecons as required (Carries forward from A)
6 Test Readiness Reviews as required (Carries forward from A)
7 CSLM-4 support ground testing for PI if required (Carries forward from A)
8 CSLM-4 Post Flight Assessment Review

## 3) Hardware/Software Deliverables

1 Repair the flight Electronic Control Unit (ECU)

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Robert W. Hawersaat, MS 77-7, Robert W. Hawersaat@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

### Document deliverables shall be as follows:

**General**

1 The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC-2 Contract Requirements. (per DID# PM-06) ON-GOING

2 Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly. ON-GOING

3 Contractor Financial Management Reporting, per DID# CD-01 ON-GOING

4 Monthly reporting, per DID# CD-03 ON-GOING

5 Problem Report and Corrective Action (PRACA) Report, per DID# PA-12 ON-GOING

6 Lessons Learned Report, per DID# PA-17 ON-GOING

**CSLM-4 Specific:**

1 Electronic Control Unit repair test plan

2 Electronic Control Unit controller options report

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order.
CSLM-2 Flight Hardware
CSLM-2 Engineering Hardware

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1 Thermal Environmental Chambers in Building 333A
2 Structural Dynamics Laboratory in Building 55
3 EMI Laboratory in Building 333A
4 Usage Elective: GRC Instrumentation Shop
5 GRC Acoustics Test Facility
6 GRC Telescience Support Center (TSC) in Building 333
7 Marshall Space Flight Center (MSFC) Off-Gassing Facilities

## 7) Government Contacts

The contractor shall have access to consultation with:

1 GRC CSLM-4 Project Manager
2 GRC CSLM-4 Project Scientist
3 MSFC ISS Ground Support Personnel
4 MSFC integration discipline engineers
5 MSFC Materials Science personnel
6 MSFC Microgravity Science Glovebox (MSG) personnel
7 GRC QA personnel
8 JSC Crew Training personnel

## 8) Period of Performance

The period of performance for this delivery order is from October 1, 2015 through December 31, 2016.

## 9) Acronym List

| Acronym | Description |
|---|---|
| **CDRL** | **Contract Data Requirements List** |
| **CSLM** | **Coarsening in Solid-Liquid Mixtures** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **ECU** | **Electronic Control Unit** |
| **EMI** | **Electromagnetic Interference** |
| **FDSP** | **Flight Data Safety Package** |
| **GFE** | **Government Furnished Equipment** |
| **GLPR** | **GRC Procedural Requirement(s)** |

| Acronym | Description |
|---|---|
| GRC | Glenn Research Center |
| ICD | Interface Control Document |
| ISS | International Space Station |
| JIT | Just In Time |
| JSC | Johnson Space Center |
| LIS | Lead Increment Scientist |
| MSFC | Marshall Space Flight Center |
| MSG | Microgravity Science Glovebox |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| PI | Principal Investigator |
| POP | Period of performance |
| PRACA | Preventive and Corrective Action |
| QA | Quality Assurance |
| RDR | Requirements Definition Review |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SPU | Sample Processing Unit |
| SSP | Space Station Program |
| TSC | Telescience Support Center |

**SpaceDOC-2 NNC14CA02C**
**DO-208 PBRE**
**Packed Bed Reactor Experiment (PBRE)**
**For DO Period February 1, 2014 through September 30, 2015**
**For the Performance Period February 1, 2014 through September 30, 2015**

## 1) Introduction

The Packed Bed Reactor Experiment (PBRE) is intended to fly on the International Space Station (ISS) as part of NASA's applied research on critical subsystems to support human life during long-duration space missions. The objective of the PBRE project is to address specific technical issues related to the design and performance of Packed Bed Reactors targeted for use in Advanced Life Support (ALS) applications. These include, but are not limited to, biological water processors, high temperature catalytic reactors for removal of volatile contaminants, packed sorption beds and Sabatier Reactors for air replenishment.

The PBRE project will advance the state of the art in chemical reactor technology as follows:

a) Develop design and operational guidelines for Fixed Packed Bed Reactors in partial and microgravity gravity conditions.
b) Develop and validate, with experimental data, macroscopic equations that can be used in partial and microgravity conditions to accurately predict flow pattern transitions, pressure drops and reaction transport rates in gas-liquid flows through randomly packed beds
c) Optimize design and operational parameters for biological and chemical reactors.
    1. Packing size and material.
    2. Flow rates (recirculation).
    3. Optimum flow regime – predict gas holdup.
    4. Develop scaling laws and quantify wall effects for reactor vessels.
    5. Determine local shear rates on packing material to quantify and control biomass sloughing conditions.

Results from this experiment will support the creation of a set of design tools, simulation models and operational guidelines for reactor beds, which are able to operate efficiently in microgravity and reduced gravity conditions.

From 2010 through 2013, PBRE completed Requirements Definition Review, all the PBRE design reviews, and Phase 0/1/2 Flight Safety Reviews. In SpaceDOC-1, three PBRE flight hardware modules were built and all major PBRE flight hardware was procured except for the flight tomography components. Also, a tomography prototype unit was developed and demonstrated. This DO calls for the design and construction of a higher fidelity tomography sensor followed by testing, scheduled to be completed by April 2014. The results of the testing will determine if tomography is a viable diagnostic for PBRE, completion of all remaining PBRE flight hardware builds, testing and verifications for Phase III Flight Safety Review by January 2015 and complete Pre-Ship Review activities for Flight Hardware Available (FHA) by March 2015. The launch date for PBRE is currently scheduled for June 2015. Activities with respect to tomography are:

1. Design and build an engineering level sensor for further testing.

**Statement of Work**

a) The contractor shall develop and complete a tomography engineering level sensor and testing by April 2014. The tomography system shall interface with the PBRE and fit in the MSG. The design shall allow for ground removal and replacement of the tomography system.

b) The contractor shall complete all the PBRE flight hardware and software builds, all testing and verifications, and all documentation and data package for Pre-Ship Reviews (PSR-1 & 2) by March 2015. The contractor shall complete all nonconformance reports, engineering change orders, and process all deviation and waivers (if any). The contractor shall complete all changes to drawings for as-built hardware. Key and progress milestones shall achieve as follow:

- Complete all PBRE flight hardware ) builds by May 2014
- Complete Thermal and EMI testing at GRC by July 2014
- Complete Integrated Verification Testing with MSG, Off-gas testing and Acoustic testing at MSFC by November 2014
- Complete Phase III Safety Review by January 2015 (For reference only, Delete/Move to DO-219)
- Complete PSR-2 by March 2015
- PBRE Turnover by April 2015

~~c) The contractor shall develop the PBRE operations handbook. Training to operate the flight experiment to Contractor and NASA personnel shall be provided.~~ Delete/Move to DO-219

d) The contractor shall complete the development and testing of an electrical capacitance volume tomography engineering prototype and conduct a tomography CDR. This added scope is to transfer the descoping content and value from SpaceDOC 1 to 2.
e) ) The contractor shall develop post processing software to synchronize the two science videos and all of the data for use during operations and in the post ops phase. It is envisioned that the post processing software at a minimum will be able to time synchronize and display at least two selectable videos and (TBD, at least ten) selectable measurements on a single display screen with an adjustable time bar. The selectable videos, measurements and format to display will be coordinated with the science team.
f) The contractor shall make the transferred PBRE brass board unit fully operational at GRC and provide training to operate it.
g) The contractor shall modify and test the Engineering Model Avionics and ship it to MSFC for the additional PBRE/MSG verification tests.

**Applicable Documents:**

a) NPR 7120.5, NASA Space Flight Program and Project Management Requirements
b) NPR 7123.1, NASA Systems Engineering Processes and Requirements
c) SSP 51700 Payload Safety Policy and Requirements for ISS
d) SSP 30599 Safety Review Process, ISS
e) GLPR 7120.5.30 Space Assurance Requirements
f) GRC ISS Projects-SEMP-01 Systems Engineering Management Plan
g) PBRE-REQ-002 PBRE Science Requirements Document
h) PBRE-PLN-015 PBRE Project Plan

*All documents are to be considered the latest revision unless specified herein

**2) Milestones and Reviews**

The contractor shall provide regularly scheduled meetings with the NASA Technical Representative for the following:

a) Monthly technical status. Items to be covered:
   1. Top Level Technical Performance/Accomplishments
   2. Near Term Activities
   3. Risks and Mitigation Strategies
   4. Problems/Issues and concerns
   5. Baselined Schedules (to include a Critical Path Schedule) progress
   6. Budget and projection on when contract funds run out

b) Phase III Flight Safety Review for PBRE January 2015 (For Reference only, Delete/Move to DO-219)
c) Pre-Ship Review (PSR-1 and 2) - March 2015
d) Tomography CDR – July2014
e) PBRE Turnover – April 2015

**3) Hardware/Software Deliverables**

The specific hardware and software deliverables called out in DO-208 are listed below.

| Deliverable No. | Item Description | Completion Date |
|---|---|---|
| 1 | PBRE flight system with two test modules | March 2015 |
| 2* | PBRE flight spare components | March 2015 |
| 3** | PBRE ground hardware and software for use to command PBRE and process PBRE data. | March 2015 |
| 4* | Tech4 ECVT unit | July 2014 |
| 5 | PBRE post processing software | September 2015 |

* All hardware is to be delivered in-place (i.e. at ZIN) unless directed by NASA GRC
** Delivered in place at ZIN or NASA GRC Tele-Science Center (TSC)

**4) Document Deliverables**

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Nang T. Pham, MS 77-7, Nang T. Pham@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, MSI/William M. Foster, Mail Stop 77-7, william.m.foster@nasa.gov
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

**Document deliverables shall be as follows:**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06)
b) Baseline schedule with Resource Loaded for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path.
c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING

d) Monthly reporting, per DID# CD-03, ON-GOING

e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING

The specific documentation deliverables are listed below.

f) Lessons Learned Report per DID PA-17 (due at the end of each major review as specified in item 2)

g) PBRE Phase III Flight Safety Data Package (FSDP) for early January 2015 review date (For reference only, Delete/Move to DO-219)

h) PBRE Pre-Ship Reviews (PSR-1 and PSR-2) document and data package (March 2015)

i) PBRE EM and flight units as-built drawings (March 2015)

j) Operations handbook per DID# OP-02 (March 2015) (For reference only, Delete/Move to DO-219)

k) Tomography CDR data package (July 2014)

**5) Government Furnished Equipment (provided in accordance with 52.245-5)**

The following are GFE for this delivery order.

In assessing the contractor budget and schedule, the following hardware and software shall be made available by the Government to the contractor:

None

**6) Government Furnished Facilities**

The Government shall make available on an as needed basis the following Government facilities:
In assessing the contractor budget and schedule, the following Government Facilities shall be made available by the Government to the contractor per agreement and coordination with the GRC Project Manager:

a) Lab Space in Building 77
b) Calibration Lab
c) EMI Laboratory in Building 333A
d) Marshall Space Flight Center (MSFC) MSG payload testing support facilities
e) Thermal Environmental Chambers in Building 333A

**7) Government Contacts**

The contractor shall have access to consultation with:

a) Project scientist/Principle and co-investigators.
b) JSC MSG Integration Manager
c) JSC PSRP
d) GRC office of S&MA
e) MSFC Payload Manager

**8) Period of Performance**

The period of performance for this delivery order is from February 1, 2014 through September 30, 2015.

**9) Acronym List**

**Acronym list:**

| Acronym | Description |
|---|---|
| ALS | Advanced Life Support |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CPIF | Cost Plus Incentive Fee |
| DID | Data Item Description |
| DO | Delivery Order |
| EDU | Engineering Development Unit |
| EVM | Earned Value Management |
| FSDP | Flight Safety Data Package |
| FSR | Flight Safety Review |
| GRC | Glenn Research Center |
| ISS | International Space Station |
| JSC | Johnson Space Center |
| MSFC | Marshall Space Flight Center |
| MSG | Microgravity Science Glovebox |
| NASA | National Aeronautics & Space Administration |
| PBRE | Packed Bed Reactor Experiment |
| PDR | Preliminary Design Review |
| PSRP | Payload Safety Review Panel |
| RFA | Request for Action |
| S&MA | Safety and Mission Assurance |
| SOW | Statement of Work |
| SpaceDOC | Space Flight Systems Development & Operations Contract |
| TSC | Tele-Science Center |
| WBS | Work Breakdown Structure |

**SpaceDOC-2 NNC14CA02C**
**DO-209 ACE**
**Advanced Colloids Experiment (ACE)**
**For DO Period January 1, 2014 through September 30, 2021**
**For the Performance Period October 1, 2019 through September 30, 2021**

# 1 OVERVIEW

The Advanced Colloid Experiment (ACE) project is a series of experiments that are scheduled to be conducted in the Light Microscopy Module (LMM) on ISS. The experiments are conducted in similar/common sample modules that interface with the ACE-T electronics base or previous base. The sample module mechanical and electrical interfaces are common to all the experiments. There are small variations in; sample material (fluid), sealing method, and specifications for the glass capillaries that hold the sample fluids.

The ~~last two deliverables are~~ ACE-T5-3 and ACE-T9-3 scheduled for NG-16. FHA (MWO closure scheduled to be completed before September 30, 2021). All Hardware, documents and equipment will be transferred to DO-237 before DO-209 is closed.

Note: Mission Integration and Operations (including Flight Safety) are captured in DO-237.

Receive the COC for ACE-T1-3 and submit for Toxicology evaluation. Receive samples for ACE-T1-3 and store samples until needed/requested. This is a transfer of item “j” from DO-237.

The latest update adds ACE-T1-3 to NG-16, Boeing-CFT or SpX-23.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2019 through September 30, 2021. The DO is expected to become inactive after ACE-T5-3 and ACE-T9-3 are delivered. Closeout by September 30, 2021.

## 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, Ronald Sicker, GRC/MSI
2) Project Scientist, William Meyer, USRA
3) Project Scientist, David Chao, GRC/LTZ

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)
4) Investigation Summary Forms (ISF)
5) Science Symposium Presentations (for LIS) Increments: 59/60, 61/62 and 63/64

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR. Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, ISS and Human Health Project Office (Ronald Sicker, Mail Stop 77-7, Ronald.J.Sicker@nasa.gov )
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Chief, ISS and Human Health Project Office, Acting Program Manager (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) Laboratory hardware located in Building 110, LMM Laboratory & Clean Room
2) Flight Hardware returned from ISS, Sample Modules, MDDs, & microscope objectives

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) As needed: Thermal Environmental Chambers in Bldg. 333A
2) As needed: Electromagnetic Interference Laboratory in Bldg. 333A (EMI).
3) As needed: Ground Interface Unit, LMM, building 333 Highbay
4) As needed: LMM Confocal Breadboard, building 110, room 129

# 4 PROJECT SPECIFIC SOW

## 4.1 PREPARE ACE SAMPLE MODULES AND ELECTRONIC BASE(S) FOR FLIGHT AND OPERATION IN THE LMM ON ISS.

The Hardware development activities include delivery of flight sample modules and supporting ground testing with the science team and FIR/LMM team.

It should be assumed that the return and re-flight of (clean) oil microscope objectives will be implemented by FCF.

Ground testing includes preparation of ground test samples modules for FCF and the science team. Use refurbished modules when needed for ground and flight unit development.

Support PI/Science Team visits, approximately 4 months prior to operations.

Procure additional VitroCom capillaries and sample module parts to complete ACE-T4.

Procure additional custom cuvettes for ACE-T5-3. The University of Louisville provided cuvettes for ACE-T5-1&2.

ACE-T1-3 will use a refurbished ACE-T module.

The ACE-T1-3 capillaries will be shipped to the PI Team at Chungnam National University (CNU), South Korea for a coating to be applied (the same as ACE-T1-1&2) at no cost (other than shipping).

### 4.1.1 Milestones

The contractor shall meet the milestones presented here. The contractor along with the FIR/LMM integrator shall propose the next available launch dates and/or increment operations based on flight hardware availability and FIR utilization. Milestones that are presented as a launch shall adjust per the launch schedule. If it moves beyond the current POP, it can be assumed deleted until an extension DO is provided.

| Milestone Number | Milestone | Date |
|---|---|---|
| 101 | FHA ACE T5-1 for NG-12, per Utilization Schedule Carried Forward (Complete) | L-5 Days |
| 102 | FHA ACE T4-1 and ACE-T4-2 for SpaceX-19, per Utilization Schedule Carried Forward (Complete) | L-5 Days |
| 103 | Third Multi-Droplet microscopy oil Dispensers (MDD-3) for SPX-21, FHA (MWO Closure) by July 31, 2020, transfer to DO-237 for launch per Utilization Schedule. | FHA (MWO Closure), July 31, 2020 |
| 104 | Forth Multi-Droplet microscopy oil Dispensers (MDD-4) transfer to DO-237 when DO-209 is closed out | August 31, 2020 |
| 105 | FHA ACE-T5-2 for SpaceX-19 per Utilization Schedule. Carried Forward (Complete) | L-5 Days |
| 106 | FHA ACE-T9-2 ready for SpaceX-20 per Utilization Schedule. Carried Forward (Complete) | L-5 Days |
| 107 | FHA ACE-T5-3 ready for NG-16 per Utilization Schedule. | L-5 Days |
| 108 | FHA ACE-T9-3 ready for NG-16 per Utilization Schedule. | L-5 Days |
| 109 | Receive Samples for ACE-T1-3 | January 31, 2021 |
| 110 | Procure ACE-T5-3 cuvettes | December 31, 2020 |
| 111 | FHA ACE-T1-3 ready for NG-16, Boeing-CFT or SpX-23 per Utilization Schedule. | L-5 Days or per Integration Template |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| ACE-T5-1 for NG-12 and ACE-T5-2 for SpX-19 per Utilization Schedule. Carried Forward (Complete) | 101, 105 |
| MDD-3 Ready for SPX-21, FHA (MWO Closure) by July 31, 2020, transfer to DO-237 for launch per Utilization Schedule. | 103 |
| ACE-T4-1 and ACE-T4-2 for SpaceX-19 per Utilization Schedule Carried Forward (Complete) | 102 |
| MDD-4 transfer to DO-237 with DO-209 closeout | 104 |
| ACE-T9-2 ready for SpaceX-20 per Utilization Schedule. Carried Forward (Complete) | 106 |
| FHA ACE-T5-3 ready for NG-16 per Utilization Schedule. | 107 |
| FHA ACE-T9-3 ready for NG-16 per Utilization Schedule. | 108 |
| FHA ACE-T1-3 ready for NG-16, Boeing-CFT or SpX-23 per Utilization Schedule. | 111 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| ERB/SAR Presentation ACE-T5 Carried Forward (Complete) | 101, 105 |
| ERB/SAR Presentation ACE-T4-1 and ACE-T4-2 Carried Forward (Complete) | 102 |
| ERB/SAR Presentation ACE T9-2 Carried Forward (Complete) | 106 |
| ERB/SAR MDD-3 information and documentation transferred to DO-237 and MDD-4 ~~will not transferred to DO-237~~ ERB/SAR information and documentation will not be required for MDD-4 | 103, 104 |
| ERB/SAR Presentation ACE-T5-3 ready for NG-16 per Utilization Schedule. | 107 |
| ERB/SAR Presentation ACE-T9-3 ready for NG-16 per Utilization Schedule. | 108 |
| Toxicology submission for ACE-T1-3 (to JSC) | 109 |

| Document Deliverables | Milestone Number |
|---|---|
| ERB/SAR Presentation ACE-T1-3 ready for NG-16, Boeing-CFT or SpX-23 per Utilization Schedule. | 111 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **ACE** | **Advanced Colloids Experiments** |
| **ACE-M** | **ACE-Microscopy** |
| **ACE-T** | **ACE-Temperature** |
| **CDRL** | **Contract Data Requirements List** |
| **COC** | **Certification of Compliance** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eAuth** | **Electronic Authentication** |
| **EDMP** | **Experiment Data Management Plan** |
| **EMI** | **Electromagnetic Interference** |
| **ERB** | **Engineering Review Board** |
| **FCF** | **Fluids and Combustion Facility** |
| **FHA** | **Flight Hardware Available** |
| **FIR** | **Fluids Integration Rack** |
| **GRC** | **Glenn Research Center** |
| **ISF** | **Investigation Summary Forms** |
| **ISS** | **International Space Station** |
| **JSC** | **Johnson Space Center** |
| **LIS** | **Lead Increment Scientist** |
| **LMM** | **Light Microscopy Module** |
| **MDD** | **Multi-Droplet microscopy oil Dispensers** |
| **MWO** | **Maintenance Work Order** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PI** | **Principal Investigator** |
| **POP** | **Period of performance** |
| **PRACA** | **Preventive and Corrective Action** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SpX** | **SpaceX** |
| **SRD** | **Science Requirements Document** |
| **USRA** | **Universities Space Research Association** |

**SpaceDOC-2 NNC14CA02C**
**DO-211 BCAT**
**Binary Colloidal Alloy Test (BCAT3-6)**
**For DO Period January 1, 2014 through October 31, 2014**
**For the Performance Period January 1, 2014 through October 31, 2014**

## 1) Introduction

The Binary Colloidal Alloy Test (BCAT) is a series of four experiments (BCAT-3, 4, 5 and 6) that have occurred over the last ten years. With the development of the Light Microscopy Module (LMM) and the Advanced Colloids Experiment (ACE) the NASA BCAT experiments are being completed and returned from ISS.

BCAT-5 returned on SpX-2, BCAT's 3 and 6 are planned to return on SpX-3 and BCAT-4 is planned to return on SpX-4 (planned for June 2014).

Work with BCAT type experiments will continue with Canadian Space Agency (CSA) and CASIS Sponsorship. This work is outside the scope of this SOW, however it is expected that general questions and requests for information will continue while this DO is active.

**Statement of Work – General**

The BCAT-3 and 6 modules will need to be returned on SpX-3 and ground tested per updated procedures. The modules will need to be disassembled and the samples sent to the science teams. A final report needs to be prepared and sent to the Co-I's.

The BCAT- 4 module will need to be returned on SpX-3 and ground tested per updated procedures. The module will need to be disassembled and the samples sent to the science teams. A final report needs to be prepared and sent to the Co-I's.

Address general questions about BCAT-3,4,5 and 6 from ISS partners (CSA and CASIS).

Facilitate the loan of ground hardware to CSA and CASIS as requested.

**Applicable Documents:**

a) NPR 7120.5, NASA Space Flight Program and Project Management Requirements
b) NPR 7123.1, NASA Systems Engineering Processes and Requirements

## 2) Milestones and Reviews

Return of BCAT-3 and 6 payloads on Spx-3 (estimate April 2014)

Return of BCAT-4 payload on Spx-4 (estimate June 2014)

Ground testing and disassembly of Flight Units

Return samples to PI teams.

Return Flight Hardware and documents to NASA

Final Reports

Storage Review if required by NASA

## 3) Hardware/Software Deliverables

Return Hardware/Software to NASA when Project is concluded.

**4) Document Deliverables**

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/Ronald Sicker, MS 77-7, Ronald.J.Sicker@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, MSI/William M. Foster, Mail Stop 77-7, william.m.foster@nasa.gov

Changes to the personnel mentioned above may be accomplished by Contracting Officer letter.

**Document deliverables shall be as follows:**

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. per DID# PM-06
b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
c) Contractor Financial Management Reporting per DID# CD-01, ON-GOING
d) Monthly reporting per DID# CD-03, ON-GOING

**BCAT- 3, 4, 6 Specific**

a) Post Flight Report (Ground testing, Inspection, disassembly)
b) Updated test plans for Post Flight Activities
c) Down mass Safety Assessment

**5) Government Furnished Equipment (provided in accordance with 52.245-5)**

The following are GFE for this delivery order.
a) BCAT ground imaging equipment

**6) Government Furnished Facilities**

The Government shall make available on an as needed basis the following Government facilities:
a) Laboratory facilities in building 333 and 110 (Clean room)
b) GRC Tele-Science Center (TSC)

**7) Government Contacts**

The contractor shall have access to consultation with:
a) Ronald Sicker GRC/MSI0
b) Bill Meyer USRA
c) Peter Lu, Harvard
d) Matt Lynch, P & G
e) Andy Hollingsworth, NYU
f) Arjun Yodh, UPENN

**8) Period of Performance**

The period of performance for this delivery order is from January 1, 2014 through October 31, 2014.

**9) Acronym List**

| Acronym | Description |
|---|---|
| ACE | Advanced Colloids Experiments |
| BCAT | Binary Colloidal Alloy Test |
| CASIS | |
| CDRL | Contract Data Requirements List |
| Co-I | Co-Investigator |
| CSA | Canadian Space Agency |
| DID | Data Item Description |
| DO | Delivery Order |
| GRC | Glenn Research Center |
| ISS | International Space Station |
| LMM | Light Microscopy Module |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| PI | Principal Investigator |
| SOW | Statement of Work |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SpX | SpaceX |
| TSC | Telescience Support Center |

**SpaceDOC-2 NNC14CA02C**
**DO-212 Cool Flame Investigation (CFI)**
**For DO Period January 1, 2014 through September 30, 2015**
**For the Performance Period January 1, 2014 through September 30, 2015**

# 1) Introduction

This Statement of Work covers the scope of the hardware procurement and preparation for the Cool Flames Investigation (CFI). CFI will be a follow-on to the Flame Extinguishment (FLEX) series of experiments and will leverage existing MDCA hardware and software. The Cool Flames Investigation (CFI) will use standard MDCA consumables, a new fiber arm assembly, and a modification to the MDCA radiometer assembly. Additionally, CFI will also coordinate and implement an integration agreement with the FCF to accomplish CFI engineering requirements, including: performance and verification requirements for an upgrade to the LLL-UV camera and a specification for a compensator with a fixed filter for use with the HiBMs camera.

The Contractor Proposal shall provide a cost, technical, and schedule estimate for the period of performance from January 1, 2014 through September 30, 2015. The effort during this performance period shall include the procurements, fabrication, build and test of the specified Cool Flames Investigation hardware.

**Cool Flames Investigation (CFI)**

The Cool Flames Investigation is a new experiment that continues the FLEX and FLEX-2 studies of fuel droplet combustion. This experiment, however, is designed to explore and expand on the recent Cool Flames discovery by the FLEX investigation. Results from the FLEX investigation have revealed a two-stage burning event where a heptane droplet that appeared to extinguish actually continues to vaporize without a visible flame. This knowledge from the microgravity study could contribute to reduced pollution and better mileage in engine design, due to improved prediction of flame behavior during combustion. The key to capturing the cool flame image and determining its post combustion chemistry is the market survey and requirements development for a new gig-E compatible intensified camera assembly.

The Cool Flames investigation would use a range of fuel types and environmental conditions (e.g., pressure, diluent concentrations, etc.) determine the necessary pre-conditions for hot-flame/cool flame transitions, cool flame stability, and spontaneous re-ignition. The data returned would then be used to develop a robust numerical modeling capability with detailed chemistry to complement analytical development of Cool Flame Theory. The knowledge gained from this experiment could directly impact the next generation engine designs, such as the HCCI (Homogeneous Charged Compression Ignition) and the RCCI (Reactivity Controlled Compression Ignition), which rely on low temperature combustion processes, such as Cool Flames, to control emissions and reduce fuel consumption. The knowledge gained would also address spacecraft fire safety concerns, as very weak, persistent flames (invisible to the unaided eye) could spontaneously re-ignite through Cool Flames combustion long after the visible flame has been extinguished. CFI will leverage off all aspects of MDCA/FLEX such as existing drawings, documentation, software, plans and procedures, testing, use of same vendors for procurement, databases (CM, PRACA, Risk Management, ECO process, Product Assurance process, etc.) to minimize costs and reduce technical and schedule risk.

The contractor shall support the GRC Cool Flames Investigation project manager and project scientist during the development and implementation phases of the project.

For the Cool Flames Investigation, the contractor shall:

a) Coordinate with the Cool Flames Project Scientist to review science requirements for Cool Flames and resolve outstanding issues of compatibility with the capabilities of the CIR and MDCA hardware. Coordinate waivers or science requirements that reflect the differences.
b) Develop an Engineering Requirements Document and Science Verification Matrix that address the full science requirements for Cool Flames.

c) Perform safety assessments and hazards analyses and develop safety data packages that will support all required Flight Safety Reviews. Delete moved to DO-219 MI&O
d) Perform a detonation hazard analysis and materials compatibility analysis.
e) Develop the CFI software requirements needed by MDCA to conduct CFI operations.
f) Support an integrated rack test with the Cool Flames hardware on the GIU rack.
g) Build, test, and verify CIR Manifold Bottles to support the science requirements.
h) Build, test, and verify fuel reservoir assemblies to support the science requirements.
i) Build, test, and verify Fiber Arm Assemblies to support the science requirements.
j) Develop design modifications to the existing MDCA radiometer array to meet science requirements.
k) Design, build, test, assemble, and verify the modified radiometer package.
l) Procure, assemble, test, and verify Fuel Deployment Needle kits to meet science requirements.
m) Develop and maintain a detailed schedule of the activities to be performed on this Delivery Order.

**Applicable Documents:**
NPR 7120, NASA Space Flight Program and Project Management Requirements
NPR 7123, NASA Systems Engineering Processes and Requirements

## 2) Milestones and Reviews

The contractor shall provide regularly scheduled meetings/reporting with the NASA Project Manager for the following:

a) Every other week status meetings with the NASA Project Manager.
b) Monthly budget and schedule reporting that will include:
   i. Top Level Technical Performance/Accomplishments
   ii. Near Term Activities
   iii. Problems/Issues/Risks and Mitigation Strategies
   iv. Schedules (to include a Critical Path Schedule)
c) Additional technical status meetings with the NASA Project Manager and the NASA Project Scientists, as needed.

The contractor shall support the major Cool Flame Investigation Project Design Reviews to include:

| | | |
|---|---|---|
| a) | Cool Flames RDR/SRR | May 2014 |
| b) | Cool Flames PDR/CDR | Jan 2015 |
| c) | Cool Flames Safety Review(s) | Contractor Proposed Delete moved to DO-219 MI&O |
| d) | Cool Flames Pre-Ship Reviews | Sept 2015 |

## 3) Hardware/Software Design, Test Integration and Operations Deliverables

The contractor shall complete and deliver the following hardware items to accommodate the science test matrix. (Some deliveries may be in a follow-on Delivery Order.)

**Cool Flames Investigation**

The contractor shall procure, refurbish, assemble, and hold flight hardware, as appropriate, for manifest to be determined by GRC:

a) Ten (10) flight CIR Manifold bottles
b) Five (5) fuel reservoirs
c) Two (2) Needle Pair Assemblies
d) Two (2) Pair of Igniter Tips
e) Five (5) Fiber Arm Assemblies
f) One (1) Auto-gained radiometer array assembly

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL). Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

**All Deliverables:**
Task Manager, MSI/A. Suttles, MS 77-7, andrew.c.suttles@nasa.gov
Configuration Management Office, MSI/Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov

**Deliver courtesy copies of cover letter only to:**
Contracting Officer, Ernest Mensurati, Mail Stop 60-1, Ernest.Mensurati@nasa.gov
Contracting Officer's Representative, MSI/William M. Foster, Mail Stop 77-7, william.m.foster@nasa.gov

A Contracting Officer letter may accomplish changes to the personnel mentioned above.

### Document deliverables shall be as follows:

**General**

a) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC-2 Contract Requirements. (per DID# PM-06)
b) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly. per DID# PM-06
c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
d) Monthly reporting, per DID# CD-02, ON-GOING
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
f) Lessons Learned Report per DID PA-17

**Cool Flames**

a) The contractor shall prepare an Interface Control Document for the Cool Flames hardware in accordance with SpaceDOC-2 Contract Requirements. (per DID# R-06)
**Delete moved to DO-219 MI&O**

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

In assessing the contractor budget and schedule, the following hardware and software shall be made available by the Government to the contractor:

a) MDCA Flight Hardware
b) MDCA Crew Training Hardware (Chamber Insert Assembly and Avionics Package)
c) MDCA/FLEX Drop Tower Rig
d) Spare HiBMS Camera and modules
e) Flight IPSU-Remora

## 6) Government Furnished Facilities

In assessing the contractor budget and schedule, the following Government Facilities shall be available by the Government to the contractor as needed:

a) Controlled Access Flight H/W Buildup Laboratory in Building 333, Room 100W-A and 100W-B and Hi-Bay.
b) Structural Dynamics Laboratory
c) Microgravity Emissions Lab and Acoustics Lab
d) Thermal Environmental Chambers in Building 333A
e) EMI Laboratory in Building 333A
f) 2.2 Second Drop Tower Facility
g) Zero G Drop Tower Facility
h) Inspection Department
i) Instrumentation Department
j) Lab Space in Building 110

## 7) Government Contacts

The contractor shall have access to consultation with:

a) GRC Cool Flames Project Manager
b) FCF Manager
c) Project Scientists for Cool Flames

## 8) Period of Performance

The period of performance for this delivery order is from January 1, 2014 through September 30, 2015.

## 9) Acronym List

| Acronym | Description |
|---|---|
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CFI | Cool Flame Investigation |
| CIR | Combustion Integration Rack |
| CM | Configuration Management |
| DID | Data Item Description |
| DO | Delivery Order |
| ECO | Engineering Change Order |
| EMI | Electromagnetic Interference |
| FCF | Fluids and Combustion Facility |
| FLEX | Flame Extinguishment Experiment |

| Acronym | Description |
|---|---|
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| H/W | Hardware |
| HCCI | Homogeneous Charged Compression Ignition |
| HiBMS | High Bit-Depth/MultiSpectral |
| IPSU | Image Processing & Storage Unit |
| ISS | International Space Station |
| LLL-UV | Low Light Level Ultraviolet |
| MDCA | Multi-User droplet Combustion Apparatus |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| PDR | Preliminary Design Review |
| PRACA | Preventive and Corrective Action |
| RCCI | Reactivity Controlled Compression Ignition |
| RDR | Requirements Definition Review |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SRR | System Requirements Review |

SpaceDOC-2 NNC14CA02C
DO-214 SoFIE Science
Solid Fluid Ignition & Extinction (SoFIE) Science
For the Performance Period January 1, 2014 through May 31, 2015

# 1) Introduction

The Solid Fuel Ignition and Extinction (SoFIE) investigation is the first solid-materials combustion experiment planned to operate in the CIR. SoFIE is comprised of a suite of five separate investigations, all of which are still in the preliminary (Phase A) planning stage. The types of specific experiments that can be accommodated range from material ignitability, fire growth and spread, and fire suppression. The experiments under the SoFIE umbrella will study the ignitability and flammability of spacecraft materials in practical geometries and within realistic atmospheric conditions. Experiments could include ignition studies of materials representing cabin materials and EVA suit designs. Furthermore, the investigations could study the suppression of burning materials by diluents, airflow reductions, and habitat air venting.

Low-gravity testing has shown that current NASA material qualification methods may not be as conservative as they are believed to be. While NASA has a long history of materials controls, they are based on a 1-g understanding of flammable materials and the data from Earth-based tests. SoFIE will improve our understanding of early fire growth behavior and help validate material flammability numerical models for reduced gravity environments.

The project will be based on the SoFIE Integrated Science Requirements Document (ISRD), which consolidates the requirements of five separate investigations under the SoFIE umbrella. The Science Concept Review (SCR) occurred in July 2013, and all five experiments have been given approval to continue on to the Requirements Definition Review, wherein the final science requirement are proposed and approved by a peer review board.

For this period of performance, the contractor will continue the Formulation Phase for SOFIE to define an experiment carrier insert and Principal Investigator specific investigation hardware for the Combustion Integrated Rack (CIR) and the associated avionics and diagnostics to support the insert. The insert will allow experimenters to use various solid fuels in flow or quiescent environments and at various pressures, oxidizer compositions, and oxygen concentrations. The SOFIE flight hardware includes the insert assembly, avionics, and diagnostic instruments including cameras, software, and replacement components. The flight hardware also will include the Principal Investigator specific flight hardware, which typically includes solid fuel samples and ancillary igniter tips and sensor rakes. The main activities in this period of performance will be the completion of documents and tasks to support the Requirements Definition Review, including but not limited to: the SOFIE Engineering Requirements Document (ERD), Science Compliance Matrix, system software requirements document, updated concept of operations, baselined systems engineering management plan, risk management plan, preliminary maintenance plan including sparing plan, risk assessment, software development plan, system safety and mission assurance plan, configuration management plan, and the verification and validation approach. The Contractor Proposal shall provide a cost, technical, and schedule estimate for the period of performance from SCR to the Requirements Definition Review (RDR).

# 2) Milestones and Reviews

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

a) In support of the SOFIE science, the contractor shall support the Requirements Definition Review, tentatively scheduled for no sooner than December 1, 2014 and no later than January 30, 2015.

## Applicable Documents

a) NPR 7120, NASA Space Flight Program and Project Management Requirements

b) NPR 7123, NASA Systems Engineering Processes and Requirements
c) NPR 7150.2 NASA Software Engineering Requirements
d) SOFIE-SRD-001, Integrated Science Requirements Document, latest version
e) SSP 51700, Payload Safety Policy and Requirements for the International Space Station
f) NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements for Payloads Using the STS/ISS
g) All other applicable SSP, MSFC, JSC, or GRC requirements for safety and mission assurance and program/project implementation and reporting

## 3) Hardware/Software Deliverables

There are no hardware or software deliverables during this period of performance.

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL).

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:
Task Manager, ISS and Human Research Projects Office (J. Mark Hickman, Mail Stop 77-7, NASA Glenn Research Center, Cleveland, OH 44135, John.M.Hickman@nasa.gov )
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:
Contracting Officer (Ernest Mensurati, Mail Stop 60-1, ernest.c.mensurati@nasa.gov )
Contracting Officer's Representative (MSI/William M. Foster, william.m.foster@nasa.gov , MS 77-7)
Chief, ISS and Human Research Project Office (MSI/Thomas St. Onge, thomas.h.stonge@nasa.gov , MS 77-7)

### Document deliverables shall be as follows:

a) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
b) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
d) Monthly reporting, per DID# CD-03, ON-GOING
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
f) Lessons Learned Report per DID PA-17
g) FCF-ICD-CIR-SOFIE, Solid Fuel Ignition and Extinction (SoFIE) Interface Control Document; due November 14, 2014 (was two weeks prior to RDR) (Delete – deliverable on BT-1)
h) FCF-IA-MV-SOFIE, Solid Fuel Ignition and Extinction (SoFIE) Integration Agreement Main Volume for the Fluids and Combustion Facility; due November 14, 2014 (was two weeks prior to RDR) (Delete – deliverable on BT-1)
i) SoFIE Concept of Operations by November 14, 2014 (was 6/14)
j) Testing reports for breadboard testing of critical subcomponents, one month after test completion
k) Engineering Requirements Document by 06/2014
l) Science Compliance Matrix by November 14, 2014 (was 6/14)
m) Software Requirements Document by November 14, 2014 (was 5/14)
n) SoFIE RDR Engineering Presentation Package and other documentation in support of the RDR; due two weeks prior to the review

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

The Government shall make the following hardware and software available to the contractor:

a) Color Camera Breadboard
b) CIR IPSU simulator
c) CIR IOP simulator
d) CIR GIU and PRCU in Building 333

## 6) Government Furnished Facilities

The following Government Facilities shall be available by the Government to the contractor as needed:

a) Controlled Access Flight H/W Buildup Laboratory in Building 333, Room 100W-A and 100W-B and Hi-Bay.
b) Structural Dynamics Laboratory
c) Microgravity Emissions Lab and Acoustics Lab
d) Thermal Environmental Chambers in Building 333A
e) EMI Laboratory in Building 333A
f) 2.2 Second Drop Tower Facility
g) Zero G Drop Tower Facility
h) Inspection Department
i) Instrumentation Department
j) Lab Space in Building 110

## 7) Government Contacts

The contractor shall have access to consultation with:

a) GRC SoFIE Project Manager
b) FCF CIR Manager
c) Project Scientist for SoFIE

## MDCA Project Team personnel 8) Period of Performance

The period of performance for this delivery order is from January 1, 2014 through February 28, 2015.

## 9) Acronym List

| Acronym | Description |
|---|---|
| **CCR** | **Configuration Change Request** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CIR** | **Combustion Integration Rack** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **EMI** | **Electromagnetic Interference** |
| **ERD** | **Engineering Requirements Document** |
| **EVA** | **Extravehicular Activity** |
| **FCF** | **Fluids and Combustion Facility** |
| **FSR** | **Flight Safety Review** |
| **GIU** | **Ground Integration Unit** |
| **GRC** | **Glenn Research Center** |
| **H/W** | **Hardware** |
| **IOP** | **Input/Output Processor** |
| **IPSU** | **Image Processing & Storage Unit** |
| **ISRD** | **Integrated Science Requirements Document** |
| **ISS** | **International Space Station** |

| Acronym | Description |
|---|---|
| JSC | Johnson Space Center |
| MSFC | Marshall Space Flight Center |
| NASA | National Aeronautics & Space Administration |
| NPR | NASA Procedural Requirement |
| PDR | Preliminary Design Review |
| POP | Period of performance |
| PRCU | Payload Rack Checkout Unit |
| RDR | Requirements Definition Review |
| RFA | Request for Action |
| SCR | Science Concept Review |
| SDP | Safety Data Package |
| SoFIE | Solid Fluid Ignition & Extinction |
| SOW | Statement of Work |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SSP | Space Station Program |
| WBS | Work Breakdown Structure |

**SpaceDOC-2 NNC14CA02C**
**DO-215 HHC NNC14JZ15D**
**Human Health Countermeasures (HHC)**
**Contract Period March 1, 2014 through March 31, 2023**
**DO PERFORMANCE PERIOD OCTOBER 1, 2021 THROUGH JULY 29, 2022**

# 1 OVERVIEW

The Delivery Order (DO) details one main effort: ground-unit sustaining operations and technical support of an exploration concept technology to be demonstrated at NASA's ground analog-mission venues, called the Advanced Twin Lifting & Aerobic System (ATLAS), which is deployed at the Russian NEK Facility for an 8-month isolation analog mission with human crewmembers.

It is expected that prompt but remote Technical Support to the Russian NEK ATLAS operations will be provided on an as-needed basis throughout the duration of the mission. If work scope exceeds plan (e.g., if problems arise with the ATLAS hardware that cannot be accommodated within scope) the DO will be renegotiated / revisited.

## 1.1 THE PERIOD OF PERFORMANCE FOR THIS DELIVERY ORDER IS FROM OCTOBER 1, 2021 THROUGH JULY 29, 2022.

## 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:
1) GRC ISS and Human Research Projects Office, Human Research Program Manager
2) GRC AEC Project Manager and Deputy Project Manager
3) GRC Lead Systems Engineer
4) GRC ISS Projects Chief S&MA Officer
5) GRC ISS Projects Chief Engineer
6) JSC ATLAS Project Scientist
7) GRC ATLAS Deputy Project Scientist
8) JSC Spacecraft Software Engineering Team (SSET)

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION (USE CURRECT APPROVED VERSION)

1) HRP-48016, Advanced Twin Lifting and Aerobic System (ATLAS) – Exploration Exercise Countermeasures System Maturation on ISS Project Plan (Baseline)
2) JSC Committee for the Protection of Human Subjects Guidelines for Investigations Proposing Human Research for Space Flight and Related Investigations (http://irb.nasa.gov)
3) SSP 50021, ISS Safety Requirements Document
4) GLPR 7120.5.30, Glenn Procedural Requirements Space Assurance Requirements
5) SSP 57000 Rev. S, Pressurized Payloads Interface Requirements Document for ISS identified as applicable
6) HRP-47052, Human Research Program Requirements Document
7) SSP 50835, ISS Interface Requirements identified as applicable
8) SSP 52005, Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures ISS

9) SSP 30237, Space Station Electromagnetic Emission and Susceptibility Requirements
10) SSP 30512, Space Station Ionizing Radiation Emission & Susceptibility Requirements for Ionizing Radiation
11) NASA-STD-8739.13, Software Safety Standard
12) NASA-STD-8739.8, Standard for Software Assurance
13) NASA-STD-8739.*, Electrical Standards
14) NPR 8000.4, NASA Program Continuous Risk Management

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Exercise Countermeasures Project, ISS & Human Research Project Office (Gail Perusek, Mail Stop 77-7, NASA Glenn Research Center, Cleveland, OH 44135, Gail.P.Perusek@nasa.gov )

Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov)
Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov

Deliver courtesy copies of cover letter only to:

Contracting Officer, Raenala C. Brown, Mail Stop 60-1,
raenala.c.brown@nasa.gov

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )

Program Manager, GRC Human Research Program, (Kelly M. Gilkey Mail Stop 77-7, kelly.m.gilkey@nasa.gov )

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated bi-weekly. ON-GOING
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17 ON-GOING

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) Hardware items prior to build-up will primarily be stored in NASA GRC Bldg. 110, Exercise Countermeasures Lab; however, the contractor shall provide a bonded storage area for some hardware systems and components as necessary.
2) MSC Adams multi-body dynamic modeling software as provided through NASA center licensing.
3) Power Generating Ergometer prototype.
4) ATLAS Engineering Development Unit (EDU) – for refurbishment by contractor Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

**List any facilities needed for this project; i.e.:**

1) Thermal Environmental Chambers in Building 333A
2) EMI Laboratory in Building 333A
3) Structural Dynamics Laboratory in Building 56
4) Calibration Lab
5) Exercise Countermeasures Laboratory in Building 110.

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### 3.2 ATLAS ANALOG TESTING SUPPORT FOR EXPLORATION EXERCISE COUNTERMEASURES

Contractor will support the Russian Academy of Sciences Nezemnyy Eksperimental'nyy Kompleks (NEK) facility and Advanced Twin Lifting and Aerobic System (ATLAS) operation there through June 2022, after which the ATLAS hardware will be returned to NASA

Breadboard prototype (Qual 4) motor drive / power management system, circuit boards and system subassemblies will be developed at contractor's discretion and subjected to testing as required to wring out issues prior integrated system testing with the EDU. Perform life cycle testing with the Qual 4 unit to understand sparing requirements and rope maintenance plan. In addition to life cycle testing of the Qual 4 unit, plan to thoroughly test the ATLAS EDU with human subjects to ring out any life cycle issues and empirically verify the maintenance/sparing plan and provision of spares. Make updates to the Maintenance/Sparing Plan as required.

Ground safety data packages and any needed inputs to electronic Institutional Review Board (eIRB) packages for human subjects testing that may occur at either GRC, JSC, or NEK. **Provide remote and field support for exercise equipment used in ground testing.** Provide technical support and Test Readiness Review package for testing ATLAS EDU for Human in the Loop (HITL) testing, life cycle testing, and analog environment (e.g., Habitat) evaluations.

No contractor trips to Russia are planned.

Prepare presentation material and data packages as needed for project support.

Plan to supply the required Test Readiness Review Documentation as required by NEK. Plan to review verification closeouts, remaining open items, hazard analysis, software code review and software status, risk assessment, required inspections, technical data package, safe shipping, handling, checkout, and operational plans and procedures with Task Manager and Chief Engineer as items are produced to ensure they are complete and ready for use by Human In the Loop (HITL) testing.

**Contractor will plan to support NEK testing with provision of spares and engineering personnel to conduct operator and user training as needed, repair hardware if required, and provide remote on-call technical support during the 8-month NEK analog mission and informal gathering of feedback. If work scope exceeds plan (e.g., if problems arise with the ATLAS hardware that cannot be accommodated within scope) the DO will be renegotiated / revisited.**

Contractor will support activities to document lessons learned from the development of the ATLAS EDU and earlier compact exercise devices, developed throughout the history of the AEC project.

### 3.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 01 | Refurbished ATLAS EDU pre-ship review | 12/8/20 (due to COVID19 was 6/2020) COMPLETE |
| 02 | Refurbished ATLAS EDU delivery to NASA (for NEK) | 12/14/20 (due to COVID19 was 7/2020) COMPLETE |
| 03 | NEK mission support (on call, remote technical support from ZIN) | July 29, 2022 (was 11/2021) |

### 3.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| ATLAS Refurbished Engineering Development Unit (EDU) | 02 |

### 3.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| ATLAS Refurbished EDU – Pre-ship Review Data Package | 01 |

## 4 ACRONYM LIST

| Acronym | Description |
|---|---|
| **AEC** | **Advanced Exercise Concept** |
| **AED** | **Automatic External Defibrillator** |
| **ARED** | **Advanced Resistive Exercise Device** |
| **ATLAS** | **Advanced Twin Lifting and Aerobic System** |
| **BAA** | **Board Area Announcement** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CITI** | **Collaborative Institutional Training Initiative** |

| Acronym | Description |
|---|---|
| **DART** | **Device for Aerobic and Resistive Training** |
| **DDT&E** | **Design, Development, Test and Evaluation** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **ECL** | **Exercise Countermeasures Laboratory** |
| **eIRB** | **electronic Institutional Review Board** |
| **EM** | **Engineering Model** |
| **EMI** | **Electromagnetic Interference** |
| **eZLS** | **Enhanced Zero-g Locomotion Simulator** |
| **FY** | **Fiscal Year** |
| **GEMCB** | **Government Equipment and Materials Control Board** |
| **GFE** | **Government Furnished Equipment** |
| **GLPR** | **GRC Procedural Requirement(s)** |
| **GN&C** | **Guidance Navigation and Control** |
| **GRC** | **Glenn Research Center** |
| **HERA** | **Human Exploration Research Analog** |
| **HHC** | **Human Health Countermeasures** |
| **HRP** | **Human Research Program** |
| **HULK** | **Hybrid Ultimate Lifting Kit** |
| **IRB** | **Institutional Review Board (i.e., generic term for JSC CPHS)** |
| **ISS** | **International Space Station** |
| **JSC** | **Johnson Space Center** |
| **M-MED** | **Multi-Mode Exercise Device** |
| **MPCV** | **Multi Purpose Crew Vehicle** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NLT** | **No Later Than** |
| **NPR** | **NASA Procedural Requirement** |
| **PDR** | **Preliminary Design Review** |
| **POP** | **Period of performance** |
| **PRACA** | **Preventive and Corrective Action** |
| **RMIT** | **Risk Management and Information** |
| **S&MA** | **Safety and Mission Assurance** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **SRR** | **System Requirements Review** |
| **STD** | **Standard** |
| **VIS** | **Vibration Isolation System** |

| Acronym | Description |
| --- | --- |
| **WBS** | **Work Breakdown Structure** |

SpaceDOC-2 NNC14CA02C
DO-216 MMB-MB 1, 2, 3
Macromolecular Biophysics - Manual Base 1, 2, 3
Performance Period August 11, 2014 to September 30, 2015

**1) Introduction**

NASA NRA OMB No. 2700-0087 selected, Professor Larry DeLucas of the University of Alabama at Birmingham, Edward Snell of the Hauptman-Woodward Medical Research Institute, and Peter Vekilov of the University of Houston, to perform Macromolecular Biophysics investigations on the International Space Station. The opportunity to operate Professor DeLucas' first sample will be increments 45-46, assuming a SpaceX-9 launch (November 2015). The manifest activities are currently underway (covered by the Sustaining Engineering DO). SpaceX-10 and 11 are tentative selections for Professors Snell and Vekilov. The experiments will be implemented in LMM using a manual base that will hold a PI provided sample. The samples will be pre-loaded on the ground, launched in a refrigeration unit provided by the Payload Developer or ISS and allowed to thaw on ISS when they are ready to be processed. As the samples thaw they will form Protein Crystals that will be imaged using LMM. This DO is for the ground testing of the samples, management, coordination, support reviews, requirement definition, and designing and building the manual-mounting base. The MI & O task DO-219 (ISS Program funded) will cover the operations, safety, procedure development, software development, and integration/manifesting activities.

**Applicable Documents:**

NPR 7120, NASA Space Flight Program and Project Management Requirements
NPR 7123, NASA Systems Engineering Processes and Requirements

**2) Milestones and Reviews**

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

a) SCR/RDR August 18-22, 2014 Complete
b) PDR/CDR for the manual mounting base November 30, 2014 Delete/Move to DO-219
c) Support Phase III Safety Review per SpX-9 template Delete/Move to DO-219
d) Ground Safety Review per template Delete/Move to DO-219
e) Flight Hardware Available to meet standard stowage on SpX-9 (Other launch options may be requested by the ISS Program) Delete/Move to DO-219
f) Trade study if existing manual bases (PETRI-Plant, LMM-Bio) can be modified for this use Complete
g) PSR/SAR to meet standard stowage on SpX-9 Delete/Move to DO-219
h) Perform proof of concept testing for up to 10 samples from investigators Delete/Move to DO-219
i) Mechanical mounting fixture to hold PI provided samples in support of design review Delete/Move to DO-219

**3) Hardware/Software Deliverables**

The contractor shall complete the design, assembly, integration, and test of the hardware as required in the implementation of Item 1 of this DO:

a) Manual sample mounting base (either modified or designed) for MMB-MB-1, SpaxeX-9 Delete/Move to DO-219
b) Support FIR/LMM software development for SpX-9 support (Sustaining Engineering Task) Delete/Move to DO-219
c) Two spare Manual sample mounting bases to support GIU, integration, procedure development, and training activities Delete/Move to DO-219
d) Mechanical mounting fixture to hold PI provided samples in support of Manual sample mounting base (either modified or designed) for MMB-MB-1, SpaxeX-9

e) Mechanical mounting fixture to hold PI provided samples in support of design review. Two spare Manual sample mounting bases to support GIU, integration, procedure development, and training activities.

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL).

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Which Division/Office (Ronald J. Sicker, Mail Stop 77-7, e-mail, Ronald.J.Sicker@nasa.gov , NASA Glenn Research Center, Cleveland, OH 44135)
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Ernest Mensurati, Mail Stop 60-1, ernest.c.mensurati@nasa.gov)
Contracting Officer's Technical Representative, Advanced Flight Projects Office Division (William M. Foster, Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Research Project Office (Tom StOnge, Mail Stop 77-7, thomas.h.stonge@nasa.gov)

**Document deliverables shall be as follows:**

a) The contractor shall prepare a Delivery Plan (technical, schedule, and cost information) in accordance with the change of scope to this DO. The plan shall include defined tests, documentation development, flight design, and detailed schedule, per DID # PM-06.
b) Monthly Contractor Performance Measurement Reports, per DID # CD-02, ON-GOING.
c) Monthly Contractor Financial Management Reports, per DID # CD-01, ON-GOING.
d) Lessons Learned Report per DID PA-17.
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING.
f) Phase III Flight Hardware (Manual Base) Safety Package. Delete/Move to DO-219
g) Materials List (MIUL) for Manual Base. Delete/Move to DO-219
h) Provide inputs for Manual Base hardware drawings, design analysis reports, and verification reports as required.

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

a) Laboratory hardware located in Building 110, LMM Lab
b) LMM-GIU

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

a) Telescience Support Center

## 7) Government Contacts

The contractor shall have access to consultation with:

a) GRC Project Manager, Ronald Sicker
b) Project Scientists, Laurel Karr, Sid Gorti, Patton Downey, MSFC
c) Principal Investigators, Larry DeLucas, Edward Snell, Peter Vekilov

## 8) Period of Performance

The period of performance for this delivery order is from July 1, 2014 through September 30, 2015.

## 9) Acronym List

| Acronym | Description |
|---|---|
| BIO | Biological |

| Acronym | Description |
|---|---|
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| DID | Data Item Description |
| DO | Delivery Order |
| FIR | Fluids Integration Rack |
| GRC | Glenn Research Center |
| GUI | Graphical User Interface |
| ISS | International Space Station |
| LMM | Light Microscopy Module |
| MB | Manual Base |
| MMB | Macromolecular Biophysics |
| MSFC | Marshall Space Flight Center |
| PDR | Preliminary Design Review |
| PSR | Pre-Ship Review |
| RDR | Requirements Definition Review |
| SAR | Space Assurance Requirements |
| SCR | Science Concept Review |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| SpX | SpaceX |

**SpaceDOC-2**
**DO-218 UPD**
**Unique Payload Development (UPD)**
**Contract Period November 30, 2014 through September 30, 2017**
**For the Performance Period October 1, 2015 through September 30, 2017**

## 1) Introduction

This delivery order is comprised of deliverables that either does not fall under a single project or is a unique payload development but not large enough to be a standalone project. Tasks are identified by each section number for ease of tying together milestones and deliverables (X.Y where X is the section and Y is the task number).

1.1) The initial deliverable is for the support of APEX-3 mission. The first objective is to support integration and operations of the APEX-3 plant growth experiment in the Light Microscopy Module (LMM). The second objective is to outfit an existing Leica DM-RXA microscope for use in supporting plant growth experiments at KSC. The third objective is machinist support for the High school students United with NASA to Create Hardware (HUNCH) project.

1.2) The third objective is machinist support for the High school students United with NASA to Create Hardware (HUNCH) project The High school students United with NASA to Create Hardware (HUNCH) project provides an innovative, strategic education partnership pairing NASA's unique capabilities and experience with the ingenuity of high school students in creating soft-goods and hardware for NASA to use in support of the International Space Station program and NASA Education Outreach programs. The HUNCH machinist will work with a team of technical and education specialists to support high school students to design, develop and fabricate NASA hardware projects. The HUNCH team works with educators at partnering schools to integrate the aerospace the fabrication projects into their curriculum and provides support the teachers and students throughout the projects phases. The period of performance for the HUNCH program is the school year from September 2014-May 2015.

Responsibilities required by the HUNCH machinist shall be:

a) Skilled in the operation of all typical machine tools including mills, lathes, saws, grinders, etc., both conventional and numerically controlled
b) Ability to program CNC mills and lathes, specifically Haas machining centers and lathes, including generating machine tool code from solid models
c) Familiarity with 3-D printing
d) Be able to understand and interpret NASA Engineering Drawings and concepts
e) Be able to coordinate multiple activities and tasks at one time at several offsite locations
f) Must be self-starter, self-empowered, motivated with the ability to work with little or no supervision
g) Be energetic with a willingness to learn and mentor educators and students
h) Ability to assist in design, redesign, rework and repair of hardware fabricated by students
i) Travel between 5 schools during normal duty hours, some weekends and be willing to perform overnight travel to schools out of the local commuting area. Local schools they visit once a week and out of state schools, they visit every other week.
    - Medina County Career Center (OH),
    - Apollo Career Center (OH),
    - Romeo Engineering and Tech Center (MI),
    - Orleans-Niagara BOCES (Boards of Cooperative Educational Services) (NY)
    - Cattaraugus-Allegany BOCES (NY)
j) Be able to communicate with the school via email, teleconference, skype, videoconference or alternate method with the schools.
k) Support the HUNCH End of Year Recognition Ceremony for participants
l) Skilled in customer service, presentation and interpersonal relationships with Schools, Educators, School District Representatives, GRC/NASA Contractors, Hardware Manufacturers, Vendors/Suppliers, GRC Managers and personnel from different organizations and NASA

Centers (Technicians, Quality Assurance, Engineers, Branch Chiefs, Division Chiefs, Astronauts and Organizational Directors)

1.3) Space Life and Physical Science's (SLPS) is combining their program content definition into an Integrated Research Plan. The plan will define program strategy and integrate the research content in one document. The contractor shall provide expertise to develop the plan. Knowledge of the history and current microgravity research program is required. A familiarity with NASA programs and projects and ISS operations is necessary. The plan will define the stakeholders, the research relevance to NASA's mission, and capabilities to perform research. Several trips to NASA Headquarters and possibly the field centers will be required.

1.4) The Flow Boiling and Condensation Experiment (FBCE) is designed to develop an integrated two-phase flow boiling/condensation facility for the International Space Station (ISS) to serve as the primary platform for obtaining two-phase flow and heat transfer data in microgravity. FBCE will be operated in the Fluids Integrated Rack (FIR) on the ISS. FBCE is being developed in-house at NASA Glenn Research Center with support from a civil servant/contractor team.

Responsibilities required by the Facilities Integration Lead shall be:

a) Manage integration requirements and the verification process
b) Facilitate requirements assessments of the design/analysis with the leads
c) Facilitate the verification documentation process
d) Develop documentation for system level requirements assessments/verifications
e) Review verification documentation to assess verification closure
f) Provide status material for requirements compliance and verification closure

1.4.1 The contractor shall serve as the FBCE Facility Integration Lead, which shall include identification of applicable requirements, developing and managing integration requirements, decomposition of requirements, developing requirements and specifications as needed for subsystems and components, and generation/coordination of appropriate documentation. The task shall also include verification planning and reporting, managing and facilitation of the verification process and support to systems engineering process execution for flight-hardware-related tasks and milestone reviews. Finally the contractor shall utilize the FIR Interface Control Document (ICD) and SSP requirements to verify the proper requirements allocation, assess the FBCE design/ FIR ICD requirements compliance, provide the FBCE design interface details for incorporation into the FIR ICD, and provide verification support of the FIR ICD.

1.4.2 The contractor shall support radiation testing on FBCE electronic components. Test support equipment, test support software and any test plan/procedures are to be provided, as needed. An appropriate test facility needs to be identified and scheduled for the tests. A written report with test results and test procedure shall document the results of the testing.

1.4.3. Investigate Radiation Test Facilities – POC: William Foster II

1.5) The Smoke Aerosol Measurement Experiment-Reflight (SAME-R) completed ISS operations in September, 2010. Select hardware items were returned on shuttle flights ULF-6 and ULF-7 and the project was closed out in 2013. The remainder of the SAME hardware in stowage aboard the ISS is being returned on SPX-8.

The contractor shall prepare and deliver Return Assessment for the SAME hardware on Space-X 8.

1.6) Provide high fidelity cost estimates and schedules for the Microgravity Wind Tunnel (MWT) and Flow Boiling & Condensation Experiment (FBCE). Provide estimates by November 1, 2016.

a) MWT
- Utilize the MWT Science Requirements Document.
- Assume the following milestones will be held: SRR, PDR, CDR, PSR, FHA.
- No longer than 3 years to achieve all milestones.
- MI&O costs should be shown separate from the hardware development costs.
- The development approach should assume an Engineering Model and Flight Unit as deliverables.
- The MWT will utilize the MSG.

b) FBCE
- Utilize the FBCE ERD.
- The estimate shall include all work required from PDR to FHA.
- No longer than a 4 years to achieve all milestones.
- Deliverables will include an Engineering Model and Flight Unit.
- MI&O costs should be shown separate from the hardware development costs.
- FBCE will utilize the FIR.
- Do not factor in the cost of boxes being supplied by FIR.
- Provide cost savings options.

**2) Milestones and Reviews**

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

2.1 APEX - Activity complete
2.2 HUNCH - Activity complete
2.3) SLPS Integrated Research Plan (Carried forward from A)

a) Kick off Review in DC – Review Outline and all requirements for Strategic Plan – February 2015
b) Interim review briefing – Trip to DC and submittal of briefing presentation – March 2015
c) Voice of customer and interview meetings with SLPS people and other NASA organizations (HQ meeting) – March 2015
d) Final Presentation Briefing of Strategic Plan and submission of Plan August (was April) with briefing presentation at HQ – September (was May) 2015

2.4 FBCE

2.4.1 FIR Integration Complete Deleted section

a) Weekly FBCE and SE&I meetings
b) Verification Review for the updated FBCE/FIR ICD – Nov 2016
c) IPSU-CL CDR - Sept 2017
d) FBCE CDR – Dec 2017
e) Provide document deliverables per list in section 4.

2.4.2 Radiation Testing Complete
2.4.3 Complete investigation - Dec 1, 2016

2.5 SAME Hardware Return

a) Provide assessment report 6 months after the hardware has been returned.

2.6 Cost Estimates due -15 business days from approval of the CCR

**3) Hardware/Software Deliverables**

3.1 APEX – None.

3.2 HUNCH – None.

3.3 SLPS Plan - Not Applicable.

3.4 FBCE Support - None

3.4.1 FIR Integration - Not Applicable.

3.4.2 Radiation Testing – None.

3.4.3 Radiation investigation – None.

3.5 Deliver returned SAME hardware to William Sheredy.

3.6 Cost estimates - None.

**4) Document Deliverables**

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL).

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Advanced Flight Projects Office Division, ISS and Human Health Office (Nancy R. Hall, MS 77-7, Nancy.R.Hall@nasa.gov ), NASA Glenn Research Center, Cleveland, OH 44135)
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Ernest Mensurati, Mail Stop 60-1, ernest.c.mensurati@nasa.gov )
Alternate Contracting Officer's Representative, Advanced Flight Projects Office Division (Andrew Suttles, Mail Stop 77-7, andrew.c.suttles@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

**Document deliverables for all tasks shall be as follows:**

a) The contractor shall prepare a Delivery Plan (technical, schedule, and cost information) in accordance with the scope of this DO. The plan shall include defined tests, documentation development, design, and detailed schedule.
b) Monthly Contractor Performance Measurement Reports, per DID # CD-02
c) Monthly Contractor Financial Management Reports, per DID # CD-03.

4.1) APEX – Activity complete
4.2) HUNCH – Activity complete
4.3) Integrated Research Plan (Carried forward from A)
SLPS Integrated Research Plan delivered to HQ.

4.4) FBCE System Engineering and Verification Lead
a) Provide monthly status of integration activities - complete

4.4) FBCE
4.4.1 FIR Requirements Integration Lead Delete section
a) FBCE/FIR Verification Matrix , due 10/15/16
b) Provide FBCE/FIR ICD Design Compliance Assessment, due 10/15/16
c) Provide documentation to support EM Design Technical Review, due 10/15/16
d) Provide draft of all FBCE/FIR ICD VIS (verification information sheets), 10/14/16,
e) FBCE/FIR ICD with FBCE interface information, due 11/25/16,

4.4.2) FBCE Radiation Testing

a) Test Procedures and/or Plan
b) Test Report

4.4.3) Report on Radiation Sites

4.5) SAME Return Assessment submitted to the Payload Safety Review Panel (PSRP)

4.6) Cost Estimates
a) MWT cost estimate
b) FBCE cost estimate

**5) Government Furnished Equipment (provided in accordance with 52.245-5)**

a) Leica DM-RXA microscope
b) FBCE electronics and Data Acquisition hardware

**6) Government Furnished Facilities**

The Government shall make available on an as needed basis the following Government facilities:

a) GRC FBCE Laboratory, Bldg 110, Rm 127 and 220
b) FIR GIU, Bldg 333 highbay
c) Thermal Environmental Chambers in Building 333A
d) Structural Dynamics Laboratory
e) EMI Laboratory in Building 333A
f) GRC Acoustics Test Facility
g) GRC ISS Payload Operation Center and satellite facilities
h) Vibration Test Laboratory in Building 55

**7) Government Contacts**

The contractor(s) shall have access to consultation with:
a) Nancy R. Hall, Delivery Order Manager
b) William M. Foster II, Alternate Delivery Order Manager

**8) Period of Performance**

The period of performance for this delivery order is from October 1, 2015 through September 30, 2017.

**9) Acronym List**

| Acronym | Description |
|---|---|
| APEX | Advance Plant Experiments |
| BOCES | Boards of Cooperative Educational Services |
| CDRL | Contract Data Requirements List |
| CNC | Computer Numerical Control |
| DC | District of Columbus |
| DID | Data Item Description |
| DO | Delivery Order |
| EMI | Electromagnetic Interference |
| FBCE | Flow Boiling Condensation Experiment |
| FIR | Fluids Integration Rack |
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| HQ | Headquarters |

| | |
|---|---|
| **HUNCH** | **High school students United with NASA to Create Hardware** |
| **ICD** | **Interface Control Document** |
| **ISS** | **International Space Station** |
| **KSC** | **Kennedy Space Center** |
| **LMM** | **Light Microscopy Module** |
| **NASA** | **National Aeronautics & Space Administration** |
| **PSRP** | **Payload Safety Review Panel** |
| **SAME-R** | **Smoke Aerosol Measurement Experiment-Reflight** |
| **SLPS** | **Space Life and Physical Sciences** |
| **SpaceDOC-2** | **Space Flight Systems Development & Operations Contract-2** |
| **SSP** | **Space Station Program** |
| **UPD** | **Unique Payload Development** |

**Abbreviations List**

| Abbreviation | Description |
|---|---|
| **MI** | **Michigan** |
| **NY** | **New York** |
| **OH** | **Ohio** |

**SpaceDOC-2 NNC14CA02C**
**DO-219 MI&O**
**Mission Integration and Operations (MIO)**
**For Contract Period November 17, 2014 to September 30,, 2018**
**For DO Performance Period October 1, 2017 to September 30, 2018**

## 1) Introduction

Funding for Mission Integration & Operations (MI&O) and Science Management have historically been from a single source, Space Life and Physical Sciences (SLPS). Starting in FY15, funding for MI&O will be provided by the International Space Station Program Office (ISSPO). Thus, for the current payload delivery orders with MI&O tasks, the MI&O portion of the work is being removed and combined in this single delivery order. This will allow the ability to track the funding from each source more effectively.

MI&O consists of the milestones and products described within the Payload Integration Template (PIT), SSP 57057. These applicable products are the defined deliverables for this delivery order. Activities include but are not limited to:

a) Interface Verification Testing (IVT)
The contractor shall plan and develop test procedures and/or procedure inputs to accomplish integrated IVT with the payload carrier. Contractor shall provide for shipping and handling of payload hardware and ground support equipment to support IVT. The contractor shall document test results and/or maintain copies of carrier provided test reports.

b) ISS/Carrier Integration:

The contractor shall develop and/or review inputs for all of the products required to accomplish the integration of the flight payload with regard to the carrier and the ISS Payloads Program as appropriate for the period of performance. The contractor shall designate a prime Point of Contact who will interface with the Payload Integration Manager (PIM) and Carrier Integration Lead and coordinate all of the integration activities with the rest of the GRC Project team. The following activities will be included:

i) Develop/revise/update all applicable safety and integration documentation per ISS and carrier requirements. Provide inputs as required for integrated Carrier/Payload safety reviews.
ii) Support ISS and carrier Technical Interchange Meetings (TIM) as necessary.
iii) Support development of Integration Agreements and Interface Control Documents with the payload carrier.

c) Turnover Activities:

The contractor shall support activities to deliver the Flight hardware to NASA GRC. For non-FCF payloads the contractor shall lead the Bench Review, and support the shipment of the hardware to the launch vehicle integrator. For non-FCF payloads the contractor shall perform activities necessary for the packing of the Flight hardware for ground shipment and launch. NASA will ship the hardware to the integrator. Shipping containers should be provided as a hardware development cost and not MI&O. For CASIS experiments, the contractor shall ship the hardware and consumables to the integrator unless as directed by NASA. Turnover activities can also include transporting late stow hardware to the launch integration site.

d) Operations:

The contractor shall support the following Operations activities:

i) Provide input for the development of operations planning products, including estimates of crew time and autonomous operations
ii) Participation in planning meetings with outside organizations
iii) Provide support to the designated Crew Procedures Engineer; provide review and feedback to developed procedures

iv) Support the development of video on-board training materials using the EM and/or Flight hardware.
v) For non-FCF payloads, provide to the carrier information to develop the Operations Plan and Operations Handbook, including off-nominal operations planning
vi) For FCF payloads, provide operational requirements and detailed procedure inputs for execution of experiment operations
vii) Ready the payload unique console(s) at the NASA GRC ISS Payload Operations Center (IPOC) for operations.
viii) For non-FCF payloads, coordinate and perform console and operations training for the ground operators and science team.
ix) For FCF Payloads, support development of payload unique console and operations training for the ground operators and science team.
x) For non-FCF payloads, conduct ISS operations from the IPOC.
xi) The contractor shall assume that ACE and LMM-BIO payloads will fund the payload developer console position from the MI&O funding.

In addition to the current payload MI&O, CASIS payloads that will be using Glenn Research Center ISS Facilities or payload equipment are included in this delivery order. Since CASIS payloads are 6 to 12 months duration, DO changes will be performed as they are identified. Experimental samples along with consumables and specific payload hardware as identified in this SOW shall be designed, developed, tested and delivered to support the identified milestones for the respective experiment payloads.

In order to still have a full cost data on each payload, the contractor shall provide a monthly report identifying the costs down to the payload level.

**1.1 through 1.14 Detail Narrative**
For Flow Boiling and Condensation Experiment (FBCE) - A software developer to support the FBCE software team. The software developer shall 1) identify flight software interface and FIR integration requirements, 2) develop preliminary flight software design, 3) write skeleton and flight software code, 4) responsible for the communication interface between the FBCE Flight Software and the FCF FIR rack, and 5) will develop C++ code that support reception of FBCE ground and FCF commands. The software developer shall also support the regular software team meetings and participate in peer reviews of the requirements, design, and analyses, as needed. The software developer shall provide inputs to sections of the FCF-DOC-4204, Software Data Dictionary, Software Architecture Design Description, and Software Test Plan.

NASA has reserved payload experiments on ISS and at time might want to conduct operations on these reserved payload experiments for example BASS-2, CFE-2, and InSPACE. The contractor shall include one NASA reserved payload experiment for the purpose of resource estimation. This pool of resources can be used for any one of the NASA reserved payload experiments with NASA approval.

For PBRE, the contractor shall update when required the post processing software.

Post Flight Assessment Review (PFAR) –The contractor shall prepare and conduct PFAR per the ISS-PLN-001, ISS SEMP, for the specified payload as identified in section 2 (Milestones and Reviews) of this SOW. In addition, the contractor shall prepare and provide a summary report as identified in section 4 for the specified payload summarizing the highlights and lowlights throughout the life of the payload experiment DO including this DO from initiation, requirements definition and development to launch, on-orbit operations, and hardware and data return. The report should include as a minimum: an introduction, DO summaries, schedule at the milestone level, payload DO costs and total cost; and significant lessons learned.

**1.15 Perform formulation of CASIS investigations**
This task is direct development of the CASIS investigations for NASA. It is not to cover the ZIN costs of providing estimates to CASIS. It is the work required to get approval through ISSPO OZ after that

estimate has been provided to NASA. There may be other associated tasks depending on the CASIS proposal.

**1.16 Petri**

This is a CASIS payload that will utilize the LMM. Integration and operations need to be provided.

**~~1.17 Zaiput~~ –** Deleted per CASIS request due to payload changes

~~This is a CASIS payload that will start in FY17 and continue in FY18. The scope is defined in the ZIN ROM Response Zaiput 2.23.2017.~~

1.18 **Additional Operations**
Please add operational hours to cover launch delays, operational constraints, LMM trouble shooting, and late NASA sample delivery

Applicable Documents

a) SSP 57057 ISS Payload Integration Template.
b) GRC ISS-PLN-001, ISS SEMP, or as tailored in the respective payload project plan (for GRC sponsored payloads, does not include CASIS).
c) GRC ISS-PLN-006, ISS SMAP, or as tailored in the respective payload project plan (for PSHR sponsored payloads, does not include CASIS).

All documents are to be considered the latest revision unless specified herein.

**2) Milestones and Reviews**

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

2.1 Observation and Analysis of Smectic Islands in Space (OASIS) MI&O

a) Operations Complete March 2016 (was 10/2015) - Completed
b) Post Flight Assessment Review – September 2016 (was 8/2016, 3/2016)-Completed
c) PAR closures for PFAR Exit Criteria #2 and #3 - July 2017 (was 1/2017)- Completed
d) PFAR Action Items #1 and #2 – March 2017- Completed
e) PFAR Exit Criteria #4 Closure – March 2017- Completed

2.2 Packed Bed Reactor Experiment (PBRE)

a) Operational Readiness Review December 2015 (ORR) - Completed
b) Launch ORB-4 - December 2015 - Completed
c) On-Orbit Operation of Wetting Module (completed 6/2016) and non-Wetting Module FY2017
d) Ground Test Science Matrix August 2016- Completed
e) Test PBRE Control Module (DACU), October 2016
f) Engineering Review Board November 2016
g) Post Flight Assessment Review - 3 months after final operations (was 5/2018)
h) PBRE Property Return - 1 month after PFAR (was 6/2018) - Completed
i) Copy flight hard drives when received, provide a copy of PBRE flight data to PI
   - Test Module 1 flight data – October 2016 - Completed
   - Test Module 2 flight data – When flight hard drives returned - Completed
j) Update the PBRE data viewer software – December 2016 – Completed
k) Test Module 1 Re-run (Reduced Test Matrix) On-orbit Operation – December 2016. This second operation of Test Module 1 was an outcome of the PBRE ERB held in October 2016. - Completed

2.3 Zero Boil-Off Tank (ZBOT)

a) Phase III and Integrated Flight Safety Review(s) (FSR) (October 2015) - Completed

b) Pre-Ship Review – November 2016 (was 4/2016)- Completed
c) FHA November 2016 (was 4/2016) - Completed
d) Operational Readiness Review (ORR) January 2017 (was 2016) - Completed
e) Operations Complete – September 2017 (was 9/2016) - Completed
f) Post Flight Assessment Review – February 2018 - Completed

Contractor should coordinate with DO-204 task

2.4 Cool Flames Investigation (CFI) – (Reserved: no task and not to price at this time)

2.5 Advanced Colloids Experiment (ACE)

a) ACE-T Base (Version 1) Pre-Ship Review and FHA - May 2016 (was 1/2016) - Completed
b) ACE-T1 Sample Module Ready for Filling* – March 2016 (was 2/2016) - Completed
c) ACE-T9 Sample Module Ready for Filling* – November 2016 (was 3/2016) - Completed
d) ACE-T6 Sample Module Ready for Filling* – November 2016 (was 6/2016) - Completed

e) ACE-M2R Sample Module Ready for Filling* – November 2016 (was 6/2016) - Completed
f) ACE-H2 Operations – March 2016 – Completed
g) ACE-T Base (Version 2) Pre-Ship Review and FHA - June 2017 - Completed
h) ACE-T7 – RFF - April 2017- Completed
i) ~~ACE-T2 – RFF - April 2017~~ Deleted
j) ~~ACE-T5 – RFF - April 2017~~ (was 8/2017) Deleted
k) ~~ACE-T4 – RFF - June 2017~~ (was 5/2017) Deleted
l) ACE-T10 – RFF - April 2017 - Completed
m) ACE-T1 Sample Module 1 Operations Complete – FY 2017- Completed
n) ACE-T1 Sample Module 2 Operations Complete - FY 2017 - Completed
o) ACE-T9 Operations Complete - FY 2018
p) ACE-T6 Operations Complete - April 2018 - Completed
q) ACE-M2R Operations Complete - FY 2018

Contractor should coordinate with DO-209 task

*Ready for Filling (RFF) means all work is complete except for final preparation for flight that is tied to launch date. Direction to proceed with filling will come from NASA based on available launch opportunities.

2.6 Macro-Molecular Light Microscopy Module Biophysics with Manual Base (LMMBIO)

a) LMMBIO Pre-Ship Review – January 2016 Completed
b) LMMBIO Ready to Fill - February 2016 Completed
c) Launch LMMBIO 1 & 3 (DeLucas & Snell) on SpX-10 - Completed
d) LMMBIO 1 & 3 Operations – FY 2017 (was 3/2017, 9/2016) - Completed
e) LMMBIO Qualification Fill 2016 - Completed
f) LMMBIO Vibration Test (Levied by PSRP) - August 2016 - Completed
g) LMMBIO Flight Hardware Ready for Filling (RRF) – August 2016 - Completed
h) LMMBIO Phase III Safety Review – October 2016 - Completed
i) LMMBIO Pre-Ship Review – January 2017 (was 11/2016) - Completed
j) LMMBIO-2 (Vekilov) Kickoff Meeting, Send samples to Vekilov – January 2017 (was 11/2016) - Completed
k) LMMBIO Provide assessment report of utilizing current design for Vekilov – March 2017 (was 1/2017) - Completed
l) LMMBIO-2 Vekilov Flight Sample Holders that integrate with PACE base - September 2017 (was 7/2017) - Completed
m) LMMBIO-2 Ground Testing – September 2017- Completed
n) LMMBIO -1 & 3 (DeLucas & Snell) RFF – SpX-10 (L- 8 weeks) - Completed
o) LMMBIO-1&3 Support Sample Filling at PI Site – SpX-10 (L- 6 weeks) - Completed
p) LMMBIO-1&3 Operations Complete – May 2017 - Completed
q) LMMBIO-1&3 support for turnover at KSC and recovery in California for flights SpX-10 & SpX-11- Completed

2.7 CASIS Investigation – Micro-channel Diffusion Experiment (MDE)
a) Launch SpX-8 – April 2016 - Completed
b) MDE Operations July 2016 (was 5/2016) - Completed

2.8 CASIS Investigation – Burning and Suppression of Solids –Milliken (BASS-M)
a) Launch on ORB-4- December 2015 - Completed
b) BASS M Operations – February 2016 (3/2016) - Completed

2.9 CASIS Investigation – Dissolution of Hard to Wet Solids – Eli Lilly (Eli-HTWS)
a) Eli-HTWS FHA – April 2016 (was 1/2016) - Completed
b) Launch on SpX 9 (was 10) – July 2016 - Completed
c) Operations September 2016 (was 6/2016) - Completed
d) Eli-HTWS Phase II Flight Safety Review – (December 2015) - Completed
e) Eli-HTWS Phase III Flight Safety Review – ( April 2016) - Completed

2.10 CASIS Investigation –Lyophilization –Eli Lilly (Eli-L)

a) Eli-L FHA November 2016 (was 2/2016)- Completed
b) Launch on SpX 12 (was 10) - Completed
c) Operations August 2017 (was 4/2016)- Completed
d) Eli-L Phase 0/I/II Flight Safety Review – (January 2016) - Completed
e) Eli-L Phase III Flight Safety Review – February 2017 - Completed
f) Eli-L MSG IVT– February 2017- Completed
g) Eli-L Flight hardware Ready to Fill – April 2017- Completed
h) Eli-L ORR – April 2017 - Completed

2.11 Flow Boiling and Condensation Experiment (FBCE)
a) FBCE Software Requirements ERB - October 2016 (was 4/2016)
b) CDR – September 2017

2.12 Reserved payload experiments
a) Operations – September 2017 (was 9/2016) - Completed

2.13 Zero Boil-Off Tank-2 (ZBOT-2)
a) Science Concept Review (SCR) /Requirements Definition Review (RDR) – September 2018 (Reference Only) **
Contractor should coordinate with DO-222 task

2.14 Two-Phase Flow Separator Experiment (TPFSE)
a) Phase 0/I Flight Safety Review - November 2017 (Reference Only) **
Contractor should coordinate with DO-221 task

2.15 Perform formulation of CASIS investigations
a) Various times through the POP based on receipt of proposals (assume 6 per year)

2.16- Petri
a) Operations – January 2018 -- Completed

~~2.17 Zaiput – Deleted~~
~~a) Start work – FY2017~~
~~b) Operations – FY2018 (Reference Only) **~~

**** Past current period of performance.**

**3) Hardware/Software Deliverables**

MI&O supports hardware and software development and provides the documentation for it.

3.1 – OASIS

a) No hardware/software

3.2 - Packed Bed Reactor Experiment (PBRE)

PBRE Software

a) Write socket monitoring software for the PBRE Image Processor – November 2016- Completed

3.3 – ZBOT

a) No HW/SW

3.4 – CFI

a) No HW/SW

3.5 – ACE

a) No HW/SW

3.6 – LMM-BIO

a) LMM-BIO-1 Sample Assembly (quantity: 2 flight, 1 flight spare) for flight SpX-10; Completed 11/30/16
b) LMM-BIO-3 Sample Assembly (quantity: 2 flight, 1 flight spare) for flight SpX-10; Completed 11/30/16
c) (was LMM-BIO-1&3 interface adapter (quantity: 2 flight, 1 flight spare, and 2 ground units) for flight SpX-10).

d) LMM-BIO-2 Sample Assembly that integrate with PACE base (quantity: 2 flight, 1 flight spare) – September 2017 - Completed
e) (was LMM-BIO-2 Interface adapter (quantity: 2 flight, 1 flight spare, and 2 ground units) – September 2017)

3.7 - MDE

a) No HW/SW

3.8 – BASS-M

a) No HW/SW

3.9 – Eli-HTWS

a) No HW/SW

3.10 – Eli Lilly

a) No HW/SW

3.11 - Flow Boiling and Condensation Experiment (FBCE)

FBCE Software

a) Software for the Coriolis flow meters – December 2016 - Completed

b) Software that delivers and executes, commands, and delivers data between the FBCE flight software and the IOP - May 31, 2017 - Completed

3.12 – Reserved payload experiments

a) No HW/SW

3.13 – ZBOT-2

a) No HW/SW

3.14 – TPFSE

a) No HW/SW

3.15 – Performance formulation of CASIS investigations

a) No HW/SW

3.16 – Perti

a) No HW/SW

~~3.17 – Zaiput - Deleted~~

~~a) No HW/SW~~

**4) Document Deliverables**

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL) for GRC and CASIS Payloads. Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

DO Manager, ISS and Human Health Office (Xuan Nguyen, Mail Stop 77/7, xuan.t.nguyen@nasa.gov NASA Glenn Research Center, Cleveland, OH 44135)
Configuration Management Office, VPL (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer, Melissa A. Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov
Contracting Officer's Representatives, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov ) and (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

**Document deliverables shall be as follows:**

**Overall delivery order deliverables:**

a) The contractor shall prepare a DO Work Plan (technical, schedule, and cost information) in accordance with the scope of this DO. The plan shall include defined documentation development and detailed schedule. The proposed resources (costs and labor hours) in the work plan shall be clearly identifiable down to the respective payload.
b) Monthly Contractor Performance Measurement Reports, per DID # CD-02
c) Monthly Contractor Financial Management Reports, per DID # CD-03.
d) Monthly Contractor Financial Management Report broken down to the payload level.

**Deliverables for each payload:**

4.1 – Observation and Analysis of Smectic Islands in Space (OASIS) MI&O
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) PFAR presentation and review package
c) Other documentation as required (Carried forward from A)

4.2 - Packed Bed Reactor Experiment (PBRE)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)
c) PFAR presentation and review package
d) Update the PBRE flight procedure to include a new procedure to tune the PBRE fluid system – November 2016
** Past current period of performance

4.3 - Zero Boil-Off Tank (ZBOT)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.4 - Cool Flames Investigation (CFI) (Reserved: no task and not to price at this time)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.5 - Advanced Colloids Experiment (ACE)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.6 – LMM Biophysics with Manual Base (LMM-BIO)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.7 – CASIS Investigation – Micro-channel Diffusion Experiment (MDE)
a) Documentation required per the Payload Integration Template (Carried forward from A )
b) Other documentation as required (Carried forward from A)

4.8 – CASIS Investigation – Burning and Suppression of Solid – Milliken (BASS-M)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.9 – CASIS Investigation - Dissolution of Hard to Wet Solids – Eli Lilly (Eli-HTWS)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.10 CASIS Investigation –Lyophilization –Eli Lilly (Eli-L)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Other documentation as required (Carried forward from A)

4.11 – Flow Boiling and Condensation Experiment (FBCE)
a) Documentation required per the Payload Integration Template (Carried forward from A)
b) Draft software ICD including documentation for Software Engineering Review Board (Carried forward from A)
c) Other documentation as required (Carried forward from A)

4.12 – Reserved payload experiments

a) Documentation required per the Payload Integration (Completed)

b) Other documentation as required (Completed)

4.13 – Zero Boil-Off Tank-2 (ZBOT-2)

4.14 – Two-Phase Flow Separator Experiment (TPFSE)

4.15- Perform formulation of CASIS investigations (assume 6 per year)

a) Minutes from meetings with CASIS investigations

b) Final cost and customer agreement (Note: This is the activity that NASA would do prior to putting the new CASIS work on this DO).

4.16- Petri

a) Documentation required per the Payload Integration and operations

b) Other documentation as required

4.17- ~~Zaiput~~ - Deleted

~~a) Documentation required per the Payload Integration and operations~~

~~b) Other documentation as required~~

**5) Government Furnished Equipment (provided in accordance with 52.245-5)**

a) Ground Support Hardware as required
b) Access to SPICE-BASS engineering hardware for functional testing
c) Other as requested

**6) Government Furnished Facilities**

The Government shall make available on an as needed basis the following Government facilities:

a) Telescience Support Center as required
b) FBCE Hardware and Software Lab (Bldg 110, Rms 127 and 220)
c) Other as requested

**7) Government Contacts**

The contractor shall have access to consultation with:

a) GRC Xuan Nguyen, Project Manager

**8) Period of Performance**

The period of performance for this delivery order is from October 1 2016 to September 30, 2018.

**9) Acronym List**

| Acronym | Description |
|---|---|
| **ACE** | **Advanced Colloids Experiments** |
| **ACE-H** | **ACE-Heated** |
| **ACE-M** | **ACE-Microscopy** |
| **ACE-T** | **ACE-Temperature** |
| **BASS** | **Burning And Suppression of Solids** |
| **BASS-M** | **Burning And Suppression of Solids-Milliken** |
| **CASIS** | **Center for the Advancement of Science in Space** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **CFI** | **Cool Flame Investigation** |
| **DACU** | **Data Acquisition and Control Unit** |

| Acronym | Description |
|---|---|
| DID | Data Item Description |
| DO | Delivery Order |
| Eli-HTWS | Eli Lilly - Hard to Wet Solids |
| Eli-L | Eli Lilly - Lyophilization |
| EM | Engineering Model |
| FBCE | Flow Boiling Condensation Experiment |
| FCF | Fluids and Combustion Facility |
| FHA | Flight Hardware Available |
| FIR | Fluids Integration Rack |
| FSR | Flight Safety Review |
| FY | Fiscal Year |
| GRC | Glenn Research Center |
| ICD | Interface Control Document |
| InSPACE | Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions |
| IPOC | ISS Payload Operations Center (was TSC) |
| ISS | International Space Station |
| ISSPO | ISS Program Office |
| IVT | Interface Verification Testing |
| LMM-BIO | Light Microscopy Module Biophysics |
| MDE | Micro-channel Diffusion Experiment |
| MIO (MI&O) | Mission Integration and Operations |
| NASA | National Aeronautics and Space Administration |
| OASIS | Observation and Analysis of Smectic Island in Space |
| ORB | Orbital |
| ORR | Operations Readiness Review |
| OZ | NASA JSC ISS Payload Integration Office |
| PACE | Preliminary Advanced Colloids Experiments |
| PAR | Payload Anomaly Report |
| PBRE | Packed Bed Reactor Experiment |
| PFAR | Post-Flight Assessment Review |
| PIT | Payload Integration Template |
| POP | Period of performance |
| PSHR | Physical Science and Human Research |
| RDR | Requirements Definition Review |
| SEMP | Systems Engineering Management Plan |
| SLPS | Space Life and Physical Sciences |
| SMAP | Safety and Mission Assurance Plan |
| SOW | Statement of Work |
| SpaceDOC-2 | Space Flight Systems Development and Operations Contract-2 |
| SPICE | Smoke Point in Coflow Experiment |
| SpX | SpaceX |
| SSP | Space Station Program |
| TIM | Technical Interchange Meeting |
| TPFSE | Two Phase Flow Separator Experiment |
| ZBOT | Zero Boil-Off Tank |

**SpaceDOC-2 NNC14CA02C**
**DO- 221 Two-Phase Flow Separator Experiment (TPFSE)**
**For DO Period October 1, 2015 through September 30, 2019**
**For the Performance Period May 1, 2018 through March 31, 2019**

# 1 OVERVIEW

The Two-Phase Flow Separator Experiment (TPFSE) Requirements Definition Review (RDR) was conducted on June 26, 2018. The science panel endorsed continued development of the project on a path to flight. The engineering panel concluded that the project demonstrated sufficient evidence to pass the review (upon closure of the Requests for Action) and that it was on a good track to design a successful experiment. However, as an outcome of the PPBE budget planning process, which began before the RDR, the project was cancelled due to a lack for funding in FY19 and beyond. DO-221 CCR-252 reflects a reduction in scope that primarily eliminates content related to the Preliminary Design Review (PDR), while retaining previously completed activities and those necessary for a proper project closeout. It also changes the Performance Period.

The following paragraphs in this overview are now outdated, but are retrained for their information and historical context:

The Two-Phase Flow Separator Experiment (TPFSE) is intended to fly on the International Space Station (ISS) as part of NASA's applied research on critical subsystems to support human life during long-duration space missions. The objective of the TPFSE project is to address specific technical issues related to the design and performance of passive two-phase flow separator technologies that are targeted for use in Advanced Life Support (ALS) applications and Active Thermal Control Systems (ATCS). These include, but are not limited to, waste water processors, internal and external thermal control systems for the separation of vapor/non-condensable gasses and liquid from a two-phase liquid input stream.

The TPFSE project will advance the state of the art in liquid/gas phase separation technology as follows:

1) Develop design and operational guidelines for cyclonic or free vortex separators in microgravity conditions.
2) Develop and validate, with experimental data, macroscopic equations that can be used in microgravity conditions to accurately predict separation efficiencies, flow pattern transitions, pressure drops and stability envelopes.
3) Optimize design and operational parameters for cyclonic two-phase flow separators
    a) Cyclone chamber height and diameter.
    b) Flow rates.
    c) Two-phase injection geometry.
    d) Gas and liquid exit port locations and geometries.
    e) Range of envelope for stable operation.
    f) Separator response to perturbations namely slugging phenomena.

4) Results from this experiment will support the creation of a set of design tools, simulation models and operational guidelines for cyclonic two-phase flow separators, which are able to operate efficiently in microgravity and reduced gravity conditions.

TPFSE is a project that is being funded by the Human Exploration and Operations Mission Directorate. Prof. Yasuhiro Kamotani, Case Western Reserve University in Cleveland, Ohio, and Dr. Georges Chahine, Dynaflow, Inc. in Maryland were selected as Principal Investigators (PIs) under NASA Research Announcement (NRA) NNH08ZTT002N "Research Opportunities in Fluid Physics". Each PI has a different concept for the cyclonic separator. The TPFSE project was restarted in 2012 and completed a Science Concept Review in March 2013. The TPFSE project team worked with the PIs to combine their science requirements. The TPFSE is planned to go in the Fluid Integrated Rack (FIR) as a fluid science experiment payload. A research test rig was developed and flown on low-g aircraft flights starting in June 2015 to evaluate the separators and their operations. The flow-loop of the test rig was designed for a continuous fluid flow and for testing different separators. The contractor may use the test rig design as a starting concept for the tasks in this SOW. The TPFSE project held a Readiness Review in the 4th Quarter of 2015 which included an overview of the test rig design. This Delivery Order includes scope for engineering activities leading to a Requirements Definition Review (RDR) and a Preliminary Design Review in July 2018 and September 2019, respectively.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from May 1, 2018 through March 31, 2019.

### 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, William Sheredy (MSI)
2) Project Scientist, Enrique Rame (USRA)
3) Principal Investigator, Georges Chahine (DynaFlow, Inc.)
4) Principal Investigator, Yasuhiro Kamotani, Case Western Reserve University (CWRU)
5) Co-Investigator: Jaikrishnan Kadambi, CWRU

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) TPFSE Project Plan
2) Science Requirements Document(s) (SRD)
3) NASA Glenn Research Center (GRC) International Space Station Projects Safety and Mission Assurance Plan, GRC ISS-PLN-006

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/ William Sheredy, MS 77-7, William.Sheredy@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles, Mail Stop 77/7, andrew.c.suttles@nasa.gov )
SLPS (Kelly Bailey, Mail Stop 77-7, kelly.a.bailey@nasa.gov)
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly. ON-GOING
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06 ON-GOING
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17, Due at the RDR

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# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) N/A

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: Calibration Lab
2) Usage Elective: EMI Laboratory in Building 333A
3) Usage Elective: GRC FCF payload testing support facilities
4) Usage Elective: Thermal Environmental Chambers in Building 332

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# 4 PROJECT SPECIFIC SOW

## 4.1 TPFSE RDR

The contractor shall:

1) Develop the TPFSE RDR products and an optimal TPFSE conceptual design for RDR review.
   a) Provide the engineering artifacts required to meet the Entrance and Success Criteria for the RDR as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest and documented in the TPFSE Plan of Document Deliverables for Requirements Definition Review, TPFSE-PLN-001; any

tailoring of the criteria and/or artifacts shall be agreed upon by the NASA PM and documented in the convening authority letter for the review.

b) Develop the TPFSE conceptual design satisfying TPFSE SRD(s) and ISS payload and safety requirements. The packaging concept shall fit within the FIR envelope. Wherever possible, the concept design should leverage the FIR capabilities and resources (i.e. Image Processing and Storage Units (IPSU), Fluid Science Avionics Package (FSAP), Camera, etc.) to the maximum extent. In addition, the experiment concept design should consider (1) experiment diagnostics that provide the ability to reconfigure, reposition and accommodate swappable test separators for additional future science, (2) minimizing the usage of on-orbit crew time for experiment assembly, dis-assembly and on-orbit science operations and (3) minimizing costs.

c) Develop engineering requirements and design verifications.

d) Develop the TPFSE/FIR/GRC ISS Payload Operations Center (IPOC) interface concept. The interface concept also includes any ancillary ground systems interfaces if required by the experiment.

e) Develop operational concept.

2) Conduct trade studies if require to down-select the experiment diagnostics to support task (a). Any trade study or study requiring breadboarding and/or testing must be driven by mitigation of identified high risks that are directly impacting a successful RDR.

3) In the course of implementing tasks 1a and 1b above in this section, work with the project science team in recommending further refinement of the SRD requirements and/or closing the SRD requirement TBDs (gaps), if any. Conduct a Technical Interchange Meeting (TIM) with each of the PI teams to finalize the combined SRD and gain agreement on the Engineering Requirements Document (ERD).

4) Perform efforts to create enhanced models of the current Test Sections and provide build documentation in preparation for Test Section breadboard activities.

5) For the above items, address new science requirements and those for which particularly significant feasibility issues have been identified, including (but not limited to) velocity measurements using bubble tracking, core interface viewing and measurement and high speed imaging of the core, including revised requirements for both top and side views.

6) Conduct efforts to develop a means of sampling data from NASA's in-house void fraction sensor at increased rates using the Universal Transducer Interface (UTI).

7) Manufacture and build liquid and gas loop breadboards to be used to assess components and demonstrate concepts to meet the science and engineering requirements. Refine the designs and configurations of these breadboards as necessary to accommodate changes to the science requirements.

8) Manufacture breadboards for the development pipe/two phase mixer, Case and Dynaflow test sections, two phase separation loop and purchase a vacuum pump and misc. integration parts that will be used for development and breadboard testing.

9) Participate in the Cyclonic Separators Technical Interchange Meeting and provide requested support materials (e.g. design concepts, engineering risks and issues, etc.).

10) Create a void fraction sensor system requirements specification.

11) Modify breadboard designs to accommodate Tech4 void fraction sensors,

wiring and control system hardware. Manufacture the parts needed to make these modifications. The scope of this effort does not include making the modifications.

12) Work with the science team to replace science and engineering requirements for void fraction measurement with requirements to estimate void fractions using the "metering method". Assess the engineering feasibility of meeting these requirements. Modify the design concepts and breadboard hardware as necessary.

Note: The scope of items 7-12 above is limited at or near their states of completion following the RDR due to discontinuation or project funding. The hardware developed is to be delivered per section 4.2.2.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 01 | Conduct the RDR | 7/31/2018<br><br>(was 4 & 1/2018) COMPLETE |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| ~~All support and breadboard hardware and software or acquired and/or created in the completion of this DO, including tools, spares and equipment purchased supplied as Government Furnished Equipment (GFE) (these items shall be delivered to the NASA PM or transferred to a follow-on DO)~~ MOVED TO 4.2.2 | 01 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| RDR Artifacts to Meet the Entrance and Success Criteria | 01 |
| Other Documentation Products per TPFSE-PLN-001 and as otherwise Specified in Section 4.1 | 01 |

| Document Deliverables | Milestone Number |
|---|---|
| Lesson Learned Report | 01 |

### 4.2 TPFSE PDR

The TPFSE Preliminary Design Review (PDR) will not be conducted. The contractor shall complete project closeout activities by providing hardware and software deliverables per section 4.2.2.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 01 | Complete project closeout activities | 11/30/2018 |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| All support and breadboard hardware and software acquired and/or created in the completion of this DO, including tools, spares and equipment purchased or supplied as Government Furnished Equipment (GFE) | N/A |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| | |
| | |
| | |
| | |
| | |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| ABS | Acoustic Bubble Spectrometer |
| ALS | Advanced Life Support |
| ATCS | Active Thermal Control Systems |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CWRU | Case Western Reserve University |
| DID | Data Item Description |
| DO | Delivery Order |
| EMI | Electromagnetic Interference |
| ERD | Engineering Requirements Document |
| FCF | Fluids and Combustion Facility |
| FHA | Flight Hardware Available |
| FIR | Fluids Integration Rack |
| FSAP | Fluid Science Avionics Package |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| IPOC | ISS Payload Operations Center (was TSC) |
| IPSU | Image Processing and Storage Unit |
| ISS | International Space Station |
| NASA | National Aeronautics and Space Administration |
| PDR | Preliminary Design Review |
| PI | Principal Investigator |
| PM | Project Manager |
| PRACA | Preventive and Corrective Action |
| RDR | Requirements Definition Review |
| SEMP | Systems Engineering Management Plan |
| SOW | Statement of Work |
| SpaceDOC-2 | Space Flight Systems Development and Operations Contract-2 |
| SRD | Science Requirements Document |
| TBD | To Be Determined |
| TPFSE | Two Phase Flow Separator Experiment |
| TSC | Telescience Support Center |
| USRA | Universities Space Research Association |
| UTI | Universal Transducer Interface |

**SpaceDOC-2 NNC14CA02C**
**DO-223 Liquid Crystal Facility (LCF)**
**For DO Period May 1, 2016 through August 15, 2021**
**FOR THE PERFORMANCE PERIOD OCTOBER 1, 2019 THROUGH AUGUST 15, 2021**

# 1 OVERVIEW

The Liquid Crystal Facility (LCF) experiment is a series of experiments designed to study liquid crystal processes in microgravity. The experiments are a follow-on to the OASIS (Observation Analysis of Smectic Islands in Space) experiment that operated in the Microgravity Science Glovebox (MSG) from July 2015 - March 2016. The goal is to utilize the OASIS flight and ground experiment hardware as the engineering model hardware. It is expected that some modification and/or upgraded design to OASIS assemblies will be needed, but it should be minimized.

The LCF originally consisted of two separate experiments, called Bulk Reference Experiment and Film Reference Experiment. However, in May 2020 SLSPRA decided not to fund the Bulk Reference Experiments so that effort is no longer part of the current SOW.

The Film Reference Experiment consists of 3 experiments with the following objectives:

- to examine thin, smectic-C films, their 2D topological defects, and nanoparticle inclusions in a microgravity environment by doping the liquid crystal films with fluorescent carbon dots via ink-jet printing technique and imaging the light emission from the dots.
- to extend the OASIS experiments to include observation and manipulation of freely suspended LC films with inclusions of magnetic and of islands on them and to study the energetics of arrays of small ferromagnetic droplets deposited by inkjet printing onto the surfaces of flat, freely suspended smectic films and
- to study three different types of the structural evolution of islands on liquid crystal films: Ostwald Ripening (the growth of larger islands at the expense of smaller ones), island-island Interactions, and Lehmann Rotation via the transport of gas molecules across the liquid crystal film bearing the chiral liquid crystal islands.

The LCF Film Reference Experiment has completed a Science Requirements Review (SCR) on April 24, 2018. The LCF Bulk Reference Experiment has completed a Requirements Definition Review (RDR) on Sept 25, 2018 and an Engineering Review Board (ERB) was held in Sept 2019 for summarize the assessment on the utilization of a COTS microscope on ISS for LCF Bulk. After the ERB, work on LCF Bulk was concluded. Two signed Science Requirements Documents (SRDs) for LCF - Bulk and three preliminary SRDs for LCF - Film have been provided to the contractor. A draft Integrated Science Requirements Document (ISRD) for LCF Film has also been provided to the contractor.

The contractor shall support engineering team meetings and science telecons to ensure the PI requirements are met and address any concerns they have from science. Occasional visit to CWRU or KSU may be required to assess the needs or requirements of those 2 PIs.

The Biological and Physical Science (BPS) program recently enacted new strategies for their FY22 portfolio to address their current broad research paradigm into three focus areas. They also decided to pause any pre-PDR major hardware developments, not directly tied to these focused areas. This resulted in a request for a termination review for LCF. The contractor shall support the activities outlined in Section 4.6 to meet the requirements of the termination review for LCF.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2019 through Aug 15, 2021.

### 1.2 GOVERNMENT CONTACTS

1) Nancy R. Hall / GRC Project Manager
2) Deboshri Sadhukhan/ GRC Deputy Project Manager
3) Padetha Tin/USRA Project Scientist
4) Tyler Hatch / GRC Deputy Project Scientist

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) SRDs for the 3 LCF-Film Experiments
2) Draft Engineering Data Management Plan (EDMP) for LCF- Film Experiments
3) Draft LCF Film Project Plan

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1, **elizabeth.a.morales@nasa.gov**

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)
GRC BPS Program Manager, (Kelly Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov )

The contractor shall deliver standard document deliverables as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the deliverables of this delivery order and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06 (due at Delivery Order Definitization)
3) Contractor Financial Management Reporting, per DID# CD-01, Monthly and Quarterly
4) Monthly reporting, per DID# CD-02, Monthly
5) Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17
7) Risk Management reporting per DID PM-02

## 3 GOVERNMENT FURNISHED

### 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

The following are GFE for this delivery order:

1) Integrated Science Requirement Document ISRD
2) Liquid Crystal Sample Material (to be delivered during flight testing)
3) LCF-Film Preliminary Concept (Student reports) delivered January 2020
4) LCF Thin Film Spreader preliminary concept drawings (to be delivered August 2020)
5) Schedule of ground based work

### 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Thermal Environmental Chambers in Building 333A
2) Structural Dynamics Laboratory
3) EMI Laboratory in Building 333A
4) GRC Telescience Support Center (TSC)
5) Vibration Test Laboratory in Building 55
6) Project Scientist: Padetha Tin's lab, Bldg. 105/Rm 209 and 210
7) Zero G Facility in Bldg 110
8) 2.2 Second Drop Tower in Bldg 45

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## 4 PROJECT SPECIFIC SOW

### 4.1 LCF - FILM TO SRR

Due to the cancelation of the LCF Project, the activities in this section will not be performed.

Following a redirection from HQ, LCF will only pursue work toward LCF-Film. The contractor shall use the LCF Film ISRD to proceed to an Interim Design Review where the ground based activities and forward planning will be vetted prior to SRR. Then the contractor shall proceed to a System Requirements Review for LCF-Film as defined in the SpaceDOC II SOW and the NASA GRC ISS SEMP, GRC-ISS-PLN-001B. In case of conflicts between the 2 defined documents, please inform the LCF PM. GRC provided a draft LCF-Film Integrated Science Requirements Document to contractor in Jan 2020. It is expected that the contractor will continue to provide comments to the ISRD requirements table via weekly meetings with the PI teams and science teams in order to finalize the ISRD such that the contractor can generate their ERD in support of the SRR for LCF-Film.

The contractor shall utilize the OASIS flight hardware (Power Enclosure, Digital I/O Assembly, Avionics Assembly and Soft Start Assembly) as an engineering model and in the design of LCF-Film flight hardware build. Key engineering requirements such power, digital input/output and avionics should be retained in the development of the LCF flight system while modification to this system should be minimize. However, major modifications, or a redesign, is expected with the Optics Module and the Experiment Module of OASIS. A preliminary concept is being developed by GRC for the Experiment Module that can be utilized as a starting point for the Film Experiment Module design. This concept was showed to the contractor in Sept 2019 during the visit to the Project Scientist lab. Engineering drawings of 3 thin film spreader devices will be provided to the contractor in Aug 2020 for fabrication. These 3 thin film spreader devices and 4th design from ZIN will be tested in the GRC 2.2 Second Drop Tower.

The contractor shall support ~~provide input to~~ discussions between the PI and GRC on the LCF-Film ISRD to ensure the science requirements are complete as these requirements are flowed down to their ERD.

The contractor shall update the SRR to FHA cost estimate for LCF-Film using the following planning milestones as a guide, some of which is outside of current POP, prior to SRR. The cost estimate shall assume using as much as the OASIS hardware along with an EM unit and flight unit. The contractor shall also assess the feasibility and cost of an FHA/Delivery date in FY 2025

| | |
|---|---|
| Interim Design Review 1 – | November 30, 2020 |
| Systems Requirements Review | – June 30, 2021 |
| Delta-System Requirements Review | – November 15, 2021* |
| Interim Design Review 2 | August 15, 2022* |
| Preliminary Design Review | – August 30, 2023* |
| Critical Design Review | – August 30, 2024* |
| FHA / Delivery | – August 30, 2025* |

The contractor shall conduct and/or support the following activities based on their response to the LCF-MUH SRR RFAs. Findings can be done via trade study, document, memo, or multiple documents. The six activities below have all been documented in the identified RFAs and have been received by the LCF PM.

- Identify potential systems in LCF-Film that may require Software Safety Criticality Assessment including assumptions of what software would control vs. hardware. Ensure those items are incorporated in the schedule. These systems may be in addition to those identified in RFA-001, 003,

- Support ground base testing in PS lab with the spatial light modulator for laser tweezer experiments (RFA-002, 011)

- Create a sensors and controls list to track sensors, controls, etc. associated with LCF Film. (RFA-005)

- Support ground base testing in PS lab on the epi-illumination system (RFA-010)

- Support ground base testing in PS lab on the sample homogenization system (RFA-012)

- Work with MSFC integration team to identify a Payload Integration Manager (PIM) to support ICD development with MSG. (RFA-013, 014, 020)

*** Items are outside DO period of performance end date.**

The contractor shall proceed with the LCF Film design, fabrication, assembly, test and launch. LCF consists of the following diagnostics and key features and is to be the basis for the design of the flight hardware in conjunction with the ISRD as well as Safety, Mission Assurance and Carrier requirements. The contractor shall identify any additional requirements needed to make the system fully functional. The science requirements are outlined in the ISRD.

- Diagnostics/hardware similar to the OASIS flight hardware such airjets, electric field, heaters, possibly 2 laser drivers for epi and trans-illumination, inkjet droplet device, translation stage and objective lens.
- Additional diagnostics/hardware systems consisting of 3 objective lens system, thin film measurement system, magnetic field and back pressure system for the inkjet device.
- Utilizing the OASIS flight hardware Power Enclosure, Digital I/O Assembly and/or Avionics Assembly with some modification to handle the new LCF Film Spreader Chamber along with a new design of the Optics/Illumination Assembly

It is expected that ground base breadboarding or prototypes will be conducted by the contractor prior to SRR. However, the scope of effort for the FY21 activities has to be replanned due to budget constraints. Therefore, the breadboard development and testing for the fluid handling system, automated film spreading mechanism and the magnetic field will be deferred until FY22.

Some of this work is in collaboration with the GRC science and PI team and some on their own, in order to address engineering feasibility issues they have identified. Some of the work is listed below:

- Thin Film Breadboard development and testing.
- Fluid handling system breadboard development. (deferred until FY22)
- Fluid system development and breadboard for Inkjet Printer (IJP) Backpressure concepts.
- Automated Film Spreading mechanisms breadboard development (deferred until FY22)
- Optical research in Thin Film creation and measurement.
- Magnetic Field development and testing (deferred until FY22)
- Support 2.2 Second Drop Tower Testing

An Interim Design Review will be held prior to SRR. The purpose of this review is to identify the ground base plan and schedule forward for SRR on both the contractor and GRC side. The date of this review is tentatively scheduled for November 30, 2020 and it may be a paper review with the scope of products required agreed upon by the contractor and GRC,

The PI team still needs to define their magnetic field requirements. The ISRD to be baselined for SRR will include draft magnetic field requirements. Finalized magnetic field requirements will be added to the revision 1 of the ISRD and will be addressed at a delta-SRR.

The contractor shall update their schedule to show the life cycle of LCF Film (including details of the various components in the film spreader as well as the integration of the OASIS hardware during their design, fab, build, integration of the overall system). GRC will also provide a schedule of their ground base work to the contractor for collaboration. While the notional schedule will be outside the scope of the period of performance, it will help with budget planning and advocacy for the later phases with NASA HQ.

### 4.1.1 Milestones

| Milestone | Expected Date |
|---|---|
| ~~LCF Film Interim Design Review~~ | ~~November 30, 2020 (was 10/15/2020) DELETED~~ |
| ~~LCF Film SRR~~ | ~~June 30, 2021 (was4, 2/2020) Carried Forward DELETED~~ |
| ~~Updated LCF Film SRR to FHA cost assessment (Phase I)~~ | ~~June 15, 2021 (was 4, 1/2020) DELETED~~ |
| ~~LCF Film Delta SRR~~ | ~~Nov 15, 2021 DELETED~~ |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Expected Date |
|---|---|
| Thin Film Spreader Design #1 – GRC | End of DO (was 1/2021; 11/2020) due to COVID |
| Thin Film Spreader Design #2 – GRC | End of DO (was 1/2021; 11/2020) due to COVID |
| Thin Film Spreader Design #3 – GRC | End of DO (was 1/2021; 11/2020) due to COVID |
| Thin Film Spreader Design #4 – ZIN | End of DO (was 1/2021; 12/2020) due to COVID |

Due to inability of the LCF project to access to GRC via the Return to Onsite Work (RTOW) process, the 3 GRC Thin Film Spreader Design were not able to be formally delivered. However, the 3 GRC designs were completed and the LCF Project Scientist was able work with the contractor on completing the assemblies, polishing the hardware as well as conduct testing with each unit. Testing was also conducted with the ZIN Thin Film Spreader Designs too.

### 4.1.3 Document Deliverables

| Document Deliverables | Expected Date |
|---|---|
| ~~Thin Film Breadboard Report~~ | ~~January 15, 2021 (was 12/15/2020) DELETED~~ |
| LCF Film Compliance Matrix Rev A - (Based on updated ISRD) | January 30, 2021 (was 1/15/2021) COMPLETED |
| ~~LCF Film SRR Presentation Package (1 week before SRR)~~ | ~~June 23, 2021 (was 4/23/2021 2/2020) Carried Forward DELETED~~ |
| ~~LCF Film Delta SRR Presentation Package (1 week before Delta SRR)~~ | ~~Nov 8, 2020 DELETED~~ |

## 4.2 LCF – Film to PDR

Due to the cancelation of the LCF Project, the activities in this section will not be performed.

During the planning to SRR, the contractor shall work with the PS to assess the ground based activities encompassing several key science diagnostics. These should be the basis or start for development of a preliminary design and initial breadboard development for LCF-Film that will allow the contractor to proceed to PDR. The PS is very knowledgeable in the area of LC film, their behavior, diagnostics, etc, having been the PS for OASIS. The PS was instrumental in supporting the OASIS engineering team with ground based testing and his expertise should be leveraged during the preliminary design activities for LCF-Film.

The contractor shall create a plan to close out all LCF-Film SRR RFAs with any significant technical work or activity that will require significant resources or schedule, identified to the PM in case any modifications to this SOW is needed. Updates to the PDR date should also be identified following this assessment.

Due to the large span of time between SRR and PDR, it is anticipated that a second Interim Design Review will be held. The scope of this review will be discussed and agreed upon between the contractor and GRC prior to holding the review.

The Preliminary Design Review demonstrates that the preliminary design meets all system requirements with acceptable risk and within cost and schedule constraints and establishes the basis for proceeding with detailed design. It should show that the correct design options have been selected, interfaces have been identified, approximately 10 percent of engineering schematics, drawings and unsigned documents in the preliminary form have been created, and verification methods have been described.

Due to concerns from the OASIS PI on how the flight software was developed, the selection of measurements displayed on the screen, and how image data was stored, especially during testing and Ops, it is critical that PI input during software development be continually addressed by the contractor. The exact details are to be negotiated between the ZIN PM and NASA PM but planning should start early during the planning to PDR.

As the LCF Film experiments will consist of both electric and magnetic fields, the contractor shall conduct preliminary EMI testing with the EM unit to assess any potential EMI issues with the current design. In addition, a more detail thermal analysis may be required depending on the temperature gradient requirements. Both of these activities are direct lessons learned from OASIS.

### 4.2.1 Milestones

| Milestones | Expected Date |
|---|---|
| ~~LCF Film PDR~~ | ~~Aug 30, 2023 *~~<br>~~(was 1/2022*)~~<br>~~DELETED~~ |
| ~~Phase 0/I Safety Review~~ | ~~October 15, 2023*~~<br>~~(was 12/15/2021*)~~<br>~~DELETED~~ |
| ~~LCF Film Interim Design Review 2~~ | ~~August 15, 2022*~~<br>~~DELETED~~ |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverables | Expected Date |
|---|---|
| N/A | |

### 4.2.3 Document Deliverables

| Document Deliverables | Expected Date |
|---|---|
| ~~LCF Film PDR presentation package (2 weeks before PDR)~~ | ~~August 15, 2023 *~~<br>~~(was 1/15/2022*~~<br>~~11/03/20)~~<br>~~DELETED~~ |

*** Items are outside DO period of performance end date.**

## 4.3 LCF – Film to CDR

Due to the cancelation of the LCF Project, the activities in this section will not be performed.

The Critical Design Review demonstrates (1) that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test; (2) that the technical effort is on track to complete the flight system based on ground system development; and (3) mission operations to meet mission performance requirements within the identified cost and schedule constraints. At the time of the CDR, approximately 90 percent of the engineering drawings and schematics should be released for fabrication.

During the planning to CDR, it is critical that the PS be provided science data for PI team to assess to ensure the hardware is meeting the science requirements. It is recommended that an opportunity be provided for the PI teams to visit and view an operational EM unit and its operation prior to CDR.

The contractor shall create a plan to close out all LCF-Film PDR RFAs with any significant technical work or activity that will require significant resources or schedule, identified to the PM.

### 4.3.1 Milestones

| Milestones | Expected Date |
|---|---|
| ~~LCF Film CDR~~ | ~~August 31, 2024*~~<br>~~(was 1/2023*)~~<br>~~DELETED~~ |
| ~~Phase II Safety Review~~ | ~~October 15, 2024*~~<br>~~(was 12/15/2022*)~~<br>~~DELETED~~ |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverables | Expected Date |
|---|---|
| N/A | |

### 4.3.3 Document Deliverables

| Document Deliverables | Expected Date |
|---|---|

| | |
|---|---|
| ~~LCF Film CDR presentation package (2 weeks before CDR)~~ | ~~August 15, 2024* (was 1/15/2023*) DELETED~~ |

*** Items are outside DO period of performance end date.**

## 4.4 LCF – Film to SAR-1/SAR-2

Due to the cancelation of the LCF Project, the activities in this section will not be performed.

The System Acceptance Review-1 (SAR-1) ensures project compliance with applicable GRC and project level requirements for successful implementation and control of all development, test, and documentation activities prior to shipment of GRC space flight hardware.

The System Acceptance Review-2 (SAR-2) is the final review of the project readiness and results in a decision by Center Management to ship. This responsibility is delegated to the SAR-2/PSR-2 Board, and the review is chaired by a representative from the Space Flight Systems Directorate, with Board members from the Engineering, Research, and Safety and Mission Assurance areas. The Approval to Operate ISS Flight Hardware form will be completed prior to operations

### 4.4.1 Milestones

| Milestones | Expected Date |
|---|---|
| ~~Phase III Safety Review~~ | ~~July 1, 2025* (was 1/10/2024*) DELETED~~ |
| ~~LCF Film SAR 1~~ | ~~August 1, 2025* (was 2/1/2024*) DELETED~~ |
| ~~LCF Film SAR 2~~ | ~~August 30, 2025* (was 2/2024*) DELETED~~ |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverables | Expected Date |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Expected Date |
|---|---|
| ~~LCF Film SAR presentation package (2 weeks before SAR 2)~~ | ~~August 15, 2025* (was 2/14/2024*)~~ |

| | |
|---|---|
| | ~~DELETED~~ |

*** Items are outside DO period of performance end date.**

## 4.5 LCF – Film to PFAR

Due to the cancelation of the LCF Project, the activities in this section will not be performed.

The System Acceptance Review-1 (SAR-1) ensures project compliance with applicable GRC and project level requirements for successful implementation and control of all development, test, and documentation activities prior to shipment of GRC space flight hardware.

The System Acceptance Review-2 (SAR-2) is the final review of the project readiness and results in a decision by Center Management to ship. This responsibility is delegated to the SAR-2/PSR-2 Board, and the review is chaired by a representative from the Space Flight Systems Directorate, with Board members from the Engineering, Research, and Safety and Mission Assurance areas. The Approval to Operate ISS Flight Hardware form will be completed prior to operations

### 4.5.1 Milestones

| Milestones | Expected Date |
|---|---|
| ~~LCF Film PFAR~~ | ~~February 28, 2026*~~<br>~~(was 2/2025*)~~<br>~~DELETED~~ |

### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverables | Expected Date |
|---|---|
| N/A | |

### 4.5.3 Document Deliverables

| Document Deliverables | Expected Date |
|---|---|
| ~~LCF Film PFAR presentation package (2 weeks before PFAR)~~ | ~~February 14, 2026*~~<br>~~(was 2/14/2025*)~~<br>~~DELETED~~ |

*** Items are outside DO period of performance end date.**

## 4.6 LCF Termination Review

. The contractor shall support GRC in the preparation of a termination review to encompass the following areas:

- Summarize all work has been done to date.

- Identify all hardware/materials and where they will be located.
- Performance data for hardware to be placed in archive.
- What would be needed to restart LCF

All design activities, breadboarding, hardware testing, etc. being done at the contractor sit shall phase to an immediate end. A summary of the work completed to date, design documentation (if available), what is needed to complete the work and lessons learned should be created to be presented at the termination review.

A list of Documents, final reports, drawings and any other data collected shall be compiled. Upon closure of the delivery order, all hardware, materials, kitting, etc. will be turned over to the government.

The one exception to the immediate end of activities is work on the 4 Film Spreader designs. The contractor shall continue with the film spreader designs, support any assembly, polishing and testing with the Project Scientist, collect data and then assembly a final report on the results to be presented at the termination review.

### 4.6.1 Milestones

| Milestones | Expected Date |
|---|---|
| LCF Termination Review | August 3, 2021 |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverables | Expected Date |
|---|---|
| Turnover of all hardware and materials | End of DO |

### 4.6.3 Document Deliverables

| Document Deliverables | Expected Date |
|---|---|
| Summary of activities completed to date | July 30, 2021 (was 7/20/21 due to COVID) |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| BPS | Biological and Physical Science |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| COTS | Commercial Off The Shelf |
| CWRU | Case Western Reserve University |
| DID | Data Item Description |
| DO | Delivery Order |
| EDMP | Experiment Data Management Plan |
| eIRB | electronic Institutional Review Board |
| EM | Engineering Model |
| EMI | Electromagnetic Interference |
| ERB | Engineering Review Board |
| FHA | Flight Hardware Available |
| FY | Fiscal Year |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| HQ | Headquarters |
| ICD | Interface Control Document |
| IJP | Ink Jet Printer |
| ISRD | Integrated Science Requirements Document |
| ISS | International Space Station |
| KSU | Kent State University |
| LCF | Liquid Crystal Facility |
| MSG | Microgravity Science Glovebox |
| MUH | Multi-User Hardware |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| OASIS | Observation and Analysis of Smectic Island in Space |
| PDR | Preliminary Design Review |
| PFAR | Post-Flight Assessment Review |
| PI | Principal Investigator |
| PIM | Payload Integration Manager |
| PM | Project Manager |
| POP | Period of performance |
| PRACA | Preventive and Corrective Action |
| PS | Project Scientist |
| RDR | Requirements Definition Review |
| RFA | Request for Action |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SCR | Science Concept Review |

| Acronym | Description |
|---|---|
| **SEMP** | **Systems Engineering Management Plan** |
| **SLPSRA** | **Space Life and Physical Sciences Research and Application** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **SRR** | **System Requirements Review** |
| **SW** | **Software** |
| **TSC** | **Telescience Support Center** |

SpaceDOC-2 NNC14CA02C
DO-225 PUMA
Portable Unit for Metabolic Analysis
For the Performance Period September 1, 2016 to December 31, 2018

## 1) Introduction

In an effort to help the Technology Transfer Office (TTO) support NASA GRCs technology for the “Portable Unit for Metabolic Analysis (PUMA)” (LEW-17945-1), the contractor shall build an operational PUMA unit. The unit will be utilized during conferences and with current and potential licensees.

The build shall be the same as the initial unit under SpaceDOC2, NNC14CA02C, DO-213 with ZIN Technologies

The PUMA unit shall be built consisting of the mask (S2136MA10000), CO2 sensor, oxygen sensor, temperature sensor and associated cabling, and also an avionics box (S2136MA20000) containing the processing electronics, wireless communication electronics and a pressure transducer enclosed in an appropriate housing. The unit shall contain all necessary hardware to operate with the exception of a laptop and the IGOR software. The unit shall pass continuity tests, and functional tests prior to being delivered.

The government will furnish the flow sensor that the contractor shall integrate into the mask and avionics box. The government will be responsible for calibrating the unit.

Delivery of a PUMA Unit within Six (6) months after the delivery of the GFE.

## 2) Milestones and Reviews

The contractor shall meet the following milestones and participate in the following meetings and reviews. The contractor shall propose the dates for milestones in accordance with respective launch dates and/or increment operations.

a) Receipt of Flow Sensors from the government
b) continuity tests
c) functional tests

## 3) Hardware/Software Deliverables

The contractor shall complete the design, assembly, integration, and test of the hardware as required in the implementation of Item 1 of this DO:

a) PUMA unit

## 4) Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL).

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Technology Transfer Office (TTO) (Irene Cierchacki, Mail Stop 77/5, Irene.cierchacki-1@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa Merrill, Mail Stop 60-1, Mellissa.A.Merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Program Manager, Technology Transfer Office (TTO) (Harvey Schabes, Mail Stop 77-5, Harvey.L.Schabes@nasa.gov )

**Document deliverables shall be as follows:**

a) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
b) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
c) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
d) Monthly reporting, per DID# CD-02, ON-GOING
e) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
f) Lessons Learned Report per DID PA-17

## 5) Government Furnished Equipment (provided in accordance with 52.245-5)

a) Flow Sensor

## 6) Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

**N/A**

## 7) Government Contacts

The contractor shall have access to consultation with:

a) GRC Task Manager, Irene Cierchacki (216-433-6036)
b) GRC TTO Technical Manager, Priscilla Diem (216-433-2095)
c) GRC DO-213 Task Manager, Sam Hussey (216-433-8312)

## 8) Period of Performance

The period of performance for this delivery order is from September 1, 2016 through December 31, 2018.

## 9) Acronym List

| Acronym | Description |
|---|---|
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| DID | Data Item Description |
| DO | Delivery Order |
| GRC | Glenn Research Center |
| ISS | International Space Station |
| NASA | National Aeronautics & Space Administration |
| PRACA | Preventive and Corrective Action |
| PUMA | Portable Unit for Metabolic Analysis |
| SpaceDOC-2 | Space Flight Systems Development & Operations Contract-2 |
| TTO | Technology Transfer Office |

**SpaceDOC-2 NNC14CA02C**
**DO-227 ACE-E**
**Advanced Colloids Experiment (ACE)**
**For DO Period December 1, 2016 through September 30, 2017**
**FOR THE PERFORMANCE PERIOD OCTOBER 1, 2017 THROUGH DECEMBER 31, 2017**

# 1 OVERVIEW

Extend the POP to conduct a modified Requirements Definition Review (RDR) planned for the week of November 6, 2017. This is intended to close out SLPSRA sponsorship and collect science and breadboard hardware data for a future restart. A final report will close out this task.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2017 through December 31, 2107.

## 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

a) Ronald Sicker GRC/MSI0
b) William Meyer, Advanced Colloids - USRA
c) David Chao - Code LTZ

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)
4) Modified Entrance and Success Criteria for a RDR
5) Draft Engineering Requirements Document (ERD)

# 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/Ronald J. Sicker, MS 77-7, Ronald.J.Sicker@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov)

Deliver courtesy copies of cover letter only to:
Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )

Contracting Officer’s Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Monthly Contractor Financial Management Reports, per DID CD-01. (ON-GOING)
2) Monthly Contractor Performance Measurement Reports, per DID CD-03 (ON-GOING)
3) Lessons Learned Report per DID PA-17 (ON-GOING)
4) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06)
5) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
6) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
7) Monthly reporting, per DID# CD-03, ON-GOING
8) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
9) Provide presentation packages for all required reviews

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

The following are GFE for this delivery order.

a) N/A

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

a) Laboratory facilities in building 333 and 110
b) GRC Tele-Science Center (TSC)
c) Confocal Test bed building 333, room 129

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# 4 PROJECT SPECIFIC SOW

## 4.1 GENERAL

The contractor will supply optic and colloid consultants/experts as required for mission planning, reviews, and technical issues.

As required, support meetings and teleconferences with the ACE-E Science teams.

#### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Modified RDR | November 2017 |
| 2 | Final Report | December 2017 |

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Final Report | 2 |
| RDR Presentation | 1 |
| Draft ERD | 1 |

#### 4.1.4 Travel

| Travel | Milestone Number |
|---|---|
| N/A | |

## 5 ACRONYM LIST

Acronym List

| Acronym | Description |
|---|---|
| **ACE** | **Advanced Colloids Experiments** |
| **ACE-E** | **ACE-Electric** |
| **ACE-T** | **ACE-Temperature** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **FIR** | **Fluids Integration Rack** |
| **ISS** | **International Space Station** |
| **LMM** | **Light Microscopy Module** |

| Acronym | Description |
|---|---|
| **NYU** | **New York University** |
| **PI** | **Principal Investigator** |
| **POP** | **Period of performance** |
| **PPBE** | **Planning Programming Budgeting & Execution** |
| **PRACA** | **Preventive and Corrective Action** |
| **RDR** | **Requirements Definition Review** |
| **SCR** | **Science Concept Review** |
| **SpaceDOC-2** | **Space Flight Systems Development & Operations Contract-2** |
| **TSC** | **Telescience Support Center** |

**SpaceDOC-2 NNC14CA02C**
**DO-228 SCENIC**
**SCaN Center for Engineering, Networking,**
**Integration, and Communications (SCENIC)**
**For DO Period October 1, 2017 through September 30, 2020**
**For the Performance Period October 1, 2019 through September 30, 2020**

## 1.0 OVERVIEW

The SCaN Center for Engineering, Networking, Integration, and Communications (SCENIC) has developed an advanced, virtualized analysis environment for space communications architectures and systems. In the early stages of development of the SCENIC engineering environment, the target user group consists of subject matter experts (SMEs) to support current and future space communications network analysis studies for the SCaN Level 2 Program Office. Continuing efforts will expand the engineering environment to a broader user base of novice users to encourage space communication and navigation analysis performance by non-experts. This delivery order is for software engineering, software development, system administration, and IT security for the SCENIC project.

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2019 through September 30, 2020.

### 1.2 Government Contacts

The contractor shall have access to consultation with:

1) SCENIC Project Manager
2) SCENIC Lead Systems Engineer
3) SCENIC Lead Communications Engineer
4) SCENIC Software Quality Assurance Representative
5) GRC SCaN Chief Safety and Mission Assurance Officer
6)

### 1.3 Available Project Specific Documentation

1) SCENIC Verification, Validation, and Credibility (VV&C) Plan
2) SCENIC Configuration Management Plan
3) SCENIC Requirements Document
4) PDMA Requirements
5) NPR-7150.2B
6) NASA-STD-7009A

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

**2.0 DOCUMENT DISTRIBUTION**

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSC (Carol A. Quinn, Mail Stop 142-3, carol.a.quinn@nasa.gov )
ISS and Human Health Project Office, Configuration Management Office (Joan B. Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa A. Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Program Manager, Elias T. Naffah, Mail stop 142-3, elias.t.naffah@nasa.gov
Contracting Officer's Representative, ISS & Human Health Office (Andrew C. Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov ) and Alternate Contracting Officer's Representative, ISS & Human Health Office (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)
Chief, ISS and Human Health Project Office (Robert R. Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
2) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
3) Monthly reporting, per DID# CD-02, ON-GOING
4) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
5) Lessons Learned Report per DID PA-17
6) Schedule
7) Software and Hardware Plan
8) Software Assurance Plan per DID# PA-10

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**3.0 GOVERNMENT FURNISHED**

**3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)**

The following are GFE for this delivery order:

1) SCENIC computational cluster and the software running on that cluster

### 3.2 GOVERNMENT FURNISHED FACILITIES

The Government will make available on an as needed basis the following Government facilities:
1) SCENIC Collaboration Space in Building 142, Room 285:

### 3.3 GOVERNMENT FURNISHED INFORMATION

1) SCMM updates
2) V&V data models and databases

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## 4.0 SCENIC SPACE COMMUNICATION SYSTEM DESIGN ENVIRONMENT

**4.1** The top-level guidance from NASA HQ for the SCENIC project is as follows:

1) **Develop models to simulate Network Performance** for the DSN, NEN, and SN. The network performance is assumed to be ideal performance corrected for operational degradation. Information required for judging network performance is as follows (from the SCaN 20-year Communication Plan).

    a. Network capability (maximum achievable data rate throughput)
    b. Network capacity (# of users simultaneously supported)
    c. Quality of Service (QoS): reliability, performance, and availability. Performance as QoS measures network bandwidth, throughput, bit error rates, latency and jitter
    d. Mission User Burden
    e. Incremental operational cost increases or decreases when an asset or capability is added or removed

2) SCENIC is to employ **open architecture** to enable seamless addition of new modules (e.g. cognitive, etc.)
3) Network performance using all SCaN antennas is to be **completed in less than 5 minutes**. Network performance when using a subset of all SCaN antennas (subset being NEN, SN or DSN) is to be done in less than 1 minute.

The Contractor is responsible for designing, developing, implementing, maintaining, and operating a software environment that will allow expert and non-expert users alike to perform a wide variety of space communications architecture and systems analyses from one integrated web-based user interface (UI). This responsibility includes the administration, maintenance, implementation of NASA Security Policies (including security patching) per NPR 2810.1, and operations of the information system (IS) on which the software development environment resides. The Contractor is responsible for following NPR 7150.2B and the SCENIC VV&C Plan for all software activities associated with this statement of work.

The web-based software application will enable all users to view SCENIC's standard communications and navigation models that will be pre-populated with SCENIC's verified and validated (V&V) data, modify standard models to create unique user-generated models, and build custom models. The software application should allow users to query information from verified and validated databases that will be developed by the contractor in support of the software development, as well as from verified and validated databases from within the SCaN program. With these data models, users will be able to run network performance analyses in the following major analysis areas:

- **Quality of Service (QoS):** Analysis to determine the reliability, performance, and availability of space C&N services, measured in throughput (data rates), error rates (errors per bit per unit of time), and latency (time it takes to deliver spacecraft data).
- **Network Capability:** Analysis of SCaN's ability to provide C&N services (data rates, throughput, frequency bands, modulation schemes, networking protocols), management of spectrum allocation, and development of space data systems standards.
- **Network Capacity:** Analysis of the maximum number of spacecraft that can be supported by SCaN services, tied to throughput capabilities of the network assets and schedule constraints.
- **Mission User Burden:** Analysis on the impact to spacecraft subsystems and user missions as a result of the current network architecture technologies and the infusion of potential future technologies.
- **Cost:** Analysis to evaluate the tradeoffs of delta costs on network operations under the circumstances of adding/removing network assets and/or services

This approach will provide non-expert users access to high-level analysis capabilities and standard models through an integrated web-based UI. The software application will leverage, through precise integration and federation, the power of engineering software tools that do not require a user to know how to use any specific tool. The engineering tools and/or analysis algorithms will be provided to the contractor following the completion of verification, validation, and credibility activities by NASA GRC.

The contractor shall:

1) Integrate both new software-based design tools and databases, with the functionality and usability that meet the customer intent within a graphical user interface. In lieu of this requirement, ZIN will continue to use industry standards and best practices for usability.
2) Comply with the SCENIC Verification, Validation, and Credibility (VV&C) Plan, following NASA-STD-7009A.
3) Each new release shall maintain previous release functionality
4) Perform bi-weekly data backups of the virtual machine servers
5) Implement and release updates for patches, updates, and security vulnerabilities for SOC-MAR criticality definitions and response requirements
6) As schedule permits, incorporate enhancements based on user feedback and comments, as agreed to by the NASA SCENIC Project Manager
7) Prior to releasing any new capabilities into "production", the contractor shall present evidence that all requirements for the new implementation(s) have been met [per an agreed-to criteria that supports justification for release] to the project management (government) in order to obtain release approval.

### 4.1.A Schedule

The Contractor shall develop a schedule, with milestone deliverable dates of maintenance and operations tasks including security updates and data back-ups, and software release versions and the tasks associated with the software development in the HW/SW Deliverable table in sections 4.1.2 & 4.2.2.

### 4.1.B VV&C

The SCENIC VV&C activities are required to deliver simulations that not only perform correctly, but have sufficient credibility for customers to be comfortable to use them. The SCENIC Project Lead Systems Engineer and Lead Communication Engineer will provide the approved verification test evidence, per analysis capability and credibility assessments against HQ-provided thresholds for each credibility factor in NASA-STD-7009A, to the contractor. The contractor shall then conduct VV&C activities on the software application to ensure that the SCENIC results match the verification test evidence provided, in order for the credibility scores to remain consistent with those provided to the contractor. In the event that the contractor cannot deliver software that meets all verification test evidence, the contractor shall enter into negotiations with the SCENIC engineers and project manager to determine whether or not the credibility assessments should be changed.

### 4.1.C Configuration Management

The contractor shall provide a Software Configuration Management Plan that describes how they will conduct configuration management that follows the SCENIC Configuration Management Plan and will include configuration management in the software document deliverables aligned with the SCENIC CDMP and NPR 7150.5B.

#### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | The contractor shall develop the Data model analysis and reporting capabilities described in HW/SW Deliverable Table - ongoing | On or before September 13, 2019 |
| 2 | Deliver SCENIC Documents as required - ongoing | On or before September 13, 2019 |
| 3 | Implement security patches, updates, and vulnerability mitigations | Monthly |
| 4 | Update SCENIC software application code | Biweekly |
| 5 | Purchase and implement Red Hat Virtualization | January 31, 2020 |

| Milestone Number | Milestone | Date |
|---|---|---|
| 6 | Annual IT security plan revisions and updates | March 28, 2020 |
| 7 | TeamWork Server Cloud implementation | December 31, 2019 |

### 4.1.2 Hardware/Software Deliverables

The contractor shall administer and maintain the computer cluster located in Building 142, Room 286B. The contractor shall deliver a plan to maintain software subscriptions and hardware functionality.

| HW/SW Deliverable | Milestone Number |
|---|---|
| Verification and validation of the new SCENIC analyses capabilities | 1 |
| Communications Mission Model Capability – ongoing<br>1) Provide the ability to perform queries on the following combination of fields and tables in the repository: Mission Sponsors; Orbit and trajectory data; Electromagnetic spectrum use; Supporting networks (i.e., SN, NEN, DSN)<br>2) Provide the ability to export the results of the query to a standardized CSV file<br>3) Provide the ability to add (import individual user mission models into the UI for all users to read/use) and delete records (user role based)<br>4) Provide the ability to import and export data into the mission model<br>4.1) Data to be exported in standard formats including: JSON; XML; CSV<br>5) Provide the ability to bulk import data directly to the data model by an automated~~, user accessible(role based) user mission~~ upload feature<br>5.1) Provide an automatic data checking feature of imported data to determine if a new data record needs to be created or the updating of existing records<br>5.2) Provide an automated data validation check of imported data to identify any incorrect data formats or “out of bounds” data values<br>5.3) Provide the ability of the imported data to be reviewed, corrected, and approved by the user prior to uploading or merging<br>6) Develop an automated reporting feature that generates complete monthly analyses. Reporting feature should include options for: complete set of currently defined analyses; generate individually selected analyses from defined set; combination of individually selected analyses (from defined set);<br>7) Provide an automated notification feature that alerts users to new analysis/reporting capabilities and data updates | 1 |

| HW/SW Deliverable | Milestone Number |
|---|---|
| Network Assets Data Model Capability – ongoing<br>1) Provide the planned network state data models at the current state plus 5, 10, 15, and 20 years in the future (use "Availability" data through 2040 from network assets)<br>2) Provide the capability to perform queries on selected combination of fields and tables in the data model including: Location, operating frequency, network connectivity<br>3) Provide the ability to export the results of the query to a standardized CSV file<br>4) Provide the ability to add (import individual network asset models into the UI for all users to read/use) and delete (archive) records (user role based)<br>5) Provide the ability to import and export data into the model<br>5.1) Data to be exported in standard formats including: JSON; XML; CSV<br>6) Provide the ability to bulk import data directly to the data model by an automated~~, user accessible (role based)~~ network asset upload feature<br>6.1) Provide an automatic data checking feature of imported data to determine if a new data record needs to be created or updating of existing records<br>6.2) Provide an automated data validation check of imported data to identify any incorrect data formats or "out of bounds" data values<br>6.3) Provide the ability of the imported data to be reviewed, corrected, and approved by the user prior to uploading or merging | 1 |
| Network Operations Data Model Capability - ongoing<br>1) Provide an Operations Data Model that shall contain daily user mission network usage (Daily Ops)<br>2) Develop a new UI to view and manage analysis/report generation of model data<br>2.1) Provide the ability to perform queries on selected combination of fields and tables in the model including: data range, asset site, and user mission<br>2.2) Provide the ability to export the results of the query to a standardized CSV file | 1 |
| Develop, test, and release feature enhancements and internal software version updates to provide the capability to share models between users and user groups in the User Interface. - ongoing | 1 |
| Implement security patches, updates, and vulnerability mitigations | 3 |
| Update SCENIC software application code | 4 |
| Purchase and implement Red Hat Virtualization | 5 |
| Implement TeamWork Server Cloud software on SCENIC information system | 7 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Updates to Software User Manual (Document number TBD) | 2 |
| Updates to SCENIC Interface Definition Document (SCENIC-IDD-001) (per DID# R-05) | 2 |
| Present SCENIC Software Design Review package to a review panel prior to implementation of new capabilities (called out in Table 1) into the UI. Review Package to include Pre-Release Success Criteria Check-sheet. Review package to be made available to review panel one week prior to review. | 1 |
| Present SCENIC Software Release Review package to a review panel prior to release of software to the users (push to production server). Review Package to include Release Success Criteria Check-sheet. Review package and access to SCENIC "Test" server shall be available one week prior to review. | 1 |
| Security status report, including work completed for the month, security risk posture changes (if any), and upcoming work planned | 3 |
| Software Version Description Document | 4 |
| System Security Plan FY20, delivered in NASA's RISCS system | 6 |
| Information System Contingency Plan, delivered in NASA's RISCS system | 6 |

### 4.2 Space Communications Mission Model (SCMM)

The contractor shall integrate the Space Communications and Navigation (SCaN) program's Space Communication Mission Model (SCMM) data into the SCENIC databases, following SCENIC Verification, Validation, and Credibility plan. The SCMM will be provided via GFI on approximately a monthly basis. Updates to the database as well as the results from analyses to determine the number of missions, organized by mission use case, per year through 2040 with graphs/charts of the results are to be provided by the contractor. Once the SCMM has been provided to the contractor, the contractor shall have one (1) month to integrate the data and provide the analyses. This data should be made available in the SCENIC Engineering Environment version 2.0 and shall be known as the Electronic SCMM (E-SCMM).

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Integrate updated SCMM data into E-SCMM Database and provide analysis reports | Monthly |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| July 2019 SCMM - ongoing | 1 |
| August 2019 SCMM - ongoing | 1 |
| September 2019 SCMM - ongoing | 1 |
| October 2019 E-SCMM | 1 |
| November 2019 E-SCMM | 1 |
| December 2019 E-SCMM | 1 |
| January 2020 E-SCMM | 1 |
| February 2019 E-SCMM | 1 |
| March 2019 E-SCMM | 1 |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Database updated with new mission model information | 1 |
| June 2019 SCMM - ongoing | 1 |
| July 2019 SCMM - ongoing | 1 |
| August 2019 SCMM - ongoing | 1 |
| September 2019 SCMM - ongoing | 1 |
| October 2019 Integrated E-SCMM | 1 |

| Document Deliverables | Milestone Number |
|---|---|
| November 2019 Integrated E-SCMM analysis | 1 |
| December 2019 Integrated E-SCMM analysis | 1 |
| January 2020 Integrated E-SCMM analysis | 1 |
| February 2020 Integrated E-SCMM analysis | 1 |
| March 2020 Integrated E-SCMM analysis | 1 |

## 5.0 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CDMP** | **Configuration/Data Management Plan** |
| **CDRL** | **Contract Data Requirements List** |
| **CSV** | **Comma seperated values** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **DSN** | **Deep Space Network** |
| **eCC** | **electronic Country Clearance** |
| **E-SCMM** | **Electronic-SCMM** |
| **FY** | **Fiscal Year** |
| **GFE** | **Government Furnished Equipment** |
| **GRC** | **Glenn Research Center** |
| **HQ** | **Headquarters** |
| **HW** | **Hardware** |
| **IDD** | **Interface Definition Documents** |
| **IS** | **Information System** |
| **ISS** | **International Space Station** |
| **IT** | **Information Technology** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NEN** | **Near Earth Network** |
| **NPR** | **NASA Procedural Requirement** |
| **PRACA** | **Preventive and Corrective Action** |
| **QoS** | **Quality of Service** |
| **RISCS** | **Risk Information and Secutiry System** |
| **SCaN** | **Space Communications and Navigation** |
| **SCENIC** | **Scan Center for Engineering, Networking, Integration and Communication** |
| **SCMM** | **Space Communication Mission Model** |

| Acronym | Description |
|---|---|
| **SME** | **Subject Matter Experts** |
| **SN** | **Space Network** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **STD** | **Standard** |
| **SW** | **Software** |
| **SWaP** | **Size, Weight and Power** |
| **TBD** | **To Be Determined** |
| **UI** | **User Interface** |
| **V&V** | **Validation and Verification** |
| **VV&C** | **Verification, Validation and Credibility** |

# SPACEDOC-2 NNC14CA02C
# DO-231 CASIS MIO
# CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE (CASIS)
# MISSION INTEGRATION AND OPERATIONS (MIO)
**DO Performance Period September 1, 2017 through March 31, 2023**
**For Performance Period October 1, 2021 through March 31, 2023**

## 1 OVERVIEW

This delivery order is to support CASIS and non-GRC mission integration and operations (MI&O) activities and other ISSPO OZ funding for CASIS payload investigations. The specific tasks for each investigation are in section 4. If non-CASIS payloads are added to this DO, standard processes are to be used. All CASIS payloads are to follow the "CASIS" process as defined in Appendix A.

CASIS Investigations may include hardware development as well as MI&O. The hardware development will be defined per investigation if required.

For this delivery order, MI&O consists of the milestones and products described within the ISS Science, Technology & Exploration (ST&E) Integration Flow (Formerly the Payload Integration Template (PIT)), SSP 57057. These milestones & products are tailorable, per project, to those required to demonstrate to the ISS program that the investigation is considered safe. When possible, the products for previous investigations will be referenced based upon similarity, re-flight and series. The applicable deliverables for this delivery order are defined in section 4 for each unique payload.

CASIS payloads that will be using Glenn Research Center ISS Facilities or payload equipment are included in this delivery order. Since CASIS payloads are short duration (6 to 18 months) duration, DO changes will be performed as they are identified. Experimental samples along with consumables and specific payload hardware as identified in this SOW shall be modified, designed, developed, tested and delivered to support the identified milestones for the respective payload investigations.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order (DO) is from October 1, 2021 through March 31, 2023.

### 1.2 GOVERNMENT CONTACTS

1) Xuan Nguyen, DO Manager
2) Kelly A. Bailey, COR

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) See applicable section for white paper estimate for each CASIS investigation.

### 1.4 FOREIGN TRAVEL

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.
Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

DO Manager, ISS and Human Health Office (Xuan Nguyen, Mail Stop 77-7, xuan.t.nguyen@nasa.gov, Research Center, Cleveland, OH 44135)
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1, **elizabeth.a.morales@nasa.gov**

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated monthly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06

3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Monthly project status (accomplishments, issues, cost information) of each 4.x task is due by the first week of each month.
6) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING

Performance of CASIS projects integration, operations, and development activities will follow the tailored CDRL located in Appendix A – CCR-156 CASIS Tailored CDRL.

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Thermal Environmental Chambers in Bldg. 333A.
2) Electromagnetic Interference (EMI) Laboratory.
3) Acoustical Testing Lab.
4) Telescience Support Center (TSC)
5) Vibro-acoustics (MEL) Lab
6) Payload Rack Checkout Unit (PRCU)
7) Combustion Integrated Rack (CIR) Ground Integration Unit (GIU)
8) Fluids Integrated Rack (FIR) GIU
9) Structural Dynamic Laboratory (SDL)

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# 4 PROJECT SPECIFIC SOW

The following are general guidance for all investigations:

1) In order to still have a full cost data on each payload, the contractor shall provide reporting on the 533 at the 4.x level.

2) Usage of FCF, TSC, and all other government facilities should not be assumed to be free. An agreement should be created for each CASIS investigation to define if any "facility" costs will be incurred on this DO. This agreement should be completed 3 months after task initiation.

3) If hardware and software are developed, it should only be delivered to NASA if it is called out as a deliverable. Otherwise, it may be turned over to the PI, retained by contractor, or disposed of.

4) Risk for CASIS investigations is owned by CASIS therefore the contractor is not obligated to follow NASA procedures/processes except for safety (as defined in Appendix A). The contractor should communicate risks to CASIS.

For payload investigations in this DO, the integration process will be conducted as follows:

The contractor shall plan and develop test procedures and/or procedure inputs to accomplish integrated Verification Testing (VT) with the payload carrier, such as FCF, MSG, Express or other ground simulator for ISS interfaces. Contractor shall provide for shipping and handling of payload hardware and ground support equipment to support VT. The contractor shall document test results and/or maintain copies of carrier provided test reports and include them in the Acceptance Data Package.

a) ISS/Carrier Integration:

The contractor shall develop and/or review inputs for all the products required to accomplish the integration of the flight payload regarding the carrier and the ISS Payloads Program as appropriate for the period of performance. The contractor shall designate a prime Point of Contact (POC) who will interface with the Payload Integration Manager (PIM) and Carrier Integration Lead and coordinate all the integration activities with the rest of the payload investigation team. The following activities will be included:

i) Develop/revise/update all applicable safety and integration documentation per ISS and carrier requirements. Provide inputs as required for integrated Carrier/Payload safety reviews, including the phase 0/I/II and phase III safety data package.

ii) Support ISS and carrier Technical Interchange Meetings (TIM) or ISS programmatic meetings as necessary.

iii) Support development of Integration Agreements and Interface Control Documents with the payload carrier when required by the facility integrator.

b) Turnover and Recovery Activities:

The contractor shall support activities to deliver the Flight experiment hardware to the ISS Program designated integrator for launch services to ISS. The contractor will follow the processes described within SPACE-DOC – 001 for flight hardware processing which describes the GRC process for “Bench Review” which is used to ensure investigation items are ready for flight. The contractor shall perform a “Bench Review” for all ISS flight items on this DO. NASA will ship the hardware to the integrator. For CASIS experiments, the contractor shall ship the hardware and consumables to the integrator unless otherwise directed by NASA. Turnover activities can also include transporting late stow hardware to the launch integration site.

When required by the investigation, the contractor shall support/perform vehicle recovery site operations necessary to return science samples to the Principal Investigator (PI).

c) Operations:

The contractor shall support the following operation activities:

i) Provide input for the development of operations planning products, including estimates of crew time and autonomous operations.

ii) Participation in planning meetings with outside organizations.

iii) Provide support to the designated Crew Procedures Engineer; provide review and feedback to developed procedures.

iv) Support the development of video on-board training materials using the EM and/or Flight hardware.

v) For non-FCF payloads, provide to the carrier information to develop the Operations Plan and Operations Handbook, including off-nominal operations planning.

vi) For FCF payloads, provide operational requirements and detailed procedure inputs for execution of experiment operations.

vii) Provide training for the payload unique console(s) at the NASA GRC ISS Payload Operations Center (IPOC), previously called the Telescience Support Center (TSC). Conduct Operational Readiness Review (ORR) and complete all requirements for payload operating at IPOC

viii) For non-FCF payloads, coordinate and perform console and operations training for the ground operators and science team.

ix) For FCF Payloads, support development of payload unique console and operations training for the ground operators and science team.

x) Conduct on-console operations per developed procedures.

After the completion of the payload operations the contractor shall prepare and provide the final operations documentation as identified in the “Document Deliverables” sections, (section 4.x.3), of this SOW. The final operations documentation should include a report that contains an introduction, DO summaries, schedule at milestone level, payload total cost, operations summary, and significant lessons learned. This shall be due 30 days after operations are completed.

### 4.1 Inertial Spreading with Vibration & Water Coalescence (ISV&WC)

There are two sub-experiments composing this investigation:

The first, sub-Experiment A, “Unmasking Inertially-spreading Contact-lines” explores the various geometries formed by water droplets on surfaces oscillating at variable frequencies. Droplet sizes will consist of 3 mm and 3 cm size droplets.

The second, sub-Experiment B, “Coalescence Experiments” observes the behavior of two separate water droplets coalescing upon a flat surface due to “Digital Micro-Fluidic Induced Coalescence.” (DMF). 2 mm sized droplets will be used during the coalescence experiment.

Reference ZIN ROM Response attachment “ISV&WC 4.11.2017” as a basis for your response.

#### 4.1.1 Milestones

| | Milestone | Date |
|---|---|---|
| | | |

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| | |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| | |

### 4.2 Capillary-driven Microfluidics in Space

This experiment will utilize the LMM in order to image fluid flow through micro-capillaries in micro-gravity.

Reference "ZIN ROM Response_OneDrop_FINAL_7.17.2017" as a basis for your response.

#### 4.2.1 Milestones

| | Milestone | Date |
|---|---|---|
| | | |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| | |

### 4.3 Inertial Spreading through Porous Surface (ISPS)

Inertial spreading and imbibition of a liquid drop through a porous surface will be studied. The investigation will be run in MSG.

Reference "ZIN ROM Response ISPS 8-11-2017" as a basis for your response.

#### 4.3.1 Milestones

| | Milestone | Date |
|---|---|---|
| | | |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| | |

### 4.4 Light Microscopy Module Biophysics (LMMBio) – Macro-Molecular Biophysics (MMB) Cells

This is not CASIS investigation therefore standard NASA GRC SpaceDOC II processes should be performed.

The first set of samples for principal investigators DeLucas (LMMBio-1) and Snell (LMMBio-3) were completed on DO-219. PI Vekilov's (LMMBio-2) first sample initial work started on DO-219 and will be completed on this DO. In DO-219, the investigation progressed through ground testing of the first set.

The second set (Set B) of samples for principal investigators, DeLucas (LMMBio-4) and Snell (LMMBio-6) and both flight sets A and B of Vekilov (LMMBio-2 & 5) have been manufactured and sent to ISS. The second set of each investigation was run with the LMM Enhancements confocal capability.

A "set" is defined as 2 flight units and 1 spare. Only 2 units should be costed for primary operations.

Additional flight samples should be built that may either serve as a reserve payload, spare, or be operated as a passive control module that will be evaluated on the ground. This fourth sample for each of the remaining four flights LMMBio-2, 4, 5, 6 will serve as reserve/spare samples for the duration of LMM where if not used in LMM will return passively. The fourth sample is to be delivered with the primary A or B set. Cost operations for these modules near the end of this POP. But, note they may not be operated.

Upon completion of flight, ZIN will support the sample cell retrieval from Space X in California.

#### 4.4.1 Milestones

| | Milestone | Date |
|---|---|---|
| N/A | | |

#### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| N/A | |

#### 4.4.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| N/A | |

### 4.5 ELECTROLYTIC GAS EVOLUTION UNDER MICROGRAVITY (CAMMED)

This experiment will utilize the MSG Facility on ISS. The experiment will utilize up to 3 MSG provided cameras to image the phenomenon, secondary power (28 VDC, +/- 12 VDC, 5 VDC), GN2 interface, and a level of containment.

Cam Med will provide a minimum of 30 cuvettes with dimensions of 10 x 10 x 40 mm filled with an aqueous solution of Sodium Sulphate. The volume of solution is approximately 5 ml. All cuvettes will be filled with the same concentration. Cam Med will qualify the cuvette assembly to include at a minimum a leak test and a list of the materials of construction. A clear tube will be attached to the cuvette to measure the displacement of the fluid as a result of generating the Hydrogen. This tube will need to have a micro valve rather than a clamp.

Reference "ZIN ROM Response CamMed 8.11.2017.docx" as a basis for your response.

#### 4.5.1 Milestones

| | Milestone | Date |
|---|---|---|
| | | |

#### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| | |

### 4.5.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| | |

## 4.6 Investigating the Structures of Paramagnetic Aggregates from Colloidal Emulsions-4 (InSPACE-4)

This InSPACE study will focus on three anisotropic particle samples (three aspect ratios), as well as one control sample of spherical particles. The existing InSPACE-3 flight hardware needs to be upgraded to meet MSG requirements and science requirements of the InSPACE-4 investigation. ZIN will perform the upgrades for InSPACE-3 flight hardware as defined in the presentation package submitted to OZ on March 23, 2019. ZIN shall complete the InSPACE-4 flight hardware development, Electromagnetic Interference (EMI) testing, Integrated Verification Testing (IVT) with MSG, and other integration and operation activities as defined in Section 4.

Reference "ZIN ROM Response_InSPACE-4 8.11.2017.docx" as a basis for your response.

Reference "InSPACE4-Path Forward 20190322.ppt"

### 4.6.1 Milestones

| | Milestone | Date |
|---|---|---|
| 3 | Data to PI per Concept of Operations | December 31, 2021 (was 9/2021, 7/2021, 12/2020, 6, 4/2021) |
| 5 | Final Documents | December 31, 2021 (was 9, 7, 6, 3/2021) |
| 6 | Complete Additional Test Points Operations | December 31, 2021 |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| | |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| Final Operations Documentation | 5 |
| All investigation data provided to PI per Concept of Operations | 3 |

### 4.7 Multi-Droplet Dispenser (MDD) in support of LMMBiophysics

Fabricate 3 MDDs to be utilized with LMM for oil objectives. The design developed for the Advanced Colloids Experiment (ACE) shall be used. The MDD shall be fabricated to a ready to fill level per milestones below. Final fill and flight readiness will be done on a needed basis. . The contractor will maintain the ready to fill "Kits" until final fill and deployment on ISS. The contractor has completed final fill for the MDD-5 and deployed it on ISS. The contractor shall kit all items needed for MDD-6 and MDD-7 and turn these over to the Government by the delivery schedules shown in the Milestones and Deliverables sections below.

#### 4.7.1 Milestones

| | Milestone | Date |
|---|---|---|
| | | |

#### 4.7.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone |
|---|---|
| | |

#### 4.7.3 Document Deliverables

| Document Deliverables | Milestone |
|---|---|
| | |

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## REPLACE 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| ACE | Advanced Colloids Experiments |
| ADP | Acceptance Data Package |
| BIO | Biological |
| CamMed | Electrolytic Gas Evolution under Microgravity |
| CASIS | Center for the Advancement of Science in Space |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| CIR | Combustion Integration Rack |
| COR | Contracting Officer Representative |
| DID | Data Item Description |
| DMF | Digital Micro-Fluidic Induced Coalescence |

| Acronym | Description |
|---|---|
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **EM** | **Engineering Model** |
| **EMI** | **Electromagnetic Interference** |
| **FCF** | **Fluids and Combustion Facility** |
| **FHA** | **Flight Hardware Acceptance** |
| **FIR** | **Fluids Integration Rack** |
| **GIU** | **Ground Integration Unit** |
| **GRC** | **Glenn Research Center** |
| **InSPACE** | **Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions** |
| **IPOC** | **ISS Payload Operations Center (was TSC)** |
| **ISPS** | **Inertial Spreading through Porous Surface** |
| **ISS** | **International Space Station** |
| **ISSPO** | **ISS Program Office** |
| **ISV&WC** | **Inertial Spreading with Vibration & Water Coalescence** |
| **LMM** | **Light Microscopy Module** |
| **MDD** | **Multi-Droplet Dispenser** |
| **MEL** | **Microgravity Environment Laboratory** |
| **MIO (MI&O)** | **Mission Integration and Operations** |
| **MMB** | **Macromolecular Biophysics** |
| **MSG** | **Microgravity Science Glovebox** |
| **NASA** | **National Aeronautics and Space Administration** |
| **OZ** | **NASA JSC ISS Payload Integration Office** |
| **PI** | **Principal Investigator** |
| **PIM** | **Payload Integration Manager** |
| **PIT** | **Payload Integration Template** |
| **POC** | **Point of Contact** |
| **POP** | **Period of performance** |
| **PRACA** | **Preventive and Corrective Action** |
| **PRCU** | **Payload Rack Checkout Unit** |
| **ROM** | **Rough Order of Magnitude** |
| **SDL** | **Structural Dynamics Laboratory** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **ST&E** | **Science, Technology & Exploration** |
| **TIM** | **Technical Interchange Meeting** |
| **TSC** | **Telescience Support Center** |
| **VT** | **Verification Testing** |

**Appendix A – "CASIS" Process**

**CCR-156: CASIS Tailored CDRL**

Note: Contract Level Documents are identified in UPPER CASE lettering

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| **CONTRACTUAL DATA** | | | |
| CD-01 | CONTRACTOR FINANCIAL MANAGEMENT REPORTING | Y | |
| CD-02 | TECHNICAL REPORTING AND MANAGEMENT REVIEWS | Y | |
| CD-03 | INFORMATION TECHNOLOGY SECURITY PLAN | Y | |
| **PROGRAM MANAGEMENT** | | | |
| PM-01 | SPACEDOC II MANAGEMENT PLAN | N | |
| PM-02 | RISK MANAGEMENT PLAN | N | CASIS Projects will use ZIN P02002 'Procedure for Risk Management'. |
| PM-03 | Software Management and Development Plan | N | |
| PM-04 | CONFIGURATION AND DATA MANAGEMENT PLAN | Y | |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| PM-05 | Engineering Change Proposals (ECPs), Deviations, Waivers and Level 1 Problem Report and Corrective Action Report | Y | |
| PM-06 | Contractor Task / Delivery Order Work Plan | Y | |
| PM-07 | Software Maintenance Plan | N | |
| PM-08 | Software Version Description Document | Y | |
| PM-09 | SYSTEMS ENGINEERING MANAGEMENT PLAN | N | |
| **PRODUCT ASSURANCE** | | | |
| PA-01 | SAFETY AND MISSION ASSURANCE PLAN | N | CASIS Projects will follow ISS levied requirements and ZIN QMS. |
| PA-02 | System Safety Plan | N | CASIS Projects will follow ISS safety standards. |
| PA-03 | System Safety Hazard Analysis | N | CASIS Projects will follow ISS and PSRP safety standards guidelines for safety data package preparation. |
| PA-04 | Fracture Control Plan | Y | |
| PA-05 | Safety Compliance Data Package | T | CASIS Projects will follow ISS safety standards but will not submit documents for review to GRC |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| PA-06 | Materials Identification and Usage List (MIUL); Material Usage Agreement (MUA) | T | CASIS Projects will follow requirements of SSP 30233. No submission to GRC for material certification letter. |
| PA-07 | Problem Report and Corrective Action Plan | T | CASIS Projects will use ZIN P13001 'Procedure for the Control of Nonconforming Product' and P14001 'Corrective and Preventive Action Procedure'. |
| PA-08 | Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL) | N | Not required for Class C or D payloads. |
| PA-09 | Contamination/Cleanliness Control Plan | N | CASIS Projects will use ZIN W09010 'Contamination Control & Cleanliness Requirements for ZIN-Tech Facilities' |
| PA-10 | Software Assurance Plan | N | |
| PA-11 | SAFETY AND HEALTH PLAN | Y | |
| PA-12 | Problem Report and Corrective Action Report | Y | CASIS Projects will use ZIN P13001 'Procedure for the Control of Nonconforming Product' and P14001 'Corrective and Preventive Action Procedure' |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| PA-13 | Reliability Report(s) | N | Not required for Class C or D payloads. |
| PA-14 | Limited Life Items List | N | CASIS Projects will construct Limited Life Items List only when expiration of said materials results in hazardous condition (documented in the safety certification process). |
| PA-15 | System Maintainability/Availability Analysis | N | Not required for Class C or D payloads. |
| PA-16 | Fastener Control Plan | Y | CASIS Projects will follow ZIN W15007 'Fastener Control Plan'. |
| PA-17 | Lessons Learned Report | N | |
| PA-18 | Probabilistic Risk Assessment (PRA) Report(s) | N | Not required for Class C or D payloads. |
| **REQUIREMENTS** | | | |
| R-01 | Systems Requirements Document | T | CASIS Projects will document engineering requirements based on Principal Investigator (PI) science summary memo. |
| R-02 | Interface Requirements Document | T | CASIS Projects will perform interface analysis and/or ground interface checks when necessary but may not write an IRD/ICD/IDD or perform validation unless |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| | | | there is a safety hazard associated with the interface. |
| R-03 | Payload Interface Agreement Main Volume, Addendums and Data Sets | T | CASIS Projects will create PIA in coordination with CASIS. |
| R-04 | Software Requirements Document | T | CASIS Projects will use NPR 7150.2 as a guide to create software requirements when applicable. |
| R-05 | Software Interface Design Document | T | CASIS Projects will perform interface analysis and/or ground interface checks when necessary but may not write an IRD/ICD/IDD or perform validation unless there is a safety hazard associated with the command set. |
| R-06 | Interface Control Document & Interface Definition Document | T | CASIS Projects will perform interface analysis and/or ground interface checks when necessary but may not write an IRD/ICD/IDD or perform validation unless there is a safety hazard associated with the interface. |
| **DESIGN** | | | |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| D-01 | Review Presentation Package | N | An internal review will be performed to determine design readiness. |
| D-02 | Engineering Trade and Analysis Data | N | |
| D-03 | Baseline System Description (Baseline Concept Description) | N | |
| D-04 | Product Drawings | T | CASIS Projects will CM drawings and store in ZIN CoMET. |
| D-05 | Accommodations Handbook | N | |
| D-06 | Software Design Document | N | |
| D-07 | Safety-Critical Structures Data Package | Y | |
| D-08 | Fracture Control Summary Report | Y | |
| D-09 | Parts-Stress Analysis | T | CASIS Projects will perform a Parts-Stress Analysis for safety critical parts only. |
| **VERIFICATION** | | | |
| V-01 | Master Requirements and Verification Compliance Plan<br><br>Master Requirements and Verification Compliance Matrix/Summary | T | CASIS Projects will document engineering and safety requirements and will track using ERD matrix and SVTL. This will comply with ZIN QMS docs. |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| V-02 | Individual Item Verification Test/Demonstration Procedure | Y | |
| V-03 | Individual Item Verification Report | Y | |
| V-04 | Software Verification and Validation Plan | T | CASIS Projects will perform interface analysis and/or ground interface checks when necessary but may not write an IRD/ICD/IDD or perform validation unless there is a safety hazard associated with the command set. |
| V-05 | Acceptance Data Package (ADP) | T | |
| V-06 | As Built Configured Item List | Y | |
| V-07 | On-orbit Performance Acceptance Test Matrix/Plan | N | |
| V-08 | SIMULATION SOFTWARE VERIFICATION AND VALIDATION PLAN | N | |
| **OPERATIONS** | | | |
| OP-01 | Integrated Logistics Support Plan | N | |
| OP-02 | Operations Handbook | N | |
| OP-03 | Mission Operations Plan | N | |

| CONTRACT DATA REQUIREMENTS LIST | | | |
|---|---|---|---|
| **DID #** | **Title** | **Applicability (Y/N/T)** | **Comments** |
| OP-04 | Launch Site Operations and Test Procedures | N | |
| OP-05 | Science and Engineering Data Management Plan | T | |
| OP-06 | Procedures | T | CASIS Projects limited to only crew procedures. |
| OP-07 | Training and Certification Plan | N | |
| OP-08 | Decommissioning Plan | N | |
| OP-09 | Operations Concept | Y | |

**SpaceDOC-2 NNC14CA02C**
**DO-232 Additive Manufacturing Support (AMS)**
**DO Period of Performance October 1, 2017 through September 30, 2019**
**For this Performance Period September 1, 2018 through September 30, 2019**

# 1 OVERVIEW

The following scope of work is for process development, capability needs and delivery of processing parameters and parts for a variety of NASA Glenn Research Center high temperature powder materials for additive manufacturing (AM). It includes design for additive, optimization of additive manufactured prototype parts and potentially low volume production of small parts, e.g., a generic hot-section. In addition, GRC shall require designing builds of representative parts for optimized AM, e.g., proper placement of support structures. NASA GRC requires access to AM machine(s) to optimize the AM processes. The optimization shall be an iterative process based upon powder properties and prototype parts built for this optimization.

Based upon past NASA work and in-house capabilities, the Government wishes to pursue selective laser melting for the AM process. This task is written to reflect that desire. The main tasks of this Delivery Order are as follows. It is expected that each of the elements described below will be tracked as separate Work Breakdown Schedule (WBS's) with lower level breakdown for individual deliverable items.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from September 1, 2018 through September 30, 2019.

## 1.2 GOVERNMENT CONTACTS

The Contractor shall have access to consultation with:
1) Laura Evans, Materials Research Engineer
2) Robert Carter, Materials Research Engineer
3) David Ellis, Technical Lead and COR
4) Bradley Lerch, Materials Research Engineer
5) Quynhgiao Nguyen, Principal Investigator
6) Timothy Smith, Materials Research Engineer
7) Cheryl Bowman, Materials Research Engineer

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)
4) NPR 7120.5E, NASA Space Flight Program and Project Management Requirements
5) NPR 7123.1B, NASA Systems Engineering Processes and Requirements
6) NASA-STD_5005B, Ground Support Equipment
7) GLM-QS-1700.1, NASA Glenn Safety Manual
8) NASA-STD-8739,Electrical Board Fabrication and Assembly Workmanship Specifications
9) NPR 8000.4, NASA Program Continuous Risk Management

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, LMA0/David L Ellis, MS 49-1, david.l.ellis@nasa.gov , Glenn Research Center, Cleveland, OH 44135)
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )
Deliver courtesy copies of cover letter only to:
Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Program Manager, Hypersonics Technology Program (Charles Leonard, Mail Stop 254, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-8032, Charles.P.Leonard@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

---

## 3 GOVERNMENT FURNISHED

### 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) Not applicable except where specific sub task requests require GFE items such as materials, models, drawings, etc.

### 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) The Government shall provide facilities for powder characterization. The Government shall provide the powder size distribution, rheological properties and morphology of the Contractor furnished powder.
2) The Government shall provide test facilities for characterizing the mechanical properties of the material for both the process development and the mechanical property samples.

3) The Government shall provide facilities for characterization of the consolidated powder and evaluation of the process parameters, builds, and other items as needed.
4) The Government shall provide HIPing of the mechanical test specimens to ensure full density.

# 4 PROJECT SPECIFIC SOW

## 4.1 Procurement of Powder for Additive Manufacturing

Provide 204 kg (448 pounds) of oxide dispersion strengthened (ODS) alloy MA-754 for use in the design and development process. The alloy shall have a nominal composition of Ni-20 Cr-1 Fe-0.5 Ti-0.3 Al-0.05 C-0.6 $Y_2O_3$. The Government can provide a list of known suppliers to assist in the purchase. If MA-754 powder cannot be procured, a similar NiCrAl-$Y_2O_3$ powder may be substituted with concurrence from the Government.

The ODS powder purchased shall meet size requirements for the selected AM process as its paramount size requirement, but it is anticipated that it shall be -325 mesh. Powder samples shall be provided to the Government for powder size distribution measurements, chemistry, rheological measurements and imaging of the powder using optical and scanning electron microscopy. It is anticipated that 1-2 kg of powder will be required for this work.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Purchase 204 kg (448 pounds) of oxide dispersion strengthened (ODS) alloy MA-754 (was 100 kg, 220 pounds) | Nov-2017 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Copy of certification of MA-754 powder and Safety Data Sheet (SDS) of MA-754 powder | 1 |

## 4.2 Additive Manufacturing Process Development

Using the procured powder, the Contractor shall initiate a series of AM runs to determine the spreadability of the powder and develop acceptable processing parameters. At all points in this process the Government shall have access to the AM machine and operator to observe the process and work with the Contractor to determine changes to optimize the processing parameters. The Contractor shall deliver a complete set of processing parameters for the selected machine and process at the end of this task as the primary deliverable.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Determine Spreadability and Set Spreading Parameters: ODS powders are generally produced by mechanical alloying. The resulting powder is very rough and non-spherical. The Contractor shall first establish an ability to spread the powder in their AM machine. Because of the nature of the powder, it is anticipated that a bar will not be suitable for the spreading. A roller such as that used on the 3D Phenix PXL Direct Metal Laser Sintering AM machine is desired. Based upon this and assuming a selective laser melting (SLM) process, spreading parameters to produce a uniform 20-50 micron thick layer in the powder bed shall be developed. A report documenting the development shall be delivered at the end of this task. | June 2018 (was 1/2018) |
| 2 | Determine Selective Laser Melting (SLM) Parameters for ODS Alloy: Working with the Government, the Contractor shall develop a suitable Design of Experiments (DoE) that explores the range of processing parameters (scan speed, laser power, scan strategy, etc.) available to determine the optimized processing parameters. Optimized shall be defined as:<br>a. Maximizing the as-built density but achieving at least 98% prior to HIPing<br>b. No clumping or gross separation of the yttria in the microstructure, e.g., formation of layers<br>c. Maximum scan speed / build rate<br>Starting parameters shall be determined by the Contractor, but it is anticipated that previously developed AM parameters for Ni-20 Cr or perhaps Ni alloy 625 will be a suitable starting point.<br><br>Using the parameters of the DoE, the Contractor shall initiate a series of iterative builds to produce small samples, e.g., 1 cm x 1 cm x 1 cm cubes to determine the optimized processing parameters for the ODS alloy. Samples shall be analyzed by GRC after the build to determine the microstructure and density. Any sample that is clearly not acceptable, e.g., does not build properly based upon simple visual | August 2018 (was 3/2018) |

| Milestone Number | Milestone | Date |
|---|---|---|
| | inspection, may be dropped from the examination as unacceptable build parameters. It is reasonable to assume that the process will require multiple iterations with refinement of the parameters between iterations. The Contractor shall be responsible for reporting the best build parameters for the machine used as a deliverable. | |
| 3 | Mechanical Property Samples: After optimization of the processing is complete and the mechanical properties of the first set of samples confirmed, the Contractor shall produce mechanical test samples to the specifications of the Government. Build plate locations of the samples shall be determined in consultation with the Government. All samples shall have a unique identification number built into the top of the sample. The Contractor shall provide access to the build files to allow the Government to determine if the build process contributes to any unusual results observed during mechanical testing. | September 2018 (was 4/2018) |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Once build parameters are determined, The Contractor shall build and deliver to the Government the following set of samples using the optimized parameter set.<br>a. Twenty-four (24) low cycle fatigue samples in the form of round bars 0.525-0.550" diameter x 6" high built in the Z-direction.<br>b. Twelve (12) tensile samples in the form of round bars 0.525-0.550" diameter x 6" high built in the Z-direction.<br>c. Two (2) microstructural samples nominally 0.5" x 1" x 6" high built 90 degrees relative to each other to provide microstructural evaluation of the build.<br><br>In consultation with the Government and dependent upon the capabilities of the machine, the samples may be divided into three groups with different build parameters to explore the three best build parameter sets. All samples still shall be built at the same time on the same build plate, though. | 2 |
| The Contractor shall provide test samples upon completion of build parameter development. The test samples shall include:<br>a. Two (2) feature sample to investigate the ability of the process to produce a standard set of features. The Government shall provide a suitable CAD file for the part. One sample shall be placed at the center of the build plate and one shall be placed at the edge of the build plate.<br>b. Four (4) microstructural samples nominally 0.5" x 1" x 6" high built 90 degrees relative to each other to provide microstructural evaluation of the build. One pair shall be near the center of the build plate, and the second pair shall be near the edge of the build plate.<br>c. Twelve (12) tensile specimens in the form of round bars 0.525-0.550" diameter x 6" high built in the Z-direction.<br>d. Three (3) tensile specimens in the form of round bars 0.525-0.550" diameter x 6" high built in the X-direction.<br>e. Three (3) tensile specimens in the form of round bars 0.525-0.550" diameter x 6" high built in the Y-direction.<br>f. Twenty-four (24) low cycle fatigue specimens in the form of round bars 0.525-0.550" diameter x 6" high built in the Z-direction.<br>g. Eighteen (18) creep specimens in the form of round bars 0.525-0.550" diameter x 6" high built in the Z-direction | 3 |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| The Contractor shall deliver a complete set of processing parameters for the selected machine and process | 2 |

## 4.3 Prototype Engineering and Manufacturing

In consultation with the Government, the Contractor shall design and produce a prototype generic hot-section/backing structure. Additional design features to accommodate anticipated thermal stresses and loads as well as enhance heat transfer may be required. The prototype may also incorporate variable geometries to test the produceability of the part, e.g., variable radii in the corners of the channels and thicknesses of the walls

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Design a hot-section/backing structure that shall consist of a series of parallel square channels nominally 1" x 1 " in cross-section with 0.020-0.250" thick walls. The hot-section shall have six such channels for a nominal 1" x 7.5" cross-section. The length of the part shall be at least 6" | November 2018 (was 6/2018) |
| 2 | Contractor shall provide design engineering support for the optimization of designs based on additive manufacturing capabilities and constraints, volume of build, material process capabilities, etc. | November 2018 (was 6/2018) |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| The Contractor shall design and produce a prototype generic hot-section/backing structure. Design engineering support shall be inclusive of part/prototype design and design for processing, e.g., supports and layup within a Direct Metal Laser Sintering (DMLS) machine requirements | 1 |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| The contractor shall document the design via Computer Aided Design (CAD) and other suitable means and deliver the files to the Government with the hardware. | 1 and 2 |

### 4.4 CHARACTERIZE ADDITIONAL ODS ALLOY

The Contractor shall secure a secondary supply of IDS alloy powder from a second supplier. A portion of the powder shall be delivered to NASA GRC for evaluation. The balance shall either be used for the primary printing task if the primary powder is not delivered in time or held for potential additional work once the parameters are set.

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Complete purchase of new powder | June 2019<br>(was 6/2018) |

#### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| 300 kg of ODS alloy, MA 754 or similar powder | 1 |

#### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **AM** | **Additive Manufacturing** |
| **AMS** | **Additive Manufacturing Support** |

| Acronym | Description |
|---|---|
| **CAD** | **Computer Aided Design** |
| **CDRL** | **Contract Data Requirements List** |
| **COR** | **Contracting Officer Representative** |
| **DID** | **Data Item Description** |
| **DMLS** | **Direct Metal Laser Sintering** |
| **DO** | **Delivery Order** |
| **DoE** | **Design of Experiments** |
| **EDMP** | **Experiment Data Management Plan** |
| **GRC** | **Glenn Research Center** |
| **HIP** | **Hot Isostatic Pressure** |
| **HTP** | **Hypersonics Technology Program** |
| **NASA** | **National Aeronautics and Space Administration** |
| **OSD** | **Oxide Dispersion Strengthened** |
| **SDS** | **Safety Data Sheet** |
| **SLM** | **Selective Laser Melting** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **WBS** | **Work Breakdown Structure** |

# SpaceDOC-2 NNC14CA02C
# DO- 233 Zero Boil-Off TANK (ZBOT) –
# Mission Integration and OPERATIONS (MIO)
# For the Performance Period October 1, 2017 through December 31, 2018

## 1 OVERVIEW

NASA Glenn Research Center (GRC) developed the ZBOT experiment for operations in the Microgravity Science Glovebox (MSG) facility aboard the International Space Station (ISS). Engineering work was previously conducted under SpaceDOC-2 DO-204 and Mission Integration and Operations (MIO) work was conducted under DO-219. The Executive Pre-Ship Review-2 (PSR-2) was successfully completed on January 17, 2017, and flight system was delivered to the International Space Station (ISS) aboard Cygnus spacecraft flight OA-7, which launched on April 18, 2017. The Operational Readiness Review was conducted on June 20, 2017.

ZBOT is a small-scale simulant-fluid experiment that will be used to obtain valuable microgravity empirical data for cryogenic storage tank pressure control design and archival science data for model validation. It will be used to build a science base for future space storage tank engineering efforts by elucidating the roles of the various interacting transport and phase change phenomena that impact tank pressurization and pressure control in variable gravity. The project science team will develop, validate, and verify two-phase CFD models for tank pressure control that can be used to aid the future scale-up tank design. ZBOT will show the feasibility of a Zero-Boil-Off (ZBO) pressure control scheme for microgravity and variable gravity applications by examining the effect of forced mixing of the bulk liquid on destratification and pressure reduction in a ventless Dewar.

The scope of this DO includes post-operations activities including the Post-Flight Assessment Review (PFAR).

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2017 through December 31, 2018.

### 1.2 Government Contacts

1) GRC Project Manager (PM), William Sheredy (MSI)
2) Project Scientist (PS), Ramaswamy Balasubramaniam (USRA)
3) Principal Investigator (PI), Mohammed Kassemi (USRA)

### 1.3 Available Project Specific Documentation

1) ZBOT Experiment Project Plan, Rev. A
2) Science Requirements Definition (SRD), Version 5.0
3) ZBOT Engineering Data Management Plan (EDMP), Version 1.0

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/ William Sheredy, MS 77-7, William.Sheredy@nasa.gov

Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )
Deliver courtesy copies of cover letter only to:
Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov )
Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly. ON-GOING
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06 ON-GOING
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17, Due at Post-Flight Assessment Review (see section 4.2)

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## 3 GOVERNMENT FURNISHED

### 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

1) N/A

### 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: GRC ISS Payload Operations Center (IPOC)

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# 4 PROJECT SPECIFIC SOW

## 4.1 ZBOT HARDWARE RETURN, INSPECTION AND TESTING

The contractor shall coordinate the return of the ZBOT flight system from the ISS to the ground and to GRC. The contractor shall take receipt of the hardware and perform the following post-flight activities. They shall be performed in sequence or as otherwise agreed upon by the NASA Project Manager:

1. Perform hardware visual inspections and functional testing per Functional Acceptance Test, ZBOT-TST-217. Address any issues identified during these activities.

2. Measure the PnP fluid fill level in the flight system using a camera image and a handheld ruler.
3. Perform Digital Particle Image Velocimetry (DPIV) test points with particulates remaining in the system from ISS operations. Imaging will be conducted at frame rates and for durations specified by the Principal Investigator PI, generating up to 200GB of data per test point. Accommodations shall be made to transfer the data from the ZBOT system and to the PI incrementally during the course of testing.

4. Perform MIE scattering tests using the Engineering Model (EM) camera with the flight system to assess the amount of free particulate in the test fluid.

5. Drain the system and evaluate the fluid from the FRA and connecting hoses for DPIV particle contamination. Perform an assessment of whether or not the flight test fluid is darkened and perform a final chemical analysis of the fluid. The chemical analysis can be performed in parallel with the activities below.

6. Perform an overall leak test of the Test Section and Fluid Reservoir Assembly (FRA) per ZBOT Fluid System Leak Test, ZBOT-TST-176, sections 6.1 and 6.2.

7. Remove the test tank from the Test Section and clean the tank, inlet nozzle and Liquid Acquisition Device (LAD) to remove DPIV particles.

8. Perform testing of the flight FRA regulator to determine cause of failed on-orbit recharging activity.
9. Partially disassemble and flush the Fluids Support Unit (FSU) to remove DPIV particles. Components to be removed include, but are not limited to the PNP pump, flow meter and membrane contactor. Clean the pump. These activities can be performed in parallel with the cleaning activities above. Use MIE scattering to assess the amount of free particulate in the test fluid.

10. Reassemble the Test Section with incremental and final leak tests performed to ensure that the system is sufficiently leak tight such that ground science testing can be performed

for two weeks at a time without the need for degassing the test fluid. This equates to an overall leak rate of 2 to 4 x $10^{-5}$ sccs of He.

11. ~~Align the flight camera utilizing the EM~~. DELETED

12. Setup the flight system in the MSG mockup. Perform dry functional testing per ZBOT-TST-217.

13. Prepare the flight system for extended storage.

The flight system shall then be transferred to ZBOT-2 DO-222 for use on that project.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Receipt of Flight Hardware at ZIN | 3/31/18 |
| 2 | Complete Post-Flight ZBOT Hardware Inspection and Functional Testing Activities | 7/13/18 (was 4/30/18 |
| 3 | Complete Post-Flight Fluid Analyses, Test Section Leak Testing, Cleaning and Flushing, Reassembly and Final Leak Testing | 11/30/18 (was 8/31/18) |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| ZBOT Flight Hardware and Software (for Transfer to ZBOT-2 DO-222) | 3 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Post-Flight Inspection and Functional Testing Report(s) | 2 |
| Post-Flight Fluid Analysis, Test Section Leak Testing, Cleaning and Flushing, Reassembly and Final Leak Testing Reports | 3 |

## 4.2 ZBOT Post Flight Assessment Review

The contractor shall conduct the activities and provide the engineering artifacts required to meet the Entrance and Success Criteria for the System Post-Flight Assessment Review (PFAR) as specified in the ISS Research Systems Engineering and Management Plan (SEMP), GRC ISS-PLN-001, Rev B or the latest; any tailoring of the criteria and/or artifacts shall be agreed upon by the NASA PM and documented in a Technical Review Plan or the convening authority letter for the review. Specifically, the contractor shall provide a final engineering project report. The Lessons Learned Report shall cover the life cycle of the project. The contractor shall prepare presentation materials and participate in the review. The contractor shall conduct activities and provide documentation required for the disposition/closure of any engineering related actions, agreements or Requests for Action (RFAs) resulting from these reviews.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Conduct the Post-Flight Assessment Review (PFAR) | 10/31/18 (was 4/30/18 |
| 2 | Complete PFAR Agreement/Action/RFA Closure Activities | 11/30/18 (was 5/31/18 |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| PFAR Artifacts to Meet the Entrance and Success Criteria | 1 |
| Final Engineering Project Report | 1 |
| Lessons Learned Report | 1 |
| Post-Flight Updates to Procedures, Plans and Analyses | 1 |
| PFAR Presentation Materials | 1 |
| PFAR Agreement/Action/RFA Related Closure Documents | 2 |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| CDRL | Contract Data Requirements List |
| CFD | Computational Fluid Dynamics |
| DID | Data Item Description |
| DO | Delivery Order |
| DPIV | Digital Particle Image Velocimetry |
| EDMP | Experiment Data Management Plan |
| EM | Engineering Model |
| FRA | Fluid Reservoir Assembly |
| FSU | Fluid Support Unit |
| GRC | Glenn Research Center |
| IPOC | ISS Payload Operations Center (was TSC) |
| ISS | International Space Station |
| LAD | Liquid Acquisition Device |
| MAMS | Microgravity Acceleration Measurement System |
| MIO | Mission Integration and Operations |
| MSG | Microgravity Science Glovebox |
| NASA | National Aeronautics and Space Administration |
| ORR | Operations Readiness Review |
| PFAR | Post-Flight Assessment Review |
| PI | Principal Investigator |
| PM | Project Manager |
| PS | Project Scientist |
| RFA | Request for Action |
| SAMS | Space Acceleration Measurement System |
| SEMP | Systems Engineering Management Plan |
| SOW | Statement of Work |
| SpaceDOC-2 | Space Flight Systems Development and Operations Contract-2 |
| SRD | Science Requirement Definition |
| USRA | Universities Space Research Association |
| ZBOT | Zero Boil-Off Tank |

# SPACEDOC-2 NNC14CA02C
# DO-235 MINI-STIRLING FLIGHT TECHNOLOGY EXPERIMENT (MISFTE)
# FOR THE PERFORMANCE PERIOD OCTOBER 1, 2017 THROUGH SEPTEMBER 30, 2019

## 1 OVERVIEW

Radioisotope Power Systems (RPS) are being developed by NASA as an option to provide high efficiency power systems for future space science missions. A variety of mission concepts have been studied by NASA and the U. S. Department of Energy that would utilize low power RPS for landers, probes, and rovers. These missions would contain science measuring instruments that could be distributed across planetary surfaces or near objects of interest where solar flux is insufficient for using solar cells. Low power RPS concepts that would use the available heat from one or more Radioisotope Heater Units (RHU) include solid state thermoelectric couple (TEC) convertors and dynamic convertors, like Stirling conversion-based systems. The vast majority of systems designed for use with one or more RHU have been based on TECs that provide relatively low conversion efficiencies from 2-4%. These designs would provide spacecraft with up to 240 mW and require significant duty cycling to support data collection and transmission, making it more difficult to discriminate between valued science data.

Dynamic power systems are capable of high efficiency power conversion, which could enable equal power for less fuel or higher power for equal fuel. Low power Stirling convertors are being developed at NASA Glenn Research Center (GRC) to provide future micro spacecraft with electrical power by converting heat from one or more RHUs. An initial concept would convert heat available from multiple RHUs to one watt of electrical power at 20% conversion efficiency for spacecraft instruments and communication. Providing spacecraft with one watt could decrease duty cycling of basic functions and increase the quality of science data. Development activity includes maturation of convertor and controller designs, performance evaluation of a vacuum foil insulation, and demonstration of a battery charger system. The system is comparable in size to a CubeSat.

The Mini-Stirling Flight Technology Experiment (MiSFTE) is a flight project to demonstrate the miniature Stirling power conversion technology in the space environment of the International Space Station. The Mini-Stirling low-power Radioisotope Power System (RPS) concept is being designed for future small satellite and micro spacecraft electrical generation and for distributed power systems architectures.

The MiSFTE protoflight unit would demonstrate the technologies required to provide high efficiency, high reliability power generation. An Avionics box would be required to control system diagnostics and return health and status data to ground. For this protoflight system, a heater unit would simulate the RHU heat source.

### 1.4 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2017 through September 30, 2019.
This project is planned to occur in four stages. The first stage Period of Performance would be from October 1, 2017 through September 30, 2018. This stage is the preliminary design formulation stage, which culminates in the Preliminary Design Review. The work for this phase is described in §4.1 below. The second phase is the design validation implementation phase, which concludes with the Critical Design Review. The Period of Performance for the second stage is from October 1, 2018 through September 30, 2019. Phase 3 is currently beyond the Period of Performance for this contract option, but is included here for completeness and to allow the contractor to understand the scope of future work. Phase 3 is the flight preparation period ending in the Pre-Ship Review and the delivery of the protoflight system. The Period of Performance for this phase is October 1, 2019 through September 30, 2020. An optional fourth phase would encompass launch, flight operations, and return. This phase would be from October 1, 2020 through September 30, 2021.

### 1.5 GOVERNMENT CONTACTS

1) GRC project manager
1) GRC Project Lead Engineer
2) GRC Systems Engineer

### 1.6 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) System Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)
4) Mini-Stirling Concept Documents, including relevant test data

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

> Task Manager, (MA/J. Mark Hickman, Mail Stop 162-6, john.m.hickman@nasa.gov, Research Center, Cleveland, OH 44135)
> Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov)

Deliver courtesy copies of cover letter only to:

> Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov)
> Chief, Space Science Project Office and MiSFTE Program Manager, (Tibor Kremik, Mail Stop 162-6, tibor.kremic@nasa.gov)
> Contracting Officer's Representative, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov)

Program Manager, SpaceDOC-2 (William Foster Mail Stop 77-7, william.m.foster@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated monthly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.4 Government Furnished Equipment (provided in accordance with 52.245-5)

1) Stirling Research Laboratory (SRL) hardware, including rack build up equipment, 3D printer, network server, test stands, and Coordinate Measurement Machine (CMM), located in Building 301, Rooms 151, 151A, 152, 152A, and 158.
2) Magnet Research Lab coil and bobbin fabrication hardware, Building 301, Room 157

## 3.5 Government Furnished Facilities

The Government shall make available, on an as needed basis, the following Government facilities:

1) Small Stirling Research Lab facilities, Building 301, Room 160.
2) LET Electronics Lab, Building 301, Room 159

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# 4 PROJECT SPECIFIC SOW

## 4.1 MiSFTE Design

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| A1 | Kickoff Meeting | DO initiation + 1 week |
| A2 | Scheduled Project Meetings & Risk Management Meetings | Monthly & as needed |
| A3 | Preliminary Design Review | DO initiation + 10 months |
| A4 | Phase 0/1 Flight Safety Review | PDR + 2 months |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| MiSFTE preliminary test units | A3 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| MiSFTE Engineering Requirements Document (ERD) | A3 |
| MiSFTE IV&V Plan | A3 |
| MiSFTE Software Development Plan | A3 |
| Preliminary Design Drawings | A3 |
| Preliminary Test Plans and Reports | A3 |
| Preliminary Interface Control Document (ICD) | A3 |
| Risk Management Plan | A3 |
| Systems Engineering Management Plan (SEMP) | A3 |
| Preliminary Operations Concept (ConOps) | A3 |
| MiSFTE Phase 0/1 Safety Data Package | A4 |
| MiSFTE PDR Presentation Package | A3 |

## 4.2 Design Validation

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| B1 | Scheduled Project Meetings & Risk Management Meetings | Monthly & as needed |

| Milestone Number | Milestone | Date |
|---|---|---|
| B2 | Critical Design Review | PDR + 1 year |
| B3 | Phase 2 Flight Safety Review | CDR + 2 months |

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| MisFTE Engineering Model Test Unit | B2 |
| MiSFTE Engineering Model Controller | B2 |
| Controller Test Software | B2 |
| MiSFTE Diagnostics Avionics Engineering Model | B2 |
| Avionics Test Software | B2 |
| Stirling Research Lab test fixture | B2 |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| PDR RID/RFA/Action Item responses | B2 |
| Test Plans and Reports | B2 |
| Updated design documents | B2 |
| Updated Operations Concept (ConOps) | B2 |
| Updated ICD | B2 |
| MiSFTE Unique Hazard Reports (Preliminary) | B3 |
| MiSFTE CDR Presentation Package | B2 |

## 4.3 Flight Preparation (Beyond the Period of Performance for this contract)

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| C1 | Scheduled Project Meetings & Risk Management Meetings | Monthly & as needed |
| C2 | Phase 3 Flight Safety Review | CDR + 9 months |
| C3 | MiSFTE Pre-Ship Review | CDR + 11 months |
| C4 | MiSFTE Flight System Delivery | PSR + 1 month |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| MiSFTE Protoflight Unit | C4 |
| MiSFTE Flight Controller Unit | C4 |
| MiSFTE Flight Controller Software | C4 |
| MiSFTE Flight Avionics | C4 |
| MiSFTE Flight Avionics Software | C4 |
| MiSFTE Flight Insulation | C4 |
| MiSFTE Flight Heater Unit | C4 |
| MISSE/MiSFTE Flight Interface Fixture | C4 |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| CDR RID/RFA/Action Item responses | C3 |
| Protoflight Test Plans and Reports | C3 |
| MiSFTE Integration Agreement and Final ICD | C3 |
| MiSFTE ERD Verification Report | C3 |
| Command and Telemetry List | C3 |
| Baselined Operations Concept (ConOps) | C3 |
| Unique Hazards Report & Phase 3 Safety Data Package | C2 |
| MiSFTE Materials Certification Letter, MIUL/MUA | C2 |
| MiSFTE PSR Presentation Package | C3 |
| MiSFTE Acceptance Data Package | C4 |

## 4.4 Ground Operations (Beyond the Period of Performance for this contract)

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| D1 | Launch | |
| D2 | Operational Readiness Review | TBD weeks prior to Ops start |
| D3 | End Operations | ~ 6 mo. after start |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Processed Health and Status Data | D2 &D3 |
| Lessons Learned | D3 + 60 days |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CDRL** | **Contract Data Requirements List** |
| **CMM** | **Coordinate Measurement Machine** |
| **ConOps** | **Concept of Operations** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **EDMP** | **Experiment Data Management Plan** |
| **ERD** | **Engineering Requirements Document** |
| **GRC** | **Glenn Research Center** |
| **ICD** | **Interface Control Document** |
| **MISFTE** | **Mini-Stirling Flight Technology Experiment** |
| **MIUL** | **Materials Identification and Usage List** |
| **MUA** | **Materials Usage Agreement** |
| **NASA** | **National Aeronautics and Space Administration** |
| **PSR** | **Pre-Ship Review** |
| **RHU** | **Radioisotope Heater Units** |
| **RPS** | **Radioisotope Power Systems** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **System Requirements Document** |
| **SRL** | **Stirling Research Laboratory** |
| **TEC** | **Thermoelectric Couple** |

**SpaceDOC-2 NNC14CA02C**
**DO-236 Flow Boiling and Condensation Experience (FBCE) -**
**Hardware Fabrication (HF)**
**For the Performance Period August 1, 2017 through October 31, 2018**

# 1 OVERVIEW

The purpose for the Flow Boiling and Condensation Experiment (FBCE) is to build an ISS Fluids Integrated Rack (FIR) insert to serve as a platform for obtaining two-phase flow heat transfer data in microgravity. The experiment hardware consists of data acquisition modules, a boiling heater module, two fluid system modules, and two interchangeable modules designed to study flow boiling and condensation. Experiment software is execute on the CCU and experimental data will be recorded to the FIR-provided IPSU-CL.

The experiment hardware and software is expected to be available in the summer of 2019 and will be integrated into the FIR in early FY 2020.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from August 1, 2018 through October 31, 2018.

## 1.2 GOVERNMENT CONTACTS

1) FBCE Project Manager, Andrew Suttles
2) FBCE Chief Engineer, Bill Taylor
3) FBCE Lead System Engineer, Tim Schuler

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) FBCE Interface Control Document, FBCE-ICD-4204

# 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/A. Suttles, MS 77-7, andrew.c.suttles@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer’s Representative, ISS & Human Health Office (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

None

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

None

# 4 PROJECT SPECIFIC SOW

## 4.1 FBCE Fill/Drain Cart

Fabricate a Fill and Drain servicing cart for the FBCE experiment. The cart will be fabricated using the ZBOT cart design. The cart is ground support equipment that will interface with the experiment flight hardware. The hardware shall be delivered with a materials certification that demonstrates materials compatibility with the normal Perfluorohexane (nPFH) and a user guide.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | FBCE Critical Design Review (CDR) | Complete |
| 2 | FBCE System Integrated Testing Readiness Review (TRR) | May 30, 2018 |
| 3 | FBCE System Fluid Fill and Leak Test | October 1, 2018 |

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Fill/Drain Cart | 2 |

#### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Materials Certification Paperwork | 2 |
| Acceptance Data Package | 2 |
| As-built Drawings updated to reflect all redlines. | 3 |
| Fluids Fill/Drain Cart User Guide | 3 |

### 4.2 FBCE Optics Bench Fabrication

Fabricate two (2) optics bench plates to be used for mounting ground FBCE development hardware. The plates will be machined from aluminum plate stock and will include holes for fasteners and UML locations, but will not include many of the other optics bench features. A drawing will be provided.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | FBCE CDR Kickoff | Complete |
| 2 | FBCE Ground System Integration | Complete |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Optics Bench Plate #1 | Complete |
| Optics Bench Plate #2 | Complete |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

### 4.3 FBCE FLOW BOILING MODULE (FBM) TEST SECTION PARTS FABRICATION

Fabricate two (2) sets of three (3) flight hardware parts per print. The parts will be machined from a 48" x 48" x 1.25" piece of ZeluxW polycarbonate supplied by the government. The parts will be machined, polished, and annealed per supplied print notes. A single piece of part number 111002MFA135 will be prioritized and delivered earlier than the five (5) remaining parts. The supplied drawing numbers are:

- 111002MFA134 FBM Top Polycarbonate Piece
- 111002MFA135 FBM Middle Polycarbonate Piece
- 111002MFA136 FBM Bottom Polycarbonate Piece

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | FBCE Polycarbonate Supplier Down selection | Complete |
| 2 | FBM Assembly | Complete |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| 1 x part number: 111002MFA135 | Complete |
| The remaining 5 pieces of machined/polished polycarbonate | Complete |

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Certificates of Conformance | Complete |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| CCU | Confocal Control Unit |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| DO | Delivery Order |
| FBCE | Flow Boiling Condensation Experiment |
| FIR | Fluids Integration Rack |
| HF | Hardware Fabrication |
| ICD | Interface Control Document |
| IPSU-CL | Image Processing and Storage Unit-Camera Link |
| nPFH | normal Perfluorohexane |
| SpaceDOC-2 | Space Flight Systems Development and Operations Contract-2 |
| TRR | Test Readiness Review |
| UML | Universal Mounting Location |

**SpaceDOC-2 NNC14CA02C**
**DO-237 ACE-MIO**
**Advanced Colloids Experiment (ACE)**
**– Mission Integration and Operations (MIO)**
**For DO Period October 1, 2017 through June 30, 2022**
**For the Performance Period October 1, 2021 through June 30, 2022**

# 1 OVERVIEW

The Advanced Colloid Experiment (ACE) project is a series of experiments that are scheduled to be conducted in the Light Microscopy Module (LMM) on ISS. The experiments are conducted in similar/common sample modules that interface with the ACE-T electronics base or ACE-M base. For each investigation, there are variations in: sample material (fluid), sealing method, and specifications for the glass capillaries that hold the sample fluids. This delivery order is for the integration and operations activities that were previously in DO-209.

For this delivery order, MI&O consists of the milestones and products described within the ISS Science, Technology & Exploration (ST&E) Integration Flow (Formerly the Payload Integration Template (PIT)), SSP 57057. These milestones & products are tailorable, per project, to those required to demonstrate to the ISS program that the investigation is considered safe. When possible, the products for previous investigations will be referenced based upon similarity, re-flight and series. The applicable deliverables for this delivery order are defined in section 4 for each unique payload.

With the last ACE-T experiment delivered for NG-16 (August 10, 2021) this DO involves the remainder of Mission Operations and Project Close-out activities.

This CCR accounts for additional time required to:

Re-assemble Raw mission data into complete data sets per the instructions of Export Control and the PSI database POC.

Provide requested inputs to complete ACE M2R, ACE-T4 and ACE-T10.

Include requested ACE-TR (CASIS) inputs in ACE T11 PCR.

Transfer the ACE ZIN (Comet) database to NASA Sharepoint file structure.

Complete PCR Packages per the schedule in 4(d).

- T12-1,2 (03/14/2022)
- T2-3 (04/08/2022)
- T11-1/R (04/08/2022)
- T5-3 (04/22/2022)
- T9-3 (04/22/2022)
- T1-1,2,3 (05/20/2022)

Additional time/cost separating returned property and disposing of chemical material.

### 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2021, through June 30, 2022.

### 1.2 Government Contacts

The contractor shall have access to consultation with:

a) Ronald Sicker, GRC/MSI0
b) William Meyer, Advanced Colloids - USRA
c) David Chao, Code LTZ

### 1.3 Available Project Specific Documentation

1) Project Plan
2) Science Requirements Document (SRD)
3) Engineering Data Management Plan (EDMP)
4) Investigation Summary Forms (ISF)
5) Science Symposium Presentations (for LIS) Increments: 59/60, 61/62, 63/64 and 65/66

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/Ronald J. Sicker, MS 77-7, Ronald.J.Sicker@nasa.gov

Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov & Donna Clements, Mail Stop 54-1, donna.j.clements@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer (Raenala C. Brown , Mail Stop 60-1, raenala.c.brown@nasa.gov )

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )

Chief, ISS and Human Health Project Office, Acting Program Manager (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Monthly Contractor Financial Management Reports, per DID CD-01. (ON-GOING)
2) Monthly Contractor Performance Measurement Reports, per DID CD-03 (ON-GOING)
3) Lessons Learned Report per DID PA-17 (ON-GOING)
4) The contractor shall prepare a Delivery Order Work Plan (technical, schedule, and cost information) in accordance with SpaceDOC Contract Requirements. (per DID# PM-06)
5) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
6) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
7) Monthly reporting, per DID# CD-03, ON-GOING
8) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
9) Provide presentation packages for all required reviews

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# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order.

1) Sample modules (flight and ground) delivered in DO-209

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) Laboratory facilities in building 333 and 110
2) GRC Tele-Science Center (TSC)
3) Confocal Test bed building 333, room 129

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# 4 PROJECT SPECIFIC SOW

For this period of performance, there are no flight modules that will be delivered by DO-209 or DO-237. This DO supports the MI&O activities that support Mission Operations and Project

Close-out. Since we are past FHA, this DO takes on all the project activities to perform operations and deliver final data to the science team and PSI.

The Mission Integration and Operations activities include safety data package development, delivery of flight sample modules and MDDs, coordinating MST and ORR inputs with the science team and FIR/LMM team, and perform the operations at the Payload Developer (PD) console during normal mission operations of the ACE modules coordinating with the FIR/LMM team. During times of off-nominal mission operations and testing Base Task six (BT-6) will lead the effort to return to normal operations.

For payload investigations in this DO, the integration process will be conducted as follows:

The contractor shall plan and develop test procedures and/or procedure inputs to accomplish integrated Verification Testing (VT) with FCF's ground simulator for ISS interfaces to close SAR, Safety Package, Hardware Turnover and ORR verifications. Contractor shall provide for shipping and handling of payload hardware and ground support equipment to support VT. The contractor shall document test results and/or maintain copies of carrier provided test reports and include them in the COMET Database.

Selected Documents will need to be transferred from COMET to the NASA maintained ACE Project Folder in the Sharepoint System.

a) ISS/Carrier Integration: (Carried Forward)

The contractor shall develop and/or review inputs for all the products required to accomplish the integration of the flight payload regarding the carrier and the ISS Payloads Program as appropriate for the period of performance. The contractor shall designate a prime Point of Contact (POC) who will interface with the Payload Integration Manager (PIM) and Carrier Integration Lead and coordinate all the integration activities with the rest of the payload investigation team. The following activities will be included:

i) Develop/revise/update all applicable safety and integration documentation per ISS and carrier requirements. Provide inputs as required for integrated Carrier/Payload safety reviews, including:
   (1) Phase 0/I/II and/or phase III safety data package form 622
   (2) Flight certification form 906
   (3) Ground safety checklist
   (4) Return safety data package

ii) Support ISS and carrier Technical Interchange Meetings (TIM) or ISS programmatic meetings as necessary.

iii) Support development of Integration Agreements and Interface Control Documents with the payload carrier when required by the facility integrator.

iiii) Support TIMs with the ISRP as requested

iv) Support NASA ERBs as requested

b) Turnover and Recovery Activities: Carried Forward

The contractor shall support activities to return the Flight experiment hardware from the ISS Program designated integrator for launch services to ISS. The contractor will follow the processes described within SpaceDOC – 001 for flight hardware processing which describes the GRC process for returning to GRC post flight.

When required by the investigation, the contractor shall support/perform vehicle recovery site operations necessary to return science samples to the Principal Investigator (PI).

c) Operations:

The contractor shall support the following operation activities:

i) Provide input for the development of operations planning products, including estimates of crew time and autonomous operations.
ii) Participation in planning meetings with outside organizations.
iii) Provide support to the designated Crew Procedures Engineer; provide review and feedback to developed procedures.
iv) Support the development of video on-board training materials using the EM and/or Flight hardware when needed.
v) Provide operational requirements and detailed procedure inputs for execution of experiment operations.
vi) Provide training for the payload unique console(s) activity at the NASA GRC ISS Payload Operations Center (IPOC), previously called the Telescience Support Center (TSC), for operations.

Ground testing is essential for successful flight operations. It is imperative that the ACE team work with the FIR/LMM team to accomplish the ground testing at the appropriate time. This testing is to be a full-dress rehearsal of the future flight operations. Currently no additional new sample modules are in the Utilization Schedule.

Develop a schedule for PI visits and GIU testing for the upcoming ACE module mission operations and provided inputs to the FCF/LMM team.

For this DO provide an estimate of hours to support the requirement development for the FBCE LMM GIU transition.

d) Project Close Out Review (PCR) (Carried Forward)

The contractor shall prepare and participate in ~~conduct~~ PCR per the Project Closeout Review Plan and Checklist. PCR will be required for: ACE-T1-1,2&3, ACE-T6-1&2, ACE-T2-3, ACE-T10-1&2, ACE-T5-3, ACE-T4-1 & 2, ACE-T11-1 & 1R, ACE-M2R, ACE-T12-1&2, and ACE-T9-3. Experiments that did not receive useful science data will only provide the requested final report. Please refer to the Utilization Schedule. Proposed schedule for PCR Meetings:

- T12-1,2 (03/14/2022)
- T2-3 (04/08/2022)

- T11-1/R (04/08/2022)
- T5-3 (04/22/2022)
- T9-3 (04/22/2022)
- T1-1,2,3 (05/20/2022)

As part of the PCR process the available flight data and requested documents are required to be transferred to the INFOMATICS (PSI) database.

Acceptance Data Packages (ADP) are required for all flight hardware deliverables.

e) Reconcile and transfer ~~all~~ ACE inventory parts, hardware, and documents from DO-237 to GRC per instructions of NASA PM.

f) The contractor shall support meetings and teleconferences with the ACE Science teams. (Carried Forward)

#### 4.1.1 Milestones

The contractor shall meet the milestones presented here. The contractor along with the FIR/LMM integrator shall propose the next available launch dates and/or increment operations based on flight hardware availability and FIR utilization. Milestones that are presented as a launch shall adjust per the launch schedule. If it moves beyond the current POP, it can be assumed deleted until an extension DO is provided.

Calculate the operations scenario for 4 weeks of operations as: 360 Hours of operations per sample module, approximately 141 hours per week). Going forward this should be the assumption.

The Contractor is expected to participate at monthly FCF Utilization Meetings and inform NASA of major cost impacts.

#### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.1.3 Document and Science Data Deliverables

| Document Deliverables | Date |
|---|---|
| The complete PCR data set (re-assembled data, selected documents, PCR presentation) for ACE-T12 | March 2022 |
| The complete PCR data set (re-assembled data, selected documents, PCR presentation) for ACE-T2-3 | April 2022 |
| The complete PCR (re-assembled data, selected documents, PCR presentation) data set for ACE-T11 | April 2022 |

| Document Deliverables | Date |
|---|---|
| The complete PCR (re-assembled data, selected documents, PCR presentation) data set for ACE-T5-3, Not required by PSI archive at GIPOC | April 2022 |
| The complete PCR (re-assembled data, selected documents, PCR presentation) data set for ACE-T9-3 | April 2022 |
| The complete PCR (re-assembled data, selected documents, PCR presentation) data set ACE-T1-3 | May 2022 |
| Contract Closeout – Including: Transfer equipment, Formal Transfer requested documents. | June 2022 |

### 4.1.4 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Final ACE/LMM Payload Operations ACE-T1-3 and Flat Field Test | November 2021 per FBCE and Utilization Schedule |
| ~~2~~ | ~~The complete PSI/PCR data set for ACE-T12~~ | ~~April 2022 Deleted~~ |
| ~~3~~ | ~~The complete PSI/PCR data set for ACE-T2-3~~ | ~~April 2022 Deleted~~ |
| ~~4~~ | ~~The complete PSI/PCR data set for ACE-T11~~ | ~~April 2022 Deleted~~ |
| ~~5~~ | ~~The complete PSI/PCR data set for ACE-T5-3, Not required by PSI archieve at GIPOC~~ | ~~April 2022 Deleted~~ |
| 6 | The complete PSI/PCR data set for ACE-T9-3 | April 2022 (was February 2022) |
| 7 | The complete PSI/PCR data set ACE-T1-3 | May 2022 (was March 2022) |
| 8 | Contract Closeout – Including: Transfer equipment, Formal Transfer requested documents | June 30, 2022 (was May 2022) |
| 9 | The complete PSI/PCR data set for ACE-T12 | April 2022 |
| 10 | The complete PSI/PCR data set for ACE-T2-3 | April 2022 |
| 11 | The complete PSI/PCR data set for ACE-T11 | April 2022 |

| Milestone Number | Milestone | Date |
|---|---|---|
| 12 | The complete PSI/PCR data set for ACE-T5-3, Not required by PSI archive at GIPOC | April 2022 |

### 4.1.5 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.6 Document and Science Data Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Provide Requested ZIN CM (COMET) documents for inclusion in the NASA Maintained ACE Sharepoint Project File. | 8 |

## 5 ACRNYM LIST

| Acronym | Description |
|---|---|
| ACE | Advanced Colloids Experiments |
| ACE-M | ACE-Microscopy |
| ACE-MIO | Advanced Colloids Experiment – Mission Integration and Operations |
| ACE-T | ACE-Temperature |
| ACE-TR | Advanced Colloids Experiment-Temperature control for the REMIS Contract |
| ADP | Acceptance Data Package |
| BT | Base Task |
| CASIS | Center for the Advancement of Science in Space |
| CCR | Configuration Change Request |
| CDRL | Contract Data Requirements List |
| COR | Contracting Officer Representative |
| DID | Data Item Description |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| EDMP | Experiment Data Management Plan |
| ERB | Engineering Review Board |
| FBCE | Flow Boiling Condensation Experiment |
| FCF | Fluids and Combustion Facility |
| FHA | Flight Hardware Available |
| FIR | Fluids Integration Rack |
| GFE | Government Furnished Equipment |
| GIU | Ground Integration Unit |
| GRC | Glenn Research Center |
| IPOC | ISS Payload Operations Center (was TSC) |
| ISF | Investigation Summary Forms |
| ISS | International Space Station |
| LIS | Lead Increment Scientist |
| LMM | Light Microscopy Module |
| MDD | Multi-Droplet Dispenser |
| MIO (MI&O) | Mission Integration and Operations |
| MST | Mission Sequence Test |
| NASA | National Aeronautics and Space Administration |
| ORR | Operations Readiness Review |
| PCR | Project Closeout Review |
| PD | Payload Developers |
| PI | Principal Investigator |
| PIM | Payload Integration Manager |

| | |
|---|---|
| **PIT** | **Payload Integration Template** |
| **PM** | **Project Manager** |
| **POC** | **Point of Contact** |
| **POP** | **Period of Performance** |
| **PRACA** | **Preventive and Corrective Action** |
| **PSI** | **Physical Sciences Infomatics** |
| **REMIS** | **Research, Engineering, Mission Integration Service Contract** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **SRD** | **Science Requirements Document** |
| **ST&E** | **Science, Technology & Exploration** |
| **TIM** | **Technical Interchange Meeting** |
| **TSC** | **Telescience Support Center** |
| **USRA** | **Universities Space Research Association** |
| **VT** | **Verification Testing** |

# SpaceDOC-2 NNC14CA02C
# DO-238 Solar Array Electrical Simulator (SAES)
# For the Performance Period November 15, 2017 through September 30, 2019

## 1 OVERVIEW

Contractor shall reverse engineer 12 Solar Array Electrical Simulator (SAES) circuit boards using available schematics and hardware to reproduce 12 identical circuit boards (PWA) that match the existing circuit boards in form, fit and function. Contractor will make every effort to verify the functionality of the boards prior to delivery. In addition contractor will provide all engineering materials to reproduce additional PWAs as needed including Bill of Material, Gerber Files, Altium Schematic Files, Assembly Drawings and PCB layout files.

### 1.1 Period of Performance

The period of performance for this delivery order is from November 15, 2017 through September 30, 2019.

### 1.2 Government Contacts

Project Manager Kristen Boomer

### 1.3 Available Project Specific Documentation

N/A

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, (Gary M. Pease, Mail Stop 77-7, gary.m.pease@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )
Deliver courtesy copies of cover letter only to:
Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representatives (COR) for SpaceDOC-2, ISS & Human Health Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov ) and (William Foster Mail Stop 77-7, william.m.foster@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

---

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

**N/A**

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

**N/A**

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# 4 PROJECT SPECIFIC SOW

## 4.1 12 Solar Array Electrical Simulator (SAES) Circuit Boards

Contractor shall reverse engineer 12 Solar Array Electrical Simulator (SAES) circuit boards using available schematics and hardware to reproduce 12 identical circuit boards (PWA) that match the existing circuit boards in form, fit and function. Contractor will make every effort to verify the functionality of the boards prior to delivery. In addition contractor will provide all engineering materials to reproduce additional PWAs as needed including Bill of Material, Gerber Files, Altium Schematic Files, Assembly Drawings and PCB layout files.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Drawings Complete | 11/15/2017 |
| 2 | PWB Received | 12/21/2017 |
| 3 | PWAs Complete | 3/8/2018 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Altium Schematic Files for 12 SAES PWA | 1 |
| PCB Layout Files for 12 SAES PWA | 2 |
| Gerber Files for 12 SAES PWA | 3 |
| Bill of Material for 12 SAES PWA | 4 |
| 12 SAES PWA that match the existing SAES PWAs in form, fit and function | 5 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Assembly Drawings for 12 SAES PWA | 1 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CDRL** | **Contract Data Requirements List** |
| **DID** | **Data Item Description** |
| **PCB** | **Printed Circuit Board** |
| **PWA** | **Printed Wire Assembly** |
| **PWB** | **Printed Wire Board** |
| **SAES** | **Solar Array Electrical Simulator** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |

**Changing the pop end date:**

# SPACEDOC-2 NNC14CA02C
# DO-239
# SUB-KILOWATT ELECTRIC PROPULSION (SKEP)
# FOR THE PERFORMANCE PERIOD FEBRUARY 1, 2018 THROUGH APRIL 30, 2019

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from February 1, 2018 through January 31April 30, 2019.

**Replace 1.1 POP:**

The period of performance for this delivery order is February 1, 2018 through April 30, 2019.

## 1.2 GOVERNMENT CONTACTS

1) GRC project manager, Dean P. Petters,
2) GRC project lead engineer, Gabriel F. Benavides

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) SKEP Attachment A: SKEP PPU Draft Requirements Document
2) SKEP Attachment B: Design of a 500W Breadboard Discharge Power Supply for a Hall Thruster, *report*.
3) SKEP Attachment C: Design of a 500W Breadboard Discharge Power Supply for a Hall Thruster, *presentation*.

# 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

- Dean P. Petters, MS 332-8, dean.p.petters@nasa.gov, Project Manager
  NASA Glenn Research Center, Cleveland, OH 44135)
- Gabriel F. Benavides, MS 301-3, gabriel.f.benavides@nasa.gov, Project Lead Engineer
  NASA Glenn Research Center, Cleveland, OH 44135)
- Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov, Configuration Management Office
  NASA Glenn Research Center, Cleveland, OH 44135)

Deliver courtesy copies of cover letter only to:

- Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov, Contracting Officer

- Andrew Suttles, Mail Stop 77-7, andrew.c.suttles@nasa.gov, Contracting Officer's Representative, ISS & Human Health Office
- William Foster Mail Stop 77-7, william.m.foster@nasa.gov, Program Manager, SpaceDOC-2

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

---

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

N/A - No government equipment shall be furnished to the contractor.

## 3.2 GOVERNMENT FURNISHED FACILITIES

N/A - No government facilities shall be furnished to the contractor.

---

# 4 PROJECT SPECIFIC SOW

## 4.1 TASK 1: DEVELOP PRELIMINARY BREADBOARD DISCHARGE SUPPLY

The contractor shall develop a preliminary breadboard discharge power supply (Rev1) based on SKEP PPU requirements (appendix A) and recent discharge supply investigations at GRC (appendix B and C). The preliminary breadboard shall be assembled on a printed circuit board (PCB) to start development of a high-performance, low-parasitics, powertrain for the power converter that can achieve project requirements. The preliminary breadboard may use commercial-grade EEE parts so long they have similar functionality and performance as space-rated parts that can be used in higher TRL PPUs. Compatible space-rated EEE parts shall be identified. The discharge supply investigations identified in appendix B and C were proof of concept. Improvements in the discharge supply architecture are expected to achieve project requirements as provided in appendix A. Some such proposed improvements are suggested in appendix B and C. The preliminary breadboard shall demonstrate functionality, but not necessarily fit or form of the flight design. Development trades shall favor simplicity and low recurring cost for flight units over enhanced capabilities, and volume efficiency over mass efficiency. Electrical efficiency shall be maximized when the impact on recurring cost and PPU volume is moderate.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 001 | Preliminary Breadboard discharge supply table-top review | 3/9/18 |
| 002 | Complete performance and functionality testing of breadboard | 5/11/2018 |
| 003 | Deliver preliminary discharge supply breadboard | 7/3/18 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Preliminary discharge supply breadboard | 003 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Preliminary discharge supply design package, including schematic | 001 |
| Test report, including recommendations for Rev2 breadboard | 002 |

## 4.2 Task 2: Develop Rev2 Breadboard Discharge Supply

The contractor shall develop a high-fidelity breadboard discharge power supply based on SKEP PPU requirements (appendix A), recent discharge supply investigations at GRC (appendix B and C), and recommendations from Task 1 accepted by GRC engineering staff. The Rev2 breadboard shall be assembled on a PCB. While part density, construction, and layout is expected to evolve between the Rev2 breadboard and the flight discharge supply design, the Rev2 breadboard should be of sufficient fidelity to identify packaging limits and associated engineering issues. Commercial-grade EEE parts can be used as long as they have similar functionality and performance as space-rated parts that can be used in higher TRL PPUs. Compatible space-rated EEE parts shall be identified. Analysis shall establish estimated differences in expected performance between the Rev2 breadboard and proposed design based on flight-qualified EEE components. Development trades shall favor simplicity and low recurring cost for flight power processing units over enhanced capabilities, and volume efficiency over mass efficiency. Electrical efficiency shall be maximized when the impact on recurring cost and PPU volume is moderate.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 004 | Rev2 discharge supply table-top review | 10/31/18 |
| 005 | Complete performance and functionality testing of Rev2 breadboard | 4/19/2018 (was 10/2/18) |
| 006 | Deliver Rev2 discharge supply breadboard | 4/30/19 (was 11/1/18) |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Rev2 discharge supply breadboard | 006 |

---

**Replaced milestone in 4.2.3**

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Rev2 discharge supply design package, including schematic | 004 |
| Test report, including recommendations for Phase 2 engineering model unit | 005 |
| ~~Discharge power supply specification~~ | ~~005~~ |

---

### 4.3 TASK 3: DEVELOP PRELIMINARY BREADBOARD AUXILIARY SUPPLY

The contractor shall develop a preliminary breadboard auxiliary power supply based on SKEP PPU requirements (appendix A). The breadboard auxiliary supply shall be assembled on a PCB. Commercial-grade EEE parts can be used as long as they have similar functionality and performance as space-rated parts that can be used in higher TRL PPUs. Compatible space-rated EEE parts shall be identified. Development trades shall favor simplicity and low recurring cost for flight units over enhanced capabilities, and volume efficiency over mass efficiency. Electrical efficiency shall be maximized when the impact on recurring cost and PPU volume is moderate.

### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 007 | Breadboard auxiliary supply table-top review | 7/3/18 |
| 008 | Complete performance and functionality testing of aux breadboard | 10/31/18 |
| 009 | Deliver preliminary auxiliary supply breadboard | 11/9/18 |

### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Auxiliary supply breadboard | 009 |

---

**Replace deliverable in 4.3.3**

### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Auxiliary supply design package, including schematic | 007 |
| Test report, including recommendations for Phase 2 engineering model unit | 008 |
| ~~Auxiliary power supply specification~~ | ~~008~~ |

---

### 4.4 Task 4: Preliminary Design, Space Claim, and Analyses for PPU Digital Control Interface Unit (DCIU)

The contractor shall develop a preliminary DCIU architecture consistent with SKEP PPU requirements (appendix A). Commercial-grade EEE parts can be assumed as long as they have similar functionality and performance as space-rated parts that can be used in higher TRL PPUs. Compatible space-rated EEE parts shall be identified. Development trades shall favor simplicity and low recurring cost for flight units over enhanced capabilities, and volume efficiency over mass efficiency. Electrical efficiency shall be maximized when the impact on recurring cost and PPU volume is moderate.

---

**Change date in 4.4.1**

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 010 | Preliminary DCIU table-top review | 12/18/19 |

---

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

---

Replace deliverables in 4.4.3

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Preliminary DCIU ~~design package, including schematic~~ architecture | 010 |
| ~~DCIU specification~~ | ~~010~~ |

---

Remove 4.5 Task

## ~~4.5 Task 5: Conduct PPU Preliminary Design Review~~

~~The contractor shall prepare required entrance documents for PPU PDR and the associated PPU PDR presentation package. The contractor shall conduct the PPU PDR. The PPU PDR may be conducted simultaneously with Thruster/Cathode and Feed System PDR if schedule coordination permits. Post-PDR, the contractor shall address any actions items and respond to any questions that may arise during the PPU PDR in order to successfully meet all PPU PDR exit criteria.~~

Remove 4.5.1 Milestones

### ~~4.5.1 Milestones~~

| ~~Milestone Number~~ | ~~Milestone~~ | ~~Date~~ |
|---|---|---|
| ~~011~~ | ~~Preliminary Design Review~~ | ~~11/1/18~~ |

Remove 4.5.2 Hardware/Software Deliverables

### ~~4.5.2 Hardware/Software Deliverables~~

| ~~HW/SW Deliverable~~ | ~~Milestone Number~~ |
|---|---|
| ~~N/A~~ | |

Remove 4.5.3 Document Deliverables

### ~~4.5.3 Document Deliverables~~

| ~~Document Deliverables~~ | ~~Milestone Number~~ |
|---|---|
| ~~Breadboard Electrical Schematics and Drawings~~ | ~~011~~ |
| ~~Breadboard Mechanical Drawings~~ | ~~011~~ |

| ~~Document Deliverables~~ | ~~Milestone Number~~ |
|---|---|
| ~~PDR Level Electrical Analyses~~ | ~~011~~ |
| ~~PDR Level Structural Analyses~~ | ~~011~~ |
| ~~PDR Level Thermal Analyses~~ | ~~011~~ |
| ~~PDR Level EEE Parts Stress~~ | ~~011~~ |
| ~~PDR Level WCA~~ | ~~011~~ |
| ~~PDR Level Materials~~ | ~~011~~ |
| ~~PDR Level Reliability~~ | ~~011~~ |
| ~~PDR Level Cost Analysis~~ | ~~011~~ |
| ~~Discharge Supply Specification~~ | ~~011~~ |
| ~~Auxiliary Supply Specification~~ | ~~011~~ |
| ~~DCIU Supply Specification~~ | ~~011~~ |
| ~~Path to Flight PPU Design Analysis~~ | ~~011~~ |
| ~~PPU PDR Presentation Package~~ | ~~011~~ |

### 4.6 Task 6: Thruster/Cathode Assembly Path to Flight Plan

In FY18, GRC will develop and demonstrate a laboratory model Thruster/Cathode assembly. In Phase Two, the contractor shall take over responsibility for manufacturing and assembly of the engineering model unit. In preparation, the contractor shall participate in Thruster/Cathode planning meetings at GRC. The contractor shall observe as necessary hardware assembly and testing when informative and appropriate. The contractor shall document vendors, materials, processes, and engineering challenges as useful to prepare for Phase Two manufacturing of the engineering model unit. The contractor shall make recommendations during design and planning meetings that may decrease product development and reoccurring costs and/or ease technology transfer to the contractor for production of the engineering and qualification units.

### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 012 | Table-top Review of Thruster/Cathode Path to Flight Plan | 4/30/19 (was 1/25/18) |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Thrust/Cathode and Feed System Path to Flight Plan | 012 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **DCIU** | **Digital Control Interface Unit** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **EEE** | **Electronic, Electrical, Electromechanical** |
| **FY** | **Fiscal Year** |
| **GRC** | **Glenn Research Center** |
| **NASA** | **National Aeronautics and Space Administration** |
| **PCB** | **Printed Circuit Board** |
| **PDR** | **Preliminary Design Review** |
| **PPU** | **Power Processing Unit** |
| **QM** | **Qualification model** |
| **RDR** | **Requirements Definition Review** |

| Acronym | Description |
|---|---|
| **SKEP** | **Sub-Kilowatt Electric Propulsion** |
| **SOA** | **State of the art** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **TD** | **Technology development** |
| **TRL** | **Technology Readiness Level** |

**SpaceDOC-2**
**DO-240 Plant Water Management (PWM)**
**For DO Period March 1, 2018 through September 30, 2021**
**For the Performance Period October 1, 2019 through September 30, 2021**

# 1 OVERVIEW

The Plant Water Management (PWM) effort is the first experiment of a planned follow-on program to investigate two phase fluid flows to support plant life in space. The PWM scope for this delivery order is intended to design and fabricate a plant water delivery method experiment for the International Space Station (ISS) Maintenance Work Area (MWA).

The PWM experiment intends to deliver multiple rapid-manufactured payload containing multiple fluid delivery method techniques. The techniques are intended to provide microgravity fluids data to inform the development of long-term plant habitats in space. The comparison of different fluid delivery and recovery methods is a component of an integrated Life-Sciences/Physical Sciences research effort into farming in space environments. This particular experiment is planned to help answer the question *"How can the delivery of nutrient rich water and oxygen to the root zones of plants be controlled in microgravity?" from Project Specific Documentation #4.*

Successful completion of the PWM experiment is expected to lead to the development of a long-term effort to enable plant growth in multiple gravity environments. This is in support of long term space habitats as detailed in NASA's Technology Roadmap and the most recent science Decadal Survey.

The contractor shall utilize readily available hardware or previously flown designs to the maximum extent possible and shall design and manufacture the PWM experiment hardware to be completed within the Maintenance Work Area (MWA). The MWA is desirable due to the availability or astronauts to interact with the equipment, necessary integration requirements, as well as the limited setup desired for this experiment. The contractor may, at contractor's own expense, propose alternative facilities if feasibility with previously flown hardware or commercial-off-the-shelf equipment can be demonstrated.

The contractor shall design, manufacture, verify, launch and operate the first two PWM modules (PWM-S01 and PWM-H01).

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2019 through September 30, 2021.

## 1.2 GOVERNMENT CONTACTS

1) Kelly Bailey / GRC Project Manager

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Documents (SRD)

3) Experiment Data Management Plan (EDMP)
4) "Key Gaps for Enabling Plant Growth in Future Missions" Section IV (Pre-Publication)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.
Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/Kelly Bailey, MS 77-7, Kelly.a.bailey@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Office Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06 (due at Delivery Order Definitization)
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING

5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

The following are GFE for this delivery order:

1) Arcellite Sample - completed
2) Plant Simulant - completed

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

1) Thermal Environmental Chambers in Building 333A
2) Structural Dynamics Laboratory
3) EMI Laboratory in Building 333A
4) GRC Acoustics Test Facility
5) GRC Telescience Support Center (TSC) and satellite facilities
6) Vibration Test Laboratory in Building 55
7) Zero G Facility
8) 2.2 Second Drop Tower
9) PWM Lab in Building 77 Room 55

# 4 PROJECT SPECIFIC SOW

## 4.1 Plant Water Management SOIL (PWM-S01) and HYDROPONICS (PWM-H01)

The contractor shall follow a modified version of the GRC 7130.5 project management instruction to complete the design portion of the PWM. The mission concept review shall consider the proper scope and risks associated with this project to meet the proposed timeline.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 5 | Mission Integration and Operations | August 2021 (was 8/2020, 8/2019) |
| 6 | Delta ORR | July 2021 |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Completed Operations and experiment data turned over to PI | 5 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **ADP** | **Acceptance Data Package** |
| **CDR** | **Critical Design Review** |
| **CDRL** | **Contract Data Requirements List** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **EDMP** | **Experiment Data Management Plan** |
| **GFE** | **Government Furnished Equipment** |
| **GFF** | **Government Furnished Facilities** |
| **GRC** | **Glenn Research Center** |
| **ISS** | **International Space Station** |
| **MCR** | **Mission Concept Review** |
| **MIUL** | **Materials Identification and Usage List** |
| **MUA** | **Materials Usage Agreement** |
| **MWA** | **Maintenance Work Area** |
| **NASA** | **National Aeronautics and Space Administration** |
| **ORR** | **Operations Readiness Review** |
| **PSR** | **Pre-Ship Review** |
| **PWM** | **Plant Water Management** |
| **PWM-H** | **Plant Water Management - Hydroponics** |
| **PWM-S** | **Plant Water Management - Soil** |
| **RDR** | **Requirements Definition Review** |
| **SCR** | **Science Concept Review** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **TSC** | **Telescience Support Center** |

**SpaceDOC-2 NNC14CA02C**
**DO-241 Microgravity Wind Tunnel (MWT)**
**For DO Period April 15, 2018 through September 30, 2019**
**Performance Period April 15, 2018 through September 30, 2019**

# 1 OVERVIEW

This delivery order is for developing the Microgravity Wind Tunnel (MWT) for the ISS Microgravity Science Glovebox (MSG). The primary purpose of the proposed wind tunnel would be fire research. For fire research, NASA currently tests materials for flammability using NASA STD-6001 Test 1, which is a normal gravity upward burning test. Unfortunately, recent testing has shown that this test may not be conservative for some materials that burn better in microgravity under spacecraft ventilation flow conditions. This MWT order is intended for design and fabrication of a flight unit within 3 years.

## 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from April 15, 2018 through September 30, 2019.

## 1.2 GOVERNMENT CONTACTS

1) Lauren Brown / GRC Project Manager

## 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) Project Plan
2) Science Requirements Document (SRD)
3) Experiment Data Management Plan (EDMP)

# 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/Lauren Brown, MS 77-7, lauren.brown@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Project Office (Andrew Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Program Manager, Physical Science Research, (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov)

Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan per DID# PM-06 (due at Delivery Order Definitization)
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

The following are GFE for this delivery order:

1) None

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Thermal Environmental Chambers in Building 333A
2) Structural Dynamics Laboratory
3) EMI Laboratory in Building 333A
4) GRC Acoustics Test Facility
5) GRC Telescience Support Center (TSC) and satellite facilities
6) Vibration Test Laboratory in Building 55
7) Zero G Facility
8) 2.2 Second Drop Tower

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# 4 PROJECT SPECIFIC SOW

## 4.1 MICROGRAVITY WIND TUNNEL (MWT) CONCEPTING AND BREADBOARDING

The MWT breadboard shall be developed, tested, and operated by the contractor. Successful completion of the MWT breadboard is expected to lead to the development of a flight unit. This is in support of multiple fire safety objectives in low oxygen environments as detailed in NASA’s Technology Roadmap.

The contractor shall design and manufacture the MWT breadboard hardware to be completed as laboratory grade**.** The concept should assume that it will be operated by astronauts and should be setup and torn down quickly.

The contractor shall complete a lifecycle cost estimate for the entire MWT experiment assuming use of the MSG and based on the preliminary schedule provided.

The contractor shall define requirements based on the science requirements document (preliminary provided). The contractor shall follow the project management requirements of ISS-PLN-001 Rev B, ISS-SEMP, Table 8-4, as agreed by contractor and government for a Class D payload instead of an ISS facility, to complete the design portion of the MWT. The Systems Requirements Review (SRR) shall consider the proper scope and risks associated with this project to meet the proposed timeline.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| | | |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| | |
| | |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Procedures (OP-06) (DRAFT UPON CLOSEOUT) | |
| System Requirements Document (R-01) (DRAFT UPON CLOSEOUT) | |
| Concept of Operations Document (OP-09) (DRAFT UPON CLOSEOUT) | |

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## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **CCR** | **Configuration Change Request** |
| **CDRL** | **Contract Data Requirements List** |
| **DID** | **Data Item Description** |

| | |
|---|---|
| **DO** | **Delivery Order** |
| **EDMP** | **Experiment Data Management Plan** |
| **EMI** | **Electromagnetic Interference** |
| **GFE** | **Government Furnished Equipment** |
| **GRC** | **Glenn Research Center** |
| **ISS** | **International Space Station** |
| **MSG** | **Microgravity Science Glovebox** |
| **MWT** | **Microgravity Wind Tunnel** |
| **NASA** | **National Aeronautics and Space Administration** |
| **PDR** | **Preliminary Design Review** |
| **PRACA** | **Preventive and Corrective Action** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **Science Requirements Document** |
| **SRR** | **System Requirements Review** |
| **STD** | **Standard** |
| **TSC** | **Telescience Support Center** |

# SPACEDOC-II NNC14CA02C DO- 243
# SCAN PROGRAM STRATEGIC PLAN DEVELOPMENT (SCAN-PSPD)
# DO PERFORMANCE PERIOD OCTOBER 1, 2018 THROUGH SEPTEMBER 30, 2021
# FOR THE PERFORMANCE PERIOD OCTOBER 1, 2019 THROUGH SEPTEMBER 30, 2021

## 1 OVERVIEW

The NASA Space Communications and Navigation (SCaN) program is developing the next generation open architecture for civilian space communications and navigation. The future architecture and system components must be flexible to meet dynamically changing needs between investments in operations (e.g., to lower cost) and development (i.e., to infuse new and emerging technologies). The resultant architecture must be affordable as well as sustainable within a flat or decreasing budget environment.

SCaN's architecture—the organization of its systems and their relationships to one another—is in the midst of an exciting transformation that will enable its systems to meet the data-intensive requirements of the ever-increasing population of the United States' space-bound missions. Leveraging NASA's prior investments in SCaN's infrastructure, the services provided by the SCaN Program are evolving to become more flexible and easier to scale to meet mission user demand. The architecture is designed to accept the rapid infusion of new technologies and to capitalize on the efficiency and capability of the United States' commercial satellite communications (COMSATCOM) industry to provide the optimal services to NASA missions. SCaN must now begin to develop the implementation strategy to begin achieving instantiation of the architectural vision.

This task requires the contractor to have extensive programmatic and strategic experience involving NASA's space network.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2019 through September 30, 2021.

### 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager,
2) SCaN Program Integration Manager

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) SCaN Program Plan (PP)
2) SCaN Systems Requirements Document (SRD)
3) SCaN Architecture Description Document (ADD)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for

review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.
Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Jacquelynne Houts, Mail Stop 142-3, Jacquelynne.houts@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer ( Elizabeth Morales, Mail Stop 60-1, elizabeth.a.morales@nasa.gov)
Contracting Officer's Representative, ISS & Human Health Office (Kelly Bailey, Mail Stop 77/7, Kelly.a.bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Program Manager, Monica Willbond, Mail stop 162-8, **monica.n.brasee@nasa.gov**
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

**Not Applicable**

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

**Not Applicable**

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# 4 PROJECT SPECIFIC SOW

## 4.1 SCaN Commercialization Strategy

This task will be to provide input as requested on the programmatic/technical documents and plans to assist the NASA SCaN program in the development of its strategic plan. The contractor will provide the expertise to assist in the development of this strategic plan as needed. This task is intended to be performed from October 1, 2018 through September 30, 2021.

The contractor shall:

A. Support SCaN Program Office updates to the SCaN PCA Program Plan and Program Management Plan, as requested
B. Provide technical and programmatic support to the SCaN Chief Engineer for technical forums, as requested
  1. Participate in Adhoc meetings and reviews, as requested
  2. Develop supporting documentation as requested
C. Participate in meetings at NASA headquarters as required to support and present items A through C, as requested.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Provide monthly status meetings with the NASA Technical Representative to include discussion of the following topics:<br>a. Top Level Technical Performance/Accomplishments<br>b. Near Term Activities<br>c. Risks and Mitigation Strategies<br>d. Problems/Issues and Concerns<br>e. Schedules<br>f. Budget and Projection on when contract funds will run out. | Monthly |

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| None | Not Applicable |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Inputs/drafts of assigned documentation as assigned. | 1 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **ADD** | **Architecture Description Document** |
| **CCR** | **Configuration Change Request** |
| **CDRL** | **Contract Data Requirements List** |
| **COMSATCOM** | **Commercial Satellite Communication** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **GRC** | **Glenn Research Center** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PCA** | **Program Commitment Agreement** |
| **PP** | **Program Plan** |
| **PRACA** | **Preventive and Corrective Action** |
| **PSPD** | **Program Strategic Plan Development** |
| **SCaN** | **Space Communications and Navigation** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-2** |
| **SRD** | **System Requirements Document** |

# SpaceDOC-2 NNC14CA02C
# DO- 245 Lunar Solar Cell Demonstration Platform (LSCDP)
# For the Performance Period May 1, 2019 through September 30, 2019

## 1 OVERVIEW

A demonstration platform for solar cells and solar array arc detection for flight on a future lunar lander. The platform includes state-of-the-art and next-generation solar cells along with a small array of solar cells with NASA-developed arc detection and mitigation circuitry. This demonstration will validate the performance of these devices on the lunar surface, raising the Technology Readiness Level (TRL) of these technologies and enhance performance models for future power generation systems.

The schedule requests for final platform delivery no later than December 31, 2019. The Assembly and Integration contractor is requested to design, fabricate and functionally test data acquisition and communications electronics and the solar cell test platform following the requirements provided.

### 1.1 Period of Performance

The period of performance for this delivery order is from May 1, 2019 through September 30, 2019.

### 1.2 Government Contacts

1) GRC project manager, Fred Elliott (MT00)
2) Co-Principal Investigator, Jeremiah McNatt (LEX0)
3) Co-Principal Investigator, Timothy Peshek (LEX)
4) Co-Principal Investigator, Norman Prokop (LCS)
5) Co-Principal Investigator, Michael Krazowski (LCS)

### 1.3 Available Project Specific Documentation

| | |
|---|---|
| 1) 2x2cell holder NSCAP710 | Specification for holder for 2cm x 2cm cells |
| 2) 4x8cell holder NSCAP710 | Specification for holder for 4cm x 8cm cells |
| 3) 8x8cell holder NSCAP710 | Specification for holder for 8cm x 8cm cells |
| 4) Solar Cell Demo Platform Proposal specifics | Document containing integration and testbed |
| 5) Astrobotic – Payload User Guide lander | Environmental and interface document for lunar |

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR. Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Project Manager, Jeremiah McNatt, LEX/Photovoltaics and Electrochemical Systems Branch, MS 302-1, jmcnatt@nasa.gov, Glenn Research Center, Cleveland, OH 44135
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

**Deliver courtesy copies of cover letter only to:**

Contracting Officer (Melissa Merrill, Mail Stop 60-1, melissa.a.merrill@nasa.gov )
Contracting Officer's Representative, ISS & Human Health Office (Andrew C Suttles Mail Stop 77/7, andrew.c.suttles@nasa.gov and Alternate COR Nancy R Hall nancy.r.hall@nasa.gov)
Program Manager, Fred Elliott, MT/Space Technology Project Office, MS 162-8, Frederick.w.elliott@nasa.gov
Program Manager, Physical Science Research, SpaceDOC-2 (Kelly Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov )
Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

1) Solar Cells mounted into NSCAP holders described below

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

N/A

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# 4 PROJECT SPECIFIC SOW

## 4.1 Develop and Deliver Solar Cell Testbed for demonstration on Lunar Lander Mission

Design, manufacture and deliver two (2) Solar Cell Testbed platforms (flight and spare) to be delivered to GRC for testing and integration into a lunar lander. Each platform includes six (8cm x 4cm) and two (2cm x 2cm) solar cell assemblies and one 8cm x 8cm solar cell string (all cells provided by GRC conforming to the dimensions specified in the Applicable Documents mounted to a machined aluminum plate not to exceed 5mm thickness secured to the top surface of a coated aluminum honeycomb core by corner connection points. Electrical assemblies will be mounted to the bottom surface. Design, manufacture, and deliver one (1) mounting bracket to attach the platform to a lunar lander as specified in the Applicable Documents.

### 4.1.1 Tasks

#### *4.1.1.1 Mechanical Design / Fab*

Develop thermal model of the platform for the determination of component temperatures including solar cells and typical electrical components during operation on the lunar surface. Refer to Thermal Environment section of Astrobotic Payload Users Guide.

Develop stack bolt pattern with consideration for solar cell assemblies on top surface and electrical components on back surface.

Develop universal bracket which shall hold the platform and provide a mounting surface which can be mounted the lander (TBD for when lander specifications are determined). Astrobotic Payload Users Guide referenced for first design. ICD to be provided when available. Appropriate hinging and release mechanism included as needed by design.

#### *4.1.1.2 Electrical Fab*

Upon receipt of build of materials (BOM) and printed wiring assembly (PWA) layout, procure components as BOM, procure circuit boards, populate circuit boards, and deliver to GRC for functional testing.

#### *4.1.1.3 Build/Assemble Testbed*

Complete wiring drawings, design aluminum plate for solar cell to honeycomb mounting, Receive accepted PWAs from GRC and solar cell assemblies. Mount solar cells to plate, conformal coat PWAs and mount PWAs to rear surface of aluminum honeycomb, solder all wiring according to plan. Inspect PWA for workmanship. Attach mounting bracket and send to GRC for acceptance testing.

#### *4.1.1.4 Engineering Support*
Provide continued support after delivery including any corrective action as determined by failure during testing. Provide support for integration to lander as needed.

### 4.1.2 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Design Review | No later than 8/30/2019 |
| 2 | Turnover platform and mounting bracket for Acceptance Testing | * No later than 11/30/2019 |
| 3 | Final Delivery of the 2 Solar Cell Testbed platforms and 1 mounting bracket to GRC | * No later than 12/31/2019 |

### 4.1.3 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Two (2) Solar Cell Testbed platforms to be delivered to GRC | * 3 |
| All electronic drawings | * 2, 3 |
| One (1) Solar Cell Testbed platform mounting bracket | * 3 |

### 4.1.4 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Monthly reports of technical and financial status | N/A |
| Design review package | 1 |

| Document Deliverables | Milestone Number |
|---|---|
| Certificate of conformance according to inspection criteria | * 2 |
| Description and interface documentation of the Solar Cell Testbed platform. Deliver to GRC. | * 2 |

*** Items are outside DO period of performance end date.**

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **BOM** | **Build of Materials** |
| **CDRL** | **Contract Data Requirements List** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **GRC** | **Glenn Research Center** |
| **ICD** | **Interface Control Document** |
| **LSCDP** | **Lunar Solar Cell Demonstration Platform** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **NSCAP** | **Near Space Characterization of Advanced Photovoltaics** |
| **PWB** | **Printed Wire Board** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **TBD** | **To Be Determined** |
| **TRL** | **Technology Readiness Level** |

**SpaceDOC-2 NNC14CA02C**
**DO-246 Microgravity Wind Tunnel-2 (MWT)-2**
**For DO Period October 1, 2020 through September 30, 2021**
**Performance Period October 1, 2020 through September 30, 2021**

# 1 OVERVIEW

This delivery order is for the development of the Microgravity Wind Tunnel (MWT) for the ISS Microgravity Science Glovebox (MSG). The MWT consists of a low speed wind tunnel facility and associated equipment, which can accommodate large fuel samples for flammability testing. The primary initial purpose is spacecraft fire safety and combustion research. The facility will provide the baseline hardware and software infrastructure to support a range of investigations, which may include investigation specific expansion hardware that can operate in a "plug and play" fashion.

NASA currently tests materials for flammability using NASA STD-6001 Test 1, which is a normal gravity upward burning test. However, recent testing has shown that this test may not be conservative for some materials that burn better in microgravity under spacecraft ventilation flow conditions. Test 1 samples are 5 or 20 cm wide and 30 cm long and have a 15 cm maximum burn length passing criteria. Existing ISS wind tunnel hardware, based on the highly successful Smoke Point in Co-flow Experiment (SPICE) duct is too small to accommodate applicable samples, so there is currently no way to directly perform comparable tests in microgravity. The goal of MWT is to fill this gap.

The supported microgravity fire research investigations will provide critical data needed to validate numerical models of fire behavior and a critically needed assessment of the conservatism of normal gravity flammability test methods. It will also enable a significantly new understanding of fire growth and materials flammability in microgravity for practical size samples.

## 1.1 Period of Performance

The period of performance for this delivery order is from October 1, 2020 through September 30, 2021.

## 1.2 Government Contacts

The contractor shall have access to consultation with:

1) GRC Project Manager
2) MWT Project Scientist
3) Principal Investigators for MWT experiments

## 1.3 Available Project Specific Documentation

1) Science Requirements Document (SRD)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests.

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/Lauren Brown, MS 77-7, lauren.brown@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov )

Deliver courtesy copies of cover letter only to:

Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1, **elizabeth.a.morales@nasa.gov**
Contracting Officer's Representative (COR), ISS & Human Health Project Office (Kelly A. Bailey, Mail Stop 77/7, kelly.a.bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77-7, robert.r.corban@nasa.gov )

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan per DID# PM-06 (due at Delivery Order Definitization)

3) Contractor Financial Management Reporting, per DID# CD-01
4) Monthly reporting, per DID# CD-02
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12
6) Lessons Learned Report per DID PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

The following are GFE for this delivery order:

1) MWT Breadboard Unit

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Thermal Environmental Chambers in Building 333A
2) Structural Dynamics Laboratory
3) EMI Laboratory in Building 333A
4) GRC Acoustics Test Facility
5) Vibration Test Laboratory in Building 55
6) GRC Telescience Support Center (TSC) and satellite facilities
7) Zero G Facility
8) 2.2 Second Drop Tower

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# 4 PROJECT SPECIFIC SOW

## 4.1 MICROGRAVITY WIND TUNNEL (MWT)

The MWT system shall be designed, tested, and operated by the contractor. The MWT system shall consist of an Engineering Model, Flight Unit, Trainer Unit, and Spares. The MWT Science Requirements Document (SRD) will be specified by GRC, and the MWT system is expected to support of multiple fire safety objectives in low oxygen environments as detailed in NASA's Technology Roadmap.

The contractor shall define requirements based on the MWT SRD, which will be provided by GRC. The contractor shall follow the project management requirements of ISS-PLN-001 Rev B, ISS-SEMP, Table 8-4, as agreed by contractor and government for a Class D payload instead of an ISS facility, to complete the design portion of the MWT.

The contractor shall design and manufacture the MWT system to be operated in the MSG on the ISS. The system is expected to be operated by astronauts and should be setup and torn down quickly.

The contractor shall complete a lifecycle cost estimate for the entire MWT system assuming use of the MSG and based on the preliminary milestone schedule provided in Table 4.1.

### 4.1.1 Milestones and Reviews

Table 4.1. MWT Milestone Reviews

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Kickoff | October 2020<br><br>Complete |
| 2 | Mission Concept Review (MCR) | May 2021<br>(was 4, 3, 1/2021)<br>Complete |
| 3 | Systems Requirements Review (SRR) | August 2021<br>(was 6/2021)<br>CANCELLED |
| 4 | Preliminary Design Review (PDR) | January 2022*<br><br>CANCELLED |
| 5 | Critical Design Review (CDR) | January 2023*<br><br>CANCELLED |
| 6 | System Acceptance Review (SAR) | October 2024*<br><br>CANCELLED |
| 7 | Termination Review | September 2021 |

* Date is past current POP end date.

The contractor shall provide regularly scheduled meetings/reporting with the NASA Project Manager for the following:

a) Weekly technical status meetings with the NASA Project Manager.
b) Monthly budget and schedule reporting that will include:
   i. Top Level Technical Performance/Accomplishments
   ii. Near Term Activities/Upcoming Events
   iii. Problems/Issues/Risks and Mitigation Strategies
   iv. Schedule status (to include a Critical Path Schedule and percent complete for all tasks)
   v. Status and planned completion dates for the milestones listed in Table 4.1 and Table 4.2.
c) Technical status meetings with the NASA Project Manager and the NASA Project Scientists, as needed.

d) Monthly Risk Status meetings.

The contractor shall support the major MWT Project Reviews to include:

a) Provide draft review packages a minimum of two weeks prior to the review, along with supporting documentation, unless otherwise specified under technical direction of the NASA PM.

### 4.1.2 Hardware/Software Deliverables

Table 4.2. Hardware Deliverables

| Hardware Deliverables | Milestone Number |
|---|---|
| MWT Engineering Unit (CANCELLED) | 5 * |
| MWT Flight Unit (CANCELLED) | 6 * |
| MWT Trainer (CANCELLED) | 6 * |
| MWT Spares (CANCELLED) | 6 * |

* Date is past current POP end date.

Software deliverables shall be prepared, documented, and delivered in compliance with the Contract Data Requirements List (CDRL), contract Attachment J2, if applicable.

Table 4.3. Software Deliverables

| Software Deliverables | Milestone Number |
|---|---|
| Software Version Description Document (VDD) (CANCELLED) | 6 * |
| Updated Software Management Plan (CANCELLED) | 6 * |
| Final Software Development Plan (CANCELLED) | 6 * |
| Final Software Requirement Spec (CANCELLED) | 6 * |
| Final SW CM Plan (CANCELLED) | 6 * |
| Final SW Design Document (CANCELLED) | 6 * |

* Date is past current POP end date.

### 4.1.3 Document Deliverables

Document deliveries shall be prepared, documented, and delivered in compliance with the Contract Data Requirements List (CDRL), if applicable.

The contractor shall provide the following documents:

1. Contractor Work Plan, per DID PM-06 within 30 days of contract start
2. Submit a Monthly Task Report in accordance with DID CD-03
3. Lessons Learned Report per DID PA-17 (yearly)
4. Non-Conformance Report action plans (as required, non-deliverable; available for surveillance)
5. GSE supporting documentation (as required)

| Document Deliverables | Milestone Number |
|---|---|
| Supporting documentation (specifications, drawings, test procedures, analysis/test reports, and operating/maintenance manuals, as applicable) for the hardware deliverables identified in Hardware Deliverables. (CANCELLED) | 6 * |
| Verification Reports on Manifested Hardware (NASA Concurrence required, by Pre-Ship Review except for packaging) (DRAFT DUE UPON CLOSEOUT) | 6 * |
| Acceptance Data Packages for delivered flight hardware to NASA (CANCELLED) | 6 * |
| MWT Documentation per SpaceDOC II SOW 4.7.3 for the SAR (PSR) (CANCELLED) | 6 * |
| Trade Study: Plug-n-Play: COTS? Custom Interface? Standards? "Reserve Inputs/Outputs, Analog & Digital"- What are the options? (DRAFT UPON CLOSEOUT) | 2 |
| Trade Study: Could a GUI system be developed that could be operated from ground or on-orbit? (DRAFT UPON CLOSEOUT) | 2 |
| Trade Study: Mechanical Interface - ways to decrease crew time (DRAFT UPON CLOSEOUT) | 2 |
| Trade Study: Airflow Measurement Techniques Push vs Pull Airflow (DRAFT UPON CLOSEOUT) | 2 |
| Experimentation with MWT 1 Bread Board (DRAFT UPON CLOSEOUT) | 2 |
| Trade Study: Existing ISS/MSG Cameras vs. TBD COTS Camera (DRAFT UPON CLOSEOUT | 2 |
| Preliminary Hazard Assessment (DRAFT UPON CLOSEOUT) | 2 |
| Trade Study: Crew Command vs. Ground Command Powered Operations. (or provide capability for both?) (DRAFT UPON CLOSEOUT) | 3 |
| Trade Study: Window Material options (DRAFT UPON CLOSEOUT) | 3 |
| Trade Study: Soot removal and filtration options (DRAFT UPON CLOSEOUT) | 3 |

| Document Deliverables | Milestone Number |
|---|---|
| Trade Study: Sensor - what kind of O2, CO2, Airflow, Humidity sensors? Small? Replaceable? (DRAFT UPON CLOSEOUT) | 3 |
| Trade Study: Reuse and /or augmentation of MWT 1 Bread Board (DRAFT UPON CLOSEOUT) | 3 |

* Date is past current POP end date.

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| CCR | Configuration Change Request |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| COTS | Commercial Off The Shelf |
| DID | Data Item Description |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| EMI | Electromagnetic Interference |
| GFE | Government Furnished Equipment |
| GRC | Glenn Research Center |
| GUI | Graphical User Interface |
| ISS | International Space Station |
| MCR | Mission Concept Review |
| MSG | Microgravity Science Glovebox |
| MWT | Microgravity Wind Tunnel |
| NASA | National Aeronautics and Space Administration |
| NPR | NASA Procedural Requirement |
| PDR | Preliminary Design Review |
| PRACA | Preventive and Corrective Action |
| SAR | System Acceptance Review (formerly Pre-Ship Review) |
| SEMP | Systems Engineering Management Plan |
| SpaceDOC-II (2) | Space Flight Systems Development and Operations Contract-2 |
| SPICE | Smoke Point in Coflow Experiment |
| SRD | Science Requirements Document |
| SRR | System Requirements Review |
| STD | Standard |
| TBD | To Be Determined |
| TSC | Telescience Support Center |

# SPACEDOC-2 NNC14CA02C
# DO-247
# ELECTRO-MOTIVE DROP TOWER (EMDT)
# FOR THE PERFORMANCE PERIOD MAY 1, 2020 THROUGH NOVEMBER 30, 2020

## 1 OVERVIEW

For more than 40 years, the NASA Glenn Research Center has been a world leader in low gravity research. The Zero Gravity Research Facility (ZGF) is a world-class test facility, which has supported this research. In operation since 1966, more than 5000 drops have been conducted in the facility supporting the development of space technologies, space experiments, and basic research. The ZGF provides a high quality low gravity environment, with gravity levels on the order of 1/100,000th of the Earth's gravity. The low gravity environment lasts for 5.18 seconds as the drop vehicle containing the experiment hardware free falls 433 ft. in a vacuum. The vacuum chamber resides in a 509-foot deep, concrete lined shaft, 28.5 ft. in diameter. NASA desires to improve the ZGF, increasing test throughput, low gravity duration, and providing intermediate gravity levels, such as lunar and Martian gravity. The concept is similar to what has been built at Leibniz University in Hannover Germany. The feasibility of constructing an Electro-Motive Drop Tower (EMDT) in the ZGF shaft has been studied extensively during the past few years. The rail guided, linear motor driven EMDT concept shows promise for nearly doubling the facility test time, increasing facility test throughput by an order of magnitude, and offering the possibility of performing tests in alternate gravity levels. The design, production, and operation of a prototype EMDT is required to provide proof of concept and to address risks to the EMDT operation identified in previous Concept Studies and Special Studies performed by Jacobs and NASA.

This particular delivery order focuses specifically on the design of the payload structure that will ride within the drop vehicle. Initial design/analysis tasks have been identified in Section 4 below; however, future tasks including hardware development may be added as information is obtained from these preliminary tasks and as the primary infrastructure project progresses.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from May 1, 2020 through November 30, 2020.

### 1.2 GOVERNMENT CONTACTS

1) GRC Project Manager, Dan Brown (MSI)

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

N/A

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review

and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.
Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, MSI/ Dan Brown, MS 77/7, Daniel.F.Brown@nasa.gov
Configuration Management Office, (Joan Emmett, Mail Stop 77-7, Joan.B.Emmett@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer (Melissa Merrill, MS 60/1, Melissa.A.Merrill@nasa.gov)
Contracting Officer's Representative, ISS & Human Health Office (Kelly Bailey, Mail Stop 77/7, Kelly.A.Bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Program Manager, Physical Science Research, SpaceDOC-2 (Kelly Bailey, Mail Stop 77/7, Kelly.A.Bailey@nasa.gov)
Chief, ISS and Human Health Project Office (Robert Corban, Mail Stop 77/7, Robert.R.Corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01
4) Monthly reporting, per DID# CD-02
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12
6) Lessons Learned Report per DID PA-17

# 3 GOVERNMENT FURNISHED

## 3.1 Government Furnished Equipment (provided in accordance with 52.245-5)

N/A

## 3.2 Government Furnished Facilities

The Government shall make available on an as needed basis the following Government facilities:

N/A

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# 4 PROJECT SPECIFIC SOW

The sub-sections that follow (4.1-4.4) contain tasks that will aid in the advancement of the EMDT project, in particular as it pertains to the payload frame design and payload mechanical interface to the drop vehicle. The facility requirements listed in Appendix A are included to provide a greater understanding of the high-level system objectives. These requirements are not intended to be verified within the scope of this SOW; however, these requirements may be used as preliminary design inputs to carry out the tasks where applicable.

## 4.1 Kick Off Meeting

A kickoff meeting will take place to bring ZIN up to speed with the state of the EMDT effort. The meeting will describe the proposed modifications to the ZGF, the programmatic objectives of the large-scale project, and the work that has been performed to date. The meeting will also review the initial tasks defined in this SOW.

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Kickoff Meeting | May 1, 2020 |

## 4.2 Conceptual Design of Payload Structure

This task will consist of a review of the existing payload frame design used in the current ZGF and developing a conceptual design of a payload frame for the proposed facility upgrade. The existing design can be used as a basis for the new design, but with the proposed removal of the facility's vacuum chamber, the payload frame size will grow to accommodate larger payloads (see Appendix A for payload target volume). The design shall be captured in a data package including, at a minimum, a solid model representation, preliminary structural analysis, and experiment attachment scheme. The design shall be discussed at a Technical Interchange Meeting at the conclusion of the effort.

ZIN should optimize the design such that a wide variety of experiment types and configurations are accommodated. The combustion drop rig, “combustion tunnel,” in Building 110 supporting Sandy Olson’s research can be used as a reference for large-scale payloads. Note that some drop payloads (for example, the combustion tunnel) require experiment pressures below one atmosphere and currently rely on the vacuum environment in the drop chamber. Removal of the chamber means that alternate sources of vacuum must be explored including onboard vacuum pumps.

A full-scale mock-up of the payload frame shall be constructed to aid in discussions and planning for the future facility upgrade.

#### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 2 | Technical Interchange Meeting (TIM) to Review Payload Frame Conceptual Design | November 18, 2020 |

#### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Mock-up of payload frame | 2 |

#### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Payload Frame Conceptual Design Package | 2 |

### 4.3 Payload In-Flight Dynamics and Vibration Isolation

While in low-gravity trajectories, the payload will be floating and mechanically isolated from the vehicle structure. However, for partial-gravity trajectories and during the transition from launch to low-g, the payload will be mechanically coupled to the vehicle. ZIN shall analyze the behavior of the payload due to disturbances transmitted through the vehicle and develop techniques for minimizing payload disturbances. ZIN shall also investigate the influence of payload center of gravity and vehicle disturbances on payload rotation.

Results of analyses and discussion of design solutions shall be documented in a Preliminary Dynamics Analysis for EMDT Payloads and discussed at the TIM. This document deliverable can be combined with the Payload Frame Conceptual Design Package if convenient.

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 2 | Technical Interchange Meeting (TIM) to Review Preliminary Dynamics Analysis | November 18, 2020 |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Preliminary Dynamics Analysis for EMDT Payloads | 2 |

### 4.4 Design of Payload Re-Centering Device

For low-g trajectories – when the payload is floating – it may drift from the centerline of the drop axis to the extent that after successive launches/drops without re-centering, the payload may come in contact with the vehicle structure. Therefore, ZIN shall explore design concepts for automatically re-centering the payload between launches/drops without the need for human intervention.

Design concepts for the re-centering device shall be delivered in a Design Concept for Payload Re-Centering document and discussed at the TIM. This document deliverables can be combined with the Payload Frame Conceptual Design Package if convenient.

#### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 2 | Technical Interchange Meeting (TIM) to Review Re-Centering Device | November 18, 2020 |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Design Concept for Payload Re-Centering | 2 |

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## 5 ACRONYM LIST

Acronym List

| Acronym | Description |
|---|---|
| **CDRL** | **Contract Data Requirements List** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **EMDT** | **Electro-Motive Drop Tower** |
| **GRC** | **Glenn Research Center** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **SOW** | **Statement of Work** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **TIM** | **Technical Interchange Meeting** |
| **ZGF** | **Zero Gravity Facility** |

# APPENDIX A PRELIMINARY FACILITY REQUIREMENTS

1) *Reduced Gravity Duration:* The time from which the payload g-level achieves the target test level to when the g-level exceeds the error bounds on the g-level shall exceed 8 seconds, with greater durations significantly desired.
2) *Reduced Gravity Quality:*
   - Low-Gravity Quality: The g-level quality shall be less than or equal to the upper bound necessary for fundamental physics experiments (defined below) for frequencies from 0.2 Hz to 100 Hz. This environment must be achieved one second after transition from launch to low-gravity. Options to provide improved g-levels are encouraged.

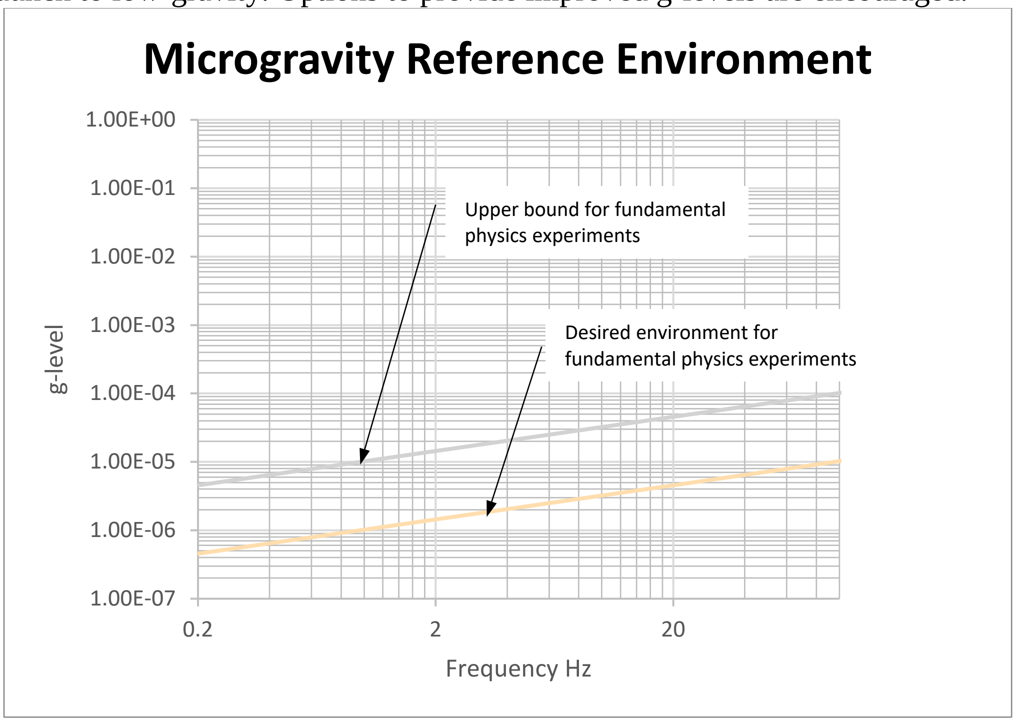


Figure 1 – Microgravity Reference Environment

   - Partial-Gravity Quality: The facility shall repeatably provide test gravitation levels from 0.01 g to 0.500 g (0 to 30 Hz) with a precision and accuracy of 0.01 g. Higher precision is strongly desired.
3) *Drop/Launch Frequency:* The facility shall be designed such that one researcher and one test operator are able to install a payload into the vehicle, prepare for the test, conduct the test, and recover the payload from the vehicle within 15 minutes without additional help or exceeding the strength requirements for typical office work.
4) *Payload Mass:* The facility shall accommodate a typical payload mass of 455 kg (total vehicle mass with payload approximately 1000 kg). The ability to increase this mass is desired.
5) *Transition from Launch to Reduce-Gravity:* The system shall be designed with a baseline average launch acceleration of 4 g (peak of 6g) with abrupt transition to low gravity. Options such as extended 2 g launch (for ~7-second test time) and sigmoidal transition to low-gravity are strongly desired. This will enable biological payloads and payloads that are sensitive to free surface stability.

6) *Complexity of Operations:* The system shall be designed so that one test operator plus one researcher can perform test and recover payload. The researcher will be an expert in their payload, but shall not be required to perform critical facility functions.
7) *Variable Acceleration:* It is desired to be able to operate the facility at more than one acceleration level during a test (e.g. starting at 1/6 g and switching to 0-g after 5 seconds).
8) *Magnetic and Electrical Fields:* The electric and magnetic field strength inside the vehicle enclosure shall be below 1 Gauss with a variation of less than 0.1 G during the test.
9) *Safety/Fall Protection:* The facility shall have OSHA compliant inherent safety systems including (but not limited to) facility power loss and personnel fall protection.
10) *Telemetry:* The facility shall not preclude the use of wireless communication between launched payload and control room for video/data transmission.
11) *Payload Volume:* The launch vehicle shall accommodate payloads 3.5’ length x 3.5’ width x 6’ height.
12) *Vehicle Deceleration:* The facility shall employ a reusable deceleration method (i.e. magnetic braking and/or compressed air) as opposed to using life-limited materials such as polystyrene beads.

# SPACEDOC-2 NNC14CA02C
# DO-249 THREAD
# TRANSLATING HUMAN RESEARCH PROGRAM (HRP) RESEARCH AND EVIDENCE INTO ACTIONABLE DELIVERABLES (THREAD)
# CONTRACT PERFORMANCE PERIOD AUGUST 1, 2020 THROUGH SEPTEMBER 30, 2021
# DO PERFORMANCE PERIOD AUGUST 1, 2020 THROUGH SEPTEMBER 30, 2021

## 1 OVERVIEW

The mission of the NASA Human Research Program's (HRP) Exploration Medical Capabilities (ExMC) Element is to advance medical system design and risk-informed decision-making for exploration beyond low earth orbit to promote human health and performance in space. ExMC seeks to mitigate adverse health outcomes and decrements in performance due to inflight medical conditions by using Model Based Systems Engineering (MBSE) tools to create a medical system requirements foundation and Probabilistic Risk Assessment (PRA) tools to conduct optimization trade studies. The MBSE and PRA tools require input data consisting of medical evidence, medical capability requirements, and a mapping between the two. The medical evidence provides information on medical conditions that could occur during spaceflight, the likelihood of the conditions occurring and the impact of their occurrence on the medical outcome risk metrics of Quality Time Lost (QTL), Loss of Crew Life (LOCL) and Removal to Definitive Care (RTDC). Medical capabilities refer to the components that may be part of a medical system, such as infrastructure, medical resources and knowledge, which are used to manage a variety of physiological conditions that could occur. The mapping between medical evidence and capabilities provides information about the effect that resource availability will have on the consequence of experiencing a medical condition.

The ExMC IMPACT Tool Suite houses the database containing the medical evidence, the medical capabilities and the mapping between the evidence and capabilities, the Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT), which is a PRA optimizer, the MBSE medical system requirements foundation model, the integration between tools, and post-processing visualization tools. IMPACT is a data-driven, risk-informed approach to inform the definition of a medical system for NASA's planned deep-space missions to the moon and Mars. It allows for the selection of what to include in a spaceflight medical system based upon minimization of medical risk. The IMPACT Tool Suite is an ecosystem of computational decision support tools that allows execution of this quantitative approach. The IMPACT project informs human health and performance risk mitigation efforts during resource constrained exploration mission development.

HRP's ExMC Element has been at the forefront of the HRP program when it comes to the development of decision support projects, although these efforts have traditionally focused only on exploration medical systems, as described above. In fiscal year 2020, ExMC began to envision a decision support tool that encompasses the entire Crew Health and Performance (CHP) system in addition to the medical system. The CHP system is part of the habitat system within space vehicles. It consists of several domains including wellness support, environmental protection, task performance, as well as the medical system. The HRP project that will strive to incorporate the CHP system into the ExMC decision support projects is called THREAD

(Translating HRP Research and Evidence into Actionable Deliverables). The objective of THREAD will be to data mine HRP risk reduction research.

Tasks associated with achieving THREAD objective will include the review of HRP research and project information located within the HRP evidence reports, the NASA Biological and Physical Sciences Division and Human Research Program (formerly known as "Space Life & Physical Sciences Research & Applications Division") Task Book entries, Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) contract awards and reports, the Human Research Roadmap Configuration Management System (HRRCMS), the NASA Life Sciences Data Archive (LSDA) and the Lifetime Surveillance of Astronaut Health (LSAH) databases, HRP analog model documentation, journal articles and other sources containing information. This information will be categorized into at least one of four categories and for incorporation into: 1) An update to NASA Standards and Reference (S&R) documents; 2) The IMPACT tool; 3) A CHP Requirements Foundation; 4) An HRP Technology Repository. Once categorized, additional tasks will include:

1. Development and population of a THREAD database to hold information about the HRP research and project information that has been reviewed.
2. Development of Concept of Operations (ConOps) scenarios describing THREAD will review HRP research and evidence and categorize it in a way that is actionable for groups within the program
3. Development of information in support of HRP's CHP MBSE system foundation (not part of THREAD) that can be used to inform future vehicle and/or mission operational requirements.

This Delivery Order (DO) focuses on THREAD project tasks to be conducted during the period of performance and those tasks have been identified in Section 4 below.

### 1.1 Period of Performance

The period of performance for this DO is from August 1, 2020 through September 30, 2021.

### 1.2 Government Contacts

1) NASA Glenn Research Center (GRC) Project Manager, Robyn Atkins (MSX)

### 1.3 Available Project Specific Documentation

N/A

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic Country Clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have

successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests

## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, (MSX/Robyn D. AtkinsAtkins, MS 142/2,
**robyn.d.atkins@nasa.gov** )
Configuration Management Office, (Joan Emmett, Mail Stop 77-7,
Joan.B.Emmett@nasa.gov)

**Deliver courtesy copies of cover letter only to:**

Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1,
**elizabeth.a.morales@nasa.gov**
Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, Kelly.A.Bailey@nasa.gov ) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov )
Program Manager, GRC Human Research Program, (Kelly Gilkey, Mail Stop 77/7,
Kelly.M.Gilkey@nasa.gov)
Chief, Exploration Systems Office (Nicole Smith, Mail Stop 162:321-14,
nicole.smith@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path and shall be updated biweekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01
4) Monthly reporting, per DID# CD-02

# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

- NASA-provided computer systems (laptops via the NASA NEST contract) including Microsoft Teams and Microsoft SharePoint capabilities
- NASA-provided MagicDraw, Teamwork Cloud, and Cameo Requirements Modeler software licenses
- NASA GRC GitLab
- NASA Amazon Web Services (AWS)

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

N/A

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# 4 PROJECT SPECIFIC SOW

This effort is to provide engineering services in support of the design, development, analysis, and concept assessment, as well as engineering support for various risk mitigation activities for the Human Research Program's (HRP) THREAD Project. The sub-sections that follow (4.1-4.1.12) contain tasks that will aid in the advancement of the THREAD project.

### 4.1.1 THREAD Methods Development

The initial THREAD Methods Development Task will be to form a THREAD team. The THREAD team shall consist of members who possess the skills necessary to complete the work outlined in this DO. The following engineering disciplines are required on the THREAD team: 1) Engineers, including various discipline engineers such as biomedical, software, and systems engineers; 2) Scientists, including various disciplines such as human performance, human behavior, human physiology, experimental, data and computer; 3) Technical writer.

Systems engineers should have the ability to develop an engineering ConOps, trade study scenarios, develop use cases, and develop Model-based Systems Engineering (MBSE) models using MagicDraw, Teamwork Cloud/Server, and Cameo Requirements modeler.

Software engineers should be skilled in decomposing functions into performance actions, developing mathematical functions, data mining, developing relational databases in MySQL and MongoDB, developing Python-based Application Program Interfaces (APIs) to connect web-based user interfaces to databases and analysis capabilities, developing web applications using modern frameworks including AngularJS, ReactJS, TypeScript, JavaScript, HTML, and CSS, develop software requirements, provide software configuration management using the NASA GRC GitLab tool, including familiarity with DevOps, Continuous Integration/Continuous

Deployment (CI/CD) pipelines, integration testing using git runners, and containerization, and be experienced in Amazon Web Services cloud architecture development within the NASA environment.

Biomedical engineers should be able to interpret results from experimental studies and determine application methods and link study interpretations to risk reduction strategies, and link study interpretations to evidence databases.

All documents delivered for THREAD shall follow the THREAD Configuration Management Plan. THREAD documents shall use THREAD naming nomenclature: ConOps (THREAD-CONOPS-001), THREAD Implementation Plan (THREAD-PLN-002), THREAD Feedback Summary Report (THREAD-RPT-00X), THREAD Software Test Plan (THREAD-PLN-003), THREAD Software Compliance Matrix (THREAD-DOC-002), THREAD Interface Document (THREAD-DOC-001) and shall use the NASA template in place for consistency across project documentation. The NASA THREAD Project Manager (PM) shall be designated as an "approved by" signatory and the NASA THREAD Project Scientist (PS) as a "concurred by" signatory also for consistency across project documentation.

To comply with NASA and federal government cyber and data security standards, ZIN shall complete all work for THREAD on NASA-provided computer systems only. NASA is responsible for the costs of the NASA-provided laptops; **ZIN is not responsible for the costs of the NASA-provided computer systems.**

### 4.1.2 Concept of Operations (ConOps)

A THREAD ConOps shall be developed during the THREAD Pilot Project (FY21). The THREAD ConOps shall contain HRP risk mitigation scenarios, CHP performance scenarios, integration activities and functions and decomposition of the activities and functions into performance actions. The ConOps shall identify the types of resources associated with the CHP system domain, alternative types of resources associated with the HRP risk solution, performance outcome metrics, strategies for mapping of CHP system domain resources to the performance outcome metrics and cost function definition for trade studies. The THREAD ConOps will also serve as the basis for developing software requirements for IMPACT and MEDPRAT. A baseline version of the THREAD ConOps will be developed during FY21. The THREAD ConOps shall use the NASA HRP ExMC document template and apply the NASA Systems Engineering Handbook outline for a Concept of Operations where applicable for the THREAD project.

ZIN shall develop scenario and use case MBSE models in NASA MagicDraw and Teamwork Cloud. NASA is responsible for the costs of the software licenses for NASA MagicDraw, Teamwork Cloud, and Cameo Requirements modeler on NASA-provided computer systems. **ZIN is not responsible for the costs of these software licenses.** The ConOps and all MBSE models shall follow the NPR 7123.1C NASA Systems Engineering Requirements and the NASA Systems Engineering Handbook (2016 or newest version) for concepts of operation development and all MBSE efforts. The THREAD team will be expected to continuously update their tasks within the NASA GitLab Kanban board and participate in the stand-up meetings and development cycle planning sessions. Lessons learned from ZIN team members shall be captured continuously throughout the period of performance using the NASA GRC GitLab Kanban board.

#### 4.1.3 Implementation Plan

This task shall also include the development of a THREAD Implementation Plan. The plan shall contain:

1. Documentation of the feedback collected during the stakeholder meetings (feedback summary reports, section 4.1.1) that ZIN is invited to attend; when not participants, NASA will provide the feedback to ZIN to integrate into the feedback collection.
2. Inclusion and prioritization criteria for HRP research and project information content.
3. Inclusion and prioritization criteria for scenarios and trade studies.
4. Definition and prioritization of the HRP research and project information that will be targeted.
5. Definition of the CHP domains associated with the HRP areas that will be targeted.
6. An outline of the steps that will be taken to action the HRP research and project information.
7. Burn rate of research and evidence review and categorization described in "HRP Research and Evidence (R&E) Review and Categorization" section

The Implementation Plan shall define how the Concept of Operations will be implemented.

#### 4.1.4 THREAD Configuration Management System (CMS)

ZIN shall set up a configuration managed system based on the previously delivered THREAD Configuration Management Plan (CMP) for the THREAD database and THREAD documentation using the NASA GRC GitLab tool for software configuration management, NASA Teamwork Cloud for MagicDraw MBSE model configuration management, and the NASA Microsoft (MS) Teams and MS SharePoint tools for document configuration management.

#### 4.1.5 HRP Research & Evidence (R&E) Review and Categorization

The THREAD team shall review the HRP evidence reports, NASA Biological and Physical Sciences Division and Human Research Program (formerly known as "Space Life & Physical Sciences Research & Applications Division") Task Book entries, SBIR/STTR contract awards and reports, the HRRCMS, LSDA and LSAH databases, HRP analog model documentation, journal articles and other sources containing information associated with the high priority HRP topic areas outlined in the THREAD Implementation Plan. Deliverable shall be captured in an Excel spreadsheet(s) until the THREAD User Interface & Database is available (and then capture in UI and Database) for all the data points collected during the review.

During FY21 the THREAD Actioning Activities will focus on reviewing 550+ projects that encapsulate the ExMC research and project information and some select information from other HRP elements. The FY21 effort will be called the FY21 THREAD Pilot Project.

The THREAD database shall be populated by defining the information that was reviewed, an interpretation of the information, which category (S&R, IMPACT, CHP System Foundation, or HRP Technology Repository) within which it will be actioned and how it corresponds to the domains within the CHP system. Citation and source location information shall be collected along with the information so that the information can be traced back to its source.

THREAD will be managed in an Agile-like manner. The THREAD task will include establishing a THREAD Kanban board using the NASA GRC GitLab tool. The THREAD team will be expected to continuously update their tasks within the NASA GitLab Kanban board and participate in the stand-up meetings and development cycle planning sessions at least once a week. The THREAD team shall keep track of the amount of time necessary for actioning the information in order to develop an actioning rate. This rate shall be documented in the THREAD Implementation Plan and used to determine the amount of content that will be targeted for actioning by the THREAD team.

ZIN shall categorize the HRP Research & Evidence into one (or more) of four categories: 1) Standards & References updates; 2) CHP IMPACT trade analyses requirements; 3) CHP System Foundation Model Input; or 4) HRP Technology Repository; Deliverable shall be captured in the GRC Gitlab Kanban board for Research & Evidence using issue tags. Additional categorization tags may be defined through the Agile process and used to categorize the R&E.

#### 4.1.6 Interim FY 21 THREAD Pilot Project Presentation

For the Interim Presentation, ZIN shall deliver the following information as an update on the FY21 THREAD Pilot Project Activities, including:

- THREAD's Research and Evidence (R&E) identification and prioritization strategy
- Recommendations on updates to NASA standards and references based on the research and evidence review and categorization
- Number of R&E projects reviewed and categorized through the due date for the presentation
    - Type of information collected during the R&E review
    - Targeted end users
    - Recommendations on how to action the information collected
- THREAD's database structure, capabilities, and features implemented by the end of June
- Update on the THREAD ConOps development efforts
- Example scenarios and use cases based on the research and evidence reviewed and categorized
- Identification of potential trade and risk metrics
- Feedback summary reports to date of the interim presentation deliverable
- Lessons learned summary as of the Interim Presentation deliverable date

#### 4.1.7 THREAD User Interface (UI), Application Program Interface (API), and Database (DB), Versions 0.5

The THREAD Methods Development Task shall also include development of a database that contains a record of all of the HRP research and project information that is reviewed, an interpretation of the information, within which category (S&R, IMPACT, CHP System Foundation, or HRP Technology Repository) it will be actioned and how it corresponds to the domains within the CHP system. The database shall include a User Interface (UI) for easy data entry. The THREAD team will be expected to continuously update their tasks within the NASA

GitLab Kanban board and participate in the stand-up meetings and development cycle planning sessions. Lessons learned from ZIN team members shall be captured continuously throughout the period of performance using the NASA GRC GitLab Kanban board.

The THREAD web application shall consist of a user interface (UI), application program interface (API), and the THREAD database (DB). The database shall be developed using MySQL. The API shall be developed using Node.js and/or Python. The UI shall be developed using Typescript, AngularJS, JavaScript, HTML, and CSS. The THREAD web application shall be developed and hosted in the NASA Amazon Web Services (AWS) and ZIN shall develop the architecture for the web application in the cloud environment based on lessons learned from HRP CMR. NASA is responsible for the costs of operating the NASA AWS cloud services. **ZIN is not responsible for the NASA AWS cloud services costs.**

ZIN shall provide software configuration management using the NASA GRC GitLab tool for the THREAD web application, including the implementation of DevOps, Continuous Integration/Continuous Deployment (CI/CD) pipelines, static code and integration testing using git runners, containerization, and releases/versioning. A user manual, including version descriptions, shall be developed within the THREAD web application.

At the beginning of the v0.2 development cycle, ZIN shall develop user interface mockups and functional workflows for the concept of the web application. NASA will review the mockups prior to full development moving forward. ZIN shall deliver monthly version releases (0.2, 0.3, 0.4, 0.5), at a minimum, through the end of the performance period, culminating in the release of a fully functional THREAD Version 0.5. Monthly version releases shall include bug fixes, security patches, code updates, testing results, and agile-based updates to the previously released version. A "fully functional" THREAD version 0.5 shall include the following capabilities and features:

**THREAD Version 0.5** shall consist of the ability to enter (write) and display from the database (read), update, and archive the following high-level datapoints from the HRP Research and Evidence review and categorization activities:

- THREAD Project Metadata including the following high-level data categories and all of the associated subcategories: Project Information, NASA Standards & References, Crew Health and Performance (CHP) System Foundation Model, CHP IMPACT Trade Analyses, HRP Technology Repository, Specialized Information, and data source, access, and security.
- A reference manager capability in American Psychology Association (APA) 7 format for capturing R&E references to source information, sharing references among users, and the ability to associate those references to the HRP R&E being reviewed categorized.

### 4.1.8 Risk Management

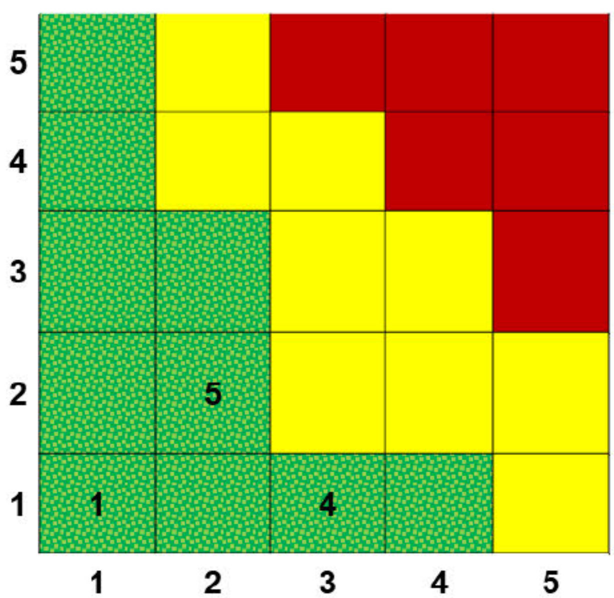
The THREAD Methods Development task will also include developing and maintaining a THREAD schedule and practicing continuous risk management by tracking risks in NASA's Risk Management Implementation Tool (RMIT) and conducting monthly risk management meetings. ZIN shall provide detailed risk charts in MS PowerPoint following the monthly risk management meetings. The risk charts shall capture the THREAD risks using the following format:

The table below provides the summary of both open and closed risks for the project. A Likelihood shall be included for all risks. The “Risk Classification” shall describe the consequences if the risk is realized. Only the classifications that apply to the specific risk need to have a consequence value.

| **Risk ID #** | **L x C Score** | **Title** | **L** | **Risk Classification** | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | **CC** | **S** | **Cst** | **HSE** | **T** |
| ID# | # x # | Open Risk Name | | | | | | |
| **Closed Risks** | | | | | | | | |
| ID# | **# x #** | Closed Risk Name | | | | | | |

CC = Center Capability, S = Schedule, Cst. = Cost, HSE = Health, Safety, Environment, T = Technical

**Risks shall be captured in the below risk matrix:**




Detailed risk charts shall be captured in the following format:

| **Last Month** | **Current Month** | **Risk Statement** | |
|---|---|---|---|

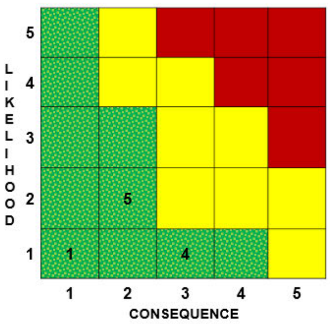
| **L x C** | **L x C** | | **FY21 Cost ($M)** |
|---|---|---|---|
| | | | |

| |
|---|
| **Scoring Rationale:** |
| **Likelihood:** **Consequence: 4** **Risk Owner:** |
| **Impact:** |

| **Task No.** | **Task Description** | **Actionee** | **ECD** | **ACD** | **Resulting L x C** | **Success Criteria** |
|---|---|---|---|---|---|---|
| 1 | | | | | | |

Below are screenshots of these tables in a PowerPoint for reference on how the monthly risk charts shall be delivered. NASA will provide ZIN with an editable template for this deliverable.

## Risk Summary
As of 03/26/2021




**Risk Classification Key**

- **CC** = Center Capability
- **S** = Schedule
- **Cst** = Cost
- **HSE** = Health, Safety, Environmental
- **T** = Technical

| Risk ID # | L x C Score | Title | L | Risk Classification CC | S | Cst | HSE | T |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **Closed Risks** | | | | | | | | |
| 1 | 1 x 1 | Scope Definition | 1 | | 1 | 1 | | |
| 4 | 1 x 3 | Reluctant Stakeholders | 1 | | 3 | | | |
| 5 | 2 x 2 | Direction from Stakeholders | 2 | | 2 | | | 2 |
| 8 | 2 x 2 | Centralized Data, Single Point Failure | 2 | | 2 | | | 2 |
| 2 | 2 x 2 | Data Conflicts | 2 | | | | | 2 |
| 9 | 1 x 4 | Security Level | 1 | | | | | 4 |
| 10 | 1 x 3 | Cloud Solution | 1 | | | | | 3 |
| 11 | 2 x 2 | Team Information Overload | 2 | | 2 | | | |
| 12 | 1 x 2 | Agile Methodology | 1 | | 2 | | | |
| 13 | 1 x 4 | Resource Availability | 1 | | 4 | 3 | | 4 |
| 6 | - | [Duplicate of Stakeholder Engagement] | | | | | | |
| 7 | - | [Disapproved risk] | | | | | | |

6

## ExMC/THREAD
Risk details as of 05/18/2021

| Last Month L x C | Current Month L x C | Risk Statement | FY21 Cost ($M) |
|---|---|---|---|
| 2x4 | 1x1 | THREAD-01: Given the project scope is still being defined; there is a possibility that the final budget and schedule estimates are significantly off. | |

**Scoring Rationale:** The project is still in the early stages of definition.

**Likelihood: 2** **Consequence: 4** **Risk Owner: Robyn Atkins**

**Impact:**

| Task No. | Task Description | Actionee | ECD | ACD | Resulting L x C | Success Criteria |
|---|---|---|---|---|---|---|
| 1 | Stakeholder Register | A. Poluse | 1/29/21 | 1/29/21 | 3x4 | Stakeholder list in the CONOPS |
| 2 | Vision diagrams, ExMC stakeholders have a clear vision | R. Atkins | 1/29/21 | 1/29/21 | 2x4 | Updated roadshow presentation |
| 3 | Consistent communication to and from stakeholders | R. Atkins<br>B. Lewandowski | | | 2 x 2 | Ongoing |
| 4 | Discussions on scope for PPBE23 to refine scope and expectations | R. Atkins<br>B. Lewandowski | 5/19/21 | 5/12/21 | 1 x 1 | Confirmed expectations for stakeholders and interfaces for THREAD with ExMC Leadership; PPBE23 costs and expectations as of May 2021 discussed. |

### 4.1.9 Monthly HRP SpaceDOC Meeting

ZIN shall deliver a Delivery Order phasing plan for HRP/ZIN Monthly meeting broken down by WBS with DO planned costs, actual costs, forecast costs, variances, upcoming deliverables, and team member changes that occurred during the reporting month.

### 4.1.10 Lessons Learned

Lessons learned from ZIN team members shall be captured continuously throughout the period of performance using the NASA GRC GitLab Kanban board.

### 4.1.11 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Monthly HRP SpaceDOC Meeting | Monthly, 5 days following 533 submission |
| 2 | Monthly Risk Management Charts | Third Friday of every month |
| 3 | HRP Research & Evidence Review and Categorization | Weekly |
| 4 | THREAD version 0.2 | June 18, 2021<br><br>COMPLETED |
| 5 | THREAD version 0.3 | July 2, 2021<br><br>COMPLETED |
| 6 | THREAD version 0.4 | July 30, 2021<br><br>COMPLETED |
| 7 | THREAD version 0.5 | August 27, 2021 |
| 8 | MBSE ConOps v1.0, Section 4.1.2 | September 10, 2021 Carried Forward |

### 4.1.12 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| HRP Research & Evidence Review, Section 4.1.5 | 3 |
| HRP Research & Evidence Categorization, Section 4.1.5 | 3 |
| THREAD Configuration Management System, Section 4.1.4 | 4 COMPLETED |
| Monthly THREAD web application updates, Section 4.1.7 | 4, 5, 6, 7 |

| HW/SW Deliverable | Milestone Number |
|---|---|
| MBSE ConOps v1.0, Section 4.1.2 | 8 |
| | |

### 4.1.13 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Delivery order phasing plan for HRP/ZIN Monthly meeting, Section 4.1.9 | 1 |
| Risk Management Charts, Section 4.1.8 | 2 |
| Feedback Summary Reports (THREAD-RPT-00X), Section 4.1.1 | 2 |
| Lessons Learned, Section 4.1.10 | 3 |
| Draft Concept of Operations (ConOps) (THREAD-CONOPS-001), Section 4.1.2 | 5<br><br>COMPLETED |
| Draft THREAD Implementation Plan (THREAD-PLN-002), Section 4.1.3 | 5<br>COMPLETED |
| Interim FY21 THREAD Pilot Project Presentation, Section 4.1.6 | 5<br><br>COMPLETED |
| | |
| | |

# 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| **API** | **Application Programming Interface** |
| **CCR** | **Configuration Change Request** |
| **CDRL** | **Contract Data Requirements List** |
| **CHP** | **Crew Health and Performance** |
| **CI/CD** | **Continuous Integration/Continuous Deployment** |
| **ConOps** | **Concept of Operations** |
| **DB** | **Database** |
| **DID** | **Data Item Description** |
| **DO** | **Delivery Order** |
| **eCC** | **electronic Country Clearance** |
| **ExMC** | **Exploration Medical Capability** |
| **GRC** | **Glenn Research Center** |
| **HRP** | **Human Research Program** |
| **HRRCMS** | **Human Research Roadmap Configuration Management System** |
| **ISS** | **International Space Station** |
| **LOCL** | **Loss of Crew Life** |
| **LSAH** | **Longitudinal Study of Astronaut Health** |
| **LSDA** | **Life Science Data Archive** |
| **MBSE** | **Model-Based System Engineering** |
| **MEDPRAT** | **Medical Extensible Dynamic Probabilistic Risk Assessment Tool** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NPR** | **NASA Procedural Requirement** |
| **PM** | **Project Manager** |
| **PRA** | **Probabilistic Risk Assessments** |
| **PS** | **Project Scientist** |
| **QTL** | **Quality Time Lost** |
| **RMIT** | **Risk Management and Information** |
| **RTDC** | **Removal to Definitive Care** |
| **S&R** | **Standards and References** |
| **SBIR** | **Small Business Innovative Research** |
| **SBU** | **Sensitive But Unclassified** |
| **SpaceDOC-II (2)** | **Space Flight Systems Development and Operations Contract-II (2)** |
| **STTR** | **Small Business Technology Transfer** |
| **THREAD** | **Translating HRP Research and Evidence into Actionable Deliverables** |
| **UI** | **User Interface** |

# SPACEDOC-2 NNC14CA02C
# DO-253 SAFFIRE VII AND VIII
# SPACECRAFT FIRE SAFETY DEMONSTRATION (SFS DEMO) PROJECT VII AND VIII
# FOR THE PERFORMANCE PERIOD OCTOBER 1, 2020 THROUGH OCTOBER 29, 2021

## 1 OVERVIEW

During PPBE23 in March 2021, the development of the Saffire VII and VIII flight experiment was cancelled. Work was to transition to end no later than September 30, 2021. . The text in this mod remains unchanged but the milestones and deliverables are adjusted to implement this transition. The intent is to end this DO on September 30, 2021.

The Spacecraft Fire Experiment (Saffire) is being developed by the Spacecraft Fire Safety Demonstration (SFS Demo) Project at NASA-GRC. The purpose of this experiment is to close spacecraft fire safety capability and knowledge gaps associated with material flammability, fire detection, fire suppression, and post-fire clean-up for NASA's exploration vehicles. Saffire-I, II, and III were developed to investigate large-scale flame spread and material flammability limits in long duration low-gravity. Saffire-IV, V, and VI continued to investigate these phenomena as well as address additional objectives such as flame growth/dynamics, fire detection, post-fire cleanup, post-fire monitoring and modeling of fire scenarios in a spacecraft. Saffire VII and VIII will investigate these same phenomena but add demonstration of fire suppression and burning a different medium, anticipated to be laptops and battery cartridges. The SFS Demo Project is funded by the Advanced Exploration Systems (AES) Division within the Human Exploration and Operations Mission Directorate (HEOMD) at NASA Headquarters (HQ). These experiments will be conducted onboard the Northrop Grumman Innovation System (NGIS)'s Cygnus vehicle after it un-berths from the International Space Station (ISS) and before it begins destructive re-entry. The experiment is operated from the NGIS Mission Control Center in Dulles, VA by a team of GRC and NGIS personnel.

### 1.1 PERIOD OF PERFORMANCE

The period of performance for this delivery order is from October 1, 2020 through October 29, 2021.

### 1.2 GOVERNMENT CONTACTS

The contractor shall have access to consultation with:

1) Gary A. Ruff – Spacecraft Fire Safety Demonstration Project Manager
2) Thomas Acquaviva – Spacecraft Fire Safety Demonstration Resource Manager
3) David L. Urban – Saffire Principal Investigator
4) David Carek, - Saffire Chief Engineer
5) George Santosuosso – Saffire Lead Systems Engineer

### 1.3 AVAILABLE PROJECT SPECIFIC DOCUMENTATION

1) SFSDP2-PLN-003: Spacecraft Fire Safety Demonstration Project Plan
2) SFSDP2-REQ-001: Experiment Science Requirements Document (ESRD)

3) SFSDP2-PLN-005: System Engineering Management Plan (SEMP)

### 1.4 Foreign Travel

For any foreign program travel related to this contract, the Contractor shall comply with NASA Procedural Requirements (NPR) 9710.1, chapter 7 entitled Foreign Travel. The Contractor shall submit all foreign travel requests to the cognizant GRC Foreign Travel Coordinator for review and approval a minimum of four weeks before the planned departure date, so that an electronic country clearance (eCC) can be obtained. The applicable program, project, agreement and/or contract should be referenced in the supporting documentation included with the request. Prior to commencing any official program foreign travel, Contractor employees shall also have successfully completed High Threat Security Overseas Training described in section 7.2 of the NPR.

Information about attending High Threat Security Overseas Training and paperwork required for travel submission can be found by contacting your Center Foreign Travel Coordinator. Travel will not be approved without completion of the required training, receipt of a country clearance, and submittal of any other supporting documentation as described in the NPR. Consult with the Contracting Officer or Foreign Travel Coordinator for additional information regarding review/approval of foreign travel requests

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## 2 DOCUMENT DISTRIBUTION

Document deliveries shall be prepared, documented, and delivered in compliance with Sections 1.3 through 1.7 of the Contract Data Requirements List (CDRL), contract Attachment J2.

Documentation electronic copy, applicable hard copy, and required cover letter shall be delivered to:

Task Manager, Exploration Systems Project Office (Thomas Acquaviva, Mail Stop 162-7, thomas.h.acquaviva@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Spacecraft Fire Safety Demonstration Configuration Management Lead, (Kelly Hall, Mail Stop 162-7, kelly.l.hall@nasa.gov)

SpaceDOC Configuration Management Office, (Joan Emmett, Mail Stop 77-7, joan.b.emmett@nasa.gov)

Deliver courtesy copies of cover letter only to:

Contracting Officer, Elizabeth A. Morales, Mail Stop 60-1, **elizabeth.a.morales@nasa.gov**

Contracting Officer's Representative, ISS & Human Health Project Office (Kelly A. Bailey Mail Stop 77-7, kelly.a.bailey@nasa.gov) and Alternate COR (Nancy R. Hall Mail Stop 77-7, nancy.r.hall@nasa.gov)

Program Manager, Exploration Systems Project Office (Gary A. Ruff, Mail Stop 162-7, gary.a.ruff@nasa.gov, NASA Glenn Research Center, Cleveland, OH 44135)

Chief, ISS and Human Health Project Office (Robert R Corban, Mail Stop 77-7, robert.r.corban@nasa.gov)

Standard document deliverables shall be as follows:

1) Baseline schedule for execution of task deliverables, due no later than 30 days following DO initiation. The schedule shall include the critical path, and shall be updated weekly.
2) Delivery Order Work Plan (technical, schedule, and cost information) per DID# PM-06
3) Contractor Financial Management Reporting, per DID# CD-01, ON-GOING
4) Monthly reporting, per DID# CD-02, ON-GOING
5) Problem Report and Corrective Action (PRACA) Report, per DID# PA-12, ON-GOING
6) Lessons Learned Report per DID# PA-17

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# 3 GOVERNMENT FURNISHED

## 3.1 GOVERNMENT FURNISHED EQUIPMENT (PROVIDED IN ACCORDANCE WITH 52.245-5)

Items delivered from DO-220 (Saffire I, II, III, IV, V, VI)

1) Ground Support Equipment (GSE) from DO-220, potentially includes but not limited to the following:
   a) Cygnus PXI chassis (emulator) with laptop,
   b) Cygnus Simulator,
   c) Lifting fixtures,
   d) Development Computers,
   e) GDU and associated parts,
   f) Misc. tools for hardware assembly,
   g) Test support tools and equipment, including hardware located in Building 110, Room 117.
2) Misc. Flight hardware and launch support equipment including hardware associated with the flight computer systems, FFD, remote sensors, and flow chamber;
3) Other NASA Center equipment:
   a) JSC CPM, Smoke Eater, $CO_2$ Scrubber, fire extinguisher, and supporting hardware.
4) Other items as may be needed.

## 3.2 GOVERNMENT FURNISHED FACILITIES

The Government shall make available on an as needed basis the following Government facilities:

1) Usage Elective: Thermal Environmental Chambers in Bldg. 333A
2) Usage Elective: Structural Dynamics Laboratory, (SDL).
3) Usage Elective: Electromagnetic Interference (EMI) Laboratory.
4) Usage Elective: Instrumentation Shop
5) Usage Elective: Saffire Imaging Lab (Bldg. 77, Room 154)

### 3.3 GOVERNMENT FURNISHED SOFTWARE

The Government shall make available the ground and flight software in the time frame documented and agreed to in the Integrated Master Schedule. This includes specialized flight-like software for performing the environmental tests.

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## 4 STATEMENT OF WORK – GENERAL

The text in this section remains the same but the milestones and deliverables have been updated to reflect the intent to end this DO on September 30, 2021.

The contractor will provide engineering, design, fabrication and test support to the SFS Demo project for the development and delivery of Saffire-VII and VIII as well as flight operations. The specific activities are sub-divided into a series of tasks that support hardware and software engineering, systems engineering and integration, configuration management, and safety and mission assurance of the SFS Demo project. These subtasks will be defined, revised, or removed as necessary throughout the different phases of the SFS Demo project. Initially, the contractor shall support the science team's identification and refinement of the engineering/science requirements by designing and developing bench-top hardware (breadboards) and rigs for laboratory and/or low-gravity ground-based testing, if needed. The concept developed during the first phase of the project will identify subsystems that address the project objectives and identify the key high-risk development areas. Engineering feasibility issues shall be identified based on the project requirements and include: identification of fundamental capabilities required to meet project objectives, assessment of technical viability based on current industry capabilities, and assessment of the engineering and diagnostic methods utilized in previous Saffire flight systems. Subsystem and component tests will be performed to reduce project risks and inform the final design of flight systems. Later phases of the project will focus on the final design, fabrication, and assembly of the Saffire flight hardware followed by environmental and functional tests. The flight system will be delivered with all documentation that demonstrates closure of engineering, safety, ISS, and NGIS requirements, except those that can only be closed during integration with the NGIS Cygnus vehicle.

The Spacecraft Fire Safety Demonstration Project has been instructed by AES that these Saffire experiments should be ready to launch on the Cygnus vehicle planned for FY24. The timing of the launches is heavily dependent on the readiness and launch of the commercial crew vehicles to the ISS and the increased trash that must be removed from ISS as a result of the larger number of crew onboard. To increase the flexibility of the

Saffire experiments to respond to anticipated changes in the launch schedule, the Saffire-VII and VIII hardware are to be completed in parallel to the greatest extent possible. A single System Acceptance Review should be planned for these two units with an initial Phase 3 Flight Safety Review for Saffire-VII and separate series/re-flight Phase 3 Flight Safety Reviews for Saffire-VIII at the appropriate interval prior to flight.

The contractor shall regularly report progress for approval of designs and implementation prior to completion of the tasks.

**Applicable Documents:**

SFSDP2-REQ-TBD: Spacecraft Fire Safety Demonstration Flight VII and VIII Experiment Science Requirements

SFSDP2-PLN-003: Spacecraft Fire Safety Demonstration Project Plan

SFSDP2-PLN-005: Systems Engineering Management Plan

GRC ISS-PLN-001, NASA GRC International Space Station Systems Engineering Management Plan

NASA-STD-8739.1 Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies

**Reference Documents:**

NPR 7120.5E, NASA Space Flight Program and Project Management Requirements

NPR 7123.1B, NASA Systems Engineering Processes and Requirements

NPR 7150.2A Software Engineering Requirements

SFSDP2-PLN-004: Configuration and Data Management Plan

SFSDP2-PLN-006: Safety and Mission Assurance Plan

SFSDP2-PLN-008: Software Management and Development Plan

SFSDP2-PLN-009: Software Configuration Management Plan

SFSDP2-PLN-010: Software Requirements Management Plan

SFSDP2-PLN-011: Software Assurance Plan

SFSDP2-PLN-013: Software Test Plan

### 4.1 SUBTASK A – SAFFIRE CONCEPT DEVELOPMENT, PRELIMINARY, AND FINAL DESIGN TASK

Saffire VII and VIII were cancelled as of March 2021. The subtask description has not changed but the milestones and deliverables have been adjusted to end this DO on September 30, 2021.

The primary focus of this subtask will be to design and analyze the hardware for the Saffire series of experiments. The contractor shall work with the engineering and science teams to develop the final design for the Saffire Flow Unit (SFU) including the flow duct and avionics bay, the Far-Field Diagnostic (FFD), and the Remote Sensors (RS).

The AES Division has authorized the Spacecraft Fire Safety Demonstration project team to develop the concept, preliminary design and final design for two additional flight systems, Saffire-VII and VIII. These experiments would be complete demonstrations of a spacecraft fire scenario including ignition, fire growth, detection, suppression, and cleanup. The hardware for these experiments are planned to be similar to Saffire-IV-VI with minimal changes. During this period of performance, the NASA Science Team will be developing requirements for Saffire-VII and VIII. The Contractor is requested to address capabilities of the current flight system relative to its ability to perform tests required in Saffire-VII and VIII.

The Contractor should prepare for and conduct the following reviews no later than the dates specified below:

1) Saffire-VII and VIII System Preliminary Design Review (PDR)
2) Saffire-VII and VIII System Critical Design Review (CDR)

### 4.1.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| 1 | Prepare a conceptual design for the Saffire-VII and VIII flight system that meets the preliminary science requirements | September30, 2021 (was 6, 2/2021) |
| ~~2~~ | ~~Conduct a system level Mission Concept Review (MCR)~~ | ~~July 31, 2021 (was 3/2021)~~ Deleted |
| ~~3~~ | ~~Conduct a system Level Preliminary Design Review (PDR) (outside of the Period of Performance)~~ | ~~February 28, 2022 * (was 7/2021)~~ Deleted |
| ~~4~~ | ~~Conduct a system level System Requirements Review (SRR) (outside of the Period of Performance)~~ | ~~November 30, 2021 *~~ Deleted |
| 5 | Complete fabrication and testing of the water spray fire extinguisher Engineering Unit | September 30, 2021 |
| 6 | Complete design of laptop battery circuit | September 30, 2021 |

*** Items are outside DO period of performance end date.**

### 4.1.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| Water spray fire extinguisher Engineering Unit | 5 |

### 4.1.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| The preliminary design of the Saffire-VII and VIII that meets the science requirements developed for these experiments. | 1 |
| Mission Concept Review (MCR) Data Package | 2 |
| System Requirements Review (SRR) Data Package | 4 |
| Deliver System Level Preliminary Design Review (PDR) Data Package | 3 |
| Data reports for water spray fire extinguisher Engineering Unit | 5 |
| Design and instructions for implementing the laptop battery charging circuit | 6 |

## 4.2 Subtask B – Saffire Flight System

Saffire VII and VIII were cancelled as of March 2021. The subtask description has not changed but the milestones and deliverables have been adjusted to end this DO on September 30, 2021.

The primary focus of this subtask is to procure materials, fabricate, assemble, and test the Saffire-VII and VIII Flight Systems designed in SubTask A. The contractor shall work with the engineering and science teams to develop a flight system hardware design for the Saffire experiments. For each flight system the contractor shall develop engineering requirements and, where necessary, breadboards to increase confidence that the hardware concepts can meet these requirements.

Each Saffire Flight System will be composed of the following:

1) The Saffire Flow Unit containing the following components:
   a) A primary structure supporting the Flow Duct and Avionics Bay.
   b) The Flow Duct made up of the Sample Card System; the Flow system (e.g., flow control and combustion gas mixing); and Instrumentation (including internal sensors).
   c) The Avionics Bay containing the Power Management System; the Avionics System (including processor, signal conditioning, DAQ cube); and the Vision system (including front and side view imaging).
2) The Far-field Diagnostics (FFD) Unit that will have several instruments for monitoring particulate and combustion products in the Cygnus PCM. It will also contain a module for post-fire cleanup.
3) Remote Sensor suite to sample the atmosphere at specified locations within the Cygnus volume.

All Saffire Flight System hardware must work as an integrated system that will be housed within the Cygnus Pressurized Cargo Module (PCM) during the Saffire flight experiment execution. Because of the anticipated similarities between Saffire-VII and VIII and Saffire-IV-VI, fabrication of the some of the components could begin shortly after the PDR (July 2021). The Project wants the Contractor to identify components with sufficient maturity that fabrication can begin.

The Far-Field Diagnostic and Saffire Flow Unit (SFU) can be integrated at either L-60 or L-20 days. However, the time for integration at L-20 is just over 1 day with practically no time to address issues if they arise. Integration of the Remote Sensors and SFU-to-RS and SFU-to-FFD cables is to occur at L-60 days even if the FFD and SFU is integrated at L-20 days.

The Contractor should prepare for and conduct the following reviews no later than the dates specified below:

1) Saffire-VII and VIII System Acceptance Review (SAR)

2) Saffire-VII and VIII System Pre-Ship Review (PSR)

For all reviews the Contractor shall use the entrance and success criteria set in the NPR 7120.5 and NPR7123.1B. With appropriate GRC Technical Authority approval, tailoring of these reviews, similar to that for previous Saffire experiments are permitted and encouraged.

### 4.2.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~Begin fabrication of the Saffire-VII and VIII hardware (outside of the Period of Performance)~~ | ~~February 28, 2022 *~~ ~~(was 9/2021)~~ Deleted |

*** Items are outside DO period of performance end date.**

### 4.2.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.2.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

## 4.3 Subtask B1 – Saffire Flight Hardware Environmental Task

**NO WORK IS TO BE PERFORMED UNDER THIS SUBTASK**

The primary focus of this subtask will be to perform verification and environmental tests of the Saffire-VII and VIII Flight Systems. The Saffire Flow Unit, Far-Field Diagnostics, and Remote Sensors may be tested individually or as an integrated system.

The contractor will perform functional and environmental tests of the Saffire-VII and VIII flight hardware. These will include the tests for the Saffire SFU, Far-Field Diagnostics and Remote Sensors for all Saffire flight systems. Saffire VII & VIII is expected to be tested concurrently. The functional and environmental tests will be performed on each unit.

#### 4.3.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| N/A | | |

#### 4.3.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.3.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

### 4.4 Subtask B2 – Saffire Storage, Shipping, Integration, and Sustaining Engineering

**NO WORK IS TO BE PERFORMED UNDER THIS SUBTASK** The Saffire VII & VIII flight systems (SFU, FFD, and remote Sensors) are planned to be delivered to NASA following the System Acceptance Review. When applicable, the flight system will enter a storage period until it is time to prepare the flight system for shipment. During storage, the flight system will undergo periodic testing to ensure proper operation of the system and sensors. The tests will be conducted by NASA but the Contractor shall provide personnel to witness these tests and review the test results.

Following the storage period, the hardware will be shipped from NASA to the Contractor site to fill the oxygen and reference gas bottles and then shipped directly to the launch site for integration. Integration of the hardware will be conducted by NGIS. Functional tests will be conducted by the NASA-led integration team and supported by the Contractor as necessary. Following integration into the Cygnus vehicle, the Contractor shall provide sustaining engineering support during mission operations to review data as needed to help interpret data and sensor output.

### 4.4.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| N/A | | |

### 4.4.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.4.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| N/A | |

## 4.5 Subtask C – Saffire Project Management Task

Saffire VII and VIII were cancelled as of March 2021. The subtask description has not changed but the milestones and deliverables have been adjusted to end this DO on September 30, 2021.

The primary focus of this subtask will be the management of all tasks within this DO. This subtask will also control the project Configuration Management/Data Management (CM/DM), Systems Engineering and Integration (SE&I), and Safety and Mission Assurance (S&MA). This subtask will be ongoing throughout the life of the project and maintain a life cycle schedule to ensure work is being performed as planned. A life-cycle cost estimate will be updated and reported at project interim milestone reviews.

### 4.5.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~Update to Project schedule~~ | ~~Bi-Weekly~~<br>Deleted |
| ~~2~~ | ~~Status of Project Budget against plan~~ | ~~Monthly~~<br>Deleted |
| ~~3~~ | ~~Update Project Lifecycle cost as outlined in this CCR~~ | ~~July 30, 2021~~<br>~~(was 3/2021)~~<br>Deleted |

#### 4.5.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

#### 4.5.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| The contractor shall develop, maintain, and regularly report on the budget and schedule throughout the execution of the delivery order. | 1, 2 |
| Spreadsheet of Project Lifecycle Costs as outlined in this CCR | 3 |

### 4.6 SUBTASK C1 – CONFIGURATION MANAGEMENT/DATA MANAGEMENT (CM/DM)

Saffire VII and VIII were cancelled as of March 2021. The subtask description has not changed but the milestones and deliverables have been adjusted to end this DO on September 30, 2021.

The Contractor shall implement Configuration and Data Management (C&DM) of requirements, documents, data, technical models, drawings, hardware, and ground support equipment associated with the Saffire-VII and VIII flight hardware systems. The contractor's CM/DM system shall be compatible with the established Saffire GRC Engineering processes and tools (GRC Sharepoint system and ProE) and shall provide the following: (1) configuration identification, (2) configuration control, (3) configuration status accounting and (4) configuration verification and audit.

The Contractor shall operate and maintain a CM/DM system(s) to ensure that proper controls are implemented to receive, store/archive, reproduce, distribute, and control project-related documentation and SW. The contractor shall deliver, at the conclusion of this DO, the CM/DM operation and maintenance procedures, as well as the documents, products, associated data and SW generated during the execution of the Saffire project.

The Contractor shall provide a Saffire CM/DM Manager and necessary staff and will be responsible for the implementation of the CM/DM function. The contractor shall maintain the CM/DM system in an organized logical fashion and provide training and/or training products to project personnel on CM/DM system and product review process. The Contractor data system shall be compliant with export control regulations. Any items considered Sensitive-But-Unclassified (SBU) must be handled in accordance with NASA Procedural Requirement (NPR) 1600.1, and must be clearly marked as SBU.

### 4.6.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~Delivery of a list of CM documents and drawings created and uploaded to the contractor CM/DM system~~ | ~~Bi-weekly~~ Deleted |

### 4.6.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.6.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| List of CM documents and drawings created and uploaded to contractor CM/DM system | 1 |

## 4.7 Subtask C2 – System Engineering and Integration (SE&I)

Saffire VII and VIII were cancelled as of March 2021. The subtask description has not changed but the milestones and deliverables have been adjusted to end this DO on September 30, 2021.

The contractor shall be responsible for all SE&I activities for Saffire-VII and VIII, including:

1) Systems Engineering: The contractor shall provide systems engineering support as required to all SE&I elements including requirement definition, manufacturing, product fabrication, interface definition and management, assembly and integration, verification and validation and test, external integration, and mission operations.
2) Assembly Integration and Test (AI&T): The contractor shall be responsible for the planning, implementation, and completion of all AI&T activities of the Flight System.
3) Verification and Validation (V&V): The contractor shall be responsible for the planning and completion of all V&V activities of the Flight and Ground System, including the development of associated verification documentation to close the open requirements in the ERD, ICD, Flight Safety Hazard Reports (HRs) and Ground & Launch Safety HRs.
4) Ground System: The contractor shall be responsible for the Development, Calibration, Maintenance, Operation, and Utilization of all Saffire Ground System Equipment (e.g. Ground Development Unit, Test Support Equipment, and Ground Support Equipment, etc.).

5) External Integration: NASA will provide lead personnel for the coordination of activities with NGIS and ISS. The contractor shall provide the necessary support for activities needed for the integration of Saffire-VII and VIII flight systems including the development of tools, documents, and processes. Additionally, contractor personnel will support the Leads during all Saffire-VII and VIII integration activities, including the preparation of equipment for shipment as well as the coordination with ISS and NGIS on all ISS and Cygnus-related issues for the Saffire flight units. The contractor will also participate in the development and maintenance of ISS interface requirements and definitions (Payload Integration Agreement, PIRN, etc.), Cygnus interface requirements and definitions (IRD, Mechanical and Electrical ICD, and Software ICD), and inputs for ISS and NGIS deliverables.

6) Specialty Engineering: The contractor shall provide a radiation hardness assessment on all electronics to determine 1) if the hardware is particularly susceptible to single-event effects (SEEs); 2) if SEE sensitive hardware is safety critical hardware associated with hazard controls; 3) the most probable loss in mission science data for SEE sensitive non-safety critical hardware. A cost and schedule estimate for radiation parts testing shall be provided for all safety critical electronics, and high impact components that, if an SEE occurred, could result in a complete or significant loss of science data

### 4.7.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~Delivery of Verification Tracking Log update~~ | ~~Bi-weekly~~<br>Deleted |

### 4.7.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.7.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Verification Tracking Log | 1 |

## 4.8 Subtask C3 – Safety and Mission Assurance (S&MA)

Saffire VII and VIII were cancelled as of March 2021. The subtask description has not changed but the milestones and deliverables have been adjusted to end this DO on September 30, 2021.

For Safety and Mission Assurance Management, the Contractor shall develop a Safety & Mission Assurance (S&MA) Plan that documents the approach for developing, reviewing and reporting required tasks and analyses. The S&MA plan shall identify and describe the activities to be implemented during the development phase to ensure the design will meet flight requirements. The Contractor will implement and maintain a Continuous Risk Management process for the project and at a minimum include the NASA Project Manager, Chief Safety Officer, Chief Engineer, and Lead Systems Engineer on their Risk Review Board.

All processes used in the fabrication of flight hardware shall be qualified in accordance with NASA workmanship requirements or Contractor equivalent requirements. Personnel performing hands on fabrication, assembly, and inspection of flight hardware shall be trained and certified in accordance with NASA workmanship requirements or Contractor equivalent requirements. All electronic assemblies shall comply with the design, workmanship, and manufacturing requirements of NASA-STD-8739.1 Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies or Contractor equivalent process documents. Flight hardware shall be maintained in controlled storage areas. Access shall be controlled and limited to those persons involved in fabrication, test, and quality assurance tasks.

The Contractor should prepare for and conduct the following reviews no later than the dates specified below:

1) Saffire-VII and VIII Phase 0 Flight Safety Review
2) Saffire-VII and VIII Phase 1/2 Flight Safety Review
3) Saffire-VII and VIII Ground Safety Review
4) Saffire-VII and VIII Phase 3 Flight Safety Review

For all reviews the Contractor shall use the entrance and success criteria set in the NPR 7120.5 and NPR7123.1B. With appropriate GRC Technical Authority approval, tailoring of these reviews, similar to that for previous Saffire experiments is permitted and encouraged.

### 4.8.1 Milestones

| Milestone Number | Milestone | Date |
|---|---|---|
| ~~1~~ | ~~Complete the Phase 0 Flight Safety Review for Saffire-VII and VIII (outside of the Period of Performance)~~ | ~~December 20, 2021 (7/2021)~~ Deleted |

### 4.8.2 Hardware/Software Deliverables

| HW/SW Deliverable | Milestone Number |
|---|---|
| N/A | |

### 4.8.3 Document Deliverables

| Document Deliverables | Milestone Number |
|---|---|
| Phase 0 Flight Safety Data Package for Saffire VII and VIII | 1 |

## 5 ACRONYM LIST

| Acronym | Description |
|---|---|
| AES | Advanced Exploration System |
| AI&T | Assembly Integration and Test |
| CCR | Configuration Change Request |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CM | Configuration Management |
| CO2 | Carbon Dioxide |
| CPM | Combustion Product Monitor |
| DAQ | Data Acquisition System |
| DID | Data Item Description |
| DM | Data Management |
| DO | Delivery Order |
| eCC | electronic Country Clearance |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| ERD | Engineering Requirements Document |
| ESRD | Experiment SRD |
| FFD | Far-Field Diagnostic |
| FY | Fiscal Year |
| GDU | Ground Demonstration Unit |
| GRC | Glenn Research Center |
| GSE | Ground Support Equipment |
| HEOMD | Human Exploration and Operations Mission Directorate |

| Acronym | Description |
|---|---|
| **HQ** | **Headquarters** |
| **HR** | **Hazard Report** |
| **HW** | **Hardware** |
| **ICD** | **Interface Control Document** |
| **IRD** | **Interface Requirements Document** |
| **ISS** | **International Space Station** |
| **JSC** | **Johnson Space Center** |
| **MCR** | **Mission Concept Review** |
| **NASA** | **National Aeronautics and Space Administration** |
| **NGIS** | **Northrop Grumman Innovation System** |
| **NPR** | **NASA Procedural Requirement** |
| **PCM** | **Pressurized Cargo Module** |
| **PDR** | **Preliminary Design Review** |
| **PIRN** | **Preliminary Interface Revision Notice** |
| **PRACA** | **Preventive and Corrective Action** |
| **RS** | **Remote Sensor** |
| **Saffire** | **Spacecraft Fire Experiment** |
| **SAR** | **System Acceptance Review (formerly Pre-Ship Review)** |
| **SBU** | **Sensitive But Unclassified** |
| **SDL** | **Structural Dynamics Laboratory** |
| **SE&I** | **Systems Engineering and Integration** |
| **SEE** | **Single Event Effects** |
| **SEMP** | **Systems Engineering Management Plan** |
| **SFS Demo** | **Spacecraft Fire Safety Demonstration** |
| **SFU** | **Saffire Flow Unit** |
| **SMA** | **Safety and Mission Assurance** |
| **SpaceDOC-2** | **Space Flight Systems Development and Operations Contract-2** |
| **SRR** | **System Requirements Review** |
| **SW** | **Software** |
| **V&V** | **Validation and Verification** |