

## **Lunar Communications**

### **BACKGROUND**

Over the coming decades, NASA will establish a long-term presence at the Moon, opening more of the lunar surface to exploration than ever before. The growth of lunar activity will require new, more robust communications, navigation, and networking capabilities.

NASA is assessing Radio Frequency (RF) Propagation Environment of the Moon in support of Lunar Surface Exploration. An Over-The-Horizon Radio Communication (OTHRCOM) demonstration is being considered as a payload for a Commercial Lunar Payload Services (CLPS) mission in calendar year 2025. The primary objective of the OTHRCOM is to demonstrate RF communication beyond lunar surface horizon as a non-relay solution.

The OTHRCOM demonstration is to deploy an over-the-horizon RF transmitter to a location between 14 km and 40 km from the lander and deploy the transmitter during the lander descent. Assuring the separated package would land intact from a likely high-altitude release would be a development challenge. Secondly, the deployment of a 10m antenna from both the transmitter package and the receiver package on the lander would also be a development challenge.

NASA Glenn Research Center (GRC) OTHRCOM team has just recently completed the Preliminary Design Review (PDR) and was given approval to proceed with the implementation phase. At PDR, the OTHRCOM design comprises key subsystems to include Software Defined Radio (SDR) receiver and transmitter, antenna with deployment mechanism, power source, and impact absorber subsystems. The two highest risks identified at PDR were associated with a) long lead fabrication and assembly of extendable flexure structures for antenna deployment and b) the availability of high radiation hardened EEE parts for the transmitter. For the OTHRCOM medium to high frequency band, the communication standards include MIL-STD-188-141D, Interoperability and Performance Standards for Medium and High Frequency Radio Systems.

Furthermore, GRC has revisited a make-or-buy decision and decided to acquire the balance of the design, development, test, and evaluation (DDT&E) through Mission Readiness Review. The transitional phase for the OTHRCOM efforts from Government to Contractor is to commence immediately following contract award.

### **BASE ORDER DESCRIPTION**

The purpose of this Base Order is to continue the OTHRCOM DDT&E through Mission Readiness Review. This Base Order is to further reduce technical risks from where the PDR has been completed and to build, qualify, and deliver a flight set of OTHRCOM for Lunar surface communications demonstration.

The Contractor is required to provide discipline specific engineering personnel for the OTHRCOM implementation phase. This SOW includes Base Order management, systems engineering, safety and mission assurance, hardware and software design, development, fabrication, assembly, integration, and test.

Life-cycle reviews are to be conducted consistent with NPR 7120.5F and NPR 7123.1C and shall be held at NASA GRC. All PDR artifacts will be available to the Contractor. After the 3 month phase-in period, the GRC OTHRCOM core team will include the Project Manager who will also be this Base Order Manager, GRC Principal Investigator, Chief Engineer, and Chief Safety and Mission Assurance Officer to oversee all aspects of OTHRCOM project.

## **SCOPE OF WORK**

The SOW Performance Work Statement 4.1, 4.2, 4.6 and 4.7 are applicable and the Contractor shall:

Perform DDT&E leading to qualify and deliver an OTHRCOM flight set for lunar surface demonstration.

Coordinate with launch service provider, CLPS lander provider, and Mission Control Center provider to ensure that the OTHROM interfaces are compatible and properly integrate with the external elements for checkout, launch and operations. Develop the required interface documents.

Coordinate with NASA GRC Spectrum Management Office and develop documentation for radio frequency authorization approval.

Develop qualification strategy to recommend an approach to cost and schedule reduction with reasonable and acceptable technical risks.

Develop and conduct end-to-end OTHRCOM system ground demonstration to support the design and operations. Key interfaces to external elements shall also be electrically and mechanically fit checked.

Develop ground support hardware/equipment and software that are required to support OTHRCOM development and mission operations.

Perform RF compatibility testing.

Perform qualification testing and acceptance testing.

Build, test, and deliver an OTHRCOM flight set to support the target launch date of no later than July 2, 2025.

Prepare and conduct the following Reviews. These reviews shall be conducted consistent with NPR 7123.1C and NPR 7120.5F. Prior to each Life-cycle review, a review plan along with a

review readiness assessment shall be accomplished by the Contractor and provided to the GRC OTHRCOM Base Order Manager for concurrence.

- Critical Design Review (CDR)
- System Acceptance Review (SAR)
- Operational Readiness Review (ORR)
- Mission Readiness Review (MRR)
- Test Readiness Reviews (TRR) shall be held to ensure that the system is ready for testing phase.
- Safety Reviews shall be conducted as required by the Carrier.

Keep NASA informed of the progress made, any risks encountered (safety, schedule, technical feasibility, personnel availability, cost, etc.), and any issues affecting work performance in a timely manner.

Develop and provide deliverable items and delivery schedule which are defined in this SOW Deliverables and Reviews section.

#### **GOVERNMENT PROPERTY**

No Government furnished property.

#### **DELIVERABLES AND REVIEWS**

- Monthly progress reports (DID# CD-02), monthly-on going.
- Review Readiness Assessment report, due 8 weeks prior to Life-Cycle Review
- Safety Review(s), prior to Life-Cycle Reviews and per tbd Carrier's requirements
- CDR, 6 months after ATP
- TRR, at least 2 weeks prior to any demonstration, qualification, or flight hardware testing.
- SAR, 15 months after ATP
- ORR, 4-8 weeks after SAR
- MRR, 2-4 weeks before Launch date
- OTHRCOM flight set, ship to Carrier for integration after successful SAR
- Reviews and non-Review Data Items Deliverables (i.e. Data Package) as per the table below. The "x" marked data items are due 4 weeks prior to each review unless identified in the table. The "y" marked data items are due per DID schedule.

DID #	Title	Non-Review Due per DID	Life-Cycle Reviews/DID Due in weeks prior to review
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CONTRACTUAL DATA			C D R	T R R	S A R	O R R	M R R
CD-01	CONTRACTOR FINANCIAL MANAGEMENT REPORTING	y					
CD-02	TECHNICAL REPORTING AND MANAGEMENT REVIEWS	y					
CD-03	INFORMATION TECHNOLOGY SYSTEM SECURITY PLAN	y					
CD-04	INFORMATION TECHNOLOGY SECURITY MANAGEMENT PLAN	y					
PROGRAM MANAGEMENT							
PM-01	SPACEDOC III MANAGEMENT PLAN	y					
PM-02	RISK MANAGEMENT PLAN	y					
PM-03	Software Management and Development Plan		x				
PM-04	CONFIGURATION AND DATA MANAGEMENT PLAN	y					
PM-05	Engineering Change Proposals (ECPs)				x	x	x
PM-06	Contractor Base Order / Delivery Order Work Plan						
PM-07	Software Maintenance Plan						
PM-08	Software Version Description Document		x	x	x	x	
PM-09	SYSTEMS ENGINEERING MANAGEMENT PLAN		x				
PM-10	Waivers and Deviations	y					
PM-11	ORGANIZATIONAL CONFLICTS OF INTREST (OCI) PLAN						
PRODUCT ASSURANCE							
PA-01	SAFETY AND MISSION ASSURANCE PLAN	y					
PA-02	System Safety Plan	y					
PA-03	System Safety Hazard Analysis		x				
PA-04	Fracture Control Plan						
PA-05	Safety Data Package		6		6	6	6
PA-06	Materials Identification and Usage List (MIUL); Material Usage Agreement (MUA)		x		x		
PA-07	Problem Report and Corrective Action (PRACA) Plan	y					

PA-08	Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL)		x					
PA-09	Contamination/Cleanliness Control Plan	y						
PA-10	Software Assurance Plan and Metrics		x					
PA-11	SAFETY AND HEALTH PLAN							
PA-12	Nonconformance Report	y		x	x	x		
PA-13	Reliability Report(s)		x					
PA-14	Limited Life Items List		x					
PA-15	System Maintainability/Availability Analysis		x					
PA-16	Fastener Control Plan	y						
PA-17	Lessons Learned Report	y						
PA-18	Probabilistic Risk Assessment (PRA) Report(s)							
<b>REQUIREMENTS</b>								
R-01	Systems Requirements Document		x					
R-02	Interface Requirements Document (IRD)		x					
R-03	Payload Interface Agreement (PIA) Main Volume, Addendums and Data Sets							
R-04	Software Requirements Document		x					
R-05	Software Interface Design Document		x					
R-06	Interface Control Document & Interface Definition Document		x					

DID #	Title	Non-Review Due per DID	Life-Cycle Reviews/DID Due in weeks prior to review				
DESIGN			C D R	T R R	S A R	O R R	M R R
D-01	Review Presentation Package		2	2	2	2	2

D-02	Engineering Trade and Analysis Data		x				
D-03	Baseline System Description (Baseline Concept Description)						
D-04	Product Drawings		x				
D-05	Accommodations Handbook						
D-06	Software Design Document		x		x		
D-07	Safety-Critical Structures Data Package		x				
D-08	Fracture Control Summary Report		x				
D-09	Parts-Stress Analysis		x				
<b>VERIFICATION</b>							
V-01	Master Requirements and Verification Compliance Plan Master Requirements and Verification Compliance Matrix/Summary		x	x	x		x
V-02	Individual Item Verification Test/Demonstration Procedure			x	x		
V-03	Individual Item Verification Report				x		
V-04	Software Verification and Validation Plan		x				
V-05	Acceptance Data Package (ADP)				x		
V-06	As Built Configured Item List				x		
V-07	On-orbit Performance Acceptance Test Matrix/Plan Individual On Orbit Performance Acceptance Test Procedures				x	x	
V-08	SIMULATION SOFTWARE VERIFICATION AND VALIDATION PLAN						
<b>OPERATIONS</b>							
OP-01	Integrated Logistics Support Plan (ILSP)		x			x	
OP-02	Operations Handbook					x	
OP-03	Mission Operations Plan		x			x	
OP-04	Launch Site Operations and Test Procedures					x	
OP-05	Science and Engineering Data Management Plan					x	

OP-06	Procedures					x	
OP-07	Training and Certification Plan					x	
OP-08	Decommissioning/Disposal Plan						
OP-09	Operations Concept					x	