National Aeronautics and
Space Administration

ATTACHMENT J-02

XEVAS SYSTEM REQUIREMENT DOCUMENT (SRD)

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to present the top-level functional, performance, and interface requirements which define the capabilities needed to accomplish Extravehicular Activity (EVA) services to the International Space Station and Artemis Programs. This document constitutes the technical requirements to be implemented by the National Aeronautics and Space Administration (NASA) Exploration EVA Services (xEVAS) contract.

Section 3.0 of this document contains the technical requirements for the xEVAS Contract, which are applicable to every International Space Station (ISS) and Artemis mission unless otherwise noted.

1.2 SCOPE

The scope of this requirements document is to define xEVAS requirements that meet or exceed the capabilities necessary to safely execute missions in Low Earth Orbit (LEO), cislunar space, lunar surface, and beyond. The xEVA System will be required to support safe and efficient EVA operations envisioned by NASA for human space exploration.

The xEVA System includes the spacesuit, tools, and vehicle interface equipment as defined in Figure 1.5.1-1, xEVA System Interfaces to ISS and Figure 1.5.1-2, xEVAS System Interfaces to the Human Landing System (HLS). Requirements applicable across each sub-system element are denoted as “xEVA System shall”. For example, this document includes requirements that drive key suit functions such as life support, but does not include the specific details on requirements for those functions as they are a part of the suit architecture and will be decomposed at the commercial provider level. For some of these requirements, the Government has provided thresholds (minimum requirements) as well as goals. The Contractor shall meet or exceed the thresholds. Goals represent the desired operational performance improvements above the threshold achievable at higher risk in cost, schedule, and technology. The Contractor shall obtain optimum performance between threshold and goal values. If a goal is not otherwise specified, the goal value for performance is the same as the threshold value.

The following summarizes the categories of requirements levied herein:

- **General Mission:** Establishes the fundamental service requirements that drive system capabilities.

- **Environments:** Protect the crewmember during exposure to the full range of environmental and gravitational conditions experienced at LEO, cislunar orbit, and Lunar surface destinations. Incorporate, where appropriate, design flexibility and modularity to allow for efficient incorporation of upgrades. Allow crewmembers to perform EVAs from existing ISS and future airlocks.

- **Performance:** Autonomously sustain the life of the crewmember for a minimum of eight hours.

- **Safety and Health:** Increase crew safety for training and flight operations over legacy systems. Enable effective performance of all EVA-related tasks and activities during training and flight without suit-induced discomfort, injury, or negative health consequences. Expand the range of flight crew anthropometries accommodated while improving mobility, fit, and comfort over legacy systems.

- **Information Management:** Provide enhanced information, communication, and monitoring systems.

- **Task Management:** Provide crew the accommodations to accomplish tasks effectively.

- **Mission Integration:** Minimize crew time, stowage, and launch mass resources as well as design considerations for reductions in required on orbit maintenance activities.

- **Process based requirements:** Multiple requirements call out minimizing or maximizing a given parameter. In these cases, for verification, analysis is expected. The analysis will be of the process the Contractor used throughout design, development, and test phases and how that process achieved the goal of the requirement.

1.3 EVA SERVICES OVERVIEW

NASA seeks to procure EVA as a commercially managed service similar to the approach used in the successful ISS Cargo Resupply Services (CRS), NASA Launch Services (NLS), and Commercial Crew Program (CCP) contracts. The commercial EVA service includes the development and integration of the xEVA System through launch, operations, and return/disposal.

Commercial EVA services provide NASA the capability to perform EVAs with the use of contractor-provided spacesuits, tools and equipment, vehicle interfaces, and support to training and real-time operations. Services includes post-certification EVA services for ISS/Artemis, including delivery/return of EVA hardware to and from the host vehicle, spacesuit unique interfaces to the Airlock including crew interfaces; planning, support for training, operations, and sustaining engineering; spacesuit donning and doffing equipment, tool kits consisting of EVA hardware necessary for the crew to perform microgravity EVAs, support to ground training and testing events at the Neutral Buoyancy Lab and other facilities; and other requirements to support EVA capability and operations. It is currently anticipated that the Government will have requirements for approximately ten ISS EVAs per year and 1 Artemis campaign per year.

NASA's intent is to transition from the traditional Government-owned hardware model to an "EVA as a Service" model. Using SSP 51073, *Exploration Extravehicular Activity (EVA) Suit Systems Requirements Document*, as a basis, the pivot to commercial services triggered the need for adapting the requirements to open the design trade space for providers.

1.4 CHANGE AUTHORITY/RESPONSIBILITY

Proposed changes to this document shall be submitted via a Change Request (CR) to the EVA Configuration Control Board (CCB) for consideration and disposition. All such requests will adhere to the EVA Office Configuration Management Change Process documented in EVA-PLN-012, *EVA Office Configuration and Data Management Plan*.

The appropriate NASA Office of Primary Responsibility identified for this document is the EVA Office.

1.5 SYSTEM INTERFACE DIAGRAM

1.5.1 ISS Interfaces

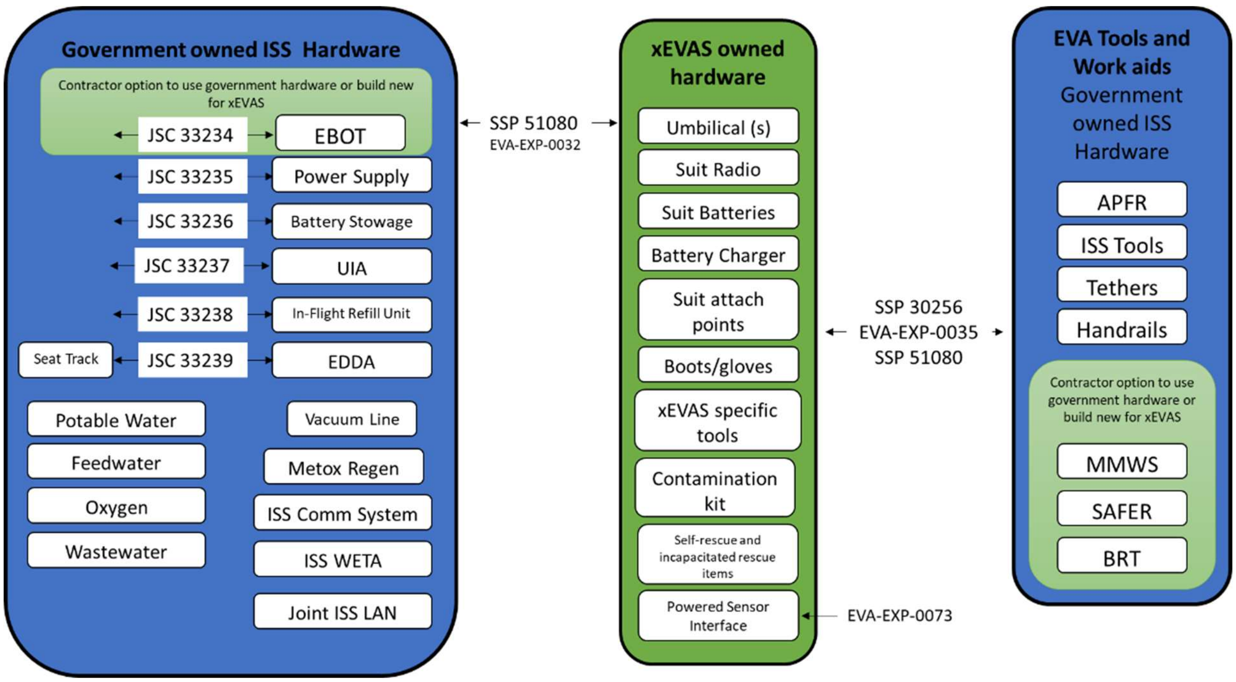


FIGURE 1.5.1-1 XEVA SYSTEM INTERFACES TO ISS

1.5.2 Artemis Interfaces

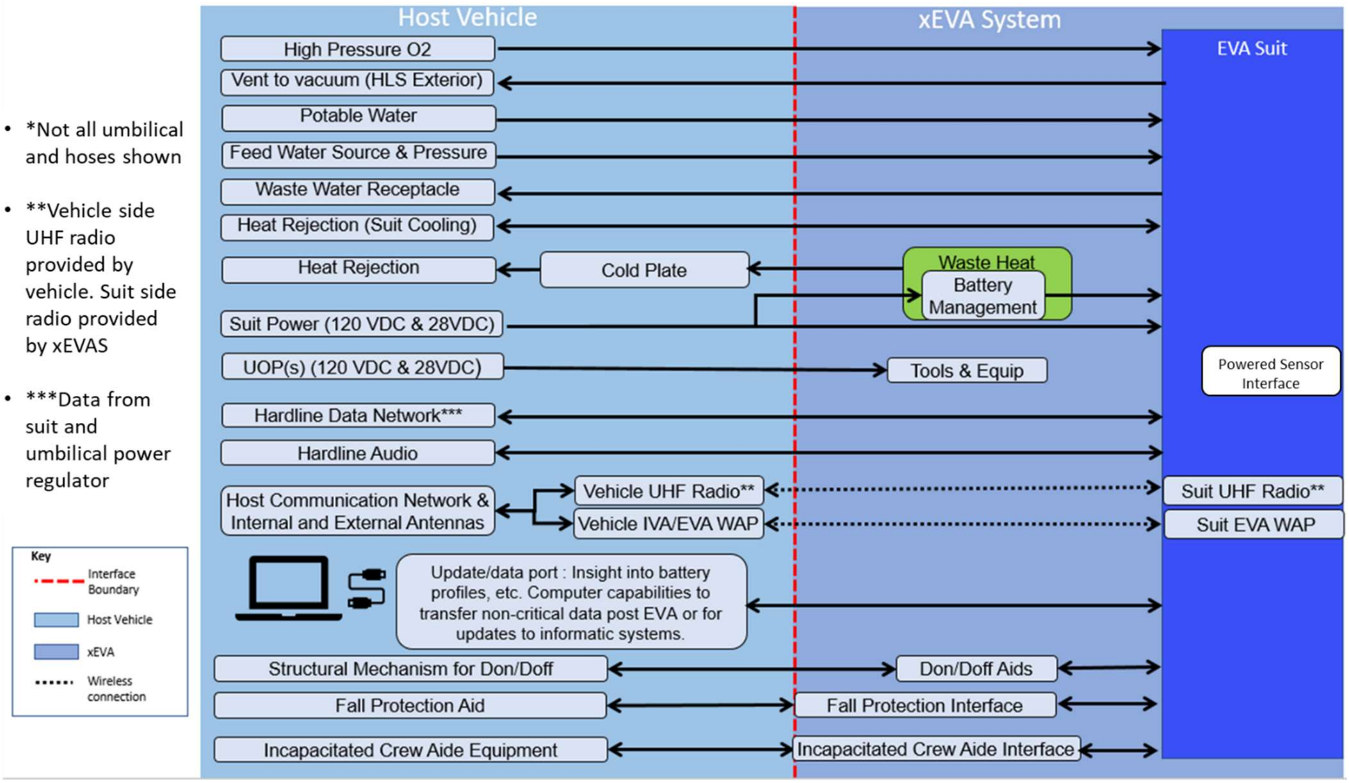


FIGURE 1.5.2-1 XEVA SYSTEM INTERFACES TO THE HUMAN LANDING SYSTEM (HLS)

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

TABLE 2.1-1 APPLICABLE DOCUMENTS

Document Number	Document Revision/Date	Document Title
ANSI/ASA S3 2-2009	12/09/2020	Method for Measuring the Intelligibility of Speech Over Communication Systems
EVA-EXP-0032	Baseline 06/05/2018	EVA-ISS Interface Definition Document
EVA-EXP-0035	Baseline 09/12/2018	Exploration EVA System Compatibility Requirements
EVA-EXP-0039	Rev A 11/19/2020	Exploration EVA System Destination Environments Specifications
EVA-EXP-0042	Rev B 10/19/2020	xEVA System Concept of Operations
EVA-EXP-0067	Draft 09/2021	HLS EVA System IRCD
EVA-EXP-0073	Draft 01/10/2019	xEVA System Accessories Interface Description Document
EVA-PLN-012	Rev A 10/02/2019	EVA Office Configuration and Data Management Plan
SSP 30256	Rev K 09/10/2020	ISS EVA Standard Interface Control Document (ICD)
SSP 51080	Rev A 04/28/2021 DCN Attached	xEMU-ISS Interface Requirement Control Document
SSP 51721	Baseline 10/18/2019	ISS Safety Requirements Document
SSP 54004	Rev K 05/26/2021	ISS Interface Definition Requirements Document (IDRD) Blank Book
SSP 57000	Rev T 01/2020	Pressurized Payloads Interface Requirements Document
GP 10023	Rev A 08/23/2019	Gateway Program Safety and Mission Assurance Requirements
JSC 20584	Baseline 09/28/2017	Spacecraft Maximum Allowable Concentrations for Airborne Contaminants
JSC 27181	Rev F April 2003	Space to Space Communications System, Specification
SLS-SPEC-159	Rev H 8/12/2020	Cross Program Design Specification for Natural Environments
NASA-STD-3001, V1	Rev A, Change 1 02/12/2015	NASA Spaceflight Human-System Standard, Volume 1: Crew Health

NASA-STD-3001, V2	Rev B 09/09/2019	NASA Spaceflight Human-System Standard, Volume 2: Human Factors, Habitability, and Environmental Health
Online EVA Tool Catalog	N/A	EVA Tools Catalog (http://toolscatalog.jsc.nasa.gov/)

2.2 REFERENCE DOCUMENTS

The following documents contain supplemental information to guide the user in the application of this document.

TABLE 2.2-1 REFERENCE DOCUMENTS

Document Number	Document Revision/Date	Document Title
ASTM F1790-05	07/01/2015	American Society for Testing and Materials (ASTM) F1790-05
NASA TM - 2003-212058	09/2003	EMU Shoulder Injury Tiger Team Report
NASA/TM-2011-217062/Volume I NESC-RP-10-00659	02/2011	In-Suit Light Exercise (ISLE) Prebreathe Protocol Peer Review Assessment
NASA/SP-2010-3407	Rev 1Rev 106/05/2014	Human Integration Design Handbook (HIDH)
SA-18-014	02/06/2018	Johnson Space Center Health and Medical Technical Authority (HMTA) Position Regarding Heart Rhythm and Heart Rate Monitoring for the Exploration Extravehicular (xEMU) Project Advanced Extravehicular Activity Exploration Extravehicular Mobility Unit (AdvEVA xEMU)
SA-18-076	N/A 10/10/2018	HMTA Concurrence with Exploration Extravehicular Activity (EVA) Suit Systems Requirements Document
CTSD-ADV-1008	Baseline 09/11/2012	Shock Hazards Present during EVA
EVA-EXP-0034	Rev C 04/28/2021	Extravehicular Activity (EVA) Office Exploration EVA System Technical Standards
EVA-EXP-0048	Draft	xEVA System- Gateway Interface Requirements Control Document
EVA-EXP-0049	Rev A 05/07/2020	Extravehicular Activity (EVA) Office Exploration EVA System Labeling Guidelines
EVA-EXP-0055	06/28/2019	xEVA Crew Time Assessment Methodology
EVA-EXP-0056	06/25/2019	xEVA System Overview: Inspired CO2 presentation
EVA-EXP-0057	06/25/2019	xEVA System Overview: Anthro Range presentation

Document Number	Document Revision/Date	Document Title
EVA-EXP-0058	02/23/2021	Lunar Ejecta
EVA-EXP-0066	06/28/2017	UV/IR Visor Protection
EVA-EXP-0074	06/25/2019	xEVA System Overview: Dust Mitigation
EVA-EXP-10005	Draft	EVA-Induced Injury Minimization - Surveillance and Verification Methods
JSC 39233 (replaced by SSP 50747)	Rev A 07/01/2009	CTBE IDD (IDD for ISS CTB)
JSC 66695	Rev B 05/21/2019	EVA Office EMU Water Quality Specification
SSP 42097	Rev F 06/30/2011	Pressurized Mating Adapter 2 & 3 To U.S. Pressurized Elements (USL to PMA-2) Interface Control Document
SSP 50261	Rev L 09/2017	Generic Ground rules, Requirements, and Constraints (GGR&C) and Crew Contingency EVA (CCE) Overview
SSP 50933	Rev D 04/15/2016	IDA to ISS and Visiting Vehicle IRD
SSP 51073	Rev B 12/11/2019	Exploration EVA Suit System Requirements Document
SSP 51073 Change 2	Rev B DRN 11/5/2020	Exploration EVA Suit System Requirements Document - Change 2: Quantify Maximum Rate of Pressure Change
SSP 51073 Change 3	Rev B DRN 11/5/2020	Exploration EVA Suit System Requirements Document - Change 3: Clarify 12-hour Suited Duration
SSP 51073 Change 4	Rev B DRN 3/3/2021	Exploration EVA Suit System Requirements Document - Change 4: Add Higher EVA Pressure Setpoint
SSP 51073 Change 5	Rev B DRN 1/20/2021	Exploration EVA Suit System Requirements Document - Change 5: Lunar Surface Communication
SSP 51073 Change 6	Rev B DRN 3/3/2021	Exploration EVA Suit System Requirements Document - Change 6: Lunar Surface PnP, Board/Panel: xEVAS Systems Panel
SSP 51073 Change 7	Rev B DRN 3/3/2021	Exploration EVA Suit System Requirements Document - Change 7: Lunar Surface Lighting
SSP 57003	Revision M 08/20/2020	External Payload Interface Requirements Document

3.0 XEVAS SYSTEM REQUIREMENTS

3.1 GENERAL MISSION

3.1.1 ISS EVA Capability (RQMT-001)

The xEVA System shall provide the capability for a mixed EVA crew complement to perform at least 10 two-person EVAs on ISS per year.

Rationale: Two EVA crewmembers are required to perform an EVA. To maximize operational flexibility, three or more EVA crewmembers will nominally be designated for each ISS Increment as defined in Increment specific IDRDs. Therefore, the capability to select any pairing of the available crew is required.

Planned and unscheduled/contingency must be considered in the 10 EVA total.

Applicability: ISS

3.1.2 Lunar EVA Capability (RQMT-003)

The xEVA System shall provide the capability for a mixed EVA crew complement to perform at least six (6) two-person EVAs on the lunar surface per Artemis mission.

Rationale: Exploration and Science mission objectives require EVAs for mission success. Capability above six (6) EVAs must be allocated if an HLS vendor design requires EVA for jettison/clean-up or ascent performance mitigation. Note: The definition of an EVA does not change in the sustained architecture. For the purpose of scoping consumables, an EVA is defined as "two suited crew". For sustaining missions with four (4) crew, a four (4) person EVA may be performed using a 2x2 buddy system and would use two (2) EVAs worth of suit consumables. Initial Artemis sortie missions will be up to six EVAs over a 6.5-day surface mission; Artemis sustaining missions will be longer surface duration with more EVAs.

Applicability: Artemis

3.1.3 EVA Rate (RQMT-004)

The xEVA System shall provide the capability to perform EVAs at rate of at least one EVA every day.

Rationale: Having the xEVA System available at this rate allows for minimizing the time to recover lost ISS capability. EVA operations are fatigue inducing activities for the suited crewmembers. For ISS, five (5) day spacing of EVAs has been established by the Flight Operations Directorate as a minimum duration to allow for crew recovery, EVA prep, and procedure review for subsequent EVAs. However, the xEVA System shall allow for a different pair of crew to perform an EVA in less time. The mission design case is an unscheduled/contingency EVA series to perform United States On Orbit Segment (USOS) *critical maintenance. An estimate of the worst-case scenario is four EVAs to perform this critical maintenance.*

For Artemis, the lander's length of stay on the surface is one limiting factor for surface EVAs. To maximize the science element of the mission, EVAs need to be performed on a pace of one EVA every day to allow for 6 EVAs for a minimum 6.5-day surface mission.

Applicability: ISS and Artemis

3.1.4 EVA Availability (RQMT-005)

The xEVA System shall be capable of supporting an ISS EVA(s) with two (2) designated crewmembers within 48 hours of notice.

Rationale: Reference SSP 50261, Generic Ground rules, Requirements, and Constraints (GGR&C) and Crew Contingency EVA (CCE) Overview. There are ISS contingencies that limit power, cooling, visiting vehicle traffic, crew rotations, etc. Recovery of ISS capabilities are critical to restore ISS systems and recover from a zero-fault tolerant state.

Applicability: ISS

3.1.5 Spacecraft Independent Operation (RQMT-006)

The xEVA System spacesuit shall sustain the life of the crewmember for a minimum of eight continuous hours of EVA operation independent of vehicle-provided life support functions.

Rationale: Eight hours has been determined to be an acceptable amount of time to complete an objective while considering consumables management and crew day. Intent of this requirement is that the eight-hour clock does not restart if the suit is connected for any reason, such as contamination bake out or consumable top off. This duration is not inclusive of the additional 1-hour contingency capability outlined in RQMT-040. The total suited duration for nominal operations in EVA configuration is 13 hours to account for Pre and Post activities (e.g., total time includes pre-EVA (suit donning, prebreathe, and depress), EVA, post EVA (repress and suit doffing)). This time does NOT account for contingencies such as DCS treatment. Note that for the purposes of this rationale statement it is assumed that the EVA duration is no more than 8 hours, the Prebreathe duration is no more than 3.5 hours, depress is no more than 0.5 hour, repress is no more than 0.5 hour, and no more than 0.5 hour for post EVA (suit doffing). This means that the entire suited duration could be as much as 13 hours and would use a mix of suit and vehicle systems to sustain the life of the crewmember.

Applicability: ISS and Artemis

3.1.6 Operation with Spacecraft Utilities and Consumable Resources (RQMT-081)

The xEVA System spacesuit shall sustain the life of the crewmember while in EVA configuration, drawing consumable resources from the spacecraft.

Rationale: This is intended to ensure the spacesuit can be operated when connected to parent spacecraft, which provides a source of consumables such as vehicle power. A spacecraft is considered to be any host vehicle such as habitats, rovers, landers, as well as orbiting and transit vehicles. This allows for spacesuit operations when the suit does not provide these consumables.

Applicability: ISS and Artemis

3.1.7 ISS Task Capability (RQMT-007)

The xEVA System shall enable all EV-qualified crewmembers to complete:

A. All ISS Contingency EVA Tasks (inclusive of Critical Contingency EVA Tasks) as defined in SSP 54004, *ISS IDRD Blank Book*, Rev K, section 6.2.4.2 (a), (b) and (c).

Rationale: Suited crewmembers will be required to perform mechanical and maintenance support, transfer, research, and inspection in the ISS microgravity environment. They will need the ability to execute scheduled, unscheduled, and contingency tasks of varying levels of complexity and difficulty, as described in SSP 54004, ISS IDRD Blank Book. Designers should employ human-centered design processes (reference NASA/SP-2010-3407, Human Integration Design Handbook (HIDH)) to ensure that user considerations, limitations, and capabilities are integrated into the xEVA System design to maximize end user performance and achieve mission objectives.

Applicability: ISS

3.1.8 Lunar Task Capability (RQMT-008)

The xEVA System shall enable all EV-qualified crewmembers to complete all general Task categories described in EVA-EXP-0042, *xEVA System Concept of Operations* sections:

4.0 - Exploration EVA and Mission Systems Overview, excluding any Vehicle Loop Mode (VLM) statements and assuming Vehicle Interface Suit Equipment (VISE) functions are provided by host spacecraft; if in conflict with SRD, SRD takes precedence

7.2 - EVA on Moon (initial missions), excluding any Vehicle Loop Mode (VLM) statements and assuming VISE functions are provided by host spacecraft; if in conflict with SRD, SRD takes precedence

Rationale: EVA tasks will include not only those for maintenance, pioneering, etc. but also those that will accomplish science objectives on the lunar surface. These science objectives will include, but are not limited to, handheld photography, general scientific descriptions, sampling using a variety of sampling tools, and science payload deployment.

Applicability: Artemis

3.1.9 Crew Time Allocation (RQMT-009)

The xEVA System shall allow for preventative and corrective maintenance, EVA Turnaround, and Average Overhead per EVA per Table 3.1.9-1 Crew Time Allotment.

TABLE 3.1.9-1 CREW TIME ALLOTMENT

Parameter	Allocation
Maintenance from one EVA to next	8 hours total of crew time (including donning and prebreathe); 16 total elapsed hours max
Average Overhead per EVA (preparation and cleanup)	10 hours of crew time
Annual Preventive and Corrective Maintenance	25 hours of crew time for ISS xEVA system; 12 hours of crew time for Artemis xEVA system, if maintained between missions

Rationale: Crew time allocations were derived from EVA-EXP-0055, xEVA Crew Time Assessment Methodology, which documents how the EVA Crew Time for Preparation and Maintenance were determined and provides guidance to xEVA System Spacesuit providers on expectations for using the Crew Time Assessment Spreadsheet.

Applicability: ISS and Artemis

3.2 ENVIRONMENTS

3.2.1 Destination Environments (RQMT-013)

The xEVA System shall meet all requirements during and after exposure to the following environments and mission phases as defined in EVA-EXP-0039, *Exploration EVA System Destination Environments Specifications*:

- Ground Handling and Processing (Section 3.1)
- Launch and Landing (Section 3.2)
- ISS Internal (Section 3.3)
- ISS External (Section 3.4)
- Exploration Mission/Vehicle (Section 3.5)

- Gateway Internal (Section 3.6)
- Gateway Induced External Environment (Section 3.7)
- Cis-Lunar Space Environment (Section 3.8)
- Lunar Surface (Section 3.9)
- HLS Internal (Section 3.10)

Rationale: xEVA System must meet their requirements either while exposed to the specified environment (for a planned operating environment) or after exposure to the specified environment (when the xEVA System will not be operated during exposure). Mission phases to which the suit will be exposed to include ground handling and processing, launch and landing, ISS Internal, ISS External, Exploration Mission/Vehicle, cislunar space, and lunar surface environment. Environmental parameters for each mission phase include, but are not limited to structural loading, neutral atmosphere, vehicle atmospheres, thermal effects, plasma, charged particle radiation, electromagnetic radiation, meteoroids, space debris, magnetic field, physical contents, gravitational field, dust, and plumes/thrusters. EVA-EXP-0039, Exploration EVA System Destination Environments Specifications, also includes environment definitions for Mars Transit, and Mars Surface, but the suit does not need to meet its requirements in these environments except as noted above.

Applicability: ISS and Artemis

3.2.2 Lunar Surface Dust Mitigation (RQMT-014)

The xEVA System shall limit the amount of regolith liberated in the cabin environment to less than 100 grams for each two-crew lunar surface EVA.

Rationale: Extensive work has been done to establish a Permissible Exposure Limit (PEL) for per suit and the expectation that all lunar surface EVAs are conducted with two Acute and Chronic exposures of flight crew to lunar surface regolith. The total value per two-crew EVA in this requirement is established to provide a worst case bounding condition for nominal scenarios so that surface assets such as Human Landers can size Environmental Control and Life Support System (ECLSS) filters and other mitigation features provided by the vehicle can be designed to achieve the relevant Acute and Chronic PELs. 100 grams is based upon an allocation of no more than 50 grams crew. It is acknowledged that this requirement is for nominal scenarios only, contingency events which lead to the termination or abort of a lunar surface EVA will likely reduce or eliminate the time and ability to execute dust mitigation activities. See EVA-EXP-0074, xEVA System Overview: Dust Mitigation for an explanation of the planned approach and methodology to provide a practical and verifiable system-level solution.

Applicability: Artemis

3.2.3 Lunar Dust Contamination (RQMT-082)

During EVA operations, the xEVA System spacesuit shall limit the levels of lunar dust particles less than 10 µm in size inside the suit below a time-weighted average of 1.6 mg/m3 during daily exposure periods that may persist up to 7 days in duration.

> *Rationale: This is an intentional allocation to the suit and when a suit enters the vehicle and is doffed other elements of the xEVA System will address mitigation of lunar dust particles. The intent is to limit the amount of dust that goes in during don/doff and that the interior of the suits does not present a location for the collection of lunar dust that can be inhaled during EVA operations. Lunar dust poses a hazard in addition to that from ordinary particulates. This limit is based on a minimum currently expected permissible limit, as estimated by the Lunar Atmosphere Dust Toxicity Assessment Group (LADTAG) in 2007. Although the standard is being conservatively applied to all inhalable particles (all particles ≤10 µm), it is most applicable to dusts in the respirable range (≤2.5 µm) that can deposit more deeply into the lungs. Studies show that the particle size of lunar dust generally falls within a range of 0.02-5 µm. Reference NASA-STD-3001, V2, Rev B, standard V2 6053. This is similar to the intent of the 7-day JSC 20584, Spacecraft Maximum Allowable Concentrations for Airborne Contaminants, value in RQMT-087. The longer-term, such as the seven-day limits, are set to fully protect healthy crewmembers from adverse effects from continuous exposure to specific air pollutants. While conservative from a duration perspective for EVA, the seven-day limits are the shortest duration guidelines set to protect effects of lunar dust and therefore remain the most appropriate. The NASA-STD-3001, V2, Rev B, standard V2 6053 are more applicable to a six-month Spacecraft Maximum Allowable Concentration (SMAC) value. See EVA-EXP-0074, xEVA System Overview: Dust Mitigation for an explanation of the planned approach and methodology to provide a practical and verifiable system-level solution.*
>
> *Applicability: Artemis*

3.2.4 Micro Meteoroids and Orbital Debris Probability of No Penetration (RQMT-015)

The xEVA System shall provide a Probability of no Penetration (PnP) of 0.9996 (risk odds of 1 in 2500) or better from meteoroids, orbital debris, and lunar surface ejecta while supporting eight hours of two person EVAs on the lunar surface or at ISS (419 km and 51.6 degree inclination for the average day in 2024), utilizing the Orbital Debris Engineering Model Release 3.1 (ORDEM 3.1) model, Meteoroid Engineering Model Release 3. (MEM-3) model, and the lunar surface ejecta model in SLS-SPEC-159, *Cross Program Design Specification for Natural Environments*.

> *Rationale: Micro Meteor Orbital Debris (MMOD) presents the largest natural contribution to Probabilistic Risk Assessments (PRAs) for loss of crew or loss of mission while EVA on ISS. "Penetration" for the exploration spacesuit is defined as any size leak of the bladder, or damage to Portable Life Support System (PLSS) or other EMU hardware, that leads to atmosphere leak or early EVA termination (same definition used for the EMU). It should be noted that the primary and secondary oxygen system for the exploration spacesuit will allow crew to survive holes of certain sizes in the bladder, and therefore MMOD*

penetrations will not necessarily result in a loss-of crew event, although penetrations would typically cause an unplanned EVA termination.

The values provided in the requirement were computed using the existing heritage EMU design and widely accessible models in an upcoming year relevant to the life of NASA's xEVA System. This approach was taken in lieu of prior efforts which cited EVA MMOD risk on STS-125 in order to provide a new reference datum that is more readily accessible for future risk comparisons. Additional details are provided in EVA-EXP-0058: Lunar Ejecta.

Applicability: ISS and Artemis

3.2.5 Lunar Surface Permanently Shadowed Region (PSR) Minimum Exposure Time (RQMT-083)

The xEVA System shall function nominally during and after exposure to at least 2 hours of the thermal environment of Permanently Shadowed Regions (PSR) of the lunar surface as specified in EVA-EXP-0039, *Exploration EVA System Destinations Environment Specifications*.

Rationale: Two hours is provided as a bounding case for lunar surface missions conducting EVA tasks within a PSR. The time duration is a balance between the harsh environment vs. minimum viable time to do meaningful tasks. This length of time includes the time in shadow to enter and leave the PSR.

Applicability: Artemis

3.2.6 Quiescent Stowage (RQMT-084)

The xEVA System shall meet all requirements after being stowed in the internal vehicle environments defined in EVA-EXP-0039, *Exploration EVA System Destinations Environment Specifications,* in quiescent mode for a Threshold duration of 210 days with a Goal duration of three years without any services or human interaction.

Rationale: Equipment must function properly after being exposed to vehicle stowage environments and not operating. Equipment should not need periodic maintenance to satisfy this requirement. This requirement presents the capability to pre-position xEVA System hardware or survive long duration exploration transits. Two years is selected for current exploration DRMs to Lunar Distant Retrograde Orbit (LDRO). Quiescent stowage is included in the post-launch service life and is not intended to be considered as an addition. It is intended that this be applicable to the period of time between launch and first use as well as after first use. However, special tasks not associated with nominal maintenance or EVA prep and post time allocation in RQMT-009 may need to be conducted in order to return a used suit to an appropriate configuration for quiescent stowage and to prepare it for reuse by crew following quiescent stowage.

Applicability: Artemis

3.3 PERFORMANCE

3.3.1 Suit Habitability (RQMT-016)

The xEVA System shall provide the crew with a safe and habitable environment within the spacesuit.

Rationale: A comfortable, breathable environment is critical to crew safety and habitability for suited crewmembers during EVA and is essential to achieving maximum productivity while executing mission objectives. The spacesuit system needs to be robust enough to regulate internal atmospheric quality and temperature within physiological ranges while ensuring adequate communications.

Applicability: ISS and Artemis

3.3.2 Spacesuit Inspired Partial Pressure of Carbon Dioxide (RQMT-085)

The xEVA System spacesuit shall nominally limit inspired partial pressure of CO2 (PICO2) to within all the criteria defined in the Spacesuit PICO2 Limits Table 3.3.2-1.

Rationale: Spacesuit design and crewmember metabolic rate and other human factors affect the extent to which CO2 accumulates and is inspired by crewmembers inside a spacesuit. Excessive levels of inspired CO2 can lead to elevated blood CO2, known as hypercapnia, which can cause adverse health and performance effects. The (PICO2) in this requirement is defined as the Time-Weighted Average (TWA) Partial Pressure Carbon Dioxide (ppCO2) measured at the mouth during inspiration and accounting for absolute pressure. Spacesuit PICO2 Limits Table values are based on utilization of a specific standardized human-in-the-loop test methodology for quantification of spacesuit inspired CO2 (Bekdash et al, 2018) and not based on measured ppCO2 at the spacesuit ventilation inlet since imperfect helmet washout of exhaled CO2 adds to the inspired ppCO2 concentration and increases the actual PICO2.

This requirement is based on a comprehensive review and community discussion of existing industry standards, literature data, and a detailed characterization of terrestrially inspired ppCO2 in 19 human subjects in the EMU spacesuit (Bekdash et al, 2018; Bekdash et al, 2017; Bekdash, EVA EMU Panel, 7/24/18). The terrestrial characterization data were then used to model predicted PICO2 from a data set including 138 flight EVAs and 205 Neutral Buoyancy Laboratory (NBL) training runs to characterize historically experienced PICO2 levels in the EMU. These data, in combination with the successful completion of more than 450 EVAs using the EMU and absence of any identified symptoms directly attributable to CO2 during these EVAs, suggest a very low likelihood of adverse acute hypercapnia symptoms at or below the levels for the given duration limits defined in the Spacesuit PICO2 Limits Table. The allowable CO2 concentration at the inlet to the spacesuit is not specified in this requirement. However, as a point of reference, the inlet ppCO2 for the EMU spacesuit is ≤ 2.0 mmHg, which is analogous to and consistent with standards for ambient atmospheric CO2 in habitats.

This requirement is consistent with NASA's current and previous EVA hardware and operations, wherein individual crewmembers have performed as many as four EVAs during a single shuttle mission. In this case, crew returned to a normal terrestrial background level shortly after exposure. Long duration ISS crewmembers have performed up to five EVAs during a six month mission, and as many as three in a nine day period (n = four crewmembers); however, most crewmembers have performed two to four EVAs during a six month mission, but oftentimes with two EVAs spaced less than a week apart.

For additional background information related to this requirement and generation of the Spacesuit PICO2 Limits Table, reference EVA-EXP-0056, xEVA System Overview: Inspired CO2 presentation. Reference NASA-STD-3001, V2, Rev B, standard V2 11039.

Applicability: ISS and Artemis

TABLE 3.3.2-1 SPACESUIT PICO2 LIMITS

PICO2 †	Allowable Cumulative Duration
(mmHg)	(hours per day)
> 15.0	Do Not Exceed
> 12.5	≤ 0.5
> 10.0	≤ 1.0
> 7.0	≤ 2.5
> 4.0	≤ 7.0
≤ 4.0	≤ 14

† Inspired ppCO2 to be calculated using NASA standardized human-in-the-loop test methodology for quantification of spacesuit inspired CO2 (Bekdash et al, 2018; Bekdash et al, 2017). This requirement is to be met in the presence of the expected average and transient metabolic rates as described in RQMT-017 for the full suited duration, including any necessary prebreathe, checkout, EVA, and repressurization time. Total duration in the suit is assumed to not exceed 14 hours.

PICO2 = (Total Pressure (mm Hg) – 47 mm Hg) * FICO2 Where 47 mm Hg is water vapor partial pressure at 37 degrees Celsius body temperature and FICO2 is dry-gas TWA decimal fraction of CO2 during inspiration as computed from TWA ppCO2 / Total Pressure.

Example:

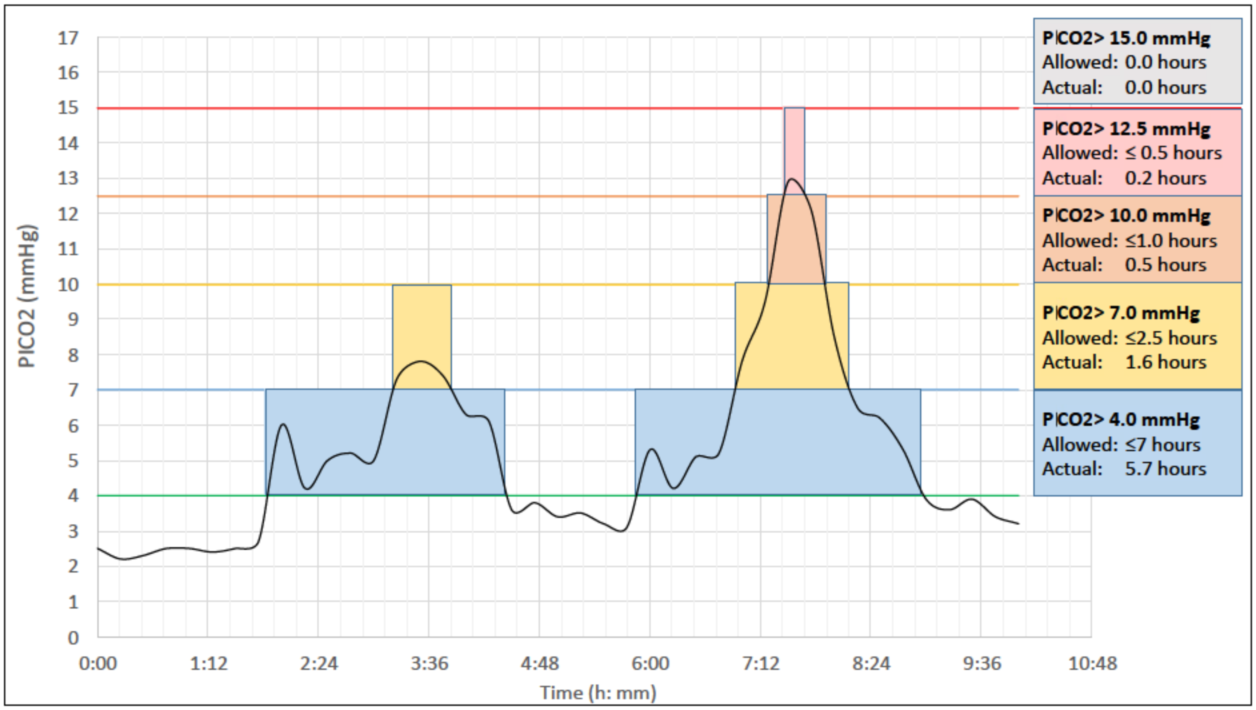


FIGURE 3.3.2-1 EXAMPLE OF A NOTIONAL EVA PICO2 PROFILE EVALUATED AGAINST THE SPACESUIT LIMITS TABLE

Note: Spacesuit PICO2 Limits Table values are anticipated to be used during the validation and verification of requirements during ground-based trials of various EVA scenarios. The monitoring of ppCO2 in the spacesuit during flight EVA operations is expected to rely on application of ground-based characterization data to predict PICO2 from such measurements as suit inlet ppCO2, suit outlet ppCO2, ventilation flow rate and crewmember metabolic rate.

3.3.3 Internal Suit Surface Temperatures (RQMT-086)

The xEVA System spacesuit shall maintain all crewmember skin contact temperatures within the range of 10ºC - 44ºC (50 ºF and 111.2 ºF) for the duration of the EVA.

Rationale: Achieving the specified temperature range is dependent on the environment and characteristics of the hardware temperature envelopes that the spacesuit is operating within. It is not expected that the suit shall meet all extremes on its own and joint thermal analysis and design with the interfacing hardware in the operating environment will be required to get to a value that the suit can reasonably manage to the specified temperature range. For the cislunar environments, vehicle touch temperatures will be assumed to be within the touch temperature ranges specified for the ISS and will be levied on future vehicles through the applicable EVA to Vehicle Interface Requirements Document (IRD). SSP 51073 / EVA-RD-001 standard values are levied from NASA-STD-3001 V2, Rev B, standards V2 9014 and V2 9015.

Applicability: ISS and Artemis

3.3.4 Trace Contaminants (RQMT-087)

The xEVA System spacesuit shall control accumulation of gaseous pollutants in the suit produced by metabolic loads, system sources, and material off-gassing so that the total toxic hazard index (T value) is maintained below 1.0 unit during crewed activities based on the seven-day SMACs defined in JSC 20584, *Spacecraft Maximum Allowable Concentrations for Airborne Contaminants*.

Rationale: Airborne exposure limits for individual trace chemical contaminants and methods for assessing exposure to trace contaminant are defined to protect crewmembers from illness and injury. The SMACs provide guidance for short-term (1 and 24 hours), medium-term (7 and 30 days), and long-term (180 days and 1000 days) exposure to individual trace chemical contaminants. Short-term SMACs are designated as emergency SMACs and are intended to be used in emergency situations, such as accidental spills or fire. Medium and long-term SMACs are guidance levels intended to avoid adverse health effects, either immediate or delayed, and to avoid degradation in performance of crew after continuous exposure for the designated duration. The SMACs also consider unique factors for human space flight including the stress on human physiology, uniform good health of astronauts, and the absence of pregnant or very young individuals. The toxic hazard index, or total T-value, is the sum of the ratios of each predicted/measured pollutant concentration to the respective limit from JSC 20584. See EVA-EXP-0034, Extravehicular Activity (EVA) Office Exploration EVA System Technical Standards, for further data supporting derivation of metabolically generated contaminants.

Applicability: ISS and Artemis

3.3.5 Sound Pressure Level Limits for Continuous Noise (RQMT-088)

The xEVA System spacesuit shall limit the suit induced Sound Pressure Levels (SPLs), created by the sum of all simultaneously operating equipment, averaged over any 20-second measurement period inside the spacesuit, at the crew-member's ears to the values in Octave Band Sound Pressure Level Limits Table or less, within each of the specified octave bands during all mission phases except launch and entry.

TABLE 3.3.5-1 OCTAVE BAND SOUND PRESSURE LEVEL LIMITS (NC-52)

Band Center Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	16k
SPL (dB)	72	65	60	56	53	51	50	49	48

Rationale: This NC-52 requirement will limit noise levels within spacesuits to allow for adequate voice communications and habitability during mission operations. The octave band sound level limits from 63 Hz to 8 kHz are equivalent to NC-52 and the 16-kHz octave band has been added to extend the range throughout the audible frequency range. This requirement does not apply to alarms, communications, approved intermittent noise sources, or to any noise experienced during maintenance activities. The noise attenuation effectiveness of hearing protection or communications headsets may be used if this equipment *is included in the nominal spacesuit design. This limit does not apply to impulse noise. Reference NASA-STD-3001, V2, Rev B, standard V2 11009.*

Applicability: ISS and Artemis

3.3.6 Noise Limit for Personal Communication Devices (RQMT-089)

The xEVA System spacesuit shall limit the maximum A-weighted sound level at the crewmember's ear created by a personal communication device to 115 Decibel a-Weighted (dBA) or less.

Rationale: Sound levels above 115 dBA have been shown to produce noise-induced hearing loss. Sound levels produced by personal communication devices can be at higher levels to overcome the noise generated during launch and descent. Volume controls will be included to allow for limiting the crews' noise exposure. A personal communication device may be an integrated part of the EVA helmet or an independent communication system. NASA-STD-3001, V2, Rev B, standard V2 6106.

Applicability: ISS and Artemis

3.3.7 O2 Partial Pressure Range for Crew Exposure (RQMT-090)

The xEVA System shall maintain inspired oxygen partial pressure (PIO2) of >149 mmHg in accordance with Suit Atmosphere Composition of FiO2 >95% oxygen atmosphere.

Rationale: The use of highly enriched or pure oxygen atmospheres for suited operations is a critical component of decreasing DCS risk to acceptable levels when combined with effective prebreathe protocols. Enriched oxygen also allows for lower suit pressures to be adopted to facilitate mobility and dexterity needed for the timely completion of EVA tasks without unacceptable crew fatigue and injury historically imparted by pressure suits at higher pressures. Finally, the normoxia PIO2 limit of 149 mmHg is a higher limit than the 127 mmHg permissible hypoxia limit allowed for IV exploration atmospheres due to the high risk nature of EVAs driving the need to preserve crew cognitive and aerobic performance (see NASA-STD-3001, V2, Rev B, standard V2 6003).

Applicability: ISS and Artemis

3.3.8 Metabolic Rate (RQMT-017)

The xEVA System shall accommodate the nominal metabolic profile as outlined in the following figures/tables: Standard Profile, Front End Loaded, and Aft End Loaded with an average metabolic rate of 351.68 W (1200 BTU/hr) for a duration of eight hours with up to a total of 30 minutes of rest inserted into the profile as needed over the course of the eight-hour EVA.

Rationale: The suit must be capable of providing variable and controllable heat rejection and carbon dioxide scrubbing equivalent to the levels defined in the three Metabolic Profile Figures: Standard Profile, Front End Loaded, and Aft End Loaded. The increase in metabolic load profile for the suit can be explained by the increase in metabolic loading seen *on ISS EVAs. As EVAs evolve and become more complicated, metabolic rates have often exceeded the Metal Oxide (METOX) certification levels on ISS EVAs. Additionally, with a terrestrial (walking suit) it would be expected that metabolic rates can be higher than seen with microgravity suits. Consistent metabolic rates across gravity conditions ensures operational margin for expected lower metabolic rates experienced during microgravity EVA. Heat rejection capabilities need to consider the suit's ability to remove a heat load from the crew member and dissipate that heat.*

Applicability: ISS and Artemis

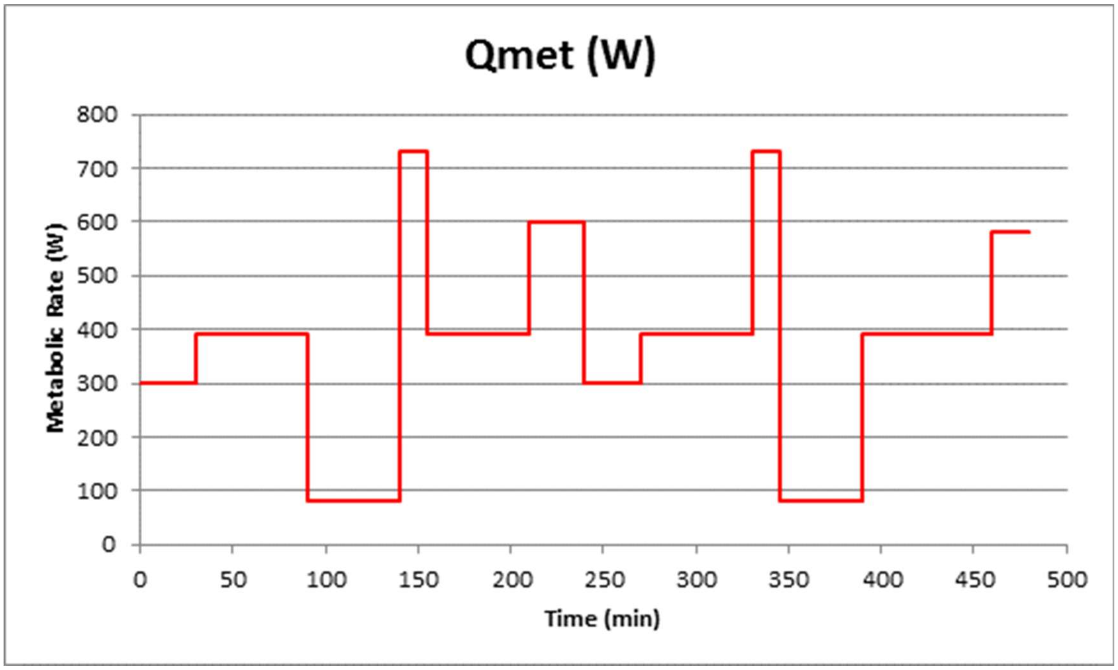


FIGURE 3.3.8-1 STANDARD PROFILE 1230 BTU/HR [360W] AVERAGE

TABLE 3.3.8-1 STANDARD PROFILE NUMBERICAL VALUE

Time (min)	Qmet (BTU/hr)	Qmet (W)
0	1025	300
30	1332	390
90	273	80
140	2493	730
155	1332	390
210	2049	600
240	1025	300
270	1332	390
330	2493	730
345	273	80
390	1332	390
460	1981	580
480	1981	580

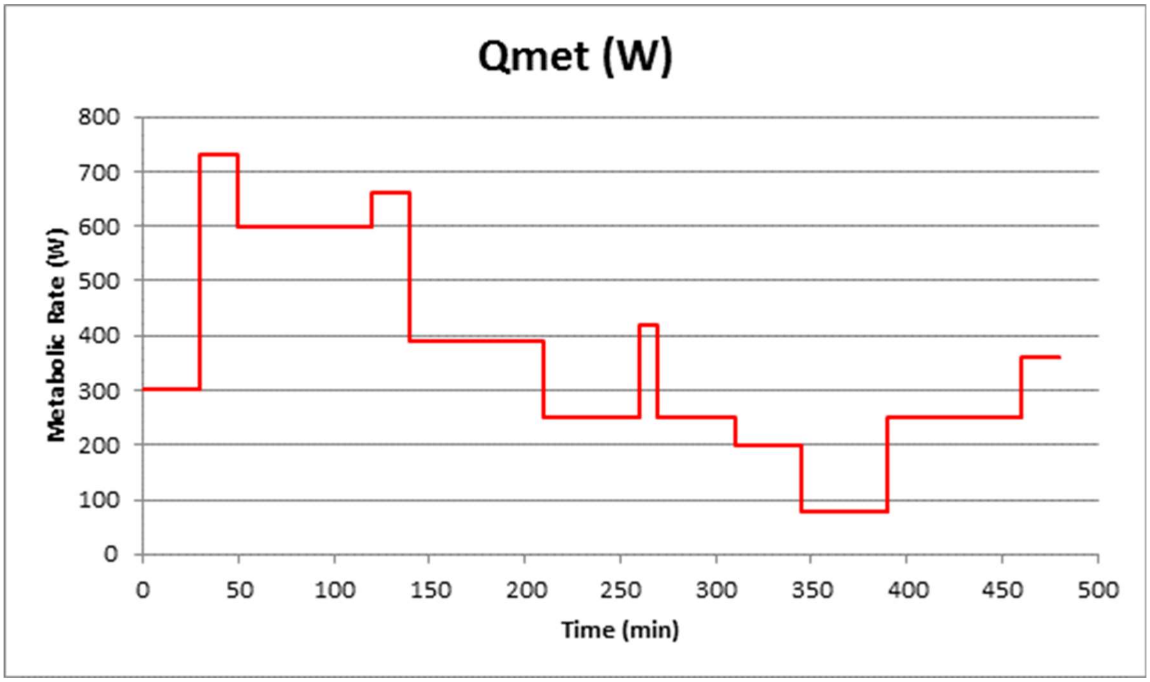


FIGURE 3.3.8-2 FRONT-END LOADED

Note: This profile provides heavy loading at the front end of an EVA profile in order to simulate a difficult egress followed by labor intensive tasks near the beginning of the EVA. Some technologies, such as Lithium Oxide (LiOH) and METOX have difficulty with this type of profile if adequate water loading of the canisters is not achieved during the lower metabolic rate pre-EVA sequence.

TABLE 3.3.8-2 FRONT-END LOADED PROFILE NUMBERICAL VALUES

Time (min)	Qmet (BTU/hr)	Qmet (W)
0	1025	300
30	2493	730
50	2049	600
120	2254	660
140	1332	390
210	854	250
260	1434	420
270	854	250
310	683	200
345	273	80
390	854	250
460	1229	360
480	1229	360

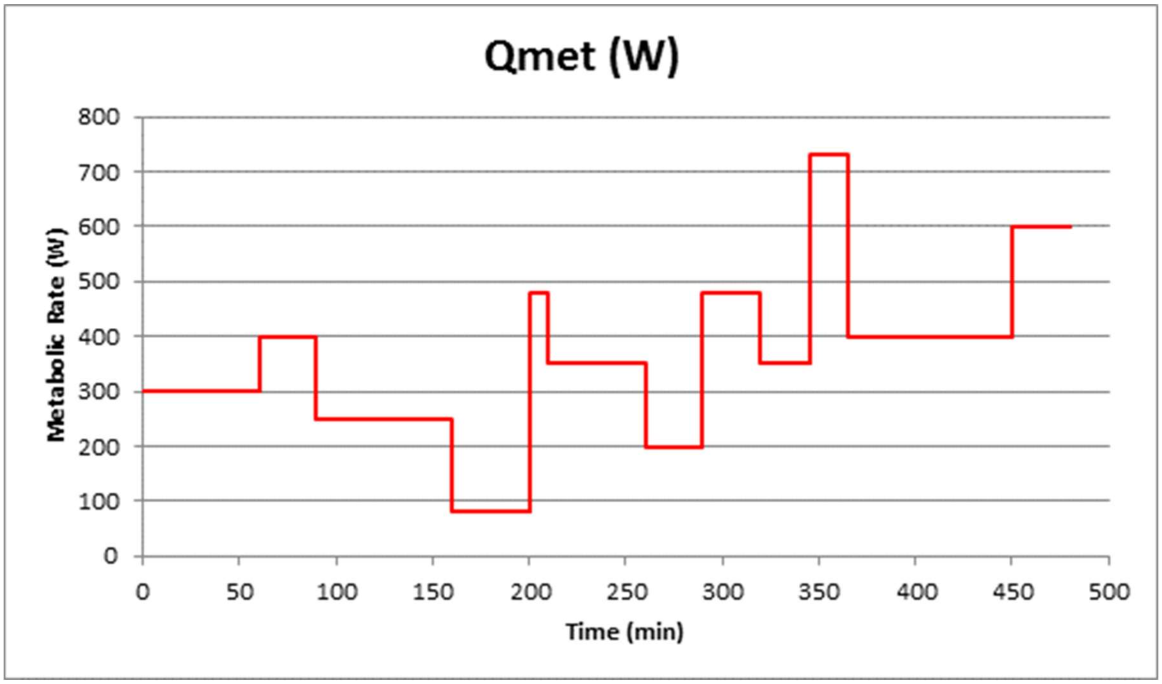


FIGURE 3.3.8-3 AFT-END LOADED

Note: The aft end loaded metabolic profile will highlight issues with technologies of finite capacity relative to the specifications with particular interest to Partial Pressure Carbon Dioxide (PPCO2) removal. A finite scrubber bed such as LiOH and METOX will trend towards break-through with a profile close to the specified performance requirements and with a reduced number of reaction sites, will trend the PPCO2 levels with the metabolic rate.

TABLE 3.3.8-3 AFT-END LOADED PROFILE NUMBERICAL VALUES

Time (min)	Qmet (BTU/hr)	Qmet (W)
0	1025	300
60	1366	400
90	854	250
160	273	80
200	1639	480
210	1195	350
260	683	200
290	1639	480
320	1195	350
345	2493	730
365	1366	400
450	2049	600
480	2049	600

3.3.9 Suit Accommodation of Metabolic Loads (RQMT-091)

The xEVA System spacesuit shall accommodate crew metabolic loads provided in RQMT-017, Metabolic Rate, during all suited phases while maintaining a core body temperature between 36.1 °C and 38.06 °C (97 °F and 100.5 °F).

Rationale: Metabolic loads, in conjunction with the operational concept, provide an upper bound for oxygen (O2) demand, carbon dioxide (CO2) production and heat rejection requirements. This information is vital for spacesuits design. The performance focuses on cooling effectiveness, because core body temperature regulation is critically important to prevent heat-related illnesses. Guidance on the use of metabolic load data in the design process can be found in Section 4.11 of JSC 66695, EVA Office EMU Water Quality Specification. Heat load (increased core temperature and the consequent skin vasodilation) can cause a variety of human system issues.

Applicability: ISS and Artemis

3.3.10 Indicate Pressure (RQMT-018)

The xEVA System spacesuit shall indicate to the suited crewmember the internal pressure of the suit without the use of power.

Rationale: Internal suit pressure is considered a critical operating parameter and must be available to the crew during any suited pressurized operation.

Applicability: ISS and Artemis

3.3.11 Impact Performance - Microgravity (RQMT-020)

The xEVA System spacesuit shall not fail catastrophically following impact with a two-inch diameter steel ball when crewed, when operating at nominal EVA pressure, in microgravity, and translating at 0.43 m/s (1.4 ft/sec).

Rationale: This requirement ensures that the spacesuit will not fail catastrophically following an impact with structure during microgravity EVA. The two-inch sphere is consistent with the impact geometry assumed for the Shuttle/ISS EMU. To avoid replanning of EVA timelines, it is desired to retain the current EVA crew manual translation rates and ISS robotic arm assisted translation rates regardless of the suit configuration worn during translation. As of the writing of this document, the current ISS EVA crew manual translation rate of 0.43 m/s (1.4 ft/sec) envelopes the applicable relative velocity that robotic assisted translation near vehicle structure creates. The verification of this requirement should account for secondary impacts and the rigidity of attached EVA tools and equipment.

Applicability: ISS and Artemis

3.3.12 Impact Performance – Partial Gravity (RQMT-021)

The xEVA System spacesuit shall not fail catastrophically following impact with a 2-inch diameter steel ball when crewed, pressurized to nominal or elevated pressure, in lunar gravity, translating at 1.2 m/s (4 ft/s), and in the heaviest EVA configuration.

> *Rationale: This requirement ensures that the risk of the spacesuit failing following an impact during a partial gravity EVA is acceptable to the program. Additional analysis will be required to determine the effects of the design specific mass and CG. Efficiency of energy transfer to the impactor will also need to be calculated.*
>
> *Applicability: Artemis*

3.3.13 Visual Capabilities (RQMT-022)

The xEVA System spacesuit shall provide the crewmember with safe and accurate visual capabilities and head mobility to perform EVA tasks in both day and night-time conditions.

> *Rationale: Visual capability is required to ensure compatibility with specified workstations and includes the ability to work during both day and night-time conditions. Spacesuits must allow for incorporation of hardware without interfering with the crewmember's visibility. This includes reduced visibility caused by helmet fogging and scratches or eye irritation. Reference NASA-STD-3001 V2, Rev B, standard V2 5001, SA/HMTA memo SA-18-076, HMTA Concurrence with Exploration Extravehicular Activity (EVA) Suit Systems Requirements Document* and *SSP 51073/RD-001 Action Items (AIs) from the Exploration Extravehicular Mobility Unit (xEMU) Systems Readiness Review (SRR), for the HMTA position on visual capabilities.*
>
> *Applicability: ISS and Artemis*

3.3.14 Protection from Ultraviolet and Infrared (RQMT-023)

The xEVA System spacesuit shall filter the intensity of wavelengths by the percent shown in the Minimum Shielding (Filtration) Necessary to Prevent Injury from Ultraviolet (UV) and Infrared (IR) Table 3.3.14-1.

> *Rationale: Limits for crew exposure to the electromagnetic spectrum from the ultraviolet (180 nm) to the far infrared (1400 nm) are necessary to protect the eye and skin from injury caused by the overexposure to radiation. The filtration percentage required is dependent on the wavelength being filtered and the intensity of the electromagnetic spectrum specific to the destination where the mission architecture is occurring and does not pertain to incidents of light flash. Reference NASA-STD-3001, V2, Rev B, standard V2 6104. Reference SA/HMTA memo SA-18-076 for the HMTA position on the Minimum Shielding (Filtration) Necessary to Prevent Injury from UV and IR Table, reference EVA-EXP-0066, UV/IR Visor Protection.*
>
> *Applicability: ISS and Artemis*

TABLE 3.3.14-1 MINIMUM SHIELDING (FILTRATION) NECESSARY TO PREVENT INJURY FROM UV AND IR

Destination	Wavelength (nm)	% Filtration Required	% Reduction of EMU Helmet with Sun Visor Up on ISS (For Reference Only)
Earth LEO and cislunar	180-330	99.99	100
	335-345	99	100
	350-395	95	100 - 96
	400-695	10	83- 29.16
	700-1400	5	29.14-72.99
	1405-3000	5	29.14-72.99

General Notes:

1) Minimum shielding necessary to prevent injury is based on NASA –STD-3001 V2 Rev A and the HIDH which include the NASA amended numerical values used by the ACGIH publication "TLVs® and BEIs® Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices."
2) With the EMU sun visor down additional filtration occurs with the lowest % reduction of ~89% occurring at 475nm and 550nm
3) Blue light values are included in the table, but are anticipated to be in the 380-500nm range
4) The range (180/190/200 to 3000nm) is typically used for the broadband hazard, but for the blackbody source of the sun, the constraining range is 700-1400nm (usually 700-3000nm). At higher wavelengths above 1400nm, filtering does not provide significant reduction of hazard from this specific source (blackbody sun). The astronaut will still have a time of roughly > 100 seconds, which is comparable to the current suit without the visor. Simple blink reflex and movement resets this hazard, since it is strictly thermal in nature and exceeding it is very unlikely. If additional comfort is needed, the visor may be used. This is intended to be a minimum to protect against injury.

3.3.15 Ability to Work in Suits (RQMT-024)

The xEVA System spacesuit shall provide mobility, dexterity, and tactility to enable the crewmember to accomplish suited tasks within satisfactory workload, fatigue, and comfort limits for all microgravity and partial gravity EVA planned and contingency mobility tasks.

Rationale: This includes all IVA prep and post-EVA activities. Suited crewmembers are to be able to perform tasks required to meet mission goals and operate human-system interfaces required for use during suited operations. Suits can limit the crew mobility, dexterity, and tactility below that of unsuited crew. Suit pressurization can further reduce crew capabilities; however, it must not preclude the ability to perform all ISS EVA maintenance tasks (this includes the CCEs). ISS EVA worksites are known to be compatible with the EMU dimensions (reference the Maximum Suit Dimensions Figure). Reference NASA-STD-3001, V2, Rev B, standard V2 11024. To fully address the intent of *this requirement the design must also account for ops convenience considerations, such as but not limited to crew identification, post-egress tool configuration time impacts.*

The Bedford Workload Scale has been selected by NASA as the workload verification method for program workload requirements. Reference NASA-STD-3001, V2, Rev B, standards 5007 and 5008. For detailed information regarding human performance capabilities, e.g., visual perception, auditory perception, cognition, and workload, see chapter 5, Human Performance Capabilities, in the NASA Human Integration Design Handbook (HIDH).

Furthermore, past testing has shown that center of gravity of the system has a high impact on the ability of an occupant to run/walk in a gravity environment. If a suit is being designed for multiple destination classes as defined in EVA-EXP-0042, Exploration EVA System Concept of Operations, then effective performance in partial gravity destination classes needs to be assured when designing a suit.

Additional tasks may also be identified through DRD xEVAS-HHP-01, Human Error Analysis (HEA) Plan, Reports, and Analysis.

Tasks to be evaluated include but are not necessarily limited to Appendix B, Mobility Matrix.

Applicability: ISS and Artemis

3.3.16 ISS Suit Mobility (RQMT-025)

The xEVA System spacesuit shall provide the overall mobility, dexterity, and tactility equal to or greater than current ISS EMU capabilities and existing EMU Phase VI glove performance.

Rationale: ISS tasks have been designed around existing suit capabilities. A new suit will need to provide similar or better capabilities to ensure critical tasks can be completed within baseline EVA planning assumptions. Pressurized EVA Glove performance, including dexterity, fatigue, grasp strength, etc. are critical to EVA Crew performance.

Applicability: ISS

3.3.17 Anthropometry (RQMT-026)

The xEVA System shall accommodate all NASA crew anthropometric dimensions provided in the Occupant Measurements Table 3.3.17-1.

Rationale: The design of physical items that interface with the crewmember must account for crew anthropometry. The fundamental intent of this requirement is to include at least 90% of the female and 90% of the male populations as defined in the 1988 Anthropometric Survey of United States (U.S.) Army Personnel (ANSUR), truncated for 35-50 years of age and projected to the year 2015 using growth trend. The Occupant Measurements provided below are the subset of human anthropometric measurements, which are historically found to drive suit design and the numerical dimensions envelope *the 1st percentile female to 99th percentile male. Filtering of the above defined ANSUR population with the combined Occupant Measurements dimensions below is known to include ~90% of the parent population. Due to variable stacking effects in arithmetic evaluation methods, inclusion of additional Measurements or reduction of the Population percentile distribution will threaten the ability to fit at least 90% of the parent database total population.*

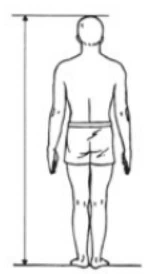
This approach is chosen for consistency with NASA's Orion Vehicle and Commercial Crew Program Anthropometry requirements. It is understood that specific design solutions will likely need to consider additional dimensions based upon issues and constraints unique to each suit design concept. It is anticipated that Supplier trades will assess and determine the most effective strategy for discrete sizing choices across individual components or subassemblies such that an effective sizing schedule is created.

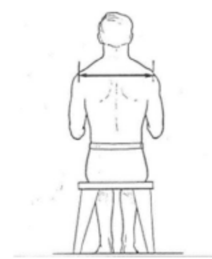
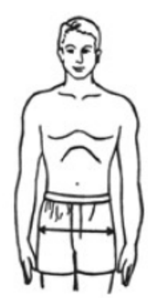
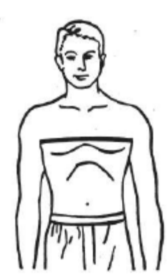
It is not anticipated that all measurements provided here or that necessarily all other design-specific measurements will automatically correlate to crewmember selection criteria. Such selection criteria are understood to be driven by combined fit and performance metrics that are separate from suit design itself.

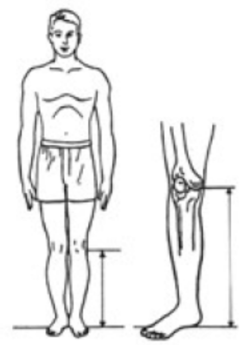
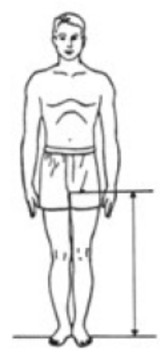
SA/HMTA memo SA-18-076, HMTA Concurrence with the EVA Suit Systems Requirements Document, provides the HMTA position on the Occupant Measurements Table. For additional background information related to this requirement and generation of the Occupant Measurements Table, reference EVA-EXP-0057, xEVA System Overview: Anthro Range presentation.

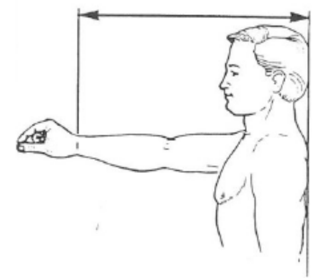
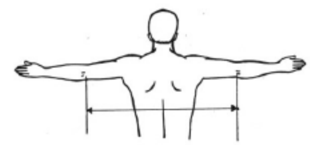
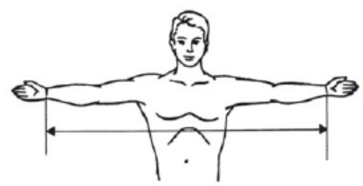
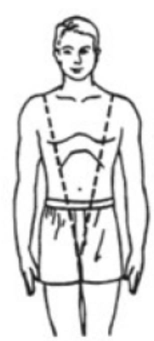
Applicability: ISS and Artemis

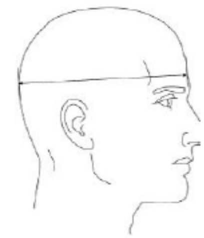
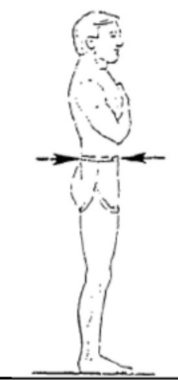
TABLE 3.3.17-1 OCCUPANT MEASUREMENTS

Measurement	Minimum	Maximum	Method	Figures
Stature[1]	58.5 in	76.6 in	Subject stands erect, head facing forward, heels together, and weight distributed equally on both feet. Measure the vertical distance from the standing surface to the top of the head with the arm of the anthropometer firmly touching the scalp.	
Chest Breadth	9.3 in	15.5 in	Subject stands erect, looking straight ahead with the arms slightly abducted. Measure the horizontal distance across the trunk at the level of the widest area of the bust point.	

Measurement	Minimum	Maximum	Method	Figures
Chest Depth	7.5 in	11.9 in	Subject stands erect looking straight ahead, arms relaxed at sides, heels together, and weight distributed equally on both feet. Measure the horizontal distance across the trunk at the level of the widest area of the bust point during normal respiration.	
Bi-acromial breadth	12.7 in	17.5 in	Subject sits erect with shoulders and upper arms relaxed, forearms and hands extended forward horizontally with palms facing each other. Measure the distance between the two acromion landmarks at the tips of the shoulders	
Hip Breadth	11.7 in	16.0 in	Subject stands erect, heels together and weight distributed equally on both feet. Measure the maximum horizontal breadth of the hips. Note: For standing measurements, the largest female hip breadth is larger than the larger male hip breadth; therefore, female data are used for both the minimum and the maximum dimension.	
Chest Circumference	29.8 in	46.7 in	Subject stands erect looking straight ahead and weight distributed equally on both feet. Arms are abducted sufficiently to allow clearance of a tape measure between the arms and trunk. Measure horizontally the circumference of the trunk at the widest point of the chest. The measurement is made at the point of normal inhalation.	

Measurement	Minimum	Maximum	Method	Figures
Thigh Circumference	18.8 in	28.3 in	Subject stands erect looking straight ahead, heels together, and weight distributed equally on both feet. Measure the circumference of the thigh horizontally as close to the crotch as possible	
Knee Height (mid patella)	15.6 in	22.8 in	Subject stands erect, heels together and weight distributed equally on both feet. Measure the vertical distance from the standing surface to the knee landmark on the right leg.	
Crotch Height	26.2 in	37.7 in	The subject stands erect looking straight ahead, with enough separation between the feet to insert the anthropometer/calipers, and weight distributed equally on both feet. The subject should place one end of the measuring device into the pubis symphysis (male subjects should move scrotum out of the way). Measure the vertical distance from the standing surface to the crotch.	
Bicep Circumference flexed	9.0 in	15.9 in	Subject stands erect looking straight ahead, upper arm extended horizontally, and the elbow flexed 90 degrees. Fist is clenched and held facing the head. Measure the circumference perpendicular to the long axis of the upper arm while the subject exerts maximum effort.	

Measurement	Minimum	Maximum	Method	Figures
Wrist-to-Wall	21.5 in	30.6 in	Subject stands erect in a corner looking straight ahead with feet together and stretching the right arm forward horizontally against a scale on the wall. Measure the distance between the back wall and the stylion landmark on the wrist of the outreached arm.	
Inter-Elbow Distance	28.6 in	39.9 in	Subject stands erect with both arms fully abducted, parallel to the standing surface with the palms facing forward. Measure the distance between the two elbow tip landmarks while standing behind the subject.	
Inter-Wrist Distance	45.3 in	63.7 in	Subject stands erect against the wall with both arms fully abducted, parallel to the standing surface with the palms facing forward. Measure the distance between the two wrist crease landmarks.	
Vertical Trunk Diameter (VTD)[1]	22.0 in	29.9 in	The subject stands erect looking straight ahead, heels far enough apart to insert anthropometer/calipers, and weight distributed equally on both feet. The subject should place one end of the measuring device into the pubis symphysis (male subjects should move scrotum out of the way). Measure the vertical distance from the crotch to the mid-shoulder landmark (have tech or engineer hold calipers). This measurement is done for both left and right side.	

Measurement	Minimum	Maximum	Method	Figures
Head Length	6.8 in	8.5 in	The distance from the glabella landmark between the browridges to the posterior point on the back of the head. Measured with a spreading caliper.	
Waist Depth (Omphalion)	5.9 in	11.8 in	The horizontal distance between the front and back of the waist at the level of the center of the navel (omphalion). Measured with a beam caliper. The subject stands erect looking straight ahead. The heels are together with the weight distributed equally on both feet.	
Midshoulder to Top of Head	9.3 in	12.7 in	Derived measurement based on delta from seated Mid-shoulder height to seated height.	
Body Surface Area of A Crewmember	2,144 in^2 (13,831 cm^2)	3,764 in^2 (24,282 cm^2)	Body surface area is an important consideration for liquid cooling garment design and play a role in heat storage calculations. Suggested range is 1st to 99th percentile to be consistent with current approach in RQMT-026. This body surface area range is consistent with actual measured persons and is not just calculated based on feasible extremes of stature and body mass.	N/A

Measurement	Minimum	Maximum	Method	Figures
Crewmember Body Mass	94 lb (42.64 kg)	243 lb (110.22 kg)	Body mass (1st to 99th) is needed to convert body mass normalized NASA-STD-3001 V1, Rev A, Aerobic Capacity Fitness for Duty Standard into absolute terms for needed analyses related to metabolic rate including inspired CO_2 and heat storage. Further, body mass is needed to calculate system center of gravity.	N/A

Flag Note:

[1]In-flight anthropometry changes: Stature measurements will increase beyond the values shown in this table by 3% and VTD measurements will increase by 6% due to spinal elongation during microgravity exposure.

3.3.18 Unassisted Suit Operation (RQMT-027)

The xEVA System spacesuit shall provide for unassisted operation of all suit functions by the suited crewmember.

Rationale: It is necessary that the crewmember be able to use all features of the suit without assistance, including but not limited to donning, doffing, umbilical operations, controls, and status selections. The intent for Decompression Sickness (DCS) treatment operation is for a single crewmember to initiate their own and another suited crewmember's in-suit DCS treatment. All tasks will be performed with all suit-worn equipment that may impact mobility installed. Controls should include, but are not limited to operational mode, radio mode, radio volume, caution and warning status and acknowledge, display lighting intensity level, power mode, cooling level, auxiliary cooling, and Helmet/DCM Purge Valve or equivalent. Reference NASA-STD-3001, V2, Rev B, standard V2 11001.

Applicability: ISS and Artemis

3.3.19 Insight and Operability (RQMT-028)

The xEVA System shall provide the capability for each suited crewmember, ground, and Intravehicular Activity (IVA) support personnel to monitor, operate, and control all systems and subsystems where:

(a) The capability is necessary to execute the mission.

(b) The capability would prevent a catastrophic event.

(c) The capability would prevent an abort or terminate.

Rationale: This capability flows from the necessity of the crew to have insight into and control over the function of the suit and system. At a minimum crew needs insight into system status, crew biomedical information, sensor values, resource levels, faults, and any configuration information. At a minimum crew needs timely control of suit internal pressure, thermal, audio volume, purge valves, activation of backup systems, and shut down of failing systems. For suits with variable pressure designs, the ability to pause pressurization within 6.9 kPa (1 psia) of crewmember discomfort can prevent barotrauma. The ability for ground and IVA to monitor and control all system and subsystems will be determined by the same criteria (a-c above) as for the suited crew to operate the suit during an EVA. The capabilities for ground and IVAs are not required to be the same as the suited crew.

Applicability: ISS and Artemis

3.3.20 Caution Warning Control System (RQMT-029)

The xEVA System shall detect, indicate, annunciate, externally transmit, and internally communicate significant faults, performance degradation, and/or excessive resource usage and time remaining for all operating suits and pre-determined mission assets.

Rationale: Rapid crewmember response to an issue or trend can make the difference between life and death, or between accomplishing or not accomplishing high priority mission objectives. While other resources (control center personnel, IVA crew) may be actively monitoring xEVA System performance, it is critical that the crewmember in the suit has direct insight into the function and remaining resources of their suit.

Indication of these conditions must include both an audible tone and a message on the display, which provides additional information about the condition. Examples of conditions, which need to be detected, include, but are not limited to, sensor failures, high/low suit pressure, high/low electrical current, high O2 use rate, and low flow rates. In the event of malfunctions that require an EVA terminate or abort the suit must provide notification of the off-nominal condition with appropriate amount of time to respond.

Applicability: ISS and Artemis

3.3.21 xEVA System-Induced Injury (RQMT-030)

The xEVA System shall minimize potential for injury to the operator.

Rationale: An operator is any person, who dons the suit, including flight crew, test subjects, or other personnel. This requirement applies to all suit operational phases including ground training, Public Outreach events, on-orbit IVA activities, EVA, etc. Injury assessment and reporting criteria along with acute and repetitive motion injuries will be defined in EVA-EXP-10005, EVA-Induced Injury Minimization - Surveillance and Verification Methods. The intent of this requirement is that suit use does not cause acute or chronic injury to the user as a result of nominal or contingency operations.

Historically there have been various types of suit-induced injuries; for example, the EMU has been a causal or contributing factor in an unacceptably large number of shoulder *injuries. The consensus of medical practitioners who have studied this problem is that the injury mechanism is related to the EMU's Hard Upper Torso (HUT) syce bearing position over the collar bone and the HUT's limitation of normal scapulothoracic motion, which prevent the suited shoulder joint from elevating normally as the upper arm moves for the overhead work that is unavoidable at many ISS EVA worksites. Designers shall closely examine shoulder mobility issues and hip mobility issues experienced with the EMU in order to protect crew from shoulder injury (reference NASA TM - 2003-212058 EMU Shoulder Injury Tiger Team Report). Other injuries as experienced include hyperextension of elbows during ingress/egress, knee injury with Articulating Portable Foot Restraint (APFR) ingress, fingernail delamination, hot spots and pinch points, general injuries to hands and feet, all of which vary by crewmember anthropometry. To assist in crew performance and protection from injury, supplies such as band-aids, mole skin, durabond, etc., should be included in the services package and accounted for in overall mass allocation. NASA can provide documentation for additional suit-induced injuries.*

Applicability: ISS and Artemis

3.3.22 Transmit/Receive Status (RQMT-031)

The xEVA System shall transmit and receive health and safety telemetry to / from the spacecraft and between each of the suited crewmembers at the same time at a rate adequate to monitor the crew and system.

Rationale: Receipt of telemetry allows for confirmation of nominal operations as well as response to off-nominal scenarios. Intended recipients are other spacecraft and/or suited crewmembers at the same time. While all data is expected to be processed and displayed via receiving spacecraft and the ground, it is anticipated that suits receiving EVA data from each other may reduce the processed/displayed quantity to only those items most immediately useful to the suited EVA Crew. This may include Alarms and Warning Tones as well as display of text-based critical display messages, and is understood that design features would need to be developed to allow EVA Crew to differentiate the source of such items (whether it is their own suit with a malfunction or the other EVA crewmember's). Processing and display of graphics, video and non-critical telemetry between EVA Suits during an EVA may be technically possible with additional design features or software upgrades but should be accompanied with compelling rationale as to why it should be implemented. Other data may include payload/sensor information, voice, environmental and physiological parameters, and other telemetry status information, commands, and files as applicable. EVA execution will be safer and more efficient with the capability for crew to receive and view such information as maps, procedures, photos/videos, text messages, timelines, etc.

Applicability: ISS and Artemis

3.3.23 Airlock Reconfiguration (RQMT-032)

The xEVA System shall not alter the ISS Airlock in such a way that it precludes an EMU or alternate provider to perform a contingency EVA within 48 total hours utilizing no more than 16 crew hours to de-configure the xEVA System.

> *Rationale: Minimize crew time and complexity of operations required to restore capability of ISS Airlock to support a two (2) suited EMU or alternate provider EVA.*
>
> *Applicability: ISS*

3.3.24 Interface Reconfigurability (RQMT-033)

The xEVA System shall interface with HLS and other Artemis and Exploration host vehicles in such a way that the host vehicle can be reconfigured to support alternate provider EVA within 48 total hours utilizing no more than 16 crew hours to de-configure the xEVA System.

> *Rationale: Minimize crew time and complexity of operations required to restore capability of host vehicle Airlock to support alternate provider EVA.*
>
> *Applicability: Artemis*

3.3.25 Standards Compliance (RQMT-034)

The xEVA Service shall be compliant with standards as described in **DRD-xEVAS-ENG-01**, *NASA Standards & Specifications Compliance & Tailoring*.

> *Rationale: The service needs to prove compliance with the specified standards to ensure that compliance was completed throughout development, testing, and certification.*
>
> *Applicability: ISS and Artemis*

3.3.26 EVA System Compatibility (RQMT-092)

The xEVA System shall meet EVA-EXP-0035, *Exploration EVA System Compatibility Requirements*.

> *Rationale: EVA-EXP-0035 contains the compatibility requirements for all hardware to be used by the suited EVA crewmember to ensure that all operations can be safely performed within the expected performance capabilities.*
>
> *Applicability: ISS and Artemis*

3.3.27 ISS EVA Generic Tools and Crew Aids Interfaces (RQMT-035)

The xEVA System shall be compatible with all NASA provided EVA Tools and Crew Aids as described in SSP 30256, *ISS EVA Standard Interface Control Document (ICD)*, EVA-EXP-0035, *Exploration EVA System Compatibility Requirements, EVA Tool Catalog, and* SSP 51080, *EVA-ISS Interface Description Document*.

Rationale: The ISS EVA Standard ICD defines the interface requirements that the xEVA System could be subjected to while performing a Flight Test on ISS. Reference SSP 30256, Section 3.2 for interaction with tools and crew aids and EVA-EXP-0035. It is intended to capture the full list from a Functional/Performance of Tasks perspective although it is possible some heritage EVA Tools and Equipment (e.g. Modified Mini-Workstation System (MMWS) and Body Restraint Tether (BRT)) that hard mount to suits may be candidates for replacement with provider's original design in order to not over-constrain the xEVA System design. For basic "do not harm" compatibility, please see the information regarding items such as touch temperature limits, sharp edges, finger entrapment, etc. in EVA-EXP-0035.

Applicability: ISS and Artemis

3.3.28 Artemis EVA Generic Tools and Crew Aids Interfaces (RQMT-036)

The four types of lunar exploration tools referenced in EVA-EXP-0042, *xEVA System Concept of Operations,* are Mobility/transportation, Construction, Geology, and Contingency. The xEVA System shall provide lunar exploration tools including but not limited to:

- Geology Hammer
- Rake
- Scoop
- Tongs
- Extension Handle
- Contingency Sampler
- Drive Tube
- Sample Bag
- Sample Bag Dispenser
- Sample Return Pack
- Sample Return Case
- Sample Collection Pack
- Bags
- Chisel
- Scale
- Suit to Tool Interface Kit
- Flag
- Gnomon
- Contact Sampling Device
- Slide Hammer
- PSR Tools: Drive Tube, Tongs, Scoop
- Handheld Flashlight
- Portable Flood Lighting
- Tool Cart/Carrier
- Dust Mitigation Tools
- Rover Tool Carrier

- Driver Hardware: Drive Tube Vacuum Sealed PSR Container, Float/Chip/Soil Vacuum Sealed PSR Container, Deep Core Drill, Deep Core Drill Container

Construction/Engineering Task tooling include but is not limited to:

- Hammer
- Prybar
- Pistol Grip Tool (PGT)-type driver and associated sockets
- Electrical connector tools
- Fluid Quick Disconnect (FQD) tools

Rationale: Given the expected tasks for Lunar surface operations as detailed in EVA-EXP-0042, the tool list represents a base set to accomplish Artemis mission objectives. Tools and equipment utilized during surface EVAs will differ from those used for microgravity operations. Large, heavy tools will need to be lighter when used in a partial-g environment. Additionally, science tools will have special cleanliness and material requirements to meet science objectives. Furthermore, dust will be a factor that needs to be accounted for in tool design and maintenance. There will also be a significant difference with how equipment will be transported during surface EVA operations as opposed to in microgravity. As science and mission objectives evolve, future tool kits may consist of a multitude of tools and equipment.

Applicability: Artemis

3.3.29 Science Sampling (RQMT-037)

The xEVA System shall be designed in such a way as to minimize contamination of science samples (contamination sources include but are not limited to off-gassing of the xEVA System-provided hardware, release of volatiles, materials of tooling, heat/light impacting samples, etc.) per the processes defined by NASA's Contamination and Research Integrity (CARI) Rapid Response Team.

Rationale: A key objective for Artemis EVAs will be gathering samples to support further scientific research. While some degree of contamination/altering of the samples is likely unavoidable, xEVA System can minimize this. The contamination can include but is not limited to mechanisms such as shedding, introduction of foreign materials and thermal. Terms of Reference for the CARI Rapid Response Team provides guidance for development activities requiring science input.

Applicability: Artemis

3.3.30 Don/Doff Volume (RQMT-038)

The xEVA System shall be designed to permit two spacesuits be simultaneously donned and doffed in the ISS Airlock Equipment Lock volume and Artemis equivalent.

Rationale: On ISS one EMU suit and one Exploration Suit or two Exploration Suits may be in the available host vehicle volume at the same time. For Artemis, it is assumed to be the same suit design in a given Artemis mission. Vehicle IRCD's are available in the xEVAS Attachment J-05, Applicable Documents List, which provide dimensions for each spacecraft's don-doff volume agreement. This also enables prebreathe at lower pressure in Equipment Lock followed by suit donning without exposure to higher pressure.

Applicability: ISS and Artemis

3.3.31 EVA Crewlock Volume (RQMT-039)

The xEVA System shall permit two fully pressurized suited crewmembers with required EVA Tools and Crew Aids and ORUs for the EVA to depress, egress, ingress and repress the ISS Airlock Crewlock (and Artemis equivalent) in one depress/repress cycle without assistance from the other crew or ground.

Rationale: Two xEVA System spacesuits will be in the Crewlock volume at the same time. The suited, pressurized crewmembers must be able to fit and operate the umbilical operations concurrently as well as perform hatch operations. The clarification of one airlock cycle is to preclude the possibility of performing two single crewmember depress/repress cycles serially. Additionally, the intent is to allow for equipment such as EVA tools to be donned prior to egress and Orbital Replacement Units (ORUs) to be transferred in or out. It is undesirable to have to wait until after egress of the hatch to attach all support equipment. Reference the EMU Reference Dimensions Figure for the current EMU dimensions and EVA-EXP-0032, EVA-ISS Interface Definition Document for ISS US Airlock General Layout and Dimensions in a two suit per EVA scenario. Reference EVA-EXP-0035, Exploration EVA System Compatibility requirement [EVASC.0013] for typical ORU size. ORUs could be as large as Bearing Motor Roll Ring Module (BMMRM), Space Station Remote Manipulator System (SSRMS) Latching End Effector (LEE), Mini-Pump Module (MPM) Flight Support Equipment (FSE) with MPM, Camera/Light/External High Definition Camera (EHDC) Bundle, ExPRESS Carrier Avionics (ExPCA). Note that these figures are for reference only and clarify what is known- that two suits of the size and shape of the ISS EMU are proven to successfully fit and operate out of the ISS US Airlock. It is understood that the Anthropometric range described in RQMT-020 *will naturally drive some suit dimensions such as Stature beyond that of the ISS EMU shown below. In addition to physical fit in the repress/depress volume, use of the airlock to permit EVA's can include the use of support hardware. Vehicle IRCD's are available in the xEVAS Applicable Documents List which provide interfaces to vehicle utilities for each spacecraft's airlock and suit servicing functions, for example see SSP 51080, xEMU-ISS Interface Requirement Control Document for available utilities in the existing ISS airlock.*

Applicability: ISS and Artemis

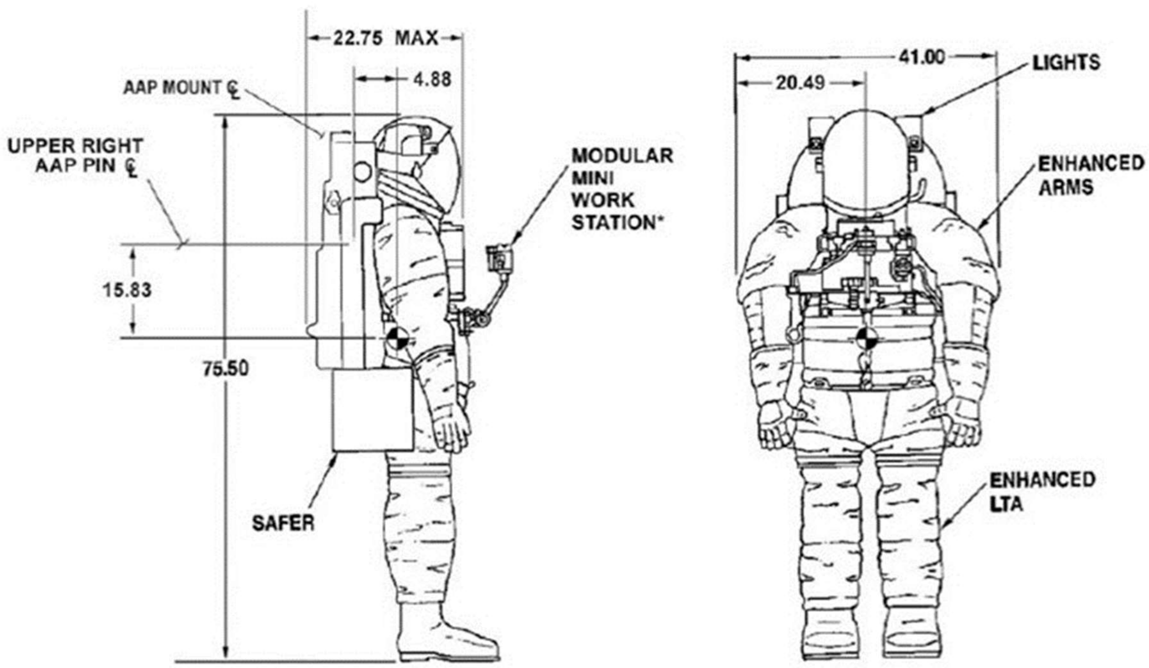


FIGURE 3.3.31-1 EMU REFERENCE DIMENSIONS

3.3.32 xEVA System Consumables Recharge (IVA)(RQMT-093)

The xEVA System shall provide for primary and emergency/secondary consumables recharge while IVA at cabin pressure.

> *Rationale: Spacesuits will need to have the capability to readily recharge the primary and emergency consumables (e.g. cooling water, oxygen, and power) that are expended every EVA. For reference, see the following documents: EVA-EXP-0032, SSP 51080, EVA-EXP-0048, and EVA-EXP-0067.*
>
> *Applicability: ISS and Artemis*

3.3.33 Purge Efficiency (RQMT-104)

xEVA System spacesuits shall limit the concentration of Nitrogen and other gases except O2, O2) and Water (H2O) to a total of 5% or less after purging a maximum of 0.39 kg (0.85 pounds) of 100% pure O2 per suit in a 101 kPa (14.7 psi) cabin.

> *Rationale: This is the most basic and relevant form for a purge requirement, which combines the EMU's original purge requirement (5% Nitrogen (N2)) with the amount of O2 used during an EMU purge without specifying purge duration or adding conservatism. The amount of N2 in the gas breathed is the concern for denitrogenation/bends. O2, CO2, and H2O are all normal gases of respiratory exchange Nitrogen is an inert gas and normally in equilibrium with the tissues, and thus needs a diffusion gradient to remove them from the tissue to reduce risk of DCS. Reference*

NASA/TM-2011-217062/Volume I NESC-RP-10-00659, In-Suit Light Exercise (ISLE) Prebreathe Protocol Peer Review Assessment. NASA will provide documentation for historical denitrogenation studies.

Applicability: ISS and Artemis

3.4 CONTINGENCY

3.4.1 Emergency Life Support (RQMT-040)

The xEVA System shall provide emergency life support for the suited crew member to safely return to and ingress/repress the host vehicle in response to any human or hardware emergencies (reference HLS Design Reference Mission (DRM) or EVA-EXP-0042, *xEVA System Concept of Operations*). For ISS, the Threshold duration is 30 minutes, with a Goal duration of 60 minutes. For Artemis the Threshold duration is 60 minutes.

Rationale: This requirement is intended to drive the development of boundary conditions for sizing of emergency capabilities such as consumables. This applies to emergency conditions while away from the host vehicle caused by external environmental factors, including but not limited to suit puncture due to MMOD or lunar ejecta, internal faults involving hardware failures, or human factors including but not limited to incapacitated crew. For reference, on ISS the range is 30 minutes for emergency ingress. ISS' existing suit system assisted rescue can take up to 51 minutes when one crew member must assist the other from certain worksites. Preliminary operations concept the crew could be up to 60-minutes away from host vehicle for lunar surface operations. The duration of secondary life support that is required to adequately control risk for a given design may be more or less than what is required on EMU and must consider the time to effect for failures of the suit that require assisted rescue.

Applicability: ISS and Artemis

3.4.2 Pressure Garment Breach (RQMT-041)

The xEVA System spacesuit shall provide the capability for the suited pressurized crew member to safely ingress and repress the airlock of the host vehicle following a breach of the pressure garment of at least 4.191mm (0.165 inches) Equivalent Sharp Edge Orifice Diameter (ESEOD). For ISS, the threshold duration is 30 minutes with a goal duration of 60 minutes. For Artemis, the threshold duration is 60 minutes.

Rationale: For ISS' existing suit system, self-rescue crew can take up to 30 minutes to return to the airlock and begin repress. For Artemis, it can take crew up to 60 minutes to traverse up to 2km to return to the HLS Airlock and repress.

Applicability: ISS and Artemis

3.4.3 Microgravity EVA Self Rescue Capability (RQMT-042)

The xEVA System shall permit the crewmember to perform self-rescue in the event the crewmember becomes detached from structure.

Rationale: Return to host spacecraft structure in the event of separation is a critical capability. Currently on ISS a human error can lead to an untethered event which drives the requirement to self-rescue. ISS EVA task efficiency costs of multiple tether solutions are too high to be practical. US EVAs performed from ISS currently use the ISS Simplified Aid for EVA Rescue (SAFER) (reference EVA-EXP-0032, EVA-ISS Interface Definition, for existing SAFER interfaces). It is expected that some features of the Exploration Suit will be different (such as Center of Gravity (CG)). The new suit could use the existing SAFER with some modifications such as mass, CG and software updates. The desire is to minimize or avoid hardware modifications to the existing SAFER. Some exploration DRMs may require additional SAFER functionality. It is expected that there likely would be a new ICD to cover the interfaces between the spacesuit and the SAFER. Should the suit developer choose to provide an alternative solution, it is expected that the developer design will meet the performance capabilities (while not significantly exceeding the mass) of the ISS self-rescue hardware. For Lunar surface EVAs, this will be covered in HLS integrated hazards.

Applicability: ISS and Artemis

3.4.4 Incapacitated EVA Crewmember Rescue (RQMT-043)

The xEVA System shall provide the capability for a single EVA crewmember to facilitate the translation, ingress, and repress of a single completely incapacitated fellow EVA crewmember. Both crewmembers shall be able to repress simultaneously following the rescue.

Rationale: The intent is for the suit and tools to include the capability to be rescued and brought back into the safe haven (e.g. airlock). This is considered to be a critical capability that covers various scenarios such as incapacitated crew, issue with a suit, crewmember becoming ill, lifting a crewmember, deceased crewmember, etc. Reference NASA-STD-3001 V2, Rev B, standard V2 8021.

Applicability: ISS and Artemis

3.5 SAFETY AND HEALTH

3.5.1 General Program Safety (RQMT-044)

The xEVA System shall meet the intent of SSP 51721, *ISS Safety Requirements Document* and GP 10023, Safety and Mission Assurance (*S&MA) Requirements*, as tailored for **DRD xEVAS-ENG-01**, *NASA Standards and Specifications Compliance and Tailoring* and per **DRD xEVAS-SMA-02**, *Safety and Mission Assurance Plan*.

Rationale: SSP 51721, GP 10023, S&MA Requirements, and Artemis equivalent provides a repository for the safety requirements applicable to pressurized and unpressurized end *items transported, transferred, stowed, operated on and/or removed from the ISS (via return or disposal), as well as for end items with any on-orbit reconfigurations or modifications which could create potentially hazardous conditions. This document assists the Safety Review Panel in an assessment of flight hardware compliance to the program safety requirements. As other Programs establish safety requirements, this requirement will be updated to reflect those safety processes.*

Applicability: ISS and Artemis

3.5.2 Fault Tolerance (RQMT-045)

The xEVA System shall be two-fault tolerant for catastrophic hazards and single fault tolerant for critical hazards.

Rationale: Failure of primary structure, structural failure of pressure vessel walls and structural failure of pressurized lines are exempted from the failure tolerance requirement provided the potentially catastrophic failures are controlled through a defined process in which approved standards and margins are implemented that account for the absence of failure tolerance. The ISS definitions for catastrophic and critical hazards can be found in SSP 51721, ISS Safety Requirements Document, GP 10023, S&MA Requirements, and Artemis equivalent. Catastrophic hazards that cannot be controlled using failure tolerance are exempted from the failure tolerance requirements with mandatory concurrence from the Technical Authorities and the Director, JSC (for crew risk acceptance) provided the hazards are controlled through a defined process in which approved standards and margins are implemented that account for the absence of failure tolerance.

Applicability: ISS and Artemis

3.5.3 Tether Points (RQMT-046)

The xEVA System shall provide means for safety tethering, local worksite stabilization in a variety of worksites, connection to an incapacitated crew for rescue, and restraint of tools.

Rationale: The suit must provide attachment points for waist, safety, and equipment tethers, and tether point extenders, to safely prevent separation of the EVA crewmember and/or equipment from the vehicle during EVA. A soft goods harness can serve as an attach point, but generally hard goods are preferred in order to avoid the crew time associated with the pre-EVA inspection of soft goods for wear/damage. EVA-EXP-0035 requirement [EVASC.0050] provides the Microgravity EVA Crew-Induced Loads Table that defines the structural loading on a tether. The source information for the EVA Induced Loading requirements is located in SSP 30256, EVA Standard ICD and SSP 57003, Payload Interface Document.

Applicability: ISS and Artemis

3.5.4 Toxic Substance Cleanup (RQMT-048)

The xEVA System shall permit the removal and conduct verification of removal of hazardous levels of toxic substances such as ammonia, hypergols, oxidizer, and fuel and oxidizer reaction products (FORP) prior to entry into the habitable environment.

Rationale: EV crew could be exposed to ammonia (ISS Thermal System), hypergols (thruster leaks), oxidizer (thruster leaks), and Fuel-Oxidizer Reaction Products (FORP) (residue around thrusters). Need to be able to remove and verify removed so crew does not bring back into habitable environment. Existing EMU uses vacuum bakeout as one means of cleanup and time at vacuum as a means of verification. A Contamination Detection Kit (CDK) and brushes is provided in the existing ISS tool kit for existing known ISS hazardous materials and could be used for the xEVA System. xEVAS is expected to develop and provide similar hardware for Artemis.

Applicability: ISS and Artemis

3.5.5 Cut Resistance (RQMT-094)

The xEVA spacesuit materials shall provide cut resistance that meets or exceeds the EMU's performance.

Rationale: The outer layer needs to be cut resistant to preserve MMOD protection, thermal performance, dust contamination control, and pressure restraint layer puncture resistance. The intent is to prevent hazardous damage to the suit and preclude breach of the suit's pressure integrity. Ideally, this reduces the need for periodic inspections of the suit during EVA. A method for comparison to historical suit material cut resistance capabilities can be used such as American Society for Testing and Materials (ASTM) F1790-05 to quantify a given material performance. Sharp edges on ISS have been accepted in non-compliance reports based upon successfully completing swatch testing (which uses EMU materials as the basis for the test). Requiring the xEVA System to have cut resistance that meets or exceeds the EMU's performance will ensure the rationale for accepting these sharp edges is not violated when using the xEVA System.

Applicability: ISS and Artemis

3.5.6 Shock Hazard (RQMT-095)

The xEVA System spacesuits shall limit the EVA crewmember's electrical exposure to 0.1 mA or less when the suit is exposed to the voltage potentials defined in EVA-EXP-0039, *Exploration EVA System Destinations Environment Specifications*.

Rationale: Electrical arcing between vehicles at different potentials and at different exploration destinations is a possible hazard. This potential difference can arise as vehicles move through the plasma environment or during lunar missions when the moon travels through Earth's geomagnetic tail. In addition to the plasma hazard, other electrical hazards include mate and demate of hot connectors as well as contact with batteries and solar *arrays. While procedural controls and keep out zones try to protect the EVA crewmember they cannot be enforced in all situations and do not protect from incidental contact.*

The EMU had no shock protection requirements when it was designed, which translated into development and flight of several pieces of hardware on ISS to mitigate the risk. For future EVA missions it is desirable for the suit to mitigate any shock hazards from the vehicle and/or environment. 160V Direct Current (DC) corresponds to the ISS power supply voltage; 0.1 mA is considered a relatively safe number in a worst-case exposure event across the chest. For comparison purposes, the startle reaction threshold is approximately 0.5-2.0 mA depending on electrical frequency. More information related to shock hazards can be found in Crew and Thermal Systems Division (CTSD)-ADV-1008, Shock Hazards during EVAs.

Applicability: ISS and Artemis

3.5.7 Decompression Sickness Prevention (RQMT-049)

The xEVA System shall provide prebreathe capability which achieves EVA readiness within 90 minutes or less of prebreathe from Exploration vehicle saturation atmospheres of 70.3 kPa (10.2 psia) (27% O2 nominal) and 56.5 kPa (8.2 psia) (34% O2 nominal), while in either microgravity or partial gravity; for EVA operations conducted from 101 kPa (14.7 psia) saturation atmospheres, the xEVA System must accommodate In-Suit Light Exercise (ISLE) prebreathe protocols.

Rationale: The planned operations and system design must protect crew from DCS related to pressure changes for EVA operations (including preparation and return) and off-nominal depressurization situations. DCS risk limits are defined in NASA-STD-3001 V1, Rev A, paragraph 4.4.3.6.1 DCS Prevention. The amount of inert gas in the tissues depends on the atmosphere exposure profile, and thus the allowable DCS risk may vary across the mission. Effective prebreathe times will necessarily be longer for larger delta pressures between staging vehicle cabin and xEVA suit.

Applicability: ISS and Artemis

3.5.8 Decompression Sickness Treatment Capability (RQMT-050)

The combined suit/vehicle system shall provide an environment of no less than 156.5 kPa (22.7 psia) (1,174 mmHg) and >95% Oxygen within 2 hours of the DCS event being identified and maintained for a minimum of 6 hours duration. In the context of a suit design that allows application of ≥ 56.5 kPa (8.2psia) to the crewmember during the EVA within 15min of probable DCS diagnosis, it is acceptable for the minimum pressure supplied by the combined suit/vehicle system within 2 hours to be 113.0 kPa (16.4 psia) (848 mmHg).

Rationale: DCS is a potential hazard of spaceflight and EVA because of changes in the operational pressure environment. Rapid and appropriate intervention is required to optimize the outcome for the affected crewmembers. Hyperbaric O2 therapy with >95% O2 is the primary treatment for DCS. Hyperbaric O2 therapy immediately reduces the volume of N2 bubbles in the body, improves tissue oxygen levels, and reduces dangerous *swelling. If treatment for DCS is instituted quickly, the outcome of therapy has a higher probability of success and will likely require less magnitude and duration of hyperbaric O2 therapy. This capability may utilize combined staging vehicle and EVA suit resources and design. The minimum required total pressures and duration of treatment outlined in this requirement are not equivalent to terrestrial medical standards of care for DCS; instead this capability aligns with ISS and other LEO spaceflight treatment capabilities and represents a baseline level of risk acceptance.*

The HLS atmosphere assumes a 56.5 kPa (8.2 psia) xEVA suit field capability. Alternate suit pressure will need to be coordinated with the HLS provider.

Applicability: ISS and Artemis

3.5.9 Heart Rate (RQMT-051)

The xEVA System in all configurations shall sense, record, and transmit heart rate of the crewmember during suited operations.

Rationale: SA-18-014, Johnson Space Center Health and Medical Technical Authority (HMTA) Position Regarding Heart Rhythm and Heart Rate Monitoring for the Exploration Extravehicular (xEMU) Project Advanced Extravehicular Activity Exploration Extravehicular Mobility Unit (AdvEVA xEMU) states that heart rate is a requirement rather than heart rhythm. Biomedical data transmission to the ground will be required for medical evaluation of crewmembers, including during suited operation (both EVA and IVA configurations). The collection and transmission of biomed data must not limit the transmission rate of the remaining suit data. Percentage of suit system data in the downlink telemetry stream will be dependent on the mission communication capabilities of the vehicle. Reference NASA-STD-3001 Volume 2, Rev B, standard V2 11023. Heritage systems interleave bio-med and suit systems data, which limits EMU, suit system data to once every two minutes during EVA. This reduces insight and is undesirable for ground situational awareness. Reference SA/HMTA memo SA-18-076 for the HMTA position on heart rate.

Applicability: ISS and Artemis

3.5.10 Radiation Monitoring (RQMT-053)

The xEVA System shall provide active radiation monitoring and alerting to the suited crew members and provide telemetry insight to the ground.

Rationale: Radiation monitoring provides primary data for assessing crew radiation exposures during EVA. The current exposure limits for deterministic effects (short-term exposure limits) are specified in NASA-STD-3001, V1, Rev A, and to demonstrate compliance, radiation monitoring is required. Reference NASA-STD-3001, V2, Rev B, standard V2 11010.

Applicability: ISS and Artemis

3.5.11 xEVA Suit System Body Waste Management (RQMT-054)

The xEVA System spacesuit shall collect, contain, isolate, stow, control odor, label and dispose of bodily waste throughout nominal suited and contingency operations in the quantities stated in Table 3.5.11-1 Suited Body Waste.

TABLE 3.5.11-1 SUITED BODY WASTE

Waste Type	Volume Allocation of Body Waste
Vomit	500 mL in a single emesis
Urine	1.7 L (57.5 oz)
	Max flow rate: 50 mL/s (1.9 oz/s)
Solid Feces	75 g (0.15 lb) (by mass) and 75 mL (2.5 oz) (by volume)
	Bristol Stool Chart Types 1-4
Menses	114 mL (3.9 oz)

Rationale: The intent is to prevent unintended use of ISS /Artemis consumables, preserve the cleanliness of xEVA systems, and mitigate body waste odor that may carry over to ISS/Artemis confined spaces during crewed operations

The total suited duration for nominal operations in EVA configuration is 13 hours to account for Pre and Post activities (e.g., total time includes pre-EVA (suit donning, prebreathe, and depress), EVA, post EVA (repress and suit doffing)). This time does NOT account for contingencies such as DCS treatment. Note that for the purposes of this rationale statement it is assumed that the EVA duration is no more than 8 hours, the Prebreathe duration is no more than 3.5 hours, depress is no more than 0.5 hr, repress is no more than 0.5 hr, and no more than 0.5 hr for post EVA (suit doffing). This means that the entire suited duration could be as much as 13 hours and would use a mix of suit and vehicle systems to sustain the life of the crewmember.

Vomiting in the suit may introduce catastrophic hazards such as aspiration by crewmembers, interference of crew vision, blockages of suit airways and damage to unprotected suit loop hardware can occur. To maintain crew health, particulates needs to be kept away or capable of being removed from the suited crewmember's oronasal region and eyes and hardware must be designed to preclude damage/degradation from free liquids and particulates.

In the event of an unrecoverable vehicle pressure failure wherein an extended stay in the suit or a safe haven is used to maintain life, crewmembers are to have the capability to access dedicated fecal and urine collection systems other than the diaper. Fecal waste collection is to be performed in a manner that minimizes escape of fecal contents into the general suit environment during microgravity operations due to the risk to both crew and hardware posed by potentially pathogenic bacteria. Voided urine is be contained by the *stowage and disposal hardware to prevent inadvertent discharge into the suit that could result in injury to the crewmember's mucous membranes or equipment.*

Applicability: ISS and Artemis

3.5.12 In-Suit Nutrition (RQMT-055)

The xEVA System spacesuit shall provide at least 1673.6 kJ (400 kcal) of crew nutrition while in a suited, pressurized configuration for EVAs of more than 4 hours duration, to be consumable at any point prior to suit doffing.

Rationale: Additional nutrients, including fluids, are necessary during suited operations as crewmember energy expenditure is greater during those activities. Nutritional supply during suited operations allows the crewmembers to maintain high performance levels throughout the duration of the EVA. Apollo astronauts strongly recommended the availability of a high-energy substance, either liquid or solid, for consumption during a surface EVA.

Consumption of additional nutrition that comes outside of xEVA System is expected to be consumed pre or post EVA. A total of 837 kJ (200kcal) per EVA hour must be provided to account for workload expenditures by a combination of EVA host vehicle and xEVA Suit System. This is the metabolic energy replacement requirement for moderate to heavy EVA tasks.

Applicability: ISS and Artemis

3.5.13 Food Quality and Safety (RQMT-080)

Microorganism levels in the food shall not exceed those specified in Table 3.5.13-1 Food Microorganism Levels at the time of consumption. Packaging must not invalidate the analysis and must minimize potential for crew error. In-suit nutrition solutions must be usable and non-hazardous to all crewmembers, accommodating known terrestrial food allergies and aversions.

TABLE 3.5.13-1 FOOD MICROORGANIISM LEVELS

Area/Item	Microorganism Tolerances	
Food Production Area	Samples Collected	Limits
Surfaces	3 surfaces sampled[a]	3000 CFU/ft^2 (total aerobic count)
Packaging Materials	Before use	3000 CFU per Pouch, Septum, 25 cm^2 or base
Air	1 sample of 320 L monthly	113 CFU/320 L (total aerobic count) (total aerobic count)

Food Product	Factor	Limits
Products that are not Commercially Sterile[b] Commercially Sterile Products (thermostabilized and irradiated)	Total aerobic count	20,000 CFU/g for any single sample (or if any two samples from a lot exceed 10,000 CFU/g)
	Enterobacteriaceae	100 CFU/g for any single sample (or if any two samples from a lot exceed 10 CFU/g). No detected serious or severe hazard human enteric pathogenic organisms
	Salmonella	0 CFU/g for any single sample
	Yeasts and molds	1000 CFU/g for any single sample (or if any two samples from a lot exceed 100 CFU/g or if any two samples from a lot exceed 10 CFU/g *Aspergillus flavus*)
	No sample submitted for microbiological analysis	100% inspection for package integrity

Notes:

a. Samples collected only on days that food facility is in operation. Additional environmental samples will be collected when there is a one-hour break in activity, or after five hours of continuous work.

b. At a Minimum, food items undergoing microbiological testing shall be considered as either raw material or finished goods (flight packaged foods). Five samples selected randomly from each lot shall be individually tested prior to packaging (raw material). A single random sample shall also be tested from the final flight packaged foods (finished goods). Food samples considered “finished goods” products that do not require additional repackaging are tested only for total aerobic counts.

Rationale: To maintain the health and safety of the crew, it is necessary to control microorganism growth. It is not expected for the EVA crew members to consume the in-suit nutrition within the first four hours of the EVA. The in-suit nutrition food source either needs to be able to be prepared (opened) when the crew is ready to consume it or once prepared (opened) capable of maintaining microorganism levels below that stated in the standard for maximum suited duration. All final packaged food should be labeled with *a name accurately descriptive of the food product, the production date, and the "best if used" by date at a minimum.*

Applicability: ISS and Artemis

3.5.14 Food Acceptability (RQMT-096)

The xEVA System food shall maintain acceptability of at least six (6) on a nine (9) point hedonic scale through the food's shelf life.

Rationale: A viable and stable food system that the crew is willing and able to consume is critical for maintaining the health of the crew. The crew's willingness to consume these foods and the nutrients -they contain is impacted by the variety (choice), ease of use in microgravity, appearance, aroma, flavor, and texture of the foods. NASA missions will require that foods maintain acceptability from packaging through consumption and under vehicle storage conditions (e.g. temperature, pressure). If food is not deemed acceptable for consumption, the crew will not eat thereby impacting their health and performance during and post mission. Food must maintain acceptability starting with the processing of the food through consumption on-orbit. Food shelf life must consider items such as pre-flight processing of food, mission delays, and pre-staging of food. Acceptability for all food items throughout all phases of the mission should exceed a score of 6.0 on a 9-pt hedonic scale by a representative panel of volunteers.

Applicability: ISS and Artemis

3.5.15 In-Suit Water Provision (RQMT-056)

The xEVA System spacesuit shall provide the suited crewmember the ability to consume a minimum of 947 mL (32 oz) potable water per microgravity ISS EVA and a minimum of 240 mL (8 oz) per hour for surface EVA.

Rationale: Potable water is necessary during suited operations to prevent dehydration caused by perspiration and insensible water loss, as well as to improve crew comfort. Having the potable water system be rechargeable from an external source is acceptable as long as the internal suit reservoir has sufficient capacity to allow ready access to water without impacting work efficiency.

*Requests for water per **DRD-xEVAS-ENG-07**, Mission Resource Allocation Document (MRAD) will be negotiated with appropriate program.*

Applicability: ISS and Artemis

3.5.16 NASA-STD-3001 Applicability (RQMT-079)

The xEVA System shall meet all the NASA-STD-3001, Volumes 1 and 2 standards marked as applicable in Appendix C, NASA-STD-3001 Applicability Matrix, of this document.

Rationale: NASA-STD-3001 V1, Rev A, defines crew health and safety standards for human spaceflight programs and applies broadly to the xEVA System. NASA-STD-3001 V2, Rev B, defines human-system integration standards for human spaceflight programs. Appendix D, NASA-STD-3001, Applicability Matrix, of this document notes which of the Volume 1 and Volume 2 standards is applicable to xEVA System development. Tailoring of applicable requirements in the standards is expected based on the design with verification that shows the intent of the requirement is met.

Applicability: ISS and Artemis

3.6 PHYSICAL CHARACTERISTICS

3.6.1 xEVA System Mass (RQMT-058)

The xEVA System shall not exceed the control mass as defined in the xEVA System Control Masses Table 3.6.1-1 for items launched to support microgravity and lunar EVA operations.

Rationale: This requirement is established as a reference datum for the purposes of design verification and is not intended to represent any specific mission's manifest. Mission-specific manifests will be used to combine quantity of suits and other EVA equipment to support the specific prime and backup crewmembers, quantity of EVAs, EVA-specific tasks, overall mission duration, etc. The mass of the crewmember wearing the EVA suit is not included in this requirement. System control mass values are outlined for one wetted EVA System fully configured for an 8-hour nominal lunar EVA. The values stipulated in this requirement are based upon averaging the masses of EVA suits sized for the smallest and largest end of the applicable Anthro range in this SRD and is not intended to be inclusive of the mass of sizing components needed to cover the rest of the applicable anthropometric range. For the purposes of lunar surface task tools, dust mitigation equipment is assumed to be included in this allocation while geology tools and payloads are not. The intent of this requirement is to communicate a "per crewmember, per EVA" approach that allows for future scaling of the xEVA System mass across various mission scenarios. The table intentionally differentiates between hardware provided "per crewmember" which allocates one-time masses for each mission, and "per crewmember, per EVA" hardware which scale with the quantity of EVAs in a given mission such as drink bags, in-suit nutrition, crew comfort, crew medical equipment, human waste control devices, etc. Vehicle-provided consumables such as oxygen and water (both potable for drink bags and cooling water for suit functions) are not accounted for in this requirement. Values for those are captured for per-EVA scaling with vehicle-specific interface documents. The requirement delineates between Artemis mission segments: Artemis Earth Launch, Artemis Lunar Descent, Artemis Lunar Ascent and Artemis Earth Return. At this time, NASA-provided Artemis Earth Return allocations are zero, while Artemis Earth Launch allocations provide an added launch packaging mass for the hardware outlined in this requirement. This control mass assumes lunar landers use a dual suit architecture" wherein one suit (EVA suit) is optimized for the applicable EVA requirements in this SRD while a separate suit (IVA suit) is optimized for dynamic phases of flight. The IVA suit provider and host spacecraft are responsible for those requirements, vehicle interfaces *and corresponding mass allocations for an IVA suit, including the use of an IVA suit for any EVA tasks such as a departure prep (jettison) EVA.*

Applicability: Artemis

TABLE 3.6.1-1 XEVA SYSTEM CONTROL MASSES

Flight phase	Mass (kg)
Artemis Earth Launch Packaging	15 kg per crewmember
Artemis Lunar Descent	232.4 kg per crewmember 2.3 kg per EVA per crewmember
Artemis Lunar Ascent	0 kg
Artemis Earth Landing	0 kg

3.6.2 Interface Requirements Control Documents

3.6.2.1 ISS Interface Requirements Control Documents (RQMT-059)

The xEVA System shall meet all required interfaces as defined in the SSP 51080, *xEMU-ISS Interface Requirement Control Document*, SSP 30256, *ISS EVA Standard ICD*, EVA-EXP-0032, *EVA-ISS Interface Definition*, EVA-EXP-0035, *EVA Office Exploration EVA System Compatibility, EVA Tool Catalog, and SSP 57000, Pressurized Payloads Interface Requirements Document, Appendix I, Command and Data Handling Interface Requirements.* .

Rationale: SSP 51080 describes the intended interface to the NASA xEMU. Many of the interfaces listed in SSP 51080 are formally documented in EVA-EXP-0032. Hardline communications are required for xEVAS per RQMT-100 and is described in EVA-EXP-0032. SSP 30256 and EVA-EXP-0035 describe the design interface that hardware constructed for EVA use and handling have been built to. The EVA Tools Catalog describes various tools that NASA has available to aid in task completion. SSP 57000, Appendix I governs on orbit IT security. Interfaces that are not applicable to the design can be marked as N/A with NASA approval.

Applicability: ISS

3.6.2.2 Artemis Interface Requirements Control Documents (RQMT-097)

The xEVA System shall meet all required interfaces as defined in the EVA-EXP-0035, *EVA Office Exploration EVA System Compatibility*, *EVA Tool Catalog* and EVA-EXP-0067, *HLS xEVAS IRCD*.

Rationale: EVA-EXP-0067 documents the specific interfaces that are required for xEVA System. EVA-EXP-0035 describes the design interface that hardware constructed for EVA use and handling have been built to. The EVA Tools Catalog describes various tools that

NASA has available to aid in task completion. Interfaces that are not applicable to the design can be marked as N/A with NASA approval.

Applicability: Artemis

3.6.3 Unpressurized Hardware Transfer (RQMT-061)

All xEVA System components shall permit translation through the 800mm (31.5 inches) diameter docking port and the Pressurized Mating Adapter.

Rationale: All xEVA System components in its launch configuration (unpressurized stowed in cargo bags and launch enclosures) should permit translation through the 800 mm (31.5 inches) diameter docking port and the Pressurized Mating Adapter.

Crew must be able to transfer an unpressurized suit in its launch packing configuration from the cargo transport vehicle to ISS/Host vehicle without requiring unpacking of the suit prior transfer. Sufficient access and free volume will be needed to allow the crew to get into the cargo vehicle to transfer items. International Docking System Adapter (IDA) Standard Pass-Through requirement is 800 mm (31.5 inches). It should be noted that this transfer may also pass through an ISS-style Pressurized Mating Adapter which is not a straight-through corridor but rather has a bend. Reference SSP 50933, IDA to ISS and Visiting Vehicle IRD, Soft Capture Ring Dimensions. Reference SSP 42097, Pressurized Mating Adapter 2 & 3 To U.S. Pressurized Elements (USL to PMA-2) Interface Control Document.

Applicability: ISS and Artemis

3.6.4 External Identification of Hardware (RQMT-062)

The xEVA System shall provide external identification for hardware that is unique to each crewmember.

Rationale: External identification for items unique to a crewmember is needed to expedite suit donning and umbilical interfacing. It also provides a means of quick visual identification during ground processing of unique hardware. The intent of this requirement is to allow the crewmember to easily identify ownership of unique suit components without the need for additional procedures, such as scanning a barcode, using a tool, removing a cover, completely unpacking a stowed item, or cross-referencing serial number. Mark items such that a crewmember can identify his/her hardware from glancing at it.

Applicability: ISS and Artemis

3.6.5 External Identification of Crew (RQMT-063)

The xEVA System shall provide the ability to visually identify which crewmember is performing an EVA operation based on the external suit markings from all sides.

Rationale: The ability to determine in video (real-time or post EVA) which crewmember performs which tasks is valuable for situational awareness of all observers and historical data purposes.

Applicability: ISS and Artemis

3.6.6 Compatibility with ECLS Systems (RQMT-098)

The xEVA System shall limit the introduction of chemicals/substances (liquids and/or gases) listed below that may adversely affect performance of the ISS ECLS System Hardware or Artemis equivalent.

Rationale: Limiting introduction of the chemicals listed through selection and/or containment design protects the ECLS system functional capabilities. Any new chemicals/substances not listed will need to be evaluated by ISS and Artemis. Introduction of these chemicals by materials off-gassing by the xEVA System is excluded from this requirement.

Applicability: ISS and Artemis

Chemicals (liquids and/or gases) used by the xEVA System that may be introduced into the atmosphere by the xEVA System during a nominal or off-nominal event will negatively impact the ISS cabin atmospheric quality and ISS life support system hardware and/or process performance (functional and/or logistics). Additionally, chemical releases may lead to unrecoverable contamination of the ISS atmosphere. ISS is required to maintain trace chemical contamination concentration gradients in the cabin atmosphere to <10% SMAC. ISS ECLS system resources are limited by logistics resupply constraints and cannot be replaced more often than the operating conditions they were originally designed to support. The quantity threshold limits of the chemicals specified are those of known and used chemicals on ISS. The concentration limits listed prevent excessive concentration gradients and protect the ISS ECLS system functional capabilities.

TABLE 3.6.6-1 CHEMICAL COMPOUNDS OF CONCERN TO ISS ECLS SYSTEM HARDWARE AND PROCESSES

COMPOUND	TOTAL RELEASED MASS (grams)	AFFECTED ECLSS HARDWARE	NOTES
Ammonia and volatile amines	170 75% of TCCS CBA capacity	TCCS charcoal bed assembly (CBA) service life impact.	Can form NO_x in contact with hot surfaces so is also SFOG operational constraint. Release rate >2.6 gram/day exceeds TCCS scrubbing rate.
Halocarbons including Bromotrifluoromethane (Halon 1301) and	50 75% of TCCS SBA capacity as dichloromethane basis	TCCS sorbent bed assembly (SBA) service life impact.	May form acid gases in contact with hot surfaces so is a solid fuel oxygen generator (SFOG) operational constraint.

COMPOUND	TOTAL RELEASED MASS (grams)	AFFECTED ECLSS HARDWARE	NOTES
Perfluorocarbons (HFE, Fluorinert, and Galden fluids)			Concentration >2 mg/m^3 concentration entering TCCS COA results in >40% loss of methane oxidation performance. Performance loss is partially recoverable with estimated 10% permanent oxidation efficiency loss.
Sulfur compounds (excluding SF_6)	2 hydrogen sulfide basis	Irreversibly poisons TCCS catalytic oxidation assembly (COA) catalyst.	Forms SO_2 upon oxidation. Concentration of 1.4 mg/m^3 concentration entering the COA results in irreversible 40% loss of methane oxidation performance. SF_6 has been shown to not react in the COA.
Thionyl chloride	5 75% of 2 $LiSOCl_2$ ½ AA batteries basis	TCCS SBA service life impact and irreversible TCCS COA catalyst poison.	Decomposes to SO_2 and HCl on contact with humidity in the atmosphere. Single ½ AA $LiSOCl_2$ battery leak may result in 70% loss of TCCS COA activity.
Organosilicones (silicone-based liquids and grease):	316 75% of TCCS CBA capacity as trimethylsilanol basis	Irreversible TCCS COA catalyst masking and Russian BMP ZPL-1M regenerable carbon bed fouling.	Organosilicone compounds are one of the higher concentration contaminants in the ISS cabin air. Could also have some deleterious effect on heat exchanger coating performance and water processor.
Polar volatile organic compounds: methanol ethanol isopropanol n-propanol n-butanol acetone ethylene glycol propylene glycol glycerol	 0.07 2.5 2.5 0.14 1 2.5 0.007 3 0.02	Water processor assembly (WPA) performance and logistics impacts.	Excessive humidity condensate loading leads to overall process inefficiencies and expendable resource consumption. Logistics resupply and recurring operating cost impacts.
Other water-soluble volatile organic compounds: Dimethyl sulfone Chloroethanol Iodoacetamide Chloroacetone Dichloroacetone Methylene chloride Methylene bromide Bromacetone Dimethyl sulfoxide 2,2-thiodiethanol	<0.7	Water processor assembly (WPA) volatile removal assembly (VRA) catalyst poisoning.	If present in significant quantities these compounds may load humidity condensate excessively. At high humidity condensate loadings (e.g., due to a spill), these compounds could break through the ISS WPA multifiltration beds and reach the oxidation reactor. The reaction rate in the reactor is so slow that they act as a poison by occupying catalyst sites and preventing the oxidation of other volatile organic compounds.

COMPOUND	TOTAL RELEASED MASS (grams)	AFFECTED ECLSS HARDWARE	NOTES
Chloroacetaldehyde Tribromoethanol Chloroacetonitrile Methyl iodide Ethyl bromide 1,3-dichloro-2-propanol Dimethyl thiourea Ethylene bromohydrin; Chloroacetamide Thiourea Methanethiol Methyl bromide Ethanethiol 2-Mercaptoethanol Thioformamide Thioacetamide Dichloroacetonitrile Ethylene thiourea Methylene iodide Bromoacetamide			

Note 1: Polar Volatile Organic Compounds (VOCs) are addressed by requirement 3.3.2.2.9.2.
Note 2: SMAC value for compound driving threshold limit.

3.7 INFORMATION MANAGEMENT

3.7.1 Suit Engineering Data Storage (RQMT-064)

The xEVA System shall provide capability to record, store and retrieve all sensor readings and faults for a single EVA including any pre-and post-activities at a rate adequate to diagnose failures for the duration of all powered suit operations.

Rationale: Data recording will provide a record of the crewmember and suit technical health and status, including radiation data and future data capabilities captured during an EVA or other powered operations and will maintain the record should there be an interruption of communication between the suit and vehicle. This will assist not only for trending engineering and crew data gathered during suited operations, but it is also intended to function like a black box should retrieval of data be necessary to support anomaly investigations. A single EVA will include both pre- and post-EVA tasks. This requirement is not intended to mandate a data sampling frequency but to size the minimum amount of data storage required and may not be used in real time on ISS or other spacecraft and test facilities unless their communications systems allow for it. This data may be erased after it has been retrieved.

Applicability: ISS and Artemis

3.7.2 Information System (RQMT-065)

The xEVA System shall provide an EVA information system and graphical display with the following key information to the suited crew member:

Key information which enable efficient mission execution include:

A. Consumable monitoring and display (Both)

B. Procedure viewer (Both)

C. Display of photo imagery and graphics (Artemis required, ISS goal)

D. Timeline viewer (Artemis)

E. Data storage (Artemis)

F. Display for send/receive of text messaging (Artemis)

G. Camera viewfinder (Artemis required, ISS goal)

H. Recording of crew audio/video/still image field notes (Artemis)

I. Map display, which includes EVA crewmember position and supports real-time navigation (Artemis Only)

J. Communication of relevant biomedical information. (Artemis required, ISS goal)

Rationale: Lack of Situational Awareness (SA) has been associated with numerous accidents and incorrect decisions by flight crews in commercial aviation and in ground-based simulation of spacecraft operations. To maximize SA and optimize operational accuracy and efficiency, designers are to perform a detailed information requirements analysis of all onboard operations and ensure that the crew-vehicle interfaces provide all required information to perform the operation. A useful and effective system design supports the crewmember's ability to rapidly and accurately assess the current situation. Occasional loss of SA is expected in an operational setting where crew may have to unexpectedly move from task to task as events demand. It is important that the system design provides the necessary information, cues, or indicators to help the crewmember easily recover SA. Determination of anticipated levels of crew capability and anticipated levels of task demands is based on a detailed task analysis. Having adequate information readily available can significantly improve operational efficiency, particularly for lunar surface/science operations.

Applicability: ISS and Artemis

3.7.3 Vehicle Based Wireless Data Communication for Low Earth Orbit International Space Station (RQMT-066)

The xEVA System spacesuit shall transmit high-rate supplemental wireless data and video with a minimum range of 100 meters (328 feet) compatible with the External Wireless Communication (EWC) as defined in SSP 57003 Payload Interface Requirements Document, section L.3.5.

Rationale: High-rate proximity communications will be necessary with exploration vehicles and suits during microgravity and surface EVAs. It is expected that design solutions may have multiple broadcast power levels. This may be chosen to facilitate power saving when operations are known/planned to be at significantly shorter distances than the overall capability required here. The vehicle will communicate with the suit over the External Wireless Communication System.

Applicability: ISS

3.7.4 Dedicated EVA Radio Frequency Communication for Low Earth Orbit International Space Station (RQMT-067)

The xEVA System spacesuit shall simultaneously transmit data and voice over safety critical RF communications with a minimum range of 100 meters (328 feet), per JSC 27181, *Space to Space Communications System, Specification*.

Rationale: EVA requires omnidirectional coverage in all three dimensions. UHF generally propagates around/through most obstacles. Current ISS EVA communication systems utilize various UHF and S-Band protocols for voice, data, and video. It is expected that design solutions may have multiple broadcast power levels. This may be chosen to facilitate power saving when operations are known/planned to be at significantly shorter distances than the overall capability required here.

Applicability: ISS

3.7.5 Simultaneous Two-Way Communications (RQMT-068)

The xEVA System spacesuit shall operate with communications systems and provide simultaneous data and two-way communication with 90% English word recognition, using ANSI/ASA S3.2-2009, Method for Measuring the Intelligibility of Speech over Communication Systems for minimum four EVA crew and all other assets simultaneously.

Rationale: The suit must use communication interfaces while providing data and voice communications between the EVA crewmembers and EVA crewmembers to local spacecraft on both RF communication and wireless data. Voice communication is to be perceived accurately. If messages are perceived with errors or low precision, important information may be missed; therefore, crew may make errors in tasks, and their safety may be jeopardized. Note: Section 10.5.3.7, Word Recognition [V2 10091], in NASA-STD-3001 V2, Rev B is not meant to apply to speech recognition software.

Applicability: ISS and Artemis

3.7.6 Voice Mode (RQMT-099)

The xEVA System spacesuit shall have a voice transmission system with push-to-talk (umbilical), voice activated, and mute modes that are controllable by the crewmember.

Rationale: The spacesuit voice transmission system must provide these three configurations to be compatible with the legacy communication system on ISS. For example, push-to-talk is needed to allow the crewmember to transmit to Mission Control Center (MCC), when using hardline comm on the umbilical. Voice is considered to be analog on ISS per Service and Performance Checkout Equipment (SPCE). Voice is considered to be data on other vehicles.

Applicability: ISS and Artemis

3.7.7 Hardline Transmit and Receive (RQMT-100)

The xEVA System spacesuit shall transmit and receive data over a hardline interface.

Rationale: The suit needs to have the capability to switch between communication modes. Data includes voice, environmental and physiological parameters, other telemetry status information, commands, and files as applicable to the current version of the architecture. This capability can be verified/demonstrated on the ground.

Applicability: ISS and Artemis

3.7.8 Audio Feedback (RQMT-101)

The xEVA System spacesuit shall accept audio inputs generated by external sources without propagating or establishing unwanted feedback loops.

Rationale: Spacesuits must work at a variety of absolute pressures and in IVA scenarios that include helmets off with nearby communication devices such as wall-mounted speakers, microphones, and other audio equipment. This requirement could be met by hardware and/or operational controls.

Applicability: ISS and Artemis

3.7.9 Programming Updates (RQMT-102)

The xEVA System spacesuit shall accept software and firmware updates.

Rationale: The ability to reprogram devices and update software is needed for maintainability. Updates can be applied when the suit is not in use. Changes to configuration data and software patches are included in the scope of software updates. The intent is to include both ground and IVA on-orbit software updates. This requirement is intended to allow all types of programming updates including devices such as Field-Programmable Gate Array (FPGAs).

Applicability: ISS and Artemis

3.7.10 Reconfigurable Communication (RQMT-069)

The xEVA System spacesuit shall have a wireless data interface which is reconfigurable in-space for different protocols or operational bandwidth.

Rationale: High-rate proximity communications with exploration vehicles and suits should be reconfigurable in order to operate with different protocols during microgravity and surface EVAs. Flexibility needs to be built in such that a comm protocol change does not require extensive, invasive hardware changeouts in flight or return of the suit assembly to Earth for extensive groundwork. There are multiple ways the intent could be met, including but not limited to using a software-defined radio or a modular radio hardware design that facilitates hardware swap out. These and other paths would enable comm protocol switches or upgrades "in mission" without undue burden on the crew.

Applicability: ISS and Artemis

3.7.11 Vehicle-Based Wireless Data Communication for Exploration Destinations Beyond Low Earth Orbit (RQMT-070)

The xEVA System shall provide high-rate supplemental wireless data and video in accordance with EVA-EXP-0067, *HLS xEVAS IRCD*, between spacesuits and host vehicle with a minimum range of 300m (984 ft) with a goal of 2km (1.24 mi) in all terrain types.

Rationale: High-rate proximity communications will be necessary with exploration vehicles and suits during microgravity and surface EVAs. Extended comm distances are anticipated to drive technologies for planetary surface DRMs. It is expected that design solutions may have multiple broadcast power levels. This may be chosen to facilitate power saving when operations are known/planned to be at significantly shorter distances than the overall capability required here. Repeater capability may be required to meet range or communicate around terrain (e.g. hill, crater wall, etc.) features.

Applicability: Artemis

3.7.12 Dedicated EVA Radio Frequency Communication for Exploration Destinations Beyond Low Earth Orbit (RQMT-071)

The xEVA System shall transmit data and voice and video in accordance with EVA-EXP-0067, *HLS xEVAS IRCD*, between spacesuits and host vehicle over safety critical RF communications with a minimum range of 500 m (1,640 ft) with a goal of 2km (1.24 mi) in all terrain types.

Rationale: It is assumed that future Exploration DRMs will use specifications similar to Space-to Space Communication Systems (SSCS) per JSC 27181 as is or develop new UHF modulation schemas to provide greater bandwidth over UHF. EVA requires omnidirectional coverage in all three dimensions. UHF generally propagates *around/through most obstacles. Extended comm distances are anticipated to drive technologies for planetary surface DRMs. It is expected that design solutions may have multiple broadcast power levels. This may be chosen to facilitate power saving when operations are known/planned to be at significantly shorter distances than the overall capability required here. Repeater capability may be required to meet range or communicate around terrain (e.g. hill, crater wall, etc.) features.*

Applicability: Artemis

3.7.13 High-Resolution Video (RQMT-072)

The xEVA System spacesuit shall record and transmit to the host vehicle real-time high-resolution motion imagery from a suit mounted camera for the duration of all powered suit operations.

Rationale: Video recording is an essential tool in mission operations; it provides Intravehicular (IV) crewmembers and ground operator's status and insight into issues during EVA execution as well as post-EVA diagnostics, analysis and failure investigations. Such situational awareness is valuable for both safety and efficiency. Video is also utilized by a Science Team for data and decision-making during science operations.

Applicability: ISS and Artemis

3.7.14 Powered Sensor Interface (RQMT-103)

The xEVA System spacesuit shall provide internal and external power and data interfaces per EVA-EXP-0073, *xEVA System Accessories Interface Description Document*, to host internal and external sensors or devices during suit operations.

Rationale: This requirement is intended to make the suit compatible with a powered internal and external sensor or other device via a common interface such as Universal Serial Bus (USB), Ethernet or other widely used/common power/data interfaces. Internal refers to the habitable portion of the suit and external refers to the environment exterior to the suit. The solution may be combined or separated (data could be implemented wirelessly, separate from hardline power). The intent is to provide limited power on the order of 2.5W, *assuming five Volt DC and a minimum of 0.5 A which is the maximum simultaneous draw allowed when internal and external sensor interfaces are combined. There are multiple design trades the supplier will likely pursue in selecting this interface and may extend this feature as a part of a central avionics bus. It is possible this data port will be utilized for additional functions (such as loading software, downloading data, etc.) which will influence which data standard is selected. The voltage and power selected allows for 20 W-h of energy to be provided which will enable a variety of sensors, which may be designed in the future for deployment on the exterior of an Exploration Suit.*

Applicability: ISS and Artemis

3.8 TASK MANAGEMENT

3.8.1 Microgravity Worksite Lighting (RQMT-073)

The xEVA System spacesuit shall provide lighting to perform EVA operations in microgravity environments as defined in EVA-EXP-0039, *Exploration EVA System Destination Environments Specifications.*

Rationale: Worksite and translation lighting is essential for EVA task execution. EVA task planning and scheduling cannot always be constrained to worksites with adequate natural illumination.

Applicability: ISS and Artemis

3.8.2 xEVA System Partial Gravity Integrated Lighting Capability (RQMT-074)

The xEVA System shall provide lighting for crewmembers to perform lunar surface EVAs and associated science objectives in accordance with the environments defined in EVA-EXP-0039, *Exploration EVA System Destination Environments Specifications*.

Rationale: Worksite and translation lighting is essential for safe EVA task execution. EVA task planning and scheduling cannot always be constrained to worksites with adequate natural illumination. The wide variety of tasks and translations paths that may be taken across a natural surface pose a wide array of interfaces with any lighting solution. Supplemental lighting capability is NOT inherently required of spacesuits themselves but rather is intended for separate devices that may or may not be continually worn on the spacesuit and allow for two-handed operations. Devices may be deployed by suited crewmembers or included on other lunar surface assets that are otherwise not considered a part of the suit.

Applicability: Artemis

3.9 MISSION INTEGRATION

3.9.1 ISS Launch/Return Packaging (RQMT-075)

The xEVA System hardware shall be certified for launch and return on all USOS resupply and crew vehicles and stowage in all USOS modules with the largest item not exceeding the equivalent size of a standard ISS 8.0 Cargo Transfer Bag Equivalent (CTBE).

Rationale: xEVA System hardware configurations for launch and/or return should be optimized to the smallest possible packages and balanced against the risk to the hardware during assembly and disassembly and on orbit crew time. Launch and return volume is a highly competitive resource especially with large items. Optimizing the packing sizes of any xEVA System hardware to smaller items and components will provide the most flexibility for launch and return without impacting other ISS objectives. It may be acceptable to use additional crew time for assembly/disassembly when compared against launch/return availability. An 8.0 CTBE is the maximum size of a packed item supported *on a launch or return vehicle, as of the writing of this document most cargo launch vehicles can only accommodate one 8.0 CTBE per item per flight. See reference JSC 39233, CTBE IDD which provides CTBE dimensions.*

Launch and return on all USOS resupply and crew vehicles and stowage in all USOS modules provides the Contractor and NASA flexibility to support the real-time EVA operations. To enable the Contractor and NASA maximum flexibility, options such as launch, return and disposal xEVA System hardware on Russian cargo and crew vehicles should be considered. While not all xEVA System components may be suitable for this environment, there may be items which could be certified to meet the Russian vehicle environments and interfaces, which may provide the Contractor additional opportunities to ensure availability of xEVA System hardware on-orbit at time of crew arrival.

Applicability: ISS

3.9.2 ISS Launch/Return Allocations (RQMT-076)

The xEVA System shall minimize launch and return manifest requirements, launch in a passive configuration and not exceed the annual ISS Launch/Return allocations per Table 3.2.9-1 ISS Launch/Return Allocations

Rationale: Based on historical EMU rate. Initial provisioning of xEVA System may exceed these limits.

Applicability: ISS

TABLE 3.9.2-1 XEVAS SRD RQMT-076 ISS LAUNCH/RETURN ALLOCATIONS

Parameter	Annual Requirement
xEVA System Total Launch Manifest	Mass: 550 kg; Volume: 3432000 cm^3
xEVA System Total Return Manifest	Mass: 240 kg; Volume: 1723000 cm^3

3.9.3 ISS Onboard Stowage Allocation (RQMT-077)

The xEVA System hardware stowage allocation on ISS shall be minimized and not exceed 20 CTBE per EVA suited/equipped crew-member capability.

Rationale: Current EMU stowage is 8.0 CTBE per EMU and 12.0 CTBE of goods and support equipment per EV crewmember capability. It is expected that typically up to 4-5 EVA capable crewmembers will be onboard simultaneously.

Applicability: ISS

4.0 VERIFICATION REQUIREMENTS

This section provides preferred method for verifying the requirements in Section 3 of this document. Suppliers will implement verification requirements at the project-level specification based upon approval by NASA and the requirement owners.

4.1 GENERAL

Table 4.3.4-1 Requirements Verification Matrix provides a cross-reference of requirements stated in Paragraph 3 with the appropriate verification guidelines.

4.2 RESPONSIBILITY FOR VERIFICATION

The Commercial Provider shall be responsible for verifying requirements of this SRD. The verification methods listed in the table below are NASA's recommended verification method. NASA expects to work with the commercial provider to come to an agreed verification plan as described by **DRD XEVAS-ENG-03**, *Verification and Validation (V&V) Plan*.

4.3 VERIFICATION METHODS

This section contains the definitions of the verification methods as well as preferred method for the verification methods and phases of the Section 3 requirements are defined in this section.

4.3.1 Inspection (I)

Inspection is a verification method of physical characteristics that determines compliance without the use of special laboratory equipment, procedures, test support items, or services. Inspection uses standard methods, such as visual gages, etc., to verify compliance with documented design requirements. Inspection also includes the inspection of design documents, material lists, code, plans, etc., to verify that requirements have been met.

4.3.2 Analysis/Similarity (A)

Analysis is a verification method that uses techniques and tools, such as math models, prior test data, simulations, and analytical assessments. Analyses are made once per item and hence are always shown as part of the Certification. Verification by a similarity analysis is acceptable if the subject article is similar or is identical in design, manufacturing process, and quality control to another article previously verified as equivalent or as meeting more stringent criteria.

4.3.3 Demonstration (D)

Demonstration is a qualitative verification method in which the properties of the subset equipment are evaluated by observation. Demonstration is used with or without special test equipment or instrumentation, so as to verify the required characteristics of operational functioning, human engineering features, service and access feature, transportability, and displayed data.

4.3.4 Test (T)

Test is a verification method in which performance requirements are verified by measurement during or after controlled application of functional and environmental stimuli. The measurements may require the use of laboratory equipment, recorded data, test support items, and services. Testing may be performed with or without humans in the loop depending on the requirement being verified and the uncertainty of human performance. Human thermal vacuum chamber testing is expected as a capstone of ground testing.

4.3.4.1 Task Verification

Various testing and demonstration activities with humans operating xEVA suits in IVA and EVA mode are expected. NASA has previously used 5 different users of various sizes to assess completion only tasks and 20 different users of various sizes to assess tasks where subjective feedback related to comfort, fatigue, and workload are required.

Verification Methods:

NA= Not Applicable

I= Inspection

A= Analysis

D= Demonstration

T= Test

TABLE 4.3-1 REQUIREMENTS VERIFICATION CROSS REFERENCE MATRIX

Requirement	**REQUIREMENT TITLE**	**Preferred METHOD**	**Applicable to ISS and/or Artemis**
RQMT-001	ISS EVA Capability	A & D & T	ISS
RQMT-002	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-003	Lunar EVA Capability	A & D & T	Artemis
RQMT-004	EVA Rate	A	ISS and Artemis
RQMT-005	EVA Availability	A	ISS
RQMT-006	Spacecraft Independent Operation	T	ISS and Artemis
RQMT-007	ISS Task Capability	T	ISS
RQMT-008	Lunar Task Capability	T	Artemis
RQMT-009	Crew Time Allocation	A	ISS and Artemis
RQMT-010	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-011	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-012	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-013	Destination Environments	A & T	ISS and Artemis
RQMT-014	Lunar Surface Dust Mitigation	A & T	Artemis

Requirement	REQUIREMENT TITLE	Preferred METHOD	Applicable to ISS and/or Artemis
RQMT-015	Micro Meteoroids and Orbital Debris Probability of No Penetration	A	ISS and Artemis
RQMT-016	Suit Habitability	A & T	ISS and Artemis
RQMT-017	Metabolic Rate	T	ISS and Artemis
RQMT-018	Indicate Pressure	I	ISS and Artemis
RQMT-019	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-020	Impact Performance - Microgravity	T	ISS and Artemis
RQMT-021	Impact Performance - Partial Gravity	T	Artemis
RQMT-022	Visual Capabilities	T	ISS and Artemis
RQMT-023	Protection from Ultraviolet and Infrared	T	ISS and Artemis
RQMT-024	Ability to Work in Suits	T	ISS and Artemis
RQMT-025	ISS Suit Mobility	T	ISS
RQMT-026	Anthropometry	A & T	ISS and Artemis
RQMT-027	Unassisted Suit Operation	D	ISS and Artemis
RQMT-028	Insight and Operability	A & T	ISS and Artemis
RQMT-029	Caution Warning Control System	A & T	ISS and Artemis
RQMT-030	xEVA System-Induced Injury	A	ISS and Artemis
RQMT-031	Transmit / Receive Status	T	ISS and Artemis
RQMT-032	Airlock Reconfiguration	A	ISS
RQMT-033	Interface Reconfigurability	A	Artemis
RQMT-034	Standards Compliance	A & T	ISS and Artemis
RQMT-035	ISS EVA Generic Tools and Crew Aids Interfaces	A & T	ISS and Artemis
RQMT-036	Artemis EVA Generic Tools and Crew Aids Interfaces	I	Artemis
RQMT-037	Science Sampling	A	Artemis
RQMT-038	Don/Doff Volume	D	ISS and Artemis
RQMT-039	EVA Crewlock Volume	D	ISS and Artemis
RQMT-040	Emergency Life Support	A & T	ISS and Artemis
RQMT-041	Pressure Garment Breach	A	ISS and Artemis
RQMT-042	Microgravity EVA Self Rescue Capability	A & T	ISS and Artemis
RQMT-043	Incapacitated EVA Crewmember Rescue	D	ISS and Artemis
RQMT-044	General Program Safety	A	ISS and Artemis
RQMT-045	Fault Tolerance	A	ISS and Artemis
RQMT-046	Tether Points	I	ISS and Artemis
RQMT-047	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-048	Toxic Substance Cleanup	A & D	ISS and Artemis

Requirement	REQUIREMENT TITLE	Preferred METHOD	Applicable to ISS and/or Artemis
RQMT-049	Decompression Sickness Prevention	A	ISS and Artemis
RQMT-050	Decompression Sickness Treatment Capability	A	ISS and Artemis
RQMT-051	Heart Rate	D	ISS and Artemis
RQMT-052	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-053	Radiation Monitoring	I	ISS and Artemis
RQMT-054	xEVA Suit System Body Waste Management	A & T	ISS and Artemis
RQMT-055	In-Suit Nutrition	A & D	ISS and Artemis
RQMT-056	In-Suit Water Provision	D	ISS and Artemis
RQMT-057	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-058	xEVA System Mass	A & T	Artemis
RQMT-059	ISS Interface Requirements Control Documents	A & T	ISS
RQMT-060	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-061	Unpressurized Hardware Transfer	A	ISS and Artemis
RQMT-062	External Identification of Hardware	I	ISS and Artemis
RQMT-063	External Identification of Crew	I	ISS and Artemis
RQMT-064	Suit Engineering Data Storage	T	ISS and Artemis
RQMT-065	Information System	T	ISS and Artemis
RQMT-066	Vehicle-Based Wireless Data Communication for Low Earth Orbit International Space Station	T	ISS
RQMT-067	Dedicated EVA Radio Frequency Communication for Low Earth Orbit International Space Station	T	ISS
RQMT-068	Simultaneous Two-Way Communications	T	ISS and Artemis
RQMT-069	Reconfigurable Communication	T	ISS and Artemis
RQMT-070	Vehicle-Based Wireless Data Communication for Exploration Destinations Beyond Low Earth Orbit	T	Artemis
RQMT-071	Dedicated EVA Radio Frequency Communication for	T	Artemis

Requirement	REQUIREMENT TITLE	Preferred METHOD	Applicable to ISS and/or Artemis
	Exploration Destinations Beyond Low Earth Orbit		
RQMT-072	High-Resolution Video	T	ISS and Artemis
RQMT-073	Microgravity Worksite Lighting	T	ISS and Artemis
RQMT-074	xEVA System Partial Gravity Integrated Lighting Capability	T	Artemis
RQMT-075	ISS Launch/Return Packaging	D	ISS
RQMT-076	ISS Launch/Return Allocations	A	ISS
RQMT-077	ISS Onboard Stowage Allocation	A	ISS
RQMT-078	***REMOVED***	***REMOVED***	***REMOVED***
RQMT-079	NASA-STD-3001 Applicability	A & T & D	ISS and Artemis
RQMT-080	Food Quality and Safety	A & T	ISS and Artemis
RQMT-081	Operation with Spacecraft Utilities and Consumable Resources	D	ISS and Artemis
RQMT-082	Lunar Dust Contamination	A & T	Artemis
RQMT-083	Lunar Surface Permanently Shadowed Region (PSR) Minimum Exposure Time	A & T	Artemis
RQMT-084	Quiescent Stowage	A & T	Artemis
RQMT-085	Spacesuit Inspired Partial Pressure of Carbon Dioxide	T	ISS and Artemis
RQMT-086	Internal Suit Surface Temperatures	A & D	ISS and Artemis
RQMT-087	Trace Contaminants	A	ISS and Artemis
RQMT-088	Sound Pressure Level Limits for Continuous Noise	T	ISS and Artemis
RQMT-089	Noise Limit for Personal Communication Devices	T	ISS and Artemis
RQMT-090	O2 Partial Pressure Range for Crew Exposure	A	ISS and Artemis
RQMT-091	Suit Accommodation of Metabolic Loads	A & T	ISS and Artemis
RQMT-092	EVA System Compatibility	A & T	
RQMT-093	xEVA System Consumables Recharge (IVA)	D	ISS and Artemis
RQMT-094	Cut Resistance	T	ISS and Artemis

Requirement	REQUIREMENT TITLE	Preferred METHOD	Applicable to ISS and/or Artemis
RQMT-095	Shock Hazard	A & T	ISS and Artemis
RQMT-096	Food Acceptability	T	ISS and Artemis
RQMT-097	Artemis Interface Requirements Control Documents	A & T	Artemis
RQMT-098	Compatibility with ECLS Systems	A	ISS and Artemis
RQMT-099	Voice Mode	D	ISS and Artemis
RQMT-100	Hardline Transmit and Receive	T	ISS and Artemis
RQMT-101	Audio Feedback	D	ISS and Artemis
RQMT-102	Programming Updates	T	ISS and Artemis
RQMT-103	Powered Sensor Interface	A & T	ISS and Artemis
RQMT-104	Purge Efficiency	T	ISS and Artemis

APPENDIX A
ACRONYMS AND ABBREVIATIONS AND GLOSSARY OF TERMS

TABLE A1.0-1 ACRONYMS AND ABBREVIATIONS

Acronym	Definition
AdvEMU	Advanced Extravehicular Mobility Unit
AI	Action Item
ANSI	American National Standards Institute
ANSUR	Anthropometric Survey of United States (U.S.) Army Personnel
APFR	Articulating Portable Foot Restraint
ASTM	American Society for Testing and Materials
BMMRM	Bearing Motor Roll Ring Module
BRT	Body Restraint Tether
BTU	British Thermal Unit
CARI	Contamination and Research Integrity
CCB	Configuration Control Board
CCE	Critical Contingency EVA
CCP	Crew Commercial Program
CDK	Contamination Detection Kit
CG	Center of Gravity
CO2	Carbon Dioxide
CR	Change Request
CRS	Commercial Resupply Services
CTBE	Cargo Transfer Bag Equivalent
CTSD	Crew and Thermal Systems Division
dBA	A-Weighted decibel
DC	Direct Current
DCS	Decompression Sickness
DRM	Design Reference Mission
EBOT	EVA Battery Operations Terminal
ECLSS	Environmental Control and Life Support System
EDDA	EMU Don/Doff Assembly
EHDC	External High Definition Camera
EMU	Extravehicular Mobility Unit
ESEOD	Equivalent Sharp Edge Orifice Diameter
EVA	Extravehicular Activity
EWC	External Wireless Communication
ExPCA	ExPRESS Carrier Avionics
FICO2	Fractional Inspiratory Volume for Carbon Dioxide
FORP	Fuel-Oxidizer Reaction Products

FPGA	Field-Programmable Gate Array
FQD	Fluid Quick Disconnects
FICO2	Fractional Inspiratory Volume for Carbon Dioxide
FSE	Flight Support Equipment
GGR&C	Generic Groundrules, Requirements, and Constraints
H2O	Water
HEA	Human Error Analysis
HIDH	Human Integration Design Handbook
HLS	Human Landing System
HMTA	Health and Medical Technical Authority
HUT	Hard Upper Torso
ICD	Interface Control Document
IDA	International Docking System Adapter
IDD	Interface Definition Document
IDRD	Increment Definition Requirements Document
IRCD	Interface Requirements Control Document
IRD	Interface Requirements Document
ISLE	In-Suit Light Exercise
ISS	International Space Station
IV	Intravehicular
IVA	Intravehicular Activity
L	Liter(s)
LADTAG	Lunar Atmosphere Dust Toxicity Assessment Group
LAN	Local Area Network
LDRO	Lunar Distant Retrograde Orbit
LEE	Latching End Effector
LEO	Low Earth Orbit
LiOH	Lithium Oxide
MCC	Mission Control Center
MEM	Meteoroid Engineering Model
METOX	Metal Oxide
mmHg	Millimeters of Mercury
MMOD	Micro Meteor Orbital Debris
MMWS	Modified Mini-Workstation System
MPM	Mini-Pump Module
MRAD	Mission Resource Allocation Document
N2	Nitrogen
NASA	National Aeronautics and Space Administration
NBL	Neutral Buoyancy Laboratory
NLS	NASA Launch Services

O2	oxygen
ORDEM	Orbital Debris Engineering Model
ORU	Orbital Replacement Unit
PEL	Permissible Exposure Limit
PGT	Pistol Grip Tool
PICO	Pre-Integration Check Out
PLSS	Portable Life Support System
PMA	Pressurized Mating Adaptor
PnP	Probability of no Penetration
ppCO2	partial pressure of CO2
PRA	Probabilistic Risk Assessments
PSR	Permanently Shadowed Regions
SA	Situational Awareness
SAFER	Simplified Aid for EVA Rescue
S&MA	Safety and Mission Assurance
SMAC	Spacecraft Maximum Allowable Concentration
SPCE	Service and Performance Checkout Equipment
SPL	Sound Pressure Levels
SRD	Systems Requirements Document
SRR	System Readiness Review
SSCS	Space-to Space Communication Systems
SSRMS	Space Station Remote Manipulator System
TBD	To Be Determined
TWA	Time-Weighted Average
UHF	Ultra-High Frequency
UIA	Umbilical Interface Assembly
U.S.	United States
USB	Universal Serial Bus
USL	United States Laboratory
USOS	United States On Orbit Segment
UV/IR	Ultraviolet/infrared
VISE	Vehicle Interface Suit Equipment
VLM	Vehicle Loop Mode
V&V	Verification and Validation
WAP	Wireless Access Point
WETA	Wireless Video System External Transceiver Assembly
xEMU	Exploration Extravehicular Mobility Unit
xEVAS	Exploration EVA Services

APPENDIX B
XEVAS SRD RQMT-024 ABILITY TO WORK IN SUITS MOBILITY MATRIX

TABLE B.0-1 XEVAS SRD RQMT-024 ABILITY TO WORK IN SUITS MOBILITY MATRIX

Task	Type	Success Criteria
Visor Reach	All	Controlled one-handed operation of sun visor open/close.
Sunshade Reach	All	Controlled one-handed operation of sunshades open/close.
Operate Switches and Controls	All	Demonstrate operation of all switches and controls intended for EVA operation. This includes the DCU and xINFO band.
Mate & Demate Umbilical	All	Mate and Demate the Umbilical.
Cross Shoulder/Elbow Touch	All	While standing, touch fingers of each hand to outside of the opposite shoulder; hold for 5 sec. While standing, touch fingers of each hand to outside of opposite elbow; hold for 5 sec.
Cranking Motion	All	Demonstrate ability to operate a hatch latch interface.
Mate & Demate NZGL Connector	All	Demonstrate ability to operate standard power and data connector that is positioned overhead.
Mate & Demate Cannon Connector	All	Demonstrate ability to operate standard power and data connector that is positioned overhead.
Mate & Demate Fluid Quick Disconnect Connector	All	Demonstrate ability to operate standard fluid connector that is positioned overhead.
Mate & Demate TA Clamp	All	Demonstrate ability to operate standard cable harness that is positioned overhead.
Detach from Don/Doff Fixture	All	Demonstrate ability to detach self from don/doff fixture for both Gateway and HLS scenarios.
Attach to Don/Doff Fixture	All	Demonstrate ability to attach self to don/doff fixture for both Gateway and HLS scenarios.
Operate power tool or instrument above head level	All	Demonstrate ability to operate the Pistol Grip Tool to drive a bolt above head level. (This satisfies off-nominal microgravity bolt operations and surface instrument operations)
Self-Doff/Don Helmet and Gloves	All	Demonstration of ability to doff helmet and gloves and then don helmet and gloves while suited without help.
Complete Microgravity Tasks While Wearing Tools	Microgravity	Demonstrate ability to complete microgravity mobility tasks while wearing TBD tools and equipment.
ISS EV Hatch Operations	Microgravity	Demonstrate ability to open and stow and the ability to unstow and close the ISS EV hatch.
ISS Airlock UIA and Depress Valve	Microgravity	Demonstrate ability to operate the ISS Airlock UIA and Depress Manual Isolation Valve with two crew

		and TBD complement of hardware bags in the Airlock.
ISS Airlock Egress and Ingress	Microgravity	Demonstrate ability to egress and ingress the ISS Airlock both as EV2 (headfirst) and EV1 (feet first) with two crew and TBD complement of hardware bags in the Airlock.
Lateral Translation	Microgravity	Weight-relieved translation or slider bar that pushes laterally for 61 cm (~24 inches) left and 61 cm (~24 inches) right.
Longitudinal Translatio n	Microgravity	Weight-relieved translation or pull loaded rope through ceiling mounted pulley.
Rotational Translation	Microgravity	Able to separate two hands at least 61 cm (~24 inches) and impart 22.2 Newtons (~5 lbf) in opposing directions with each hand (such that it would result in rotational suit motion)
Foot Restraint Retrieval	Microgravity	Able to release the locking mechanism that holds the foot restraint to a passive WIF.
Foot Restraint Pitch Knob Actuation	Microgravity	Able to unlock the foot restraint pitch knob, adjust the pitch setting, and lock the pitch knob.
Foot Restraint Ingress/Egress	Microgravity	Ingress and Egress the foot restraints.
Body Restraint Tether (BRT) Operations	Microgravity	Using body restraint tether mounted to square boss, stow Crewlock EVA Bag, rigidize ballstack, rotate Bag/BRT combo to side and behind body, rotate Bag/BRT back to front, unstow Bag, de-rigidize ballstack.
Body Restraint Tether (BRT) Stowage	Microgravity	Using body restraint tether mounted to square boss, demonstrate stowage and retrieval from five commonly used configurations: Looped CCW, Looped CW, Over the DCU/MWS, Over the Shoulder, End Effector to the MWS T-Bar.
Pistol Grip Tool (PGT) Retrieve and Stow	Microgravity	Retrieve PGT from R swing Arm. Configure settings on PGT. Position PGT on bolt. Drive bolt to torque. Stow PGT on R swing arm.
Pistol Grip Tool (PGT) Socket Swap	Microgravity	Using RET with PIP Pin, remove socket from PGT and re-install onto PGT.
ISS MWS T-Bar Clutch	Microgravity	Demonstrate actuation of the MWS T-Bar clutch to re-position the T-bar in various positions.
ISS MWS Tether Ops	Microgravity	Using a RET, demonstrate the attachment of the equipment hooks on all possible connection points on the MWS with the right swing arm and Dual Tether Points attached.
Tether Point Reach	Microgravity	Using the unmounted, Retracting Equipment Tether (RET) with the large crew hook and equipment hook, place the large crew hook on the xEMU waist tether point. Extend the RET to connect the equipment hook to each other xEMU tether point (in series).
Crew Tether Ops	Microgravity	Install small crew hook end of a Waist Tether to the xEMU LTA D-ring and remove it.

Complete Surface Task s While Wearing Tools	Surface (at 0.165 g)	Demonstrate ability to complete surface mobility tasks while wearing 22 kg (~48.5 lb) of tools and equipment.
Standing	Surface (at 0.165 g)	Hold a standing posture for 15 min.
Standing Toe Touch	Surface (at 0.165 g)	Controlled motion down, touch fingers to top of each boot and rotate adjustment device, if present (may touch boot with hand of choice), controlled motion back to standing.
Walking	Surface (at 0.165 g)	Walk a TBD distance (m), time (mins), and/or speed (m/s) on a level surface.
Walking - Positive Slope	Surface (at 0.165 g)	Walk up a 20-degree slope on unconsolidated regolith with 25 cm (~10 inches) diameter rocks and smaller covering 20% of the area.
Walking - Negative Slope	Surface (at 0.165 g)	Walk down a 20-degree slope on unconsolidated regolith with 25 cm (~10 inches) diameter rocks and smaller covering 20% of the area.
Walking - Cross Slope	Surface (at 0.165 g)	Walk across a 20-degree slope on unconsolidated regolith with 25 cm (~10 inches) diameter rocks and smaller covering 20% of the area.
Seated Position	Surface (at 0.165 g)	Hold a seated posture for 15 min.
Single Kneel	Surface (at 0.165 g)	Controlled motion to a single kneeling posture; return to standing in a controlled motion.
Single Kneel - Static Hold	Surface (at 0.165 g)	Controlled motion to a single kneeling posture; hold kneeling posture for 15 min; return to standing in a controlled motion.
Single Kneel - Single Hand Object Pick-up	Surface (at 0.165 g)	Controlled motion to a single knee for 1 min, lift a 2 kg (~4.4 lb) object (minimum size 8 x 5 x 10 cm (~3 inches x 2 inches x 4 inches)) with one hand (no handhold), return to standing in a controlled motion while maintaining hold of object.
Single Kneel - Two Hand Object Pick-up	Surface (at 0.165 g)	Controlled motion to a single knee for 2 mins, lift a 5 kg (~11 lb) object (minimum size 20 cm (~8 inches) cube) with two hands (no handholds), return to standing in a controlled motion while maintaining hold of object.
Double Kneel	Surface (at 0.165 g)	Controlled motion to a double kneeling posture; return to standing in a controlled motion.
Scrambling	Surface (at 0.165 g)	Success criteria – TBD
Drag	Surface (at 0.165 g)	Demonstrate ability to drag 250 kg (~551 lb) for 1 hour.
Carry	Surface (at 0.165 g)	Demonstrate ability to lift 110 kg (~243 lb), carry it for 150 m (~492 ft), and it set down in a controlled fashion.
Recovery from Prone	Surface (at 0.165 g)	Lying face-down, demonstrate unaided controlled motion to return to a standing position.
Recovery from Supine	Surface (at 0.165 g)	Lying face-up, demonstrate unaided controlled motion to return to a standing position.

Attach fall protection	Surface (at 0.165 g)	Demonstrate ability to attach fall protection system on self with no assistance.
Detach fall protection	Surface (at 0.165 g)	Demonstrate ability to detach fall protection system from self with no assistance.
Recover from fall in fall protection system	Surface (at 0.165 g)	Demonstrate ability to recover a stable body position in starting condition as if a fall happened while in the fall protection system.
Fall	Surface (at 0.165 g)	Demonstrate ability to fall safely in various directions, heights, and on various lunar simulated surfaces
Transfer from platform to ladder	Surface (at 0.165 g)	Demonstrate ability to transfer between ladder and platform at a TBD range of angles.
Descend a Ladder	Surface (at 0.165 g)	Demonstrate ability to climb a ladder at a TBD range of angles.
Climb a Ladder	Surface (at 0.165 g)	Demonstrate ability to climb a ladder at a TBD range of angles.
Transfer from ladder to platform	Surface (at 0.165 g)	Demonstrate ability to transfer between ladder and platform at a TBD range of angles.
Step Off Ledge	Surface (at 0.165 g)	Demonstrate ability to step down from ledge of TBD height.
Step Up onto Ledge	Surface (at 0.165 g)	Demonstrate ability to step up onto ledge of TBD height.
Climb up steps	Surface (at 0.165 g)	Demonstrate ability to walk/climb up steps
Descend steps	Surface (at 0.165 g)	Demonstrate ability to walk/climb down steps
Cross-Body Reach	Surface (at 0.165 g)	While standing, grasp handle of 2 kg (~4.4 lb) object (or equivalent) from approximate subject eye-height with two hands on subject's left side, controlled motion to bring handle/object to subject's knee height on right-hand side at a distance of 30 cm (~12 inches) to the right of the subject, controlled return to start position. Repeat for opposite side.
Camera Use	Surface (at 0.165 g)	Demonstrate ability to use camera in both suit-attached and un-attached configurations.
Retrieve hardware from high stowage	Surface (at 0.165 g)	Retrieve object of TBD volume and TBD mass from shelf above chest level and place on ground.
Stow hardware into high stowage	Surface (at 0.165 g)	Retrieve object of TBD volume and TBD mass from ground and stow on shelf above chest level.
Install Tools onto Suit	Surface (at 0.165 g)	Insert hammer, scoop, and chisel into holsters on suit. Self-don the utility belt (waist pack preinstalled). Attach sample bag dispenser
Load & Unload Tools onto a Carrying Device	Surface (at 0.165 g)	Demonstrate loading and unloading tools onto a carrying device (e.g. a tool cart).
Push/Pull a Cart	Surface (at 0.165 g)	Demonstrate both pushing and pulling a cart on uneven unconsolidated regolith with 25 cm (~10 inches) diameter rocks and smaller covering 20% of the area.

Conduct Rake Samplin g	Surface (at 0.165 g)	Use a rake to collect small rock samples and place into sample bag with and without extension handle. Close sample bag and stow bag in waist pack.
Conduct Float Sampling	Surface (at 0.165 g)	Use scoop or rake to pick up sample and place into sample bag with and without extension handle. Close sample bag and stow bag in waist pack.
Conduct Rock Chip Sampling	Surface (at 0.165 g)	Use hammer to break off chip samples (with and without chisel). Use tongs to retrieve chip samples and place into sample bag with and without extension handle.
Conduct Drive Tube Sampling Operation	Surface (at 0.165 g)	Attach upper and lower drive tubes and install onto extension handle. Drive tube into simulant with hammer and slide hammer. Remove drive tubes by hand, cap, disassemble, place into sealed container.
Conduct Trenching Operations	Surface (at 0.165 g)	Use a tool (e.g. scoop) to dig a trench in unconsolidated regolith; obtain a stoke length of TBD length.
Unstow Samples from Waist Pack	Surface (at 0.165 g)	Remove samples from suit-attached waist pack; place samples on/in another stowage location.
Remove Tools from Suit	Surface (at 0.165 g)	Remove hammer, scoop, and chisel from suit-attached holsters; self-doff the utility belt (with waist pack preinstalled); remove sample bag dispenser.
Dust Removal	Surface (at 0.165 g)	Demonstrate ability to access all surfaces of the suit and suit-mounted hardware with a brush to simulate dust removal.

APPENDIX C
NASA STANDARD 3001 APPLICABILITY MATRIX

These applicability matrices outline the standards that are applicable to xEVAS System design and the appropriate requirements-level compliance is required to meet NASA-STD-3001, Volume 1 Revision A with Change 1 and NASA-STD-3001, Volume 2 Revision B.

APP= Applicable, Standard shall be met as a requirement

N/A= Not Applicable, Standard does not need to be met

The column 'Comments' is for reference only and annotates if there is an existing SRD or DRD that maps to an Applicable standard. Per RQMT-079, a verification is expected for each applicable Standard.

TABLE C.0-1 NASA-STD-3001 VOLUME 1 APPLICABILITY

Vol. 1 Section	Standard Title	xEVAS Applicability	Comments
V1 4.2.3	Fitness for Duty Aerobic Capacity Standard	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 4015]
V1 4.2.10	Space Permissible Exposure Limit for Space Flight Radiation Exposure Standard	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 6095]
V1 4.4.3.1	Risk Management and Data Integration	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 11023]
V1 4.4.3.6.1	Decompression Sickness Prevention	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 6008] and [V26009]
V1 4.4.3.6.2	EVA Suit Monitoring	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 6001], [V2 6095], [V2 6100], [V2 11010], [V2 11036]
V1 4.4.3.6.3	Biomedical Data Availability	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 11023] and [V2 11035]
V1 4.4.3.6.4	DCS Treatment	APP	This is addressed by NASA-STD-3001 Volume 2, [V2 6009]
V1 4.4.3.7	Toxic Exposure Prevention	APP	

TABLE C.0-2 NASA-STD-3001 VOLUME 2 APPLICABILITY

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 3006	Human-Centered Task Analysis	APP	Reference DRD: XEVAS-HHP-01
V2 4001	Data Sets	APP	Reference RQMT-026
V2 4002	Data Set Characteristics	APP	Reference RQMT-026 Reference RQMT-059 Reference DRD XEVAS-ENG-01
V2 4003	Population Definition	APP	Reference RQMT-026
V2 4004	Data Set Assumptions	APP	Reference RQMT-026
V2 4005	Body Length Data	APP	Reference RQMT-025

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 4006	Changes in Body Length	APP	Reference RQMT-026
V2 4007	Range of Motion Data	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025 Reference RQMT-027 Reference RQMT-030
V2 4008	Reach Data	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025 Reference RQMT-027 Reference RQMT-030
V2 4009	Body Surface Area Data	APP	Reference RQMT-026
V2 4010	Body Volume Data	APP	Reference RQMT-026
V2 4011	Body Mass Data	APP	Reference RQMT-024
V2 4012	Strength Data	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025 Reference RQMT-027 Reference RQMT-030
V2 4013	Muscle Effects	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025 Reference RQMT-027 Reference RQMT-030
V2 4015	Aerobic Capacity	APP	
V2 5001	Visual Capabilities	APP	Reference RQMT-022
V2 5002	Auditory Perceptual Capabilities	APP	
V2 5003	Sensorimotor Capabilities	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025 Reference RQMT-028
V2 5004	Cognitive Capabilities	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024
V2 5005	Time and Performance	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025 Reference RQMT-065
V2 5006	Situational Awareness (SA)	APP	Reference RQMT-065
V2 5007	Nominal Cognitive Workload	APP	Reference RQMT-024
V2 5008	Off-Nominal Cognitive Workload	APP	Reference RQMT-024
V2 6001	Trend Analysis of Environmental Data	APP	
V2 6002	Inert Diluent Gas	N/A	
V2 6003	O2 Partial Pressure Range for Crew Exposure	APP	Reference RQMT-090

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 6004	Nominal Vehicle/Habitat Carbon Dioxide Levels	N/A	
V2 6006	Total Pressure Tolerance Range for Indefinite Crew Exposure	APP	
V2 6007	Rate of Pressure Change	APP	
V2 6008	Decompression Sickness (DCS) Risk Identification	APP	Reference RQMT-049
V2 6009	Decompression Sickness Treatment Capability	APP	Reference RQMT-050
V2 6010	Relative Humidity	N/A	
V2 6011	Post-Landing Relative Humidity	N/A	
V2 6012	Comfort Zone	N/A	
V2 6013	Temperature Comfort Range	N/A	
V2 6014	Crewmember Heat Storage	N/A	
V2 6017	Atmospheric Control	N/A	
V2 6019	Remote Adjustment	N/A	
V2 6020	Atmospheric Data Recording	N/A	
V2 6021	Atmospheric Data Displaying	N/A	
V2 6022	Atmospheric Monitoring and Alerting	N/A	
V2 6023	Trace Constituent Monitoring and Alerting	N/A	
V2 6024	Combustion Monitoring and Alerting	N/A	
V2 6025	Contamination Monitoring and Alerting	N/A	
V2 6026	Water Physiochemical Limits	APP	Reference RQMT-056
V2 6027	Water Microbial Limits	APP	Reference RQMT-056
V2 6029	Drinking Water Quantity	N/A	
V2 6030	Food Rehydration Water Quantity	N/A	
V2 6031	Hot Rehydration Water Quantity	N/A	
V2 6032	Personal Hygiene Water Quantity	N/A	
V2 6033	Eye Irrigation Water Quantity	N/A	
V2 6034	Medical Contingency Water Quantity	N/A	
V2 6035	Water Quantity for Suited EVA Operations	N/A	
V2 6036	Fluid Loading Water Quantity for Earth Entry	N/A	
V2 6037	Crew Recovery Water Quantity	N/A	
V2 6038	Sampling Water Quantity	N/A	
V2 6039	Water Dispensing Rate	N/A	
V2 6040	Water Dispensing Increments	N/A	
V2 6041	Hot Beverage Water Temperature	N/A	
V2 6042	Cold Beverage Water Temperature	N/A	
V2 6043	Food Hydration Water Temperature	N/A	
V2 6044	Personal Hygiene Water Temperature	N/A	
V2 6045	Medical Water Temperature	N/A	
V2 6046	Water Quality Monitoring	N/A	DRD-xEVAS-ENG-07 Mission Resource Allocation Document will be negotiated with provider. Assume water is provided by Host Vehicle.

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 6047	Toxic Hazard Level Three	APP	
V2 6048	Toxic Hazard Level Four	APP	
V2 6049	Chemical Decomposition	APP	
V2 6050	Atmosphere Contamination Limit – Airborne Contaminants	APP	Reference RQMT-087
V2 6051	Water Contamination Control	APP	
V2 6052	Particulate Matter	APP	
V2 6053	Lunar Dust Contamination	APP	Reference RQMT-014 Reference RQMT-082
V2 6054	Fungal Contamination	APP	
V2 6055	Bacterial Contamination	APP	
V2 6056	Surface Cleanability	APP	
V2 6057	Surface Microbial Contamination during Nominal Systems Operations	APP	
V2 6058	Condensation Limitation	APP	
V2 6059	Microbial Air Contamination Prevention	APP	
V2 6060	Biological Payloads	N/A	
V2 6061	Cross-Contamination	APP	
V2 6062	Availability of Environmental Hazards Information	N/A	
V2 6063	Contamination Cleanup	APP	
V2 6064	Sustained Translational Acceleration Limits	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.
V2 6065	Rotational Velocity	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.
V2 6066	Sustained Rotational Acceleration Due to Cross-Coupled Rotation	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.
V2 6067	Transient Rotational Acceleration	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.
V2 6068	Acceleration Rate of Change	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.
V2 6069	Acceleration Injury Prevention	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 6070	Injury Risk Criterion	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember.
V2 6073	Launch, Entry, and Abort Noise Exposure Limits	N/A	
V2 6074	Ceiling Limit for Launch and Entry	N/A	
V2 6075	Ceiling Limit for Launch Abort	N/A	
V2 6076	Launch, Entry, and Abort Impulse Noise Limits	N/A	
V2 6077	Hazardous Noise Limits for All Phases Except Launch, Entry, and Abort	APP	
V2 6078	Continuous Noise Limits	N/A	
V2 6079	Crew Sleep Continuous Noise Limits	N/A	
V2 6080	Intermittent Noise Limits	APP	
V2 6081	Alarm Maximum Sound Level Limit	APP	
V2 6082	Annoyance Noise Limits for Crew Sleep	N/A	
V2 6083	Impulse Noise Limit	APP	
V2 6084	Narrow-Band Noise Limits	APP	
V2 6085	Infrasonic Sound Pressure Limits	N/A	
V2 6087	Acoustic Monitoring	N/A	
V2 6088	Individual Noise Exposure Monitoring	N/A	
V2 6089	Vibration During Pre-Flight	N/A	
V2 6090	Vibration Exposures During Dynamic Phases of Flight	APP	Applicability dependent on design solution for any xEVA System hardware that provides mode of force or change in acceleration to the crewmember. [Reference DRD-XEVAS-ENG-09]
V2 6091	Long-Duration Vibration Exposure Limits for Health during Non-Sleep Phases of Mission	APP	
V2 6092	Vibration Exposure Limits during Sleep	N/A	
V2 6093	Vibration Limits for Performance	APP	
V2 6094	Hand Vibration	APP	
V2 6095	Ionizing Radiation Protection Limit	APP	
V2 6096	Crew Age/Gender Definition for Design Requirements	N/A	
V2 6097	Crew Radiation Exposure Limits	N/A	Reference RQMT-053 NASA sets the ALARA thresholds
V2 6098	Radiation Environments	N/A	NASA sets the ALARA thresholds
V2 6099	Space Weather Monitoring	N/A	
V2 6100	Ionizing Radiation Alerting	APP	Reference RQMT-053
V2 6101	Ionizing Radiation Dose Monitoring	N/A	

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 6102	RF Non-Ionizing Radiation Exposure Limits	APP	
V2 6103	Laser Exposure Limits	APP	Reference RQMT-023
V2 6104	Limits on Exposure to Incoherent Electromagnetic Radiation	APP	Reference RQMT-023
V2 6105	Total Iodine Concentration at the Point of Consumption	APP	
V2 6106	Noise Limit for Personal Communication Devices	APP	Reference RQMT-089
V2 7001	Food Quality	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7002	Food Acceptability	APP	Reference RQMT-096 Reference DRD: XEVAS-HHP-04
V2 7003	Food Caloric Content	APP	Reference RQMT-055 Reference DRD: XEVAS-HHP-04
V2 7004	EVA Food Caloric Content	APP	Reference RQMT-055 Reference DRD: XEVAS-HHP-04
V2 7005	Food Macronutrients	APP	Reference RQMT-055 Reference DRD: XEVAS-HHP-04
V2 7006	Food Micronutrients	APP	Reference RQMT-055 Reference DRD: XEVAS-HHP-04
V2 7007	Food Microorganism Levels	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7008	Food Preparation	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7009	Food Preparation and Cleanup	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7010	Food Contamination Control	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7011	Food and Beverage Heating	N/A	
V2 7012	Dining Accommodations	N/A	
V2 7013	Food System Waste	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7014	Food Spill Control	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7015	Food System Cleaning and Sanitizing	APP	Reference RQMT-080 Reference DRD: XEVAS-HHP-04
V2 7016	Personal Hygiene Capability	N/A	
V2 7017	Body Cleansing Privacy	N/A	
V2 7018	Personal Hygiene Provision	N/A	
V2 7019	Hygiene Maintainability	N/A	
V2 7020	Body Waste Management Capability	N/A	
V2 7021	Body Waste Management System Location	N/A	
V2 7022	Body Waste Management Privacy	N/A	
V2 7023	Body Waste Management Provision	N/A	
V2 7024	Body Waste Accommodation	APP	Reference RQMT-054
V2 7025	Body Waste Containment	N/A	
V2 7026	Body Waste Odor	APP	Reference RQMT-054
V2 7027	Body Waste Trash Receptacle Accessibility	N/A	

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 7028	Private Body Inspection Accommodation	N/A	
V2 7029	Body Waste Management Maintenance	N/A	
V2 7030	Average Feces per Day	APP	Reference RQMT-054
V2 7031	Maximum Feces per Event	APP	Reference RQMT-054
V2 7032	Average Diarrhea per Day	N/A	
V2 7033	Maximum Diarrhea per Event	APP	Reference RQMT-054
V2 7034	Urine Capacity	N/A	
V2 7035	Urine per Crewmember	N/A	
V2 7036	Urine Rate	APP	Reference RQMT-054
V2 7037	Vomitus per Collection and Containment	APP	Reference RQMT-054
V2 7038	Physiological Countermeasures Capability	N/A	
V2 7039	Volume Accommodations	N/A	
V2 7040	Physiological Countermeasure Operations	N/A	
V2 7041	Environmental Control	N/A	
V2 7042	Orthostatic Intolerance Countermeasures	N/A	
V2 7043	Medical Capability	N/A	
V2 7044	Medical Treatment Spatial Accommodation	N/A	
V2 7045	Medical Equipment Usability	N/A	
V2 7046	Medical Treatment Restraints	N/A	
V2 7047	Biological Waste Containment and Disposal	N/A	
V2 7048	Medical Equipment Disposal	N/A	
V2 7049	Deceased Crew	APP	Reference RQMT-0043; meeting the incapacitated crew rescue requirement sufficiently addressed this topic.
V2 7050	Stowage Provisions	APP	
V2 7051	Personal Stowage	N/A	
V2 7052	Stowage Location	N/A	
V2 7053	Stowage Interference	N/A	
V2 7054	Stowage Restraints	APP	
V2 7055	Priority of Stowage Accessibility	N/A	
V2 7056	Stowage Operation without Tools	N/A	
V2 7057	Stowage Access while Suited	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025
V2 7058	Identification System	N/A	
V2 7059	Inventory Tracking	N/A	
V2 7060	Inventory Operations	N/A	
V2 7061	Nomenclature Consistency	APP	Reference RQMT-0062, EVA-EXP-0049 which dictate the need for labels.

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 7062	Unique Item Identification	APP	Reference RQMT-0062, EVA-EXP-0049 which dictate the need for labels.
V2 7063	Interchangeable Item Nomenclature	APP	Reference RQMT-0062, EVA-EXP-0049 which dictate the need for labels.
V2 7064	Trash Accommodation	N/A	
V2 7065	Trash Volume Allocation	N/A	
V2 7066	Trash Stowage Interference	N/A	
V2 7067	Trash Odor Control	N/A	
V2 7068	Trash Contamination Control	N/A	
V2 7069	Labeling of Hazardous Waste	N/A	
V2 7070	Sleep Accommodation	N/A	
V2 7071	Behavioral Health Privacy	N/A	
V2 7073	Partial-g Sleeping	N/A	
V2 7074	Clothing Quantity	N/A	
V2 7075	Exclusive Use	N/A	
V2 7076	Safety and Comfort	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025
V2 7077	Clothing Donning and Doffing	APP	Reference RQMT-027
V2 7079	Accessibility for Cleaning	APP	
V2 7080	Particulate Control	APP	
V2 7081	Surface Material Selection	APP	
V2 7082	Surface Material Cleaning	APP	
V2 7083	Cleaning Materials	APP	
V2 7084	Recreational Capabilities	N/A	
V2 7085	Fecal and Urine Elimination Concurrence	APP	Reference RQMT-054
V2 8001	Volume Allocation	N/A	
V2 8002	Volume for Crewmember Accommodation	N/A	
V2 8003	Volume for Mission Accommodation	N/A	
V2 8005	Functional Arrangement	N/A	
V2 8006	Interference	N/A	
V2 8007	Spatial Orientation	N/A	
V2 8008	Consistent Orientation	N/A	
V2 8009	Interface Orientation	N/A	
V2 8010	Location Identifiers	N/A	
V2 8011	Location Aids	N/A	
V2 8012	Visual Distinctions	N/A	
V2 8013	Internal Translation Paths	N/A	
V2 8014	Emergency Translation Paths	N/A	
V2 8015	Ingress, Egress and Escape Translation Paths	N/A	
V2 8016	Translation Path Interference	N/A	
V2 8017	Simultaneous Use	N/A	
V2 8018	Hazard Avoidance	N/A	
V2 8019	Path Visibility	N/A	

Vol 2. Standard Number	Standard Title	xEVAS Applicability	Comments
V2 8020	Crew Egress Translation Path - Ground	N/A	
V2 8021	Crew Ingress/Egress Translation Path in Space	APP	Reference RQMT-043
V2 8022	Hatch Cover and Door Operation without Tools	N/A	
V2 8023	Unlatching Hatch Covers	N/A	
V2 8024	Hatch Cover and Door Operating Times	N/A	
V2 8025	Hatch Cover and Door Operating Force	N/A	
V2 8026	Hatch Cover and Door Gravity Operations	N/A	
V2 8027	Hatch Size and Shape	N/A	
V2 8028	Pressure Equalization across the Hatch	N/A	
V2 8029	Visibility across the Hatch	N/A	
V2 8030	Hatch Cover and Door Interference	N/A	
V2 8031	Hatch Cover Closure and Latching Status Indication	N/A	
V2 8032	Hatch Cover Pressure Indication	N/A	
V2 8033	Crew Restraint Provision	N/A	
V2 8034	Crew Restraint Design	N/A	
V2 8035	Crew Restraint Posture Accommodation	N/A	
V2 8036	Crew Restraint Interference	N/A	
V2 8037	Crew Restraints for Controls Operation	N/A	
V2 8038	Mobility Aid Standardization	N/A	
V2 8039	Mobility Aid Structural Strength	N/A	
V2 8040	Mobility Aid for Assisted Ingress and Egress	N/A	
V2 8041	Unassisted Ingress, Egress and Escape Mobility Aids	APP	
V2 8042	IVA Operations Mobility Aids	N/A	
V2 8043	Window Provisioning	N/A	
V2 8045	Window Optical Properties	N/A	
V2 8046	Window Obstruction	N/A	
V2 8049	Window Light Blocking	N/A	
V2 8050	Window Accessory Replacement/Operation without Tools	N/A	
V2 8051	Illumination Levels	APP	Reference RQMT-073
V2 8052	Exterior Lighting	APP	Reference RQMT-073
V2 8053	Emergency Lighting	APP	Reference RQMT-073 Reference RQMT-074
V2 8055	Circadian Entrainment	N/A	
V2 8056	Lighting Controls	APP	Reference RQMT-073 Reference RQMT-074
V2 8057	Lighting Adjustability	N/A	
V2 8058	Glare Prevention	APP	

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V2 8059	Lighting Chromaticity	APP	Reference RQMT-073 Reference RQMT-074
V2 8060	Lighting Color Accuracy	APP	Reference RQMT-073 Reference RQMT-074
V2 9001	Crew Interface Commonality	APP	
V2 9002	Differentiation	APP	
V2 9003	Routine Operation	APP	Reference RQMT-009
V2 9004	Training Minimization	APP	
V2 9005	Mechanical Hazard	APP	
V2 9006	Entrapment	APP	
V2 9007	Potential Energy	APP	
V2 9008	Protection from Projectiles and Structural Collapse	APP	Reference RQMT-015
V2 9009	Sharp Corners and Edges - Fixed	APP	
V2 9010	Protection from Functionally Sharp Items	APP	
V2 9011	Sharp Corners and Edges - Loose	APP	
V2 9012	Burrs	APP	
V2 9013	Pinch Points	APP	
V2 9014	High-Temperature Exposure	APP	Reference RQMT-086
V2 9015	Low-Temperature Exposure	APP	Reference RQMT-086
V2 9016	Equipment Handling	APP	
V2 9017	Power Interruption	APP	
V2 9018	Energized Status	APP	
V2 9019	Nominal Physiological Electrical Current Limits	APP	
V2 9020	Catastrophic Physiological Electrical Current Limits for all Circumstances	APP	
V2 9021	Catastrophic Physiological Electrical Current Limits for Startle Reaction	APP	
V2 9022	Body Impedance for Voltage Calculations Utilizing Electrical Current Thresholds	APP	
V2 9023	Leakage Currents – Equipment Designed for Human Contact	APP	
V2 9024	Fluid/Gas Release	APP	
V2 9025	Fluid/Gas Isolation	APP	
V2 9026	Fluid/Gas Containment	APP	
V2 9027	Protection	APP	
V2 9028	Isolation of Crew from Spacecraft Equipment	N/A	
V2 9029	Hardware and Equipment Mounting and Installation	APP	
V2 9030	Connector Spacing	APP	
V2 9031	Connector Actuation without Tools	APP	
V2 9032	Incorrect Mating, Demating Prevention	APP	
V2 9033	Mating, Demating Hazards	APP	
V2 9034	Cable Management	APP	
V2 9035	Cable Identification	APP	

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V2 9036	Design for Maintenance	APP	Reference RQMT-009 Reference RQMT-058 Reference RQMT-075 Reference RQMT-076
V2 9037	Commercial Off-the-Shelf Equipment Maintenance	N/A	
V2 9038	In-Flight Tool Set	APP	This is specific to tools provided to maintain xEVAS provided hardware.
V2 9039	Maintenance Time	APP	Reference RQMT-009
V2 9040	Minimizing Maintenance	APP	Reference RQMT-009 Reference RQMT-058 Reference RQMT-075 Reference RQMT-076
V2 9041	Equipment Modularity	APP	
V2 9042	Captive Fasteners	APP	
V2 9043	Minimum Number of Fasteners - Item	APP	Reference RQMT-009
V2 9044	Minimum Variety of Fasteners - System	APP	Reference RQMT-009
V2 9045	Maintenance Item Location	APP	Reference RQMT-009
V2 9046	Check and Service Point Accessibility	APP	
V2 9047	Maintenance Accommodation	APP	
V2 9048	Visual Access for Maintenance	APP	
V2 9049	Hand Clearance for Maintenance	N/A	
V2 9050	Tool Clearance	N/A	
V2 9051	Fault Detection	APP	
V2 9052	Failure Notification	APP	Reference RQMT-028 Reference RQMT-029
V2 9053	Protective Equipment	N/A	
V2 9054	Protective Equipment Use	N/A	
V2 9055	Protective Equipment Automation	N/A	
V2 9056	Use of Hearing Protection	N/A	
V2 9057	Hearing Protection Provision	N/A	
V2 9058	Hearing Protection Interference	N/A	
V2 9059	Fire Detecting, Warning, and Extinguishing	N/A	
V2 9060	Fire Protection System Health and Status	N/A	
V2 9061	Fire Protection System Failure Alerting	N/A	
V2 9062	Fire Protection System Activation	N/A	
V2 9063	Portable Fire Extinguishers	N/A	
V2 9064	Emergency Equipment Accessibility	N/A	
V2 10001	Usability Acceptance Criteria	APP	
V2 10002	Crew Interface Effectiveness	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025

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V2 10003	Crew Interface Efficiency	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-009 Reference RQMT-024 Reference RQMT-025
V2 10004	Controllability and Maneuverability	N/A	
V2 10005	Crew Interfaces Standardization	APP	
V2 10006	Operations Nomenclature Standardization	APP	
V2 10007	Display Standards, Labelling Plan, and Icon Library	APP	EVA-EXP-0049
V2 10008	Units of Measure	APP	
V2 10009	Crew Interface Operations Standardization	APP	
V2 10010	Consistent Displays and Controls	APP	
V2 10011	Displays and Controls Commonality	APP	
V2 10012	Consistent Procedures	APP	
V2 10013	Display and Control Distinctions	APP	
V2 10014	Syntax Distinction	APP	
V2 10015	Use of Cues	APP	
V2 10016	Cue Saliency	APP	
V2 10017	System Health and Status	APP	
V2 10018	System Messages	APP	
V2 10019	Display Update	APP	
V2 10020	Missing Data Display	APP	
V2 10021	Control Feedback	APP	
V2 10022	System Feedback	APP	
V2 10023	Current Procedure Step	APP	
V2 10024	Completed Procedure Steps	APP	
V2 10025	View of Procedure Steps	APP	
V2 10026	Procedure Flexibility	APP	
V2 10027	Inadvertent Operation Prevention	APP	
V2 10028	Inadvertent Operation Recovery	APP	
V2 10030	Display and Control Location and Design	APP	
V2 10031	High Priority Displays and Controls	APP	
V2 10032	Display and Control Grouping	APP	
V2 10033	Display-Control Relationships	APP	
V2 10034	Display and Control Movement Compatibility	APP	
V2 10035	Display and Control Sequence of Use	APP	
V2 10036	Display Identifying Features	APP	
V2 10037	Display Area	APP	
V2 10038	Display Interpretation	APP	
V2 10039	Display Readability	APP	
V2 10040	Display Information	APP	
V2 10042	Display Information Flow	APP	
V2 10043	Display Navigation	APP	
V2 10044	Display Nomenclature	APP	
V2 10045	Display Coding Redundancy	APP	
V2 10046	Measurement Units	APP	

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V2 10047	Visual Display Legibility	APP	
V2 10048	Visual Display Parameters	APP	
V2 10049	Visual Display Character Parameters	APP	
V2 10050	Display Font	APP	
V2 10052	Intelligibility of Electronically Stored Speech Messages	APP	
V2 10053	Sound Pressure Level	APP	
V2 10054	Sound Distortion Level	APP	
V2 10055	Distinguishable and Consistent Alarms	APP	
V2 10056	Audio Display Sound Level	APP	
V2 10057	Reverberation Time	APP	
V2 10058	Frequency	APP	
V2 10059	Auditory Alarms for Sleeping Crewmembers	N/A	
V2 10060	Label Provision	APP	Reference EVA-EXP-0049
V2 10061	Label Standardization	APP	Reference EVA-EXP-0049
V2 10062	Label Display Requirements	APP	Reference EVA-EXP-0049
V2 10063	Label Location	APP	Reference EVA-EXP-0049
V2 10064	Label Categories	APP	Reference EVA-EXP-0049
V2 10065	Label Distinction	APP	Reference EVA-EXP-0049
V2 10066	Label Font Height	APP	Reference EVA-EXP-0049
V2 10067	Control Shape	APP	
V2 10068	Control Identification	APP	
V2 10069	Emergency Control Coding	APP	
V2 10070	Control Size and Spacing	APP	
V2 10071	Control Arrangement and Location	APP	
V2 10072	Control Proximity	APP	
V2 10073	Control Operation during Accelerations	N/A	
V2 10074	Control Operating Characteristics	APP	
V2 10075	Control Input-Response Compatibility	APP	
V2 10076	Control Latency	APP	
V2 10077	Control Resistive Force	APP	
V2 10078	Detent Controls	APP	
V2 10079	Stops Controls	APP	
V2 10080	Command Confirmation	APP	
V2 10081	Suited Control Operations	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025
V2 10082	Suited Control Spacing	APP	
V2 10083	Communication System Design	APP	Reference RQMT-068
V2 10084	Communication Capability	APP	
V2 10085	Communication Speech Levels	APP	
V2 10086	Communication Operational Parameters	APP	
V2 10087	Communication Environmental Parameters	APP	
V2 10088	Communication Controls and Procedures	APP	

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V2 10089	Communication Transmitter and Receiver Configuration	APP	
V2 10090	Audio Communications Quality	APP	
V2 10091	Speech Intelligibility	APP	Reference RQMT-068
V2 10093	Private Audio Communication	N/A	
V2 10094	Video Communications Visual Quality	APP	
V2 10095	Video Communications Spatial Resolution	APP	
V2 10096	Video Communications Temporal Resolution	APP	
V2 10097	Video Communications Color and Intensity	APP	
V2 10098	Video Communications Bit Rate	APP	
V2 10099	Audio-Visual Lag Time	APP	
V2 10100	Automated and Robotic System Provision	APP	
V2 10101	Automated and Robotic System Design	APP	
V2 10102	Robotic Control Stations - Common and Consistent	N/A	
V2 10103	Automated and Robotic System Situational Awareness	N/A	
V2 10104	Automation Levels	APP	
V2 10105	Automation Level Status Indication	APP	
V2 10106	Robotic System Status	N/A	
V2 10107	Robotic System Arbitration	N/A	
V2 10108	Automated and Robotic System Operation – with Communication Limitations	APP	
V2 10109	Automation and Robotics Shut Down Capabilities	APP	
V2 10110	Automation and Robotics Override Capabilities	APP	
V2 10111	Crew Interfaces to Robotic Systems - Spatial Disorientation	N/A	
V2 10112	Crew Interfaces to Robotic Systems - Frames of Reference	N/A	
V2 10113	Information Management Capabilities – Provision	APP	Reference RQMT-028 Reference RQMT-029 Reference RQMT-065
V2 10114	Visual and Audio Annunciations	APP	Reference RQMT-028 Reference RQMT-029
V2 10115	Set-Point Alerts	APP	
V2 10116	Audio Annunciation Silencing	APP	
V2 10117	Visual and Auditory Annunciation Failures	APP	
V2 10118	Visual Alerts - Red	APP	
V2 10119	Visual Alerts - Yellow	APP	
V2 10120	Information Management Methods and Tools	APP	

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V2 10121	Information Management Standard Nomenclature	APP	
V2 10122	Information Management Compatibility	APP	
V2 10123	Information Management Operation Rate	APP	
V2 10124	Information Management Data Provision	APP	
V2 10125	Information Management Security	APP	
V2 10126	Information Management Ground Access	APP	
V2 10127	Information Capture and Transfer	APP	
V2 10128	Information Annotation	N/A	
V2 10129	Information Backup and Restoration	APP	
V2 10130	Alternative Information Sources	APP	Reference RQMT-045
V2 10131	Software System Recovery	APP	
V2 11001	Suited Donning and Doffing	APP	Reference RQMT-027 Reference RQMT-030
V2 11002	Translation Paths for Suited Crewmembers	N/A	
V2 11003	Mobility Aid Provision for Suited Operations	N/A	
V2 11005	EVA Translation Path Hazard Avoidance	N/A	
V2 11006	Suit Pressure Set-Points	APP	
V2 11007	Suit Equilibrium Pressure	APP	
V2 11009	Continuous Noise in Spacesuits	APP	Reference RQMT-088 Reference RQMT-089
V2 11010	EVA Suit Radiation Monitoring	APP	Reference RQMT-053
V2 11011	Suited Crewmember Heat Storage	APP	
V2 11012	Restraints for Suited Operations – Provision	N/A	
V2 11013	Suited Body Waste Management – Provision	APP	Reference RQMT-054
V2 11014	LEA Suit Urine Collection	N/A	
V2 11015	Suit Urine Collection per Day - Contingency	N/A	
V2 11016	Suit Feces Collection per Day – Contingency	N/A	
V2 11017	Suit Isolation of Vomitus	APP	
V2 11018	Suited Field of Regard	APP	Reference RQMT-022
V2 11019	Suit Helmet Optical Quality	APP	Reference RQMT-022
V2 11020	Suit Helmet Luminance Shielding	APP	Reference RQMT-022
V2 11021	Suit Helmet Visual Distortions	APP	Reference RQMT-022
V2 11022	Suit Helmet Displays	APP	Reference RQMT-022
V2 11023	Suit Information Management	APP	Reference RQMT-028 Reference RQMT-031 Reference RQMT-051 Reference RQMT-065

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V2 11024	Ability to Work in Suits	APP	Reference RQMT-007 Reference RQMT-008 Reference RQMT-024 Reference RQMT-025
V2 11025	Suited Nutrition	APP	Reference RQMT-055
V2 11027	Suited Medication Administration	N/A	
V2 11028	EVA Suit Urine Collection	APP	Reference RQMT-054
V2 11029	LEA Suited Hydration	N/A	
V2 11030	EVA Suited Hydration	APP	Reference RQMT-056
V2 11031	Suited Relative Humidity	APP	
V2 11032	LEA Suited Decompression Sickness Prevention Capability	N/A	
V2 11033	Suited Atmospheric Control	APP	
V2 11034	Suited Atmospheric Data Recording	APP	
V2 11035	Suited Atmospheric Data Displaying	APP	Reference RQMT-031 Reference RQMT-051 Reference RQMT-065
V2 11036	Suited Atmospheric Monitoring and Alerting	APP	
V2 11037	Suited Metabolic Rate Measurement	APP	
V2 11038	Suited Metabolic Rate Display	APP	Reference RQMT-065
V2 11039	Nominal EVA Spacesuit Carbon Dioxide Levels	APP	Reference RQMT-085