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Gateway Payload Users Guide

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1.0 - INTRODUCTION

1.1 - PURPOSE

This Gateway Payload Users Guide is provided as an introduction to science operations on the Gateway for potential Payload Developer (PD) teams. It is not intended to be a comprehensive guide that answers detailed questions that may arise. More detailed information and resources will be provided as PD teams work toward launch and flight operations. This document does not contain payload or system requirements. Payload requirements are contained in GP-10037: Gateway Payload Interface Definition Document. Applicable requirements from GP-10037 will be derived into payload-specific requirements documents.

For more information on NASA's Gateway Mission, see the public Gateway webpage found here.

1.2 - SCOPE

The Users Guide structure is, as follows:

Section 3.1 provides a brief introduction to the Artemis Program.

Section 3.2 gives a brief introduction to the Gateway Program and how it fits into the Artemis Program.

Section 3.2.1 provides an explanation of Gateway Modules that support utilization functions by providing interfaces and resources.

Section 3.2.2 provides basic information on the Logistics Module (LM).

Section 3.2.3 introduces some of the ground support teams that payload teams will interact with during the integration and operational phases.

Section 3.2.4 provides information on Gateway's orbit and pointing direction.

Section 3.3 gives an overview of utilization interfaces and resources on the Gateway.

Section 3.3.1 discusses some of the limitations and constraints on Gateway Utilization.

Section 3.3.2 provides information on specific interfaces for utilization payloads.

Section 3.3.3 introduces the payload feasibility process.

Section 3.3.4 gives an introduction to design for potential Gateway payloads.

2.0 - DOCUMENTS

2.1 - APPLICABLE DOCUMENTS

2.2 - REFERENCE DOCUMENTS

The documents listed in this section are referenced in content of the document.

Table 2.2-1
: Reference Documents

Document Number	Revision	Document Title
SLS-SPEC-159	Rev I	Design Specification for Natural Environments (DSNE)
GP 10004	Rev C with Change 1	Gateway Subsystem Specification for Environmental Control & Life Support Systems (ECLSS)
GP 10028	Baseline	Utilization Concept of Operations for the Gateway
GP 10036	Rev B with Change 1	Gateway Subsystem Specification for Utilization
GP 10037	Rev D	Gateway Payload Interface Definition Document (PIDD)
GP 10057	Rev B with	Gateway Space Induced Environments Requirements

	Change 2	
GP 10092	Baseline	Gateway Payload System Manager (PSM) Concept of Operations
GP 10102	Baseline	Gateway Portable Equipment Panel User Interface Requirements Document (IRD)
GP 10121	Rev A	Gateway to Payloads Software Interface Requirements Document
GP 10129	Rev A with Change 1	Gateway Program Requirement Specification for Gateway Portable Computer (GPC)
GP 10139	Baseline with Change 1	Gateway Stowage Interface Control Document
GP 10251	Baseline	Gateway External Lunar Dust Data Book

3.0 - PAYLOAD USERS GUIDE

3.1 - ARTEMIS OVERVIEW

With Artemis missions, NASA will land the first woman and first person of color on the moon, utilizing innovative technologies to explore more of the lunar surface than ever before. This will be accomplished through collaboration with commercial and international partners and will establish the first long-term human presence on the Moon. Then, lessons learned on and around the Moon will be used to accomplish the next giant leap: sending the first astronauts to Mars.

Artemis consists of several vehicles, or projects. These include: the Orion Spacecraft, Space Launch System (SLS) Rocket, Exploration Ground Systems, Lunar Gateway, and Human Landing System (HLS), and Extravehicular and Human Surface Mobility (EHP). For more information on the Artemis Program and the corresponding vehicles, see NASA's public Artemis website, found at this link: NASA Artemis.

3.2 - INTRODUCTION TO GATEWAY PROGRAM

Per Space Policy Directive 1, NASA was instructed to "…Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the moon for long-term exploration and utilization, followed by human missions to Mars and other destinations…" This set the foundation of Gateway, along with the other Artemis programs.

Gateway is made up of U.S. and international space agency partners bound by Memorandums of Understanding (MOUs). These partnerships only apply to the Gateway Program.

Once in lunar orbit, the Gateway will enter a period of scientific operations, known as utilization. Gateway is designed to operate autonomously and with internationally agreed-upon interoperability standards, which will provide a unique platform to conduct science investigations in deep space and outside the protection of the Earth's Van Allen Radiation Belts. The U.S. and the international science community has identified example areas of science associated with heliophysics, radiation, space weather, and dust monitoring as high-priority investigations to fly on Gateway. The data gathered by these investigations, coupled with Gateway operational experience, will be leveraged to enable sustainable lunar operations, and successfully complete the first crewed mission to Mars.

The Payload and Mission Operations Division (PMOD) located at Marshall Space Flight Center (MSFC) will perform operations integration functions for NASA payloads internal or external to Gateway. PMOD also encompasses the Huntsville Operations Support Center (HOSC) which provides payload missions systems support including processing and distributing payload data, video, and commands. The PMOD team will aid in integrating payload operations with the overall Artemis and Gateway Missions. They provide expert assistance with developing crew procedures, planning products, operational safety implementation, scientific constraints documentation, Flight Rules, training, etc. Certified PMOD flight controllers will also support real-time operations which include telemetry monitoring, commanding, anomaly response and troubleshooting, mission planning, etc. The HOSC and the Artemis Control Center at Johnson Space Center (JSC) will also be responsible for distributing data to applicable International Partners.

Gateway will be assembled in phases. The first phase will include the Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO), which will launch integrated as a Co-Manifested Vehicle (CMV) on a SpaceX Falcon Heavy rocket. After CMV separates from the rocket, the PPE will slowly guide the HALO to lunar orbit. The Logistics Module (LM) and Human Lander System (HLS) will launch on commercial launch vehicles that support the Artemis mission campaign. A Lunar International Habitat (I-Hab) is expected to launch later. A second LM with a Robotic Arm is planned for the same timeframe. The ESPRIT Refueling Module and an airlock are planned to arrive later.

Assembly phases are divided into two time-specific capability phases: initial capability and sustained capability. Initial capability is the initial complement of modules needed to support a lunar landing. This capability phase consists of PPE, HALO and LM. Sustained capability includes the remaining elements of the architecture to support longer duration missions and greater utilization capability. This phase consists of Lunar I-Hab, Airlock, Extravehicular Robotics, and the ESPRIT Refueling Module.

3.2.1 - GATEWAY ELEMENTS

The Gateway HALO provides:

- Docking ports for Orion, HLS, and LM
- Augmented Life Support: Environment Control and Life Support (ECLSS)
- Power Storage and Distribution
- Thermal Control System
- Initial backbone for Avionics, Power, and Software
- Communications with Visiting Vehicles and Lunar Surface
- Accommodations for internal and external utilization payloads found in Table 2.3.2-1.

HALO will be provided by Northrup Grumman.

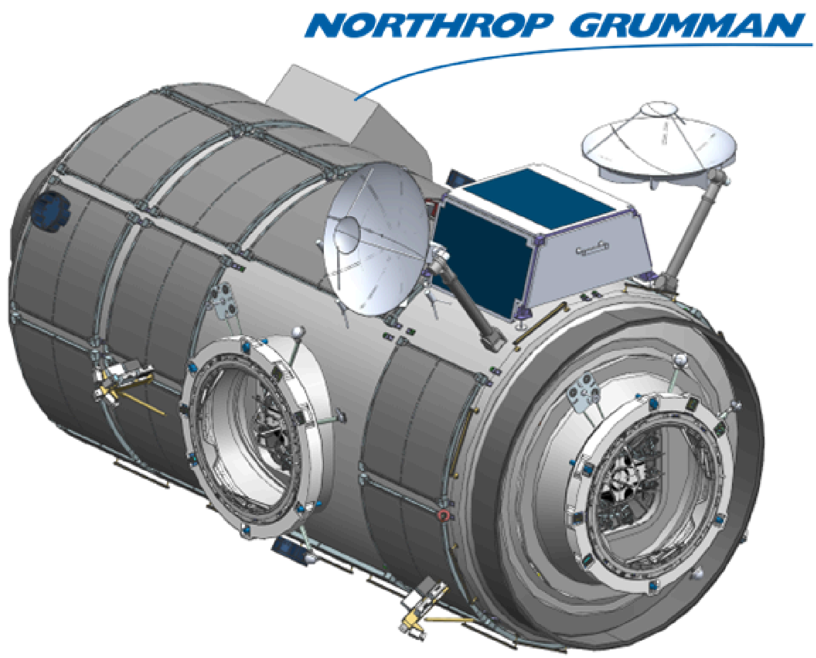

Figure 3.2.1-1
: GATEWAY HABITATION AND LOGISTICS OUTPOST

The Gateway PPE provides power for the other Gateway elements, attitude control and orbital maintenance of the Gateway integrated stack, communication with Earth and Lunar Surface systems, and two external XORI interfaces for external utilization payloads. PPE does not have an internal pressurized volume, and therefore does not support internal payload utilization. PPE will be provided by MAXAR.

Figure 3.2.1-2
: GATEWAY POWER AND PROPULSION ELEMENT

The Gateway Lunar I-Hab module contributed by ESA and JAXA provides a habitable volume and two axial and two radial docking ports as well as robotic attachment interfaces. The Lunar I-Hab module will have its own Thermal Control System, Life Support System, Data Management System and Power Storage and Distribution System and support utilization. Table 2.3.2-1 summarizes the internal and external utilization interfaces supported by Lunar I-Hab.

Figure 3.2.1-3
: ESA/JAXA GATEWAY LUNAR I-HAB MODULE

The Canadian Space Agency (CSA) is providing the GERS. The GERS provides the capability to transfer external payloads delivered by the LM to the external payload accommodations defined in Table 2.3.2-1. After research is completed for an external payload, the GERS can transfer the external payload to the LM for disposal. The GERS can provide power and data resources to an external payload via the Dexterous Grapple Fixture (DGF) while grappled for transfer, if required. The GERS will be launched to the Gateway on an Artemis mission. Payloads are required to adhere to the requirements found in CSA-GWY-ID-0001 Gateway Extra-Vehicular Robotics (GEVR) Interface

Requirements & Definition Document (IRDD). All of the Small ORU Robotics Interface (SORI) variants can be found in this document as well (see section on external payloads for more information on SORIs).

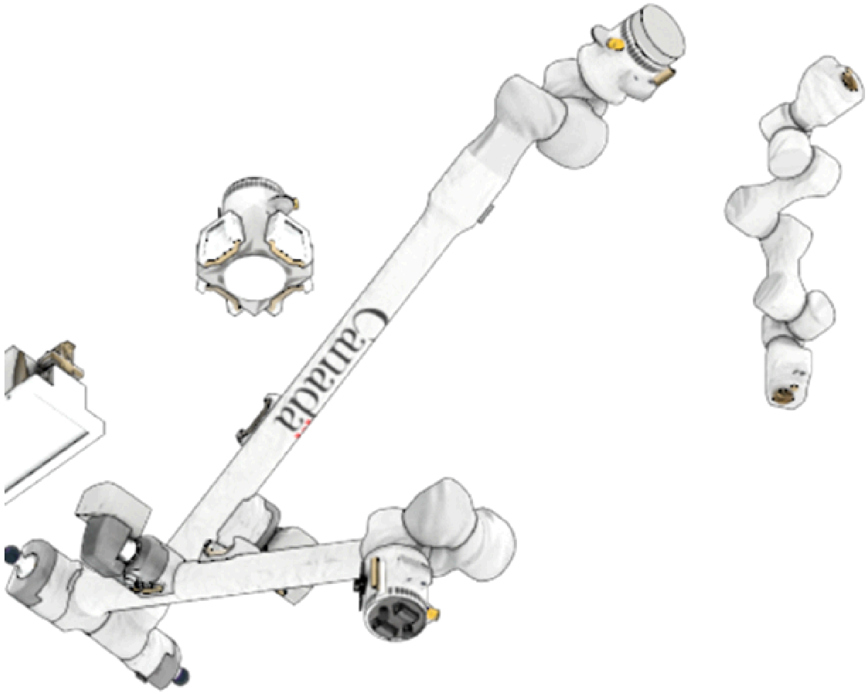

Figure 3.2.1-4
: CSA GATEWAY EXTRA-VEHICULAR ROBOTIC SYSTEM

The Gateway will provide a robotically compatible science airlock. The Gateway Airlock provides an equipment lock enabling the capability to transfer payloads/ORUs from the internal Gateway environment to the external environment (and vice versa). The payload envelope, which can be accommodated by the airlock, is TBD. Additionally, the Airlock will support two XORI interfaces for external payload accommodations, as defined in Table 2.3.2-1. More information on capabilities will be added when available.

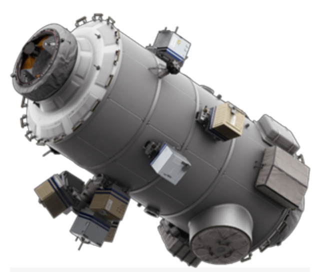

Figure 3.2.1-5
: MBRSC GATEWAY AIRLOCK MODULE

3.2.2 - VISITING VEHICLES

The Gateway LM is a mission-dependent visiting vehicle that provides the capability to deliver cargo, experiments, and other supplies to Gateway. Docked stays at Gateway are estimated to range from six to twelve months at a time. At least one standard logistics service mission is anticipated for each Artemis SLS/Orion crewed mission to Gateway. The Gateway Deep Space Logistics (DSL) Office will procure the services of several Logistics Modules (LMs) under the Gateway Logistics Services (GLS) contract. JAXA is providing an HTV-XG as an LM option.

The LM will be configured to support the launch of internal payload hardware in a stowed configuration. The LM may also support hard-mounted internal payloads and provide the associated power, thermal and data interfaces for internal payload operations during transit to the Gateway, if required. While payloads can be transferred to Gateway from LM, depending on science objectives, an internal payload may launch within the LM and remain in the LM for the duration of the LM stay at Gateway.

The LM will also launch external payload hardware. Power and data resources will be offered to launch-in-place external payloads. The external payload may be transferred from the LM to another Gateway element by the Gateway Extra-Vehicular Robotics System (GERS).

Additionally, an external payload may launch on the LM and remain on the LM for the duration of the LM stay at Gateway. For this payload operations concept, a unique fixed mount interface to the LM may be implemented.

Figure 3.2.2-1
: GATEWAY LOGISTICS MODULE

3.2.3 - GROUND/OPERATIONS SUPPORT

There will be support provided for payload teams, both during the integration phase and the operations phase. A Payload Integration Manager (PIM) will be assigned to payloads during the integration phase to help with requirements verification and other tasks.

The Payload and Mission Operations Division (PMOD) located at Marshall Space Flight Center (MSFC) will perform operations integration functions for NASA payloads internal or external to Gateway. PMOD also encompasses the Huntsville Operations Support Center (HOSC) which provides payload missions systems support including processing and distributing payload data, video, and commands. The PMOD team will aid in integrating payload operations with the overall Artemis and Gateway Missions. They provide expert assistance with developing crew procedures, planning products, operational safety implementation, scientific constraints documentation, Flight Rules, training, etc. Certified PMOD flight controllers will also support real-time operations which include telemetry monitoring, commanding, anomaly response and troubleshooting, mission planning, etc. The HOSC and the Artemis Control Center at Johnson Space Center (JSC) will also be responsible for distributing data to applicable International Partners.

3.2.4 - GATEWAY ORBIT AND POINTING DIRECTION

Gateway is intended to operate in a cislunar halo orbit. The established baseline orbit is a Near-Rectilinear Halo Orbit (NRHO) in the Earth-Moon system.

The reference NRHO is an L2 Southern NRHO with a 9:2 lunar synodic resonance, wherein there is an average of 9 orbit revolutions for every 2 lunar months. The illustration below shows the proposed location for the Gateway orbit. The Gateway NRHO appears as the dashed red line while the blue line shows trajectories of entry and departure from the NRHO.

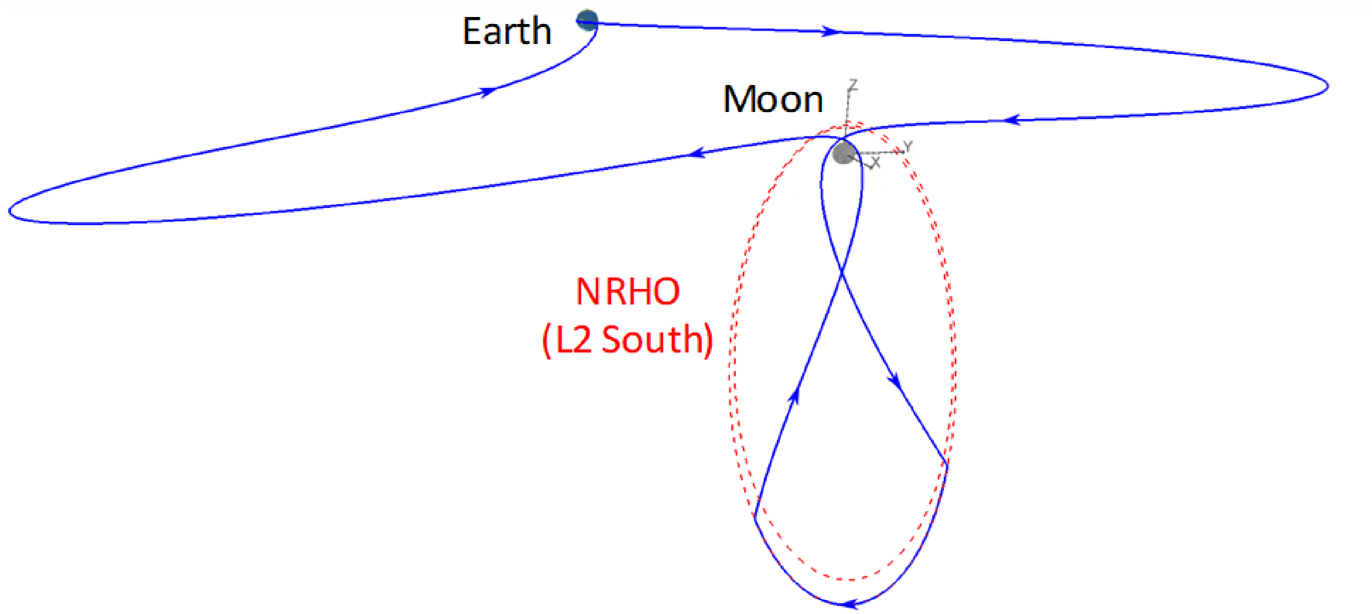

Figure 3.2.4-1
: REFERENCE NRHO FOR GATEWAY IN THE EARTH-MOON ROTATING FRAME

The Design Specification for Natural Environments (DSNE) documents the expected natural environment at NRHO. This document is publicly available at the following web address: https://ntrs.nasa.gov/citations/20210024522. External environments addressed here include, but are not limited to, the following:

- Total Dose
- Single Event Effects
- Plasma Charging
- Ionizing Radiation Environment for Crew Exposure
- Micrometeoroid and Orbital Debris environments
- Gravitational Fields
- Thermal Environments
- Solar Illuminations
- Geomagnetic Fields

Additionally, the Gateway Program has defined external contamination induced environments addressing quiescent molecular contamination sources (e.g. materials outgassing), non-quiescent molecular contamination sources (e.g. vacuum vents, thruster plumes), and external lunar dust. These environments are defined in GP 10057 Gateway Space Induced Environments Requirements as well as GP 10251 Gateway External Lunar Dust Data Book to capture and document design environments for Gateway Element external surfaces and hardware during the 15-year life of the Gateway.

Solar radiation pressure tries to “weathervane” the Gateway stack into an orientation that equalizes solar pressure on the exposed surface area of the stack. This orientation results in a Solar Pressure Equilibrium Attitude (SPEA) which will vary according to the present vehicles and modules docked to the Gateway stack. Visiting vehicles may also have atittude control requirements that can impact the attitude Gateway will maintain. In general, the Gateway stack will be oriented such that it is pointed toward the sun along the +X or -Y axes (plus or minus several degrees) in order to minimize the energy required to hold attitude. The +X-to-Sun configuration is seen in the figure below.

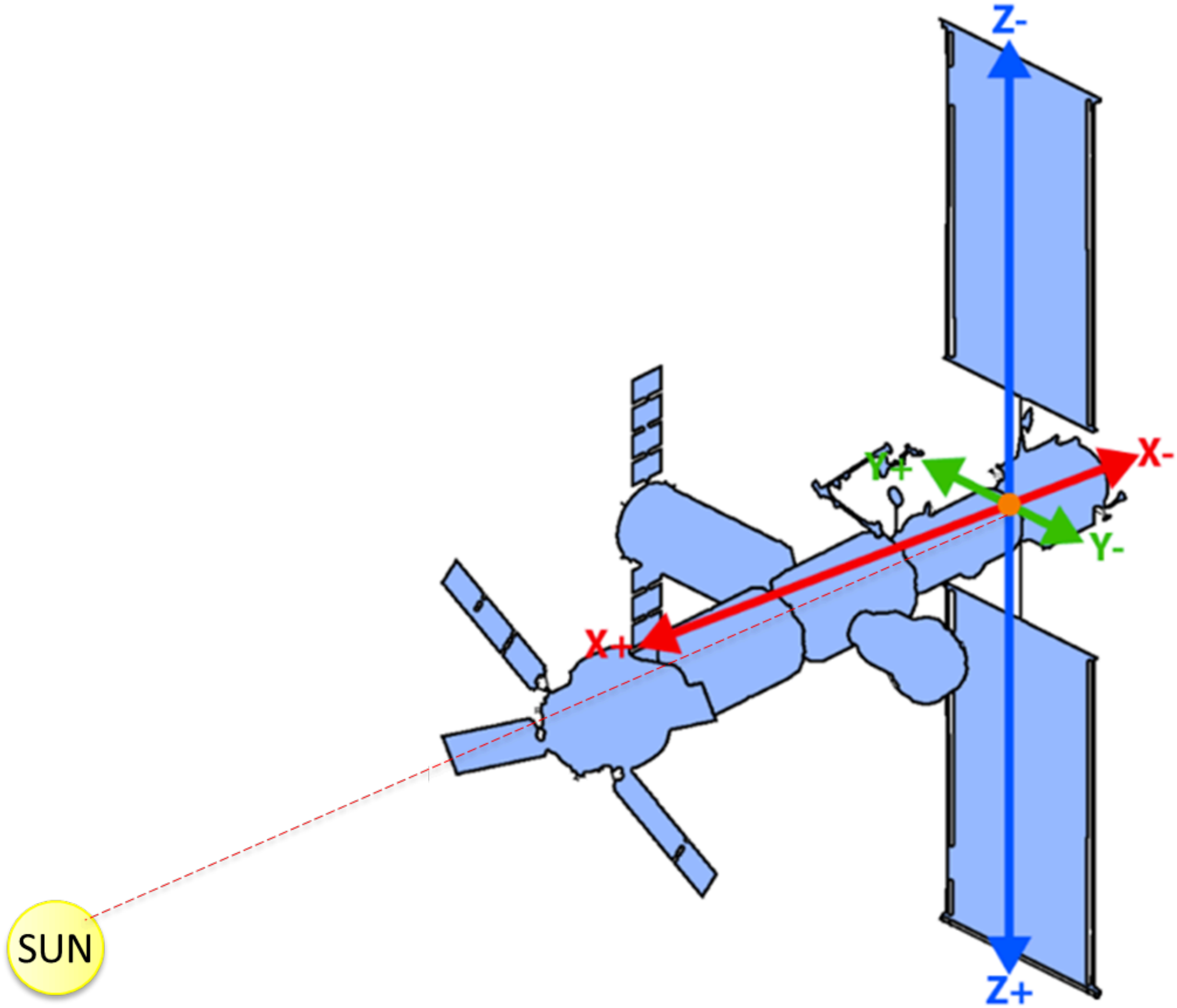

Figure 3.2.4-2
: GATEWAY POINTING DIRECTION

3.3 - GATEWAY UTILIZATION

3.3.1 - GATEWAY UTILIZATION LIMITATIONS & GOALS

Gateway utilization resources are very limited compared to those of the International Space Station (ISS). Gateway is a relatively small vehicle with little external real estate, limited internal volume and stowage, and limited thermal capabilities. Since logistics flights are infrequent, upmass is limited. Orion is the only vehicle with return capabilities, and the management of its return mass resource is not within the scope of the Gateway Payload User's Guide. Crew presence on Gateway is also limited (~17 days per year initially, with 2 crewmembers on the lunar surface for 7 of these days: this could change for future sustained phase missions). Two crewmembers will remain on Gateway for the initial lunar landings. There will be other times when crew is unavailable, such as when preparing to occupy HLS. Payloads are able to operate during uncrewed phases, but need to be designed for the uncrewed conditions. When crewed, Gateway's ECLSS will keep the relative humidity between 25%-75%. Pressure range when crewed is 70 kPa-101.3 kPa. When uncrewed, diluent gas will be used as make-up gas for pressure control. Note that depressurization will occur in the event that there is a cabin air leak or fire. The temperature range when uncrewed will be 4°C (39°F)-27°C (81°F). When crewed, it will range from 20°C (68°F)-27°C (81°F). For more information on these parameters, see GP-10004: Gateway Subsystem Specification for the ECLSS. Power and communications resources will also be available during uncrewed periods.

In order to best maximize available resources, collaborative, multi-lateral payloads, data sharing, and equipment sharing is emphasized to maximize limited utilization resources. In early Artemis missions (4&5), Internal payloads will have limited crew time due to first-time outfitting of new elements and should be more simple to implement by requiring little crew time and come plug-in ready. A majority of crew time in specific phases of the mission will be focused on logistics and preparation for lunar surface work, and Payload Utilization will be prioritized accordingly. In later and more sustained Artemis missions (6+), there may be greater chances for more complexity of Payload Utilization, but in specific phases there may still be more constrained crew time that will need to be prioritized. While two crewmembers are on the lunar surface, the two that remain on Gateway will have time to perform Payload Utilization on the lunar Gateway, but crew time will still be prioritized according to the Mission Priorities Summit. Note that most payload hardware should be disposed of in a LM due to limited volume. Repeatedly flown payloads need to plan for multiple hardware copies to launch each mission.

The vehicle's attitude is expected to be controlled predominantly with reaction wheels, but may require desaturation, which may be achieved with either the Solar Electric Propulsion (SEP) or Reaction Control System (RCS). The vehicle is also expected to require periodic orbital maintenance maneuvers (OMM) to maintain the Gateway 15-year NRHO reference trajectory. The OMMs will be performed by SEP (uncrewed operations) or RCS (crewed operations).

Assumptions, resources, and capabilities are subject to change as design and mission requirements develop.

3.3.2 - GATEWAY PAYLOAD ACCOMMODATIONS

Each Gateway module will contain interfaces that will provide resources for use by payloads. Gateway payloads are designed to remain on Gateway. Payloads that plan to utilize resources on more than one Artemis element, such as moving from Gateway to HLS for lunar surface operations, are known as cross-program payloads.

See Table 2.3.2-1: GW Module Payload Accommodations for more information on these interfaces provided for both internal and external payloads.

Table 3.3.2-1
: GW MODULE PAYLOAD ACCOMMODATIONS

TYPE	PPE	HALO	LUNAR I-HAB	AIRLOCK
Internal Payload Accommodations	Not Applicable	Up to 8 Single Payload Bank Enclosures/Lockers; PEP	Up to 8 Single Payload Bank Enclosures/Lockers; PEP	Transfer of TBD Size Payload; PEP
External Payload Accommodations	2 SORI	1 SORI[1]	4 SORI[1]	2 XORI

Note 1: Most XORI locations will end up being SORIs due to location and approach corridor constraints.

3.3.2.1 - PAYLOAD STOWAGE

Payload banks will be compatible with the Gateway Stowage System such that unused locations will be able to accommodate some stowage per GP 10139 Gateway Stowage Interface Control Document. <FWD-10265-0001>

3.3.2.2 - GATEWAY PORTABLE COMPUTERS

Gateway Portable Computers (GPCs) can be made available for use by payloads. Payloads requiring the use of one of these devices will submit a request during the payload integration process. Note that a GPC dedicated to payloads for the duration of crewed operations is not expected. Further, operational scenarios (i.e. crew control of robotics systems) may dictate that all GPCs be dedicated to critical activities. As a result, payloads relying on the GPC must accommodate the possibility of interruptions in access and software execution on the GPC. For more specific information on GPC performance and capabilities, see GP-10129: Gateway Program Specification for the Gateway Portable Computer. Note that payloads utilizing GPCs are required to adhere to the requirements found in GP 10221 Gateway Portable Computer Host Operating System Software Requirements Specification. <FWD-10265-0002>

3.3.2.3 - COMMAND & DATA HANDLING (C&DH)

Gateway will provide C&DH resources for use by both internal and external payloads.

The payload's interaction with the Gateway Architecture is through a local module Payload System Manager (PSM), which includes a range of data interfaces. Payloads using best-effort (BE) Ethernet communication onboard the vehicle can use either User Datagram Protocol (UDP) or Transmission Control Protocol (TCP) to specified network sockets. UDP is connectionless and emphasizes speed, while TCP is connection-based and emphasizes reliability over speed. Dedicated network socket(s) for interfaces with PSM enable the reception of commands and enable the output of payload common telemetry (i.e. health and status, faults, etc.). Communication with a local module PSM is the minimum required communication from the payload to operate and monitor a payload. Additional communication paths can be implemented to send payload data to Gateway applications for storage or downlink, or to support a direct session from a ground computer to the payload flight computer. Direct session communications are subject to constraints regarding the allowable protocols, the available bandwidth, the availability of communications (especially in uncrewed phases) and round-trip communcations delay. <FWD-10265-0003>

These interfaces allow payloads to do the following:

- **Receive commands:** Payloads have the capability to receive commands from the payload developer. These commands serve the purpose of managing payload tasks and adjusting payload states as required. Commands must conform to a standardized format established by the Artemis Program.

- **Transmit Command Responses:** Payloads are equipped to transmit responses to received commands back to the payload developer. This closed-loop communication ensures effective command execution.
- **Sending Health and Status (H&S) Telemetry:** Payloads are designed to transmit Health and Status (H&S) data or telemetry to the Gateway. This data exchange supports fault management and PSM Sequence control. This capability is assessed for operations on Logistics Module if needed. Telemetry must conform to a standardized format established by the Artemis Program.
- **Enable Payload Fault Management:** The payload software interfaces contribute to fault management by facilitating safing and/or recovery procedures. These mechanisms are in place to ensure the operational integrity of the payload. This capability is assessed for operations on Logistics Module if needed.
- **Receive Ancillary Data:** If necessitated by the payload's operational requirements, ancillary data such as power consumption, thermal conditions, temperature, humidity, operating mode, orbital position, and attitude can be received from the Gateway through the payload software interfaces.
- **Output/Stream Payload Science Data:** Payload science data will be able to be downloaded via direct session allocation.

For more information on C&DH interfaces and the PSM, see the following documentation: GP-10121: Gateway to Payloads Software IRD; GP-10028: Utilization Concept of Operations for the Gateway; GP-10037: Gateway Payload Interface Definition Document; GP-10092: Gateway PSM Concept of Operations.

3.3.2.4 - PAYLOAD DATA STORAGE

Gateway will support module data storage for payloads designed for ASMA operations. This storage may include telemetry, backup files, software applications, training videos, or other general data. However, Gateway-provided data storage may not be sufficient to accommodate all payload needs. Payloads should consider implementing internal payload data storage for research data to be preserved during long communications outages or failures. Data storage on Logistics Modules can be assessed if needed. To optimize utilization of communications bandwidth to Earth, payloads may also consider performing on-board data reduction to extract the information of most scientific interest.

Delay Tolerant Network (DTN) capability will not be available at Gateway until the Sustained Capability Phase (TBR).

3.3.2.5 - ELECTRICAL POWER

Internal payloads installed in a Payload Bank or using a Portable Equipment Panel (PEP) will have access to 120 Vdc up to 10 A, and 3-28 Vdc up to 7.14 A. Internal payloads should be designed to withstand an abrupt loss of power for an indefinite period of time and remain in a safe configuration. External payloads will have access to 120 Vdc. Externals should be able to survive for a minimum of 12 hours without power if not designed to receive power from the Dexterous Grapple Fixture (DGF). If they do receive power from the DGF, they should be able to survive for a minimum of 3 hours without power. Note that the LM will provide power to payloads installed in it.

3.3.2.6 - AUDIO/VIDEO TRANSMISSION

This section is reserved.

<FWD-10265-0004>

3.3.2.7 - EXTERNAL PAYLOAD ACCOMMODATIONS

3.3.2.7.1 - SORI, LORI

The Gateway Extravehicular Robotic (EVR) interfaces include a family of robotically compatible interfaces capable of supporting different mass classes of payloads. These are generically referred to as “X” ORU Robotic Interfaces (XORIs) and include the Small ORU Robotics Interface (SORI), and the Large ORU Robotics Interface (LORI). The XORI family design allows for full cross-compatibility, where any XORI platform can be mated to any XORI receptacle, regardless of variant. XORI platform is abbreviated as XOP, or XORI-p, while XORI receptacle is abbreviated as XOR, or XORI-r.

There are nine planned external payload interface locations which will provide such resources as power, data, and an EVR-compatible attachment point. The locations include two for PPE, one for HALO, four for I-HAB and two on the Airlock.

The SORI is a modular interfacing system used both to launch small payloads, and to allow robotic replacement of Orbital Replacement Units (ORUs) or on-orbit payloads. The SORI features a wedge interface and, if needed, a panel to mount the payload and launch locks. The SORI-

LV-4 includes a panel to mount the payload, four launch locks, and a wedge. For more information on SORI resources available for payloads, see Table 2.3.2.4.1-1: XORI Resources for Payloads.

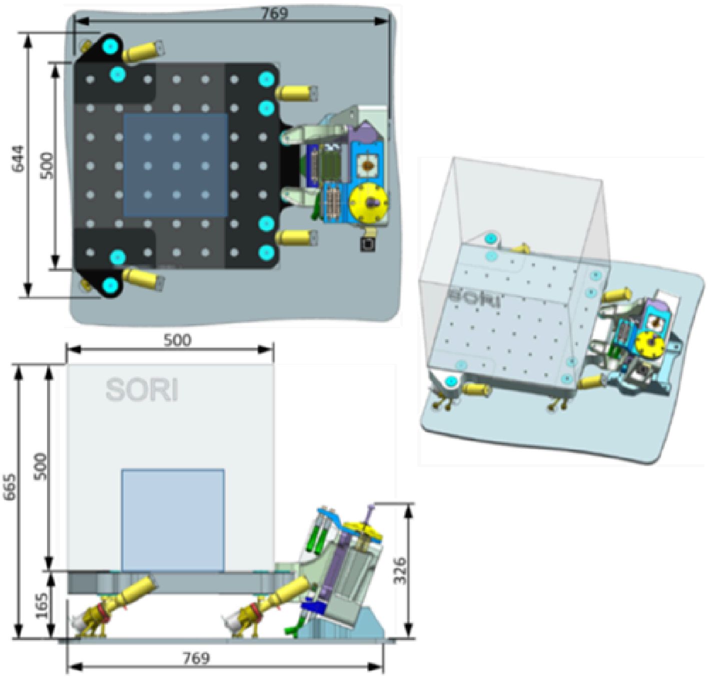

Figure 3.3.2.7.1-1
: SORI INTERFACE WITH DIMENSIONS

The LORI is a modular interfacing system used to launch large payloads and facilitate robotic replacement of payloads on-orbit. All variants of the LORI feature a wedge interface that transfers primary electrical services, a panel to mount the payload, and four launch locks. Reference Table 2.3.2.4.1-1: XORI Resources for Payloads for a summary of LORI resources.

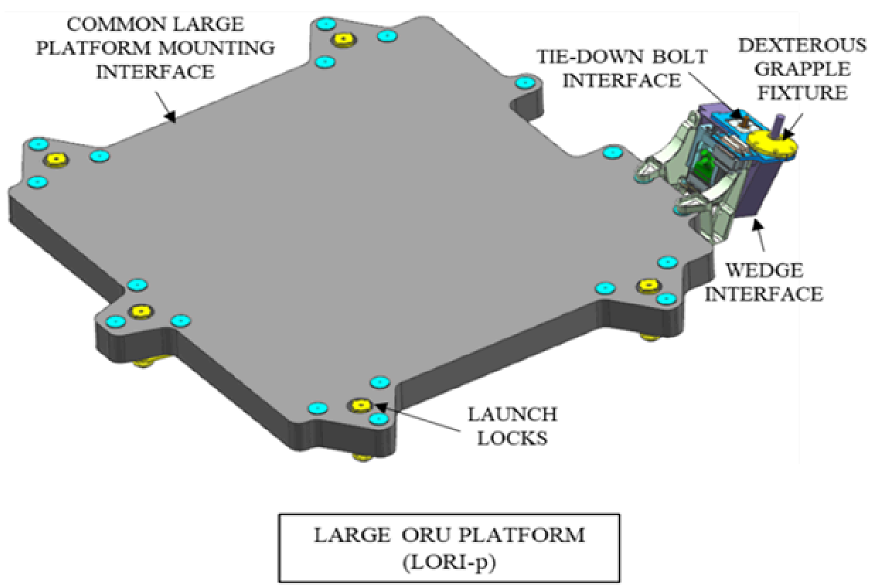

Figure 3.3.2.7.1-2
: LORI INTERFACE

The external attached payload will need to be designed to rely solely on payload-based thermal control mechanisms, such as optical coating selection, insulating blankets, heater circuits, heat-pipe radiators, etc. Payload Developers are expected to do integrated thermal analysis with guidance found in the Thermal Induced Environments Databook and Simulation Manual (TIEDS-M) and corresponding Gateway Integrated Thermal Environment Model (GITEM). The external PD will be required to develop and deliver a standalone Thermal Integration Model to be applicable teams for integrated analysis.

Payloads expecting to be transferred via EVR from one location to another can receive electrical services from the robotics (i.e. for heater power to stay alive during transfer).

Table 3.3.2.7.1-1
: XORI RESOURCES FOR PAYLOADS

RESOURCE	AVAILABILITY	NOTES
Primary Power	Max 500 W @ 120 Vdc	Active payloads during EVR transfer have TBD primary power connectivity. Cannot be combined with secondary power draw to obtain greater than 500 W total draw across both power interfaces.
Secondary Power	Max 500 W @ 120 Vdc	Active payloads during EVR transfer have TBD secondary power connectivity. Cannot be combined with primary power draw to obtain greater than 500 W total draw across both power interfaces.
Thermal	None	No thermal resources are provided to external payloads.
Wired Ethernet	• Two (2) 1000BASE-T wired connections for HALO, I-HAB, LM, and Airlock locations • Two (2) 100BASE-TX wired connections for PPE XORI locations	Active payloads during EVR transfer have 100BASE-TX connectivity.
Wireless (Wi-Fi)		External wireless network access is available. Note that installation for external Wi-Fi and the exact characteristics of Wi-Fi implementation are TBD.
Mass Limit for Launch	• 17 kg (SORI-LV0) • 25 kg (SORI-LV4) • 150 kg (LORI)	
Mass Limit On-Orbit	280 kg	Includes payload + platform mass.
SORI Maximum Volume	0.5m x 0.5m x 0.5m	
LORI Maximum Volume	1.0m x 1.0m x 1.0m (TBD)	

3.3.2.8 - INTERNAL PAYLOAD BANK ACCOMMODATIONS

Gateway will have standardized payload interfaces across the modules. This simplifies the payload integration processes; provides operational flexibility in payload placement before and during missions; simplifies ground support equipment, simulators, and testing; minimizes flight controller training; reduces documentation; and minimizes sustaining over the Gateway lifecycle.

There are 16 planned internal payload interface locations which will provide power, data, coldplate cooling, and limited cabin air cooling. Gaseous Nitrogen and waste gas venting is also available on a very limited basis. The locations of these interfaces include eight for HALO and eight for I-HAB.

The LM will provide additional internal and external payload locations for rotation of payloads, operation of short-duration payloads, and research during transit.

Cabin air cooled payloads that are front-breathers can be mounted on the Payload Bank coldplate.

3.3.2.8.1 - INTERNAL PAYLOAD ENCLOSURES

The Gateway HALO and I-HAB modules provide a Payload Bank that provides standard mechanical, thermal, power, and data interfaces for up to 8 internal payloads each. Payloads can be mounted in the payload bank in a single, double, triple, or quadruple locker configuration. The payload bank provides moderate temperature coldplate cooling, as well as limited low temperature fluid connection point in one location in IHAB. Temperature ranges and heat rejection capabilities are captured in GP-10036: Gateway Subsystem Specification for Utilization. The design of the Payload Bank helps maximize module volume, as no fans or ducts are included for rear air cooling. The absence of fans also improves Electromagnetic Interference (EMI) and acoustics concerns.

Payload enclosures/lockers are provided by the payload developers; single enclosures may be provided as Government Furnished Equipment (GFE). Payload Bank payloads will launch integrated in the enclosure.

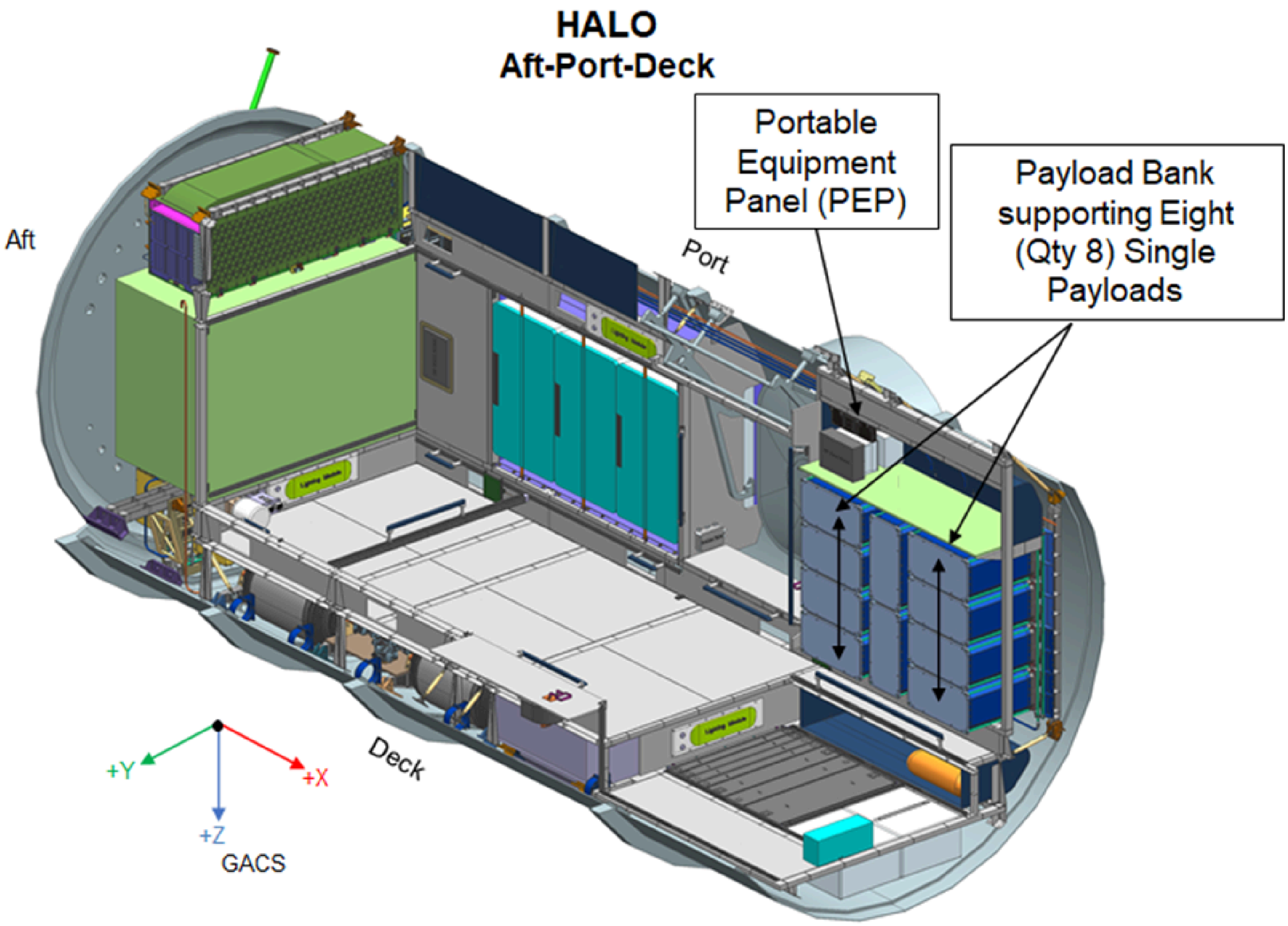

Figure 3.3.2.8.1-1
: INTEGRATED PAYLOAD BANK AND PORTABLE EQUIPMENT PANEL

Table 3.3.2.8.1-1
: PAYLOAD BANK SINGLE ENCLOSURE/LOCKER SERVICES

RESOURCE	PAYLOAD ENCLOSURE/LOCKER SINGLE INTERFACE	NOTES
Launch-in-place Mass	33 kg	Launch in place mass is measured from the backplate mounting surface, and 33 kg represents the mass for a single enclosure payload. This limit is for launch (transportation). Once on-orbit, this restriction does not apply (see GP-10036: GW Subsystem Spec for Utilization).
Volume	0.5 x 0.5 x 0.25 m ($0.0625\ m^3$) (*Double/Triple/Quad possible*)	• 8 locations in HALO • 8 locations in Lunar I-Hab • LM quantity is mission-dependent

Power	120 Vdc, 10 A 3-28 Vdc, 7.14 A	The combination of the two power feeds to a single payload cannot exceed 1200 Watts; however, thermal heat rejection is constrained to 600 Watts at a single payload location.
Thermal	• Moderate Temperature Coldplate (16-28°C): Up to 600 W • Low Temperature Location in Lunar I-Hab (3.3-16°C): Up to 1000 W • Cabin Air*: 100-500 W per module	*As cabin air cooling is a shared resource across all payloads in a module, individual payload operations may have to be limited and/or prioritized to prevent exceeding the constraint. Developers of payloads in the Payload Bank are strongly encouraged to use the Moderate Temperature coldplate cooling as the primary cooling resource and to minimize heat rejection to the cabin to increase the opportunities for payload operations and decrease the risk of operational constraints on the payload. To accommodate Gateway insufficient heat rejection capability, the payload must be capable of being unpowered for an indefinite period of time and/or turned on/off on a weekly basis.
Data	2x Ethernet with minimum 100BaseTX	One port will be wired for 1000BaseT, but vehicle services might only provide 100BaseTX; refer to module-specific interface documentation for more information
Wireless (Wi-Fi)	• Initial capability provided by GW WAPs: Wi-Fi Certified N™ at 2.4 GHz band and Wi-Fi Certified AC™ at 5 GHz band • Sustained capability provided by GW WAPs: Wi-Fi certified 6™ at 2.4 GHz band and Wi-Fi Certified 6™ at 5 GHz band	Payload must support WPA2. Support for WPA3 is also preferred. An antenna is required on the external front surface of the payload.
Waste Gas Vent	One connection in Lunar I-Hab	
Potable Water	Water bags or payload-provided	

3.3.2.8.2 - PORTABLE EQUIPMENT PANEL

Gateway will also provide a Portable Equipment Panel (PEP) interface for aisle-deployed payloads. Payloads utilizing the PEP will have access to 100BaseTx Ethernet (upgradable to 1000BaseT). The number of data connectors on the PEP will be determined jointly by the element provider and Gateway management, as will the total number of PEPs per module. They will also have access to 120 Vdc up to 10 A, and 3-28 Vdc up to 7.14 A via two power connections. Cabin air cooling is the only cooling source available to heat generating aisle-deployed payloads. See Figure 2.3.2.5.2-1: Notional PEP Layout for a visual depiction.

Figure 3.3.2.8.2-1: NOTIONAL PEP LAYOUT

Note: Notional layout is not intended to display all requirements nor precise location of features.

Payload developers will be responsible for providing electrical/data cables and auxiliary boxes, if needed. Tie downs, straps, and hook & loop straps to help secure loads will be provided by the Gateway Modules. Operational locations forpayloads will be assigned based on translation paths and volume constraints on a Mission-by-Mission basis. Portable Equipment connecting with the PEP will be able to access redundant power by utilizing two different PEP connectors (J1 &J2). See GP 10102 Gateway Portable Equipment Panel User Interface Requirements Document for more information.

Given the limited internal volume of Gateway, aisle deployed payload can easily hinder Astronaut safety and comfort by constraining mobility. Developers of payloads are strongly encouraged to use the Payload Banks especially when Gateway is crewed. Maximum volume envelope for aisle-deployed payloads is <TBD-10265-0001>.

3.3.3 - Gateway Payload Feasibility

Several data points will be required by the Gateway Utilization Team to properly assess payload feasibility. Note that not all details will have to be finalized during the initial phases of integration. First, the payload team needs to provide a basic description of payload characteristics, to include:

- Payload and sample mass and volume
- Operational volume
- Potential hazards to the crew and the vehicle
- Expected instrument performance
- Any conditioned stowage

Also, a description of the payload's operations concept, which includes the following characteristics:

- Nominal operations overview
- Any constraints (Early start of operations, etc.)
- Internal or external, along with structural attachment concept
- Description of requirements during both crewed and uncrewed phases
- Expected crew tasks
- Robotic interaction
- Pointing direction (if external), including minimum stare durations and pointing accuracy
- Commanding frequency/volume
- Duration of operations (days/months/years)
- Disposal plan

The Utilization Team will also need to be made aware of the resources needed from the Gateway vehicle. Note that not all details will have to be finalized during the initial phases of integration. Resources include, but are not necessarily limited to, the following:

- Crew time
- Power (includes tolerance to outages)
- Thermal control concept (cabin air/coldplate heat dissipation amount, use of any internal fans, expected coldplate interface temperature(s), coldplate interface filler material)
- Data (includes bandwidth and frequency). Note that comm is not continuous when Gateway is uncrewed
- Other Gateway telemetry [Time, Guidance, Navigation, and Control (GN&C) data, etc.]
- Video and imagery requirements
- Computing resources (laptop, data storage, processing, etc.) and details of any payload-supporting software to be installed on Gateway computing resources

- Other requirements (Microgravity, Gaseous Nitrogen, Vacuum, Potable Water, logistics information, etc.)

Other information and data points may be requested as needed.

3.3.4 - Gateway Payload Design

GP 10037 Gateway Payload Interface Definition Document (PIDD) provides payload teams with the information needed to design a payload for Gateway . This PIDD is an initial resource containing all the information, design constraints, key references, and requirements necessary to aide in successful payload design, verification, and validation to support payload launch, transit operations, onboard Gateway research, and hardware return, if required. The PIDD is a template document and applicable interface requirements will be contained in the Payload Unique Interface Requirements Document (IRD), which is tailored for each payload.

A.0 - ACRONYMS LIST

Table A-1
: ACRONYMS AND ABBREVIATIONS

ASMA	Autonomous System Management Architecture
BE	Best-Effort (ethernet traffic)
C&DH	Command and Data Handling
CSA	Canadian Space Agency
DAT	Dexterous Adapter Tool
DGF	Dexterous Grapple Fixture

DSNE	Design Specification for Natural Environments
DTN	Delay Tolerant Network
ECLSS	Environmental Control and Life Support System
EE	End Effector
EMI	Electromagnetic Interference
ERCP	External Robotics Control Processor
ERM	ESPRIT Refueling Module
ESA	European Space Agency
EVA	Extravehicular Activity
EVR	Extravehicular Robotics
FDIR	Fault Detection, Isolation, and Recovery
GERS	Gateway External Robotics Systems
GFE	Government Furnished Equipment
GN&C	Guidance, Navigation, and Control
H&S	Health and Status
HALO	Habitation and Logistics Outpost
HLS	Human Landing System
HOSC	Huntsville Operations Support Center
I-Hab	International Habitat
ISS	International Space Station
IVA	Intravehicular Activity
JAXA	Japan Aerospace Exploration Agency
LAN	Local Area Network
LM	Logistics Module
LORI	Large Orbital Replacement Unit Robotics Interface
LPEE	Low Profile End Effector
MBRSC	Mohammed bin Rashid Space Centre
MSFC	Marshall Space Flight Center
NRHO	Near-Rectilinear Halo Orbit
ORU	Orbital Replacement Unit
PEP	Portable Equipment Panel
PMOD	Payload and Mission Operations Division
PPE	Power and Propulsion Element
PSM	Payload System Manager
RC	Rate-Constrained
RCS	Reaction Control System
RPCS	Robotics Planning and Control Station
SDA	SORI to DGF Adapter
SEP	Solar Electric Propulsion
SLS	Space Launch System
SORI	Small ORU Robotics Interface
SPEA	Solar Pressure Equilibrium Attitude

TCP	Transmission Control Protocol
TOC	Tool and ORU Caddie
TTE	Time-triggered Ethernet
UDP	User Datagram Protocol
VST	Vision Sensor Tool
VV	Visiting Vehicle
XDA	Exploration Dexterous Arm
XLA	Exploration Large Arm
XOR	XORI Receptacle
XORI	“X” ORU Robotics Interface
XORI-p	XORI Platform

B.0 - OPEN WORK

The FWD is inserted as a placeholder wherever the required data is needed and is formatted in **bold** within <brackets>. The FWD item is numbered based on the document number, including the annex, as applicable. *Example:* **<FWD-10265-001>**.

As each FWD is resolved, the updated text is inserted in each place that the FWD appears in the document and the item is removed from this table. As new FWD items are assigned, they will be added to this list in accordance with the above numbering scheme. Original FWDs will not be renumbered.

Forward Work (FWD) Items: Used where activities were not yet completed due to the timely availability of required information that may or may not need to be in the document.

Table B-1
: FORWARD WORK

FWD	SECTION	COMMENT
<FWD-10265-0001>	3.3.2.1	Expound on stowage options for payloads
<FWD-10265-0002>	3.3.2.2	Expound on GPC/GSS (memory limitations, hardware specs, bluetooth, etc.)
<FWD-10265-0003>	3.3.2.3	Uplink/downlink estimated data rates, bandwidth, command/downlink frequency
<FWD-10265-0004>	3.3.2.6	Audio/video transmission (IVA & EVA)