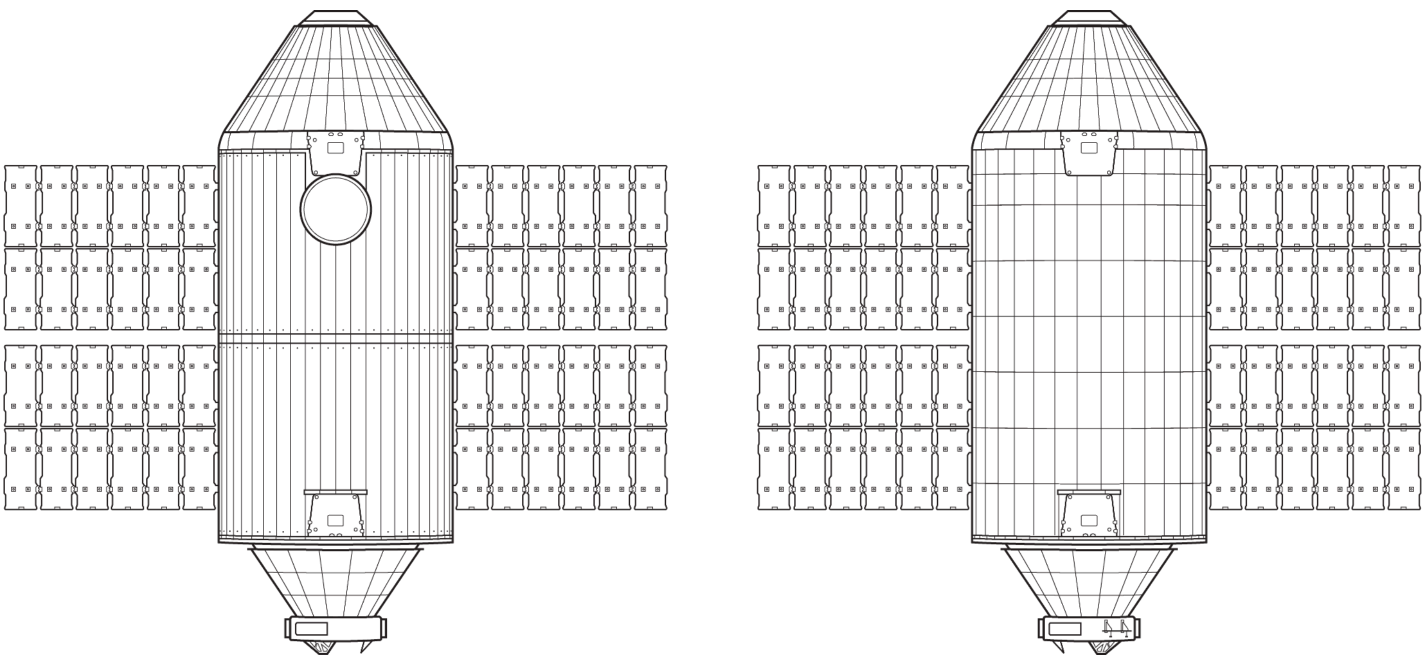
VAST

Haven-1 User's Guide



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Revision Control

Revision #	Revision Details	Release Date
<0.6	First external release - document history available upon request	13 December 2024
0.6.1	■ Corrections to electrical interface definitions in Appendices A and B ■ Minor other technical refinements throughout	27 January 2025
0.7	Updated Haven-1 launch & crew readiness timelines	6 February 2025
0.8	■ Clarified MLE payload to conform with SSP 57000 interfaces ■ Updated Single MLE and Double MLE external dimensions ■ Updated power and data connector part numbers ■ Clarified NC 34 Noise requirement ■ Deleted 6.4 Shock, 6.5 Acoustic environments section (enveloped by random vibe) ■ Updated Acceleration Loads to reflect latest Haven-1 launch loads ■ Added EMC guidance	24 July 2025
0.9	■ Update to Vast Inc., and mission clarifications ■ Added additional compatible power and data connectors	25 November 2025

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1 Introduction

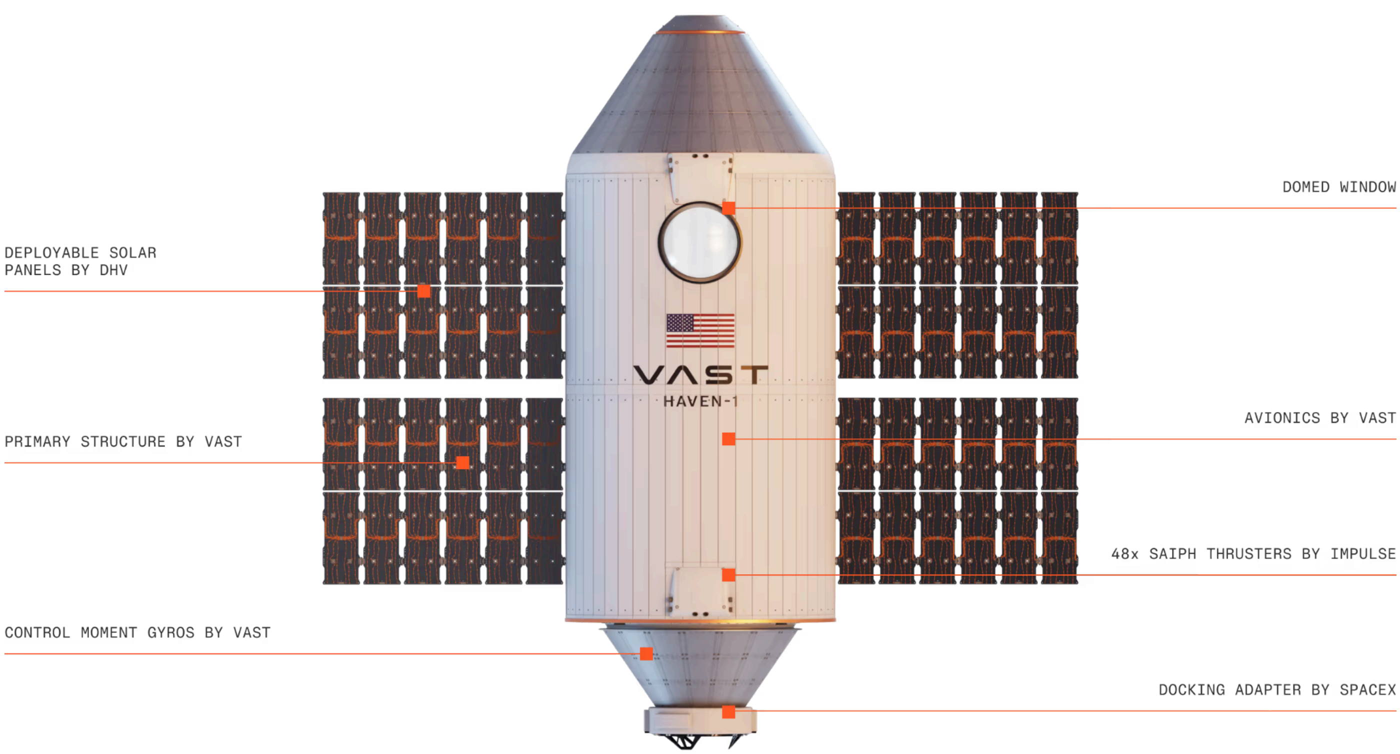
1.1 Purpose

The Haven-1 User's Guide (HUG) provides key information pertaining to the space station's capabilities, operations, and services. This document is intended to be a technical overview for payload developers and operators and a general reference guide for Haven-1 crew members.

1.2 Company Overview

Vast is developing humanity's next-generation space stations and pioneering the path to long-term living and thriving in space. Haven-1 will be home to the world's first commercial crewed microgravity research, development, manufacturing platform, and space station. Vast is also developing its future Haven-2 space station to compete for NASA's Commercial LEO Destinations (CLD) program.

These Haven stations are designed to test a range of micro and artificial gravity environments, with a fully realized artificial gravity station launching in the 2030s and reaffirming Vast's commitment to ensuring a spacefaring future for all.



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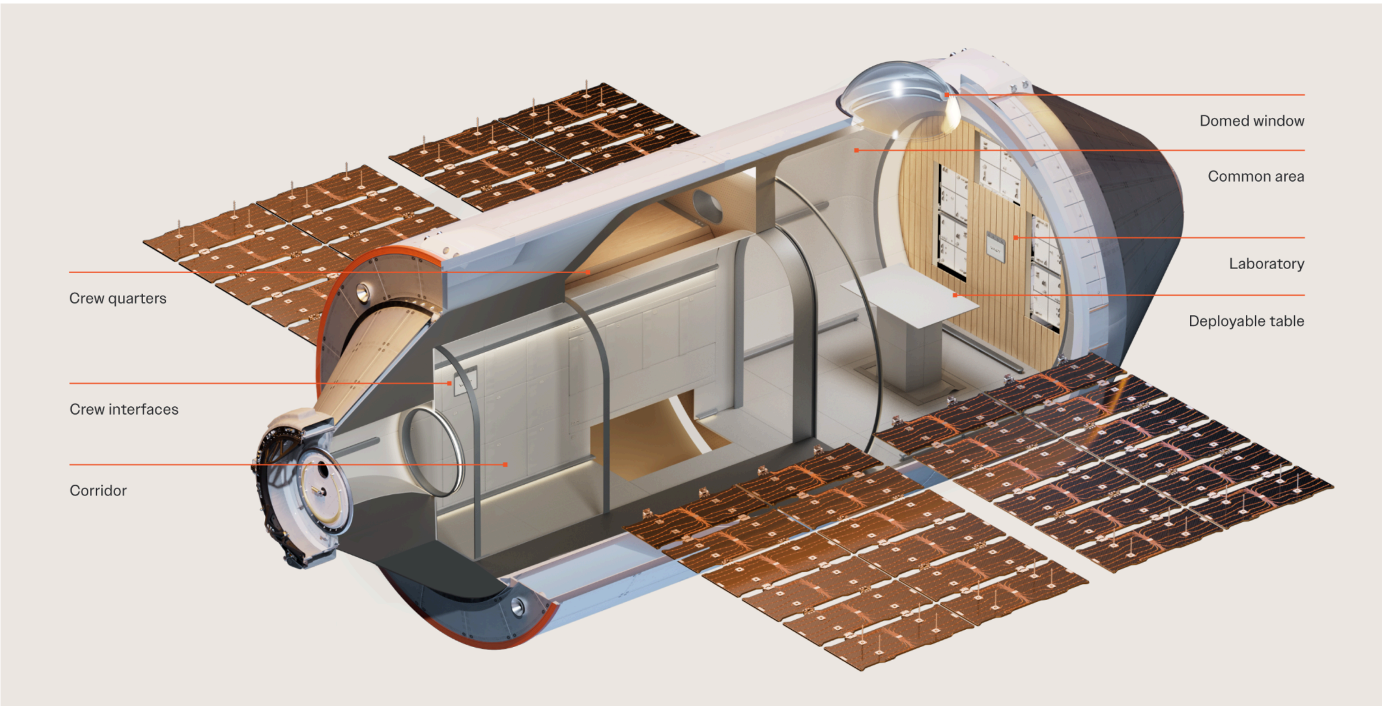
1.3 Haven-1 Overview

Haven-1 is a single-module orbital space station with the capability to host four crew members for up to 40 days. Haven-1 accommodates crew and cargo in a microgravity, pressurized environment. Payloads hosted on Haven-1 will be installed in Haven-1 Lab using interfaces modeled after industry standard, pressurized payload accommodations. The accommodations will provide power, data, and thermal management. Haven-1 will operate in a 425 km circular, 51.6° inclination orbit, and is designed for a 3-year on orbit lifetime.



1.4 Mission Overview

Haven-1 will launch on a SpaceX Falcon 9 rocket to low-Earth orbit (LEO) no earlier than 2026. Vast crewed missions will then launch in a SpaceX Crew Dragon spacecraft and rendezvous and dock with Haven-1. Crewed missions will accommodate up to four crew members, who will inhabit Haven-1 for notionally 10 day missions.

1.5 Scope and Use

The Haven-1 User's Guide is for informational purposes only and details payload accommodations and environments that are specific to the payload rack on Haven-1. Accommodations and environments for payloads that launch and return on SpaceX Crew Dragon are provided in a separate document. The mission Interface Control Document (ICD) will take precedence over any accommodations or requirements stated in this document. If you have any questions that fall outside the scope of this guide, or would like to inquire about pricing information, please contact sales@vastspace.com.

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2 Haven-1 Payload Rack Overview

Haven-1 has pressurized payload accommodations for scientific experiments to be performed while on-orbit. These accommodations are modeled after the heritage Middeck Locker Equivalent (MLE) standard used on the International Space Station (ISS). An overview of the Haven-1 Payload Rack is shown below in Figure 1.

Detailed interfaces for the Haven-1 Payload Rack are described below in Section 3. The Payload Rack accommodations and capabilities include:

- Middeck Locker equivalent (MLE) payload slots – single and double MLE payload compatible
- 30 kg of mass per single MLE payload rack slot
- 100 W of power per single MLE payload rack slot, and two non-rack payload interfaces
- 100 W of air-based heat rejection per single MLE payload rack slot
- Quiescent microgravity environment: during uncrewed portions of the Haven-1's lifetime, payloads will not be subjected to the crew induced vibration environment typically present on the ISS
- Crew hands-on time: during crewed portions of Haven-1's lifetime, there will be opportunities for crew interaction with the payloads

FIGURE 1. HAVEN-1 PAYLOAD RACK OVERVIEW

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3 Payload Rack Accommodations

Note: Accommodations in this section that reference "per payload slot" assume a single MLE payload. Double MLE payloads will be provided with double the accommodation of a single MLE payload.

3.1 Mass

The Haven-1 Payload Rack can accommodate payloads of up to 30 kg per payload slot due to Payload Rack loads constraints during ascent. Payloads with a higher mass will be considered upon request. Contact Vast for additional information.

3.2 Form Factor

The Haven-1 Payload Rack is designed to accommodate payloads that conform to the Middeck Locker Equivalent (MLE) form factor. The Payload Rack accommodates single and double MLE payloads. Mechanical interfaces can be found in Appendix A.

3.3 Power

The Haven-1 Payload Rack provides regulated 28.5 VDC ± 1 VDC power to payloads. Connectors are listed in section 4.1.2 Electrical Power Interface. 100 W of power is notionally allocated to each payload during nominal crewed and uncrewed operations. However, payload power will be reduced to 50 W per payload during docking and Haven-1 launch ascent phases. Table 1 provides a summary of the Haven-1 Payload Rack power accommodations during each mission phase. Payloads with higher power needs will be considered upon request. Contact Vast for additional information.

TABLE 1. HAVEN-1 PAYLOAD RACK POWER ACCOMMODATIONS

Mission Phase	Single Payload Locker Nominal Power (W)	Double Payload Locker Nominal Power (W)
Haven-1 Ascent	50	100
Nominal Operations	100	200
Haven-Dragon Docking	50	100
Haven-Dragon Undocking	50	100

3.4 Data

The Haven-1 Payload Rack provides an Ethernet connection for data relay to Haven-1 network. Data connectors are listed in section 4.1.3 Data Interface. Haven-1 can accommodate up to 100 MB per day of payload data transfer at a data rate of 500 kilobits per second (kbps) per MLE, subject to groundstation availability. RS-422 may be accommodated upon request. Table 2 provides a summary of the Haven-1 Payload Rack data accommodations during each mission phase.

TABLE 2. HAVEN-1 PAYLOAD RACK DATA ACCOMMODATIONS

Mission Phase	Single Payload Locker Downlink/Uplink (MB/Day)	Double Payload Locker Downlink/Uplink (MB/Day)
Haven-1 Ascent	Not Offered	Not Offered
Nominal Operations	100	200
Haven-Dragon Docking	100	200
Haven-Dragon Undocking	100	200

3.5 Thermal Control

The Haven-1 Payload Rack provides up to 100 W of thermal management to each payload slot. The air supply and return are both routed from the rear of the payload rack following SSP 57000 vent locations. Payloads shall not introduce heat to Haven-1 except through air exhaust. Payloads shall not contain exothermic reactions except with written approval from Vast. Payloads shall create, using integrated fans, a net positive pressure differential across the inlet and the outlet ports displacing 15±3 cubic feet per minute (CFM) of air. Haven-1 provides 15±3 CFM exhaust air flow with bypass vents and does not force air through payloads. Table 3 provides a summary of the Haven-1 payload rack thermal control accommodations during each mission phase.

TABLE 3. HAVEN-1 PAYLOAD RACK THERMAL CONTROL ACCOMMODATIONS

Mission Phase	Single Payload Locker Nominal Thermal Control (W)	Double Payload Locker Nominal Thermal Control (W)
Haven-1 Ascent	50	100
Nominal Operations	100	200
Haven-Dragon Docking	50	100
Haven-Dragon Undocking	50	100

3.6 Carbon Dioxide Production

Each payload on Haven-1 may produce no greater than 0.03 g of CO_2 per day during the mission. Contact Vast for additional information if greater carbon dioxide production is desired.

3.7 Oxygen Production

Each payload on Haven-1 may produce no greater than 0.2 g of O_2 per day during the mission. Contact Vast for additional information if greater oxygen production is desired.

3.8 Water Production

Each payload on Haven-1 may produce no greater than 0.01 g of H_2O per day during the mission. Contact Vast for additional information if greater water production is desired.

3.9 Noise

In order to provide a livable environment for astronauts, payloads shall conform to NC 34 noise limits measured at 0.6 meters distance from equipment. Noise criterion levels are defined in SSP 57000 Rev R Table G.3.12.1-1 Noise Limits for Non-rack and Subrack payloads.

3.10 Flammability

All material used in the payload shall self-extinguish when exposed to a standard ignition source.

4 Payload Rack Interfaces

4.1 Middeck Locker Interfaces

4.1.1 Structural Interface

The Haven-1 Payload Rack has MLE interfaces conforming to the backplate specification defined in SSP 57000 Figure F.3.1.2.1-1, supporting Type A (Milson) and Type B (1/4-28") captive fasteners. Maximum external payload dimensions are defined in SSP 57000 E.3.1.3 and reproduced in Table 4. Note that the length dimension must include the Haven-1 provided connector length per SSP 57000 Figure E.3.1.3-1.

TABLE 4. HAVEN-1 PAYLOAD RACK MIDDECK LOCKER FORM FACTOR ACCOMMODATIONS

	Property	Imperial	Metric
Single Middeck Locker Equivalent	Length	24.6 in	62.48 cm
	Width	18.125 in	46.03 cm
	Height	10.757 in	27.32 cm
	Maximum Payload Mass	66.1 lbm	30 kg
Double Middeck Locker Equivalent	Length	24.6 in	62.48 cm
	Width	18.125 in	46.3 cm
	Height	21.882in	55.58cm
	Maximum Payload Mass	132.2 lbm	60 kg

4.1.2 Electrical Power Interface

Power interface and connector specification is shown in Table 5 with pinout shown in Table 6.

TABLE 5. HAVEN-1 PAYLOAD RACK ELECTRICAL POWER INTERFACE

	Payload Side (Customer)	Harness Side (Haven-1)
Power	NB0E14-4PNT or MS3470L14-4P or alternatives (e.g., MS3471L14-4P, MS3472L14-4P, MS3474L14-4P)	MS3475L14-4S

TABLE 6. HAVEN-1 PAYLOAD RACK ELECTRICAL POWER INTERFACE

Pin	Function	Wire Gage (AWG)	Signal
A	+28 V Power	12	Power
B	Not Used	12	N/A
C	28 V Return	12	Power Return
D	Ground	12	Ground

4.1.3 Data Interface

The Haven-1 Payload Rack data connector specification is shown in Table 7 with pinout shown in Table 8.

TABLE 7. HAVEN-1 PAYLOAD RACK ELECTRICAL POWER INTERFACE

	Payload Side (Customer)	Harness Side (Haven-1)
Data	MS27468T15F35P or alternatives (e.g., MS27456T15F35P, MS27458T15F35P, MS27466T15F35P)	MS27467T15F35S

TABLE 8. HAVEN-1 PAYLOAD RACK DATA INTERFACE

Pin	Rack Connector Function	Wire Gage (AWG)	Payload Connector Function
1 to 13	Not Used	N/A	Not Used
14	Ethernet RX (+) IN	24	Ethernet TX (+) OUT
15	Ethernet RX (-) IN	24	Ethernet TX (-) OUT
16	Ethernet TX (+) OUT	24	Ethernet RX (+) IN
17	Ethernet TX (-) OUT	24	Ethernet RX (-) IN
18 to 33	Not Used	N/A	Not Used
34	RS-422 RX (+)	24	RS-422 TX (+)
35	RS-422 RX (-)	24	RS-422 TX (-)
36	RS-422 TX (+)	24	RS-422 RX (+)
37	RS-422 TX (-)	24	RS-422 RX (-)

5 Payload Rack Operations Overview

5.1 Payload Integration And Launch

Haven-1 will be launched on a SpaceX Falcon 9 launch vehicle from Cape Canaveral, Florida. During the launch campaign, the payload will be received at the payload processing facility where the customer will have the opportunity to perform post-shipment checkouts prior to integration with the Haven-1 Payload Rack. After completion of Haven-1 encapsulation in the Falcon 9 fairing and fairing mate with the launch vehicle, the launch vehicle will be rolled out to the launch pad and proceed with the launch of Haven-1. There will be no late load for payloads launching on Haven-1. See Section 5.4.1 for late load availability for payloads launching to Haven-1 on Dragon.

5.2 Haven-1 Checkout

After separation from Falcon 9, Haven-1 will begin its on-orbit checkouts. Upon completion of these initial checkouts, the pressurized payloads will be powered on to begin their post-launch checkouts. Payloads may begin experiments prior to arrival of the Vast crewed mission.

5.3 Start Of Payload Operations

Autonomous payload operations will continue to occur after checkouts. Payloads will have the opportunity for approximately 45 days of microgravity research and experimentation prior to the first Vast crewed mission.

5.4 Vast Crewed Missions

5.4.1 Upmass Capability

Vast Crew missions can accommodate limited cargo when visiting Haven-1. Late load capability is available on Crew Dragon with payload handover to Vast no later than 32 hours before launch. Contact Vast to request mass and volume allocation on Vast Crew missions.

5.4.2 Crew Payload Interaction

After completion of the Haven-1 checkouts, notionally 45 days, a Falcon 9 rocket will launch a SpaceX Dragon spacecraft with four crew members and additional cargo. Vast crewed missions will rendezvous and dock with Haven-1. Nominal docked duration for a crew mission is 10 days. Crew time can be requested to operate pressurized payloads. Payload experiments may continue while the astronauts are living on Haven-1. Crew schedules will be mission-specific, but Vast anticipates that each MLE payload may be afforded up to 5 hours of crew time per 10-day mission. Vast can evaluate payloads that require more crew time on a case-by-case basis. Contact Vast for more information.

5.4.3 Downmass Capability

Vast Crew missions have limited downmass capabilities to return experiments and samples. Contact Vast to request mass and volume allocation on Vast Crew missions.

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5.5 Uncrewed Payload Operations

Once a Vast crewed mission departs from Haven-1, payloads may continue autonomous operation and have additional opportunities to perform experiments in a more pristine microgravity environment.

5.6 Deleted

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6 Payload Environments

This section provides guidance for the environments that the payload will experience during ground processing, ascent, and while on-orbit. The environments will be updated over time as Vast further refines its analyses.

6.1 Random Vibration

The maximum expected random vibration loads that payloads will be subjected to during ascent on Haven-1 are shown below in Figure 2 and Table 9. SpaceX Dragon return environments can be provided upon request.

FIGURE 2. PAYLOAD RANDOM VIBRATION MAXIMUM PREDICTED ENVIRONMENT – ASCENT

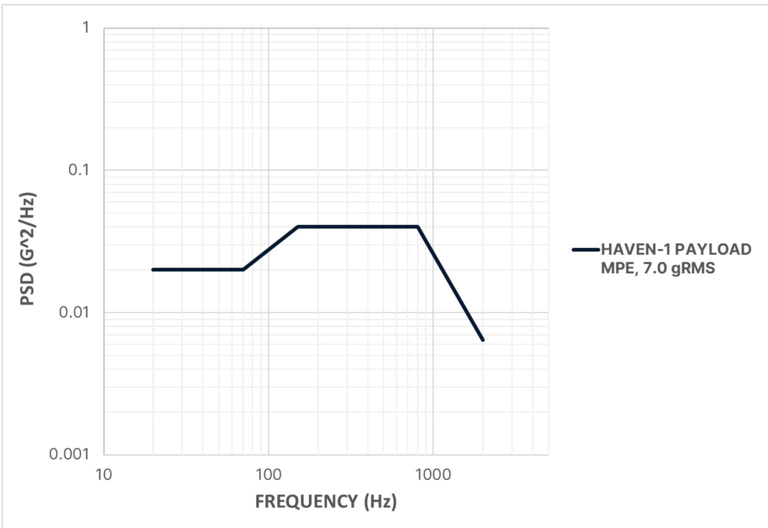

TABLE 9. PAYLOAD RANDOM VIBRATION MAXIMUM PREDICTED ENVIRONMENT – ASCENT

FREQUENCY (Hz)	**HAVEN-1 ASCENT PAYLOAD MPE, ALL AXES** (g^2/Hz)
20	0.02
70	0.02
150	0.04
800	0.04
2000	0.0064
gRMS	7.0
Duration	60 sec/axis

6.2 Acceleration

The maximum expected acceleration loads that payloads will be subjected to during ascent on Haven-1 are shown below in Table 10.

TABLE 10. PAYLOAD QUASI-STATIC LIMIT LOADS – HAVEN-1 LAUNCH

Axial (g, Launch direction)	Lateral (g)
+/- 14.5	+/- 10.0

6.3 Deleted

6.4 Deleted

6.5 Thermal

Haven-1 cabin temperature will range between 65 to 85 °F (18.3 to 29.4 °C).

6.6 EMI/EMC

Payloads shall be designed to meet the intent of SSP 57000 Rev R sections 3.2.2, 3.2.3 and 3.2.4, shown in Table 11, or certify to MIL-STD-461G. Payloads are expected to provide test reports showing compliance, and demonstrate at least 3 dB of EMI Safety Margin against CE/CS environments.

Haven-1 EMI/EMC environments can be provided upon request.

TABLE 11. EMI AND EMC OVERVIEW

Requirement	SSP 57000 Reference
Conducted Emissions limits (CE01 and CE03)	3.2.2.1.1, 3.2.2.1.2
Conducted Susceptibility limits (CS01 and CS02)	3.2.2.2.1, 3.2.2.2.2
Radiated Emissions limits (RE02)	3.2.2.1.3
Electrostatic Discharge - shall not create hazards, should be immune	3.2.2.6
Radiated Susceptibility limits (RS03)	3.2.2.2.4
Magnetic Field Emissions (time-varying) limits	3.2.2.3
Magnetic Field Emissions (static) limits	3.2.2.4
Electrical Bonding - shall meet Class H, R and S bonds	3.2.2.8

6.7 Pressure

Haven-1 will be pressurized to 1.5 Barr (1.48 atm) during ground operations and launch and early orbit phase. Payloads that launch with Haven-1 will be subjected to this environment until several hours after launch, at which time the Haven-1 cabin is depressurized to 1 atm.

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7 Mission Integration and Support

7.1 Schedule

Following contract signature, Vast's mission management team will contact the customer to schedule a kickoff meeting. During this meeting, the customer will be briefed on an overview of the mission and the path forward on the mission design process. This will include definition of the payload constituents and documentation of requirements in the mission ICD. An overview of the notional mission schedule is shown below in Table 12 and Figure 3.

TABLE 12. MISSION SCHEDULE OVERVIEW

LAUNCH (L) MINUS/PLUS DATE	OPERATION
L-12 months (no later than)	Contract signature
L-10 months (no later than)	Payload Data Package delivery to Vast
L-3 months	Mission ICD signature
L-60 days (to be confirmed)	Payload delivery to payload processing facility
L-30 days (to be confirmed)	Payload integration into Haven-1
L-2 days	Launch readiness review
HAVEN-1 LAUNCH	
Approximately L+45 days	Haven-1 checkouts complete and ready to receive crew
CREWED MISSION LAUNCH	
L+1 days	Crewed mission rendezvous and docking with Haven-1
L+1 days	Crew entry to Haven-1
L+11 days*	Crew departs Haven-1
L+12 days*	Crew returns to Earth

*Assumes 10-day crewed mission duration with Haven-1

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FIGURE 3. HAVEN-1 NOTIONAL MISSION TIMELINE

7.2 Safety

As a part of the Payload Data Package, each payload customer is required to provide a summary of payload hazards following SSP 51721 identified standards, in addition to meeting all requirements in the Mission ICD. This will help the payload customer and Vast understand the hazards associated with handling, launching, and operating the payload on-orbit.

7.3 Verification Approach

Vast will work with the payload customer to determine a verification and validation plan that is appropriate for the mission's ICD requirements.

Appendix A: Single Middeck Locker Equivalent (MLE)

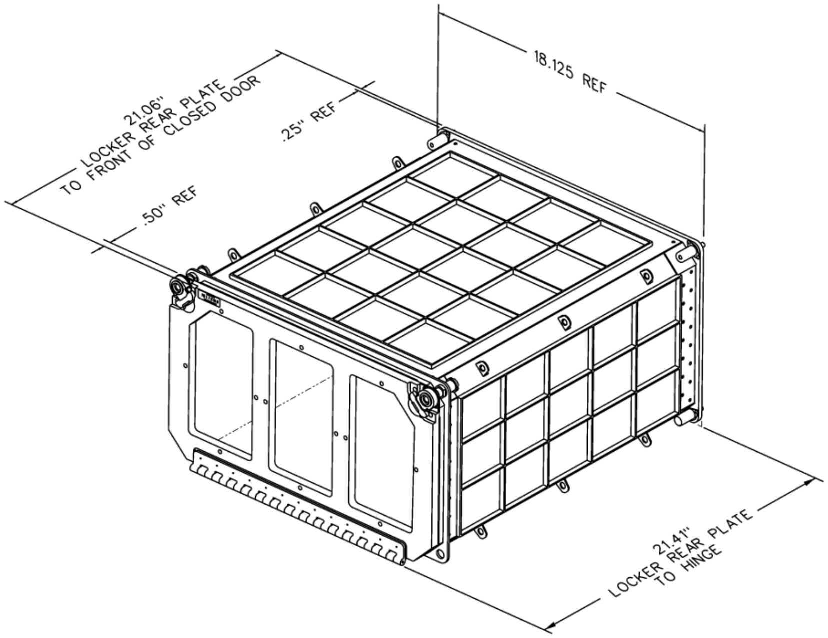

FIGURE 4. SINGLE MLE EXAMPLE (SSP 57000 FIGURE F.3.1.2.4-1, COURTESY NASA)

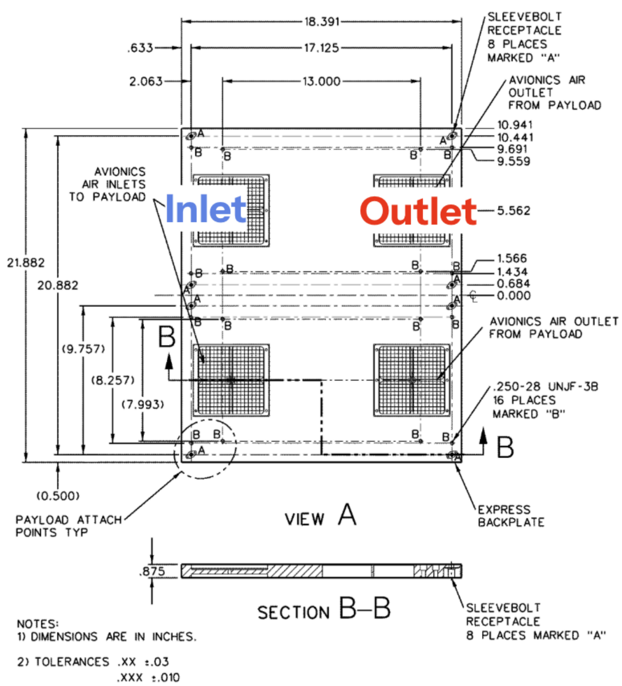

FIGURE 5. BACKPLATE INTERFACE (SSP 57000 FIGURE 3.2.1-3, COURTESY NASA) (FRONT VIEW)

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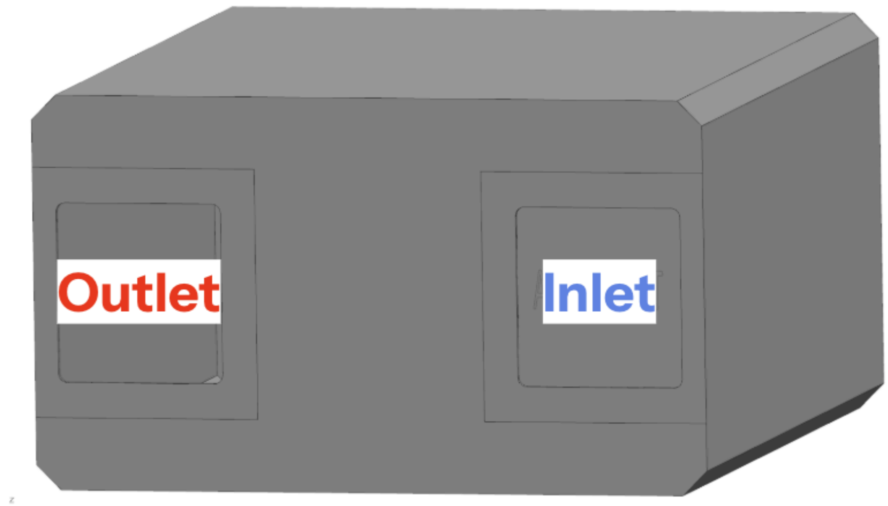

FIGURE 6. SINGLE MLE AIR INLET / OUTLET GUIDE (BACK VIEW)

