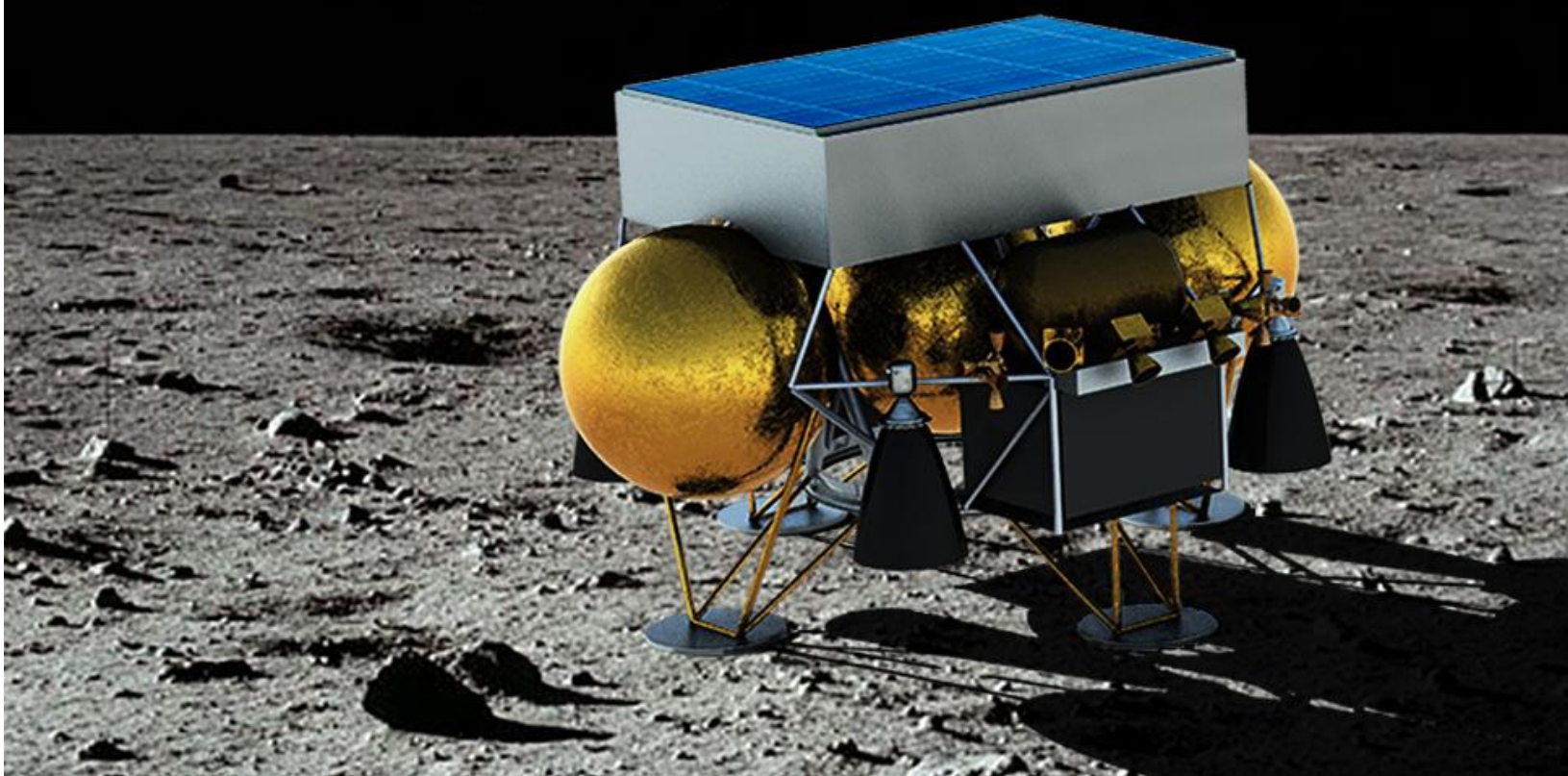
Masten

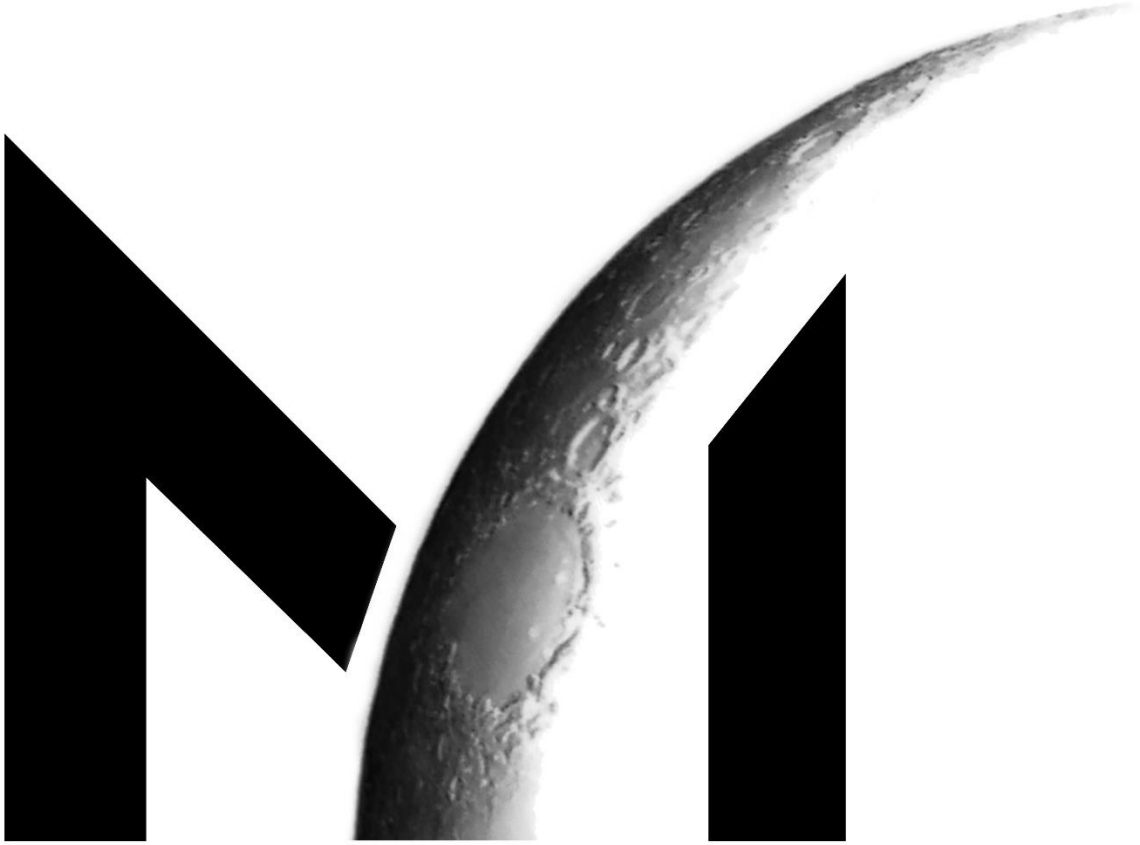
Masten Lunar Delivery Service

Payload User's Guide

Rev. 1.0

February 4, 2019





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February 4, 2019

An introduction to unlocking the moon for developers, researchers, program managers, entrepreneurs, space leaders, and space enthusiasts.

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Table of Contents

Audience, Purpose, and Distribution 1
Masten Lunar Technology Roadmap 2
Overview: Masten Lunar Delivery Service Baseline Capability 3
Masten Differentiation 5
Lunar Delivery Service 7
- Introduction 7
- Pricing 7
- Landing Location 7
- Payload Interfaces 8
  - Mechanical 8
  - Electrical 8
  - Data and Communications 8
- Environments 9
  - Atmospheric Environment 9
  - Mechanical Environment 9
  - Electromagnetic Environment 9
  - Thermal Environment 10
- Payload Integration Process 11
  - Process Overview 11
  - Interface Definition 11
  - Integration Analysis 12
  - Payload Integration and Test 13
  - Payload Integration and Test Facilities 15

Expanded Lunar Landing Location Service 16
Lunar Surface Capabilities 16
Cis-Lunar Orbit Delivery Service 17
- Introduction 17
- Pricing 17
- Deployment Location 17
- Payload Interfaces 18

Mechanical 18
Electrical 18
Data 18
Environments 18
Atmospheric Environment 18
Mechanical Environment 18
Electromagnetic Environment 18
Thermal Environment 18
Payload Integration Process 18
Process Overview 18
Interface Definition 18
Integration Analysis 18
Payload Integration and Test 18
Payload Integration and Test Facilities 18
CLPS Task Order 1 Evaluation Criteria 20

LIST OF TABLES

Table 1: Vehicle Overview and Payload Accommodations 3
Table 2: Baseline Payload Accommodation 4
Table 3: Landing Site Constraints 8
Table 4: RF Systems and Frequencies 10
Table 5: Payload Bay Expected Temperatures 10
Table 6: Required Payload Analyses 12
Table 7: Required Payload Models and Documentation 13

LIST OF FIGURES

Figure 1: XL-1 Lander Overview 3
Figure 2: XL-1 Example Payload 7
Figure 3: Falcon 9 load factors envelope (standard mass payload) 9
Figure 4: XL-1 Thermal Model 11
Figure 5: Masten's assembly, integration, and test process 15
Figure 6: XL-1 in Lunar Orbit 17

Audience, Purpose, and Distribution

Audience

This Payload Users Guide is written to speak to:

- NASA CLPS team
- NASA Leadership
- NASA lunar payload developers
- Other US Government lunar payload developers
- Commercial lunar payload developers

Purpose

This document is written to:

- Provide guidance to lunar payload developers and initiate conversation with Masten
- Provide guidance to the NASA CLPS team about Masten capabilities to help shape the CLPS program

Distribution

This version of the Masten Lunar Delivery Service Payload Users Guide is not for general distribution. This document should not be posted on any publicly available site.

NASA employees can use this for internal NASA use and share with other NASA employees and contractors as appropriate for the formulation of engagement with Masten.

Other parties receiving this document directly from Masten can use it for internal use to engage with Masten.

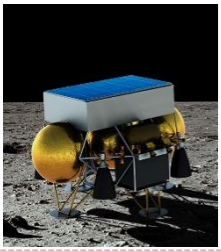
Future versions will be written for wider distribution.

Masten Lunar Technology Roadmap

Masten is currently developing multiple vehicles that will enable lunar exploration by providing increasingly advanced propulsive, guidance, and survival capabilities. Masten's iterative engineering approach allows for rapid near-term mission execution and system adaptability as customer requirements continue to be redefined. Masten's progression towards larger landers supports NASA's roadmap for near-term robotic landers, mid-term landers evolved to survive the lunar night, reusable systems, sample return capability, and long-term heavy landers capable of developing the infrastructure for future manned missions.

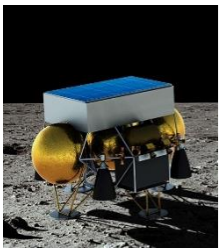
XL-1

XL-1 is Masten's first lunar lander and will demonstrate robotic lunar surface delivery with a payload capacity of 100kg. The vehicle uses a new, unique, and proprietary green, non-toxic propellant. The majority of this document is focused on the capability of the XL-1 lander.



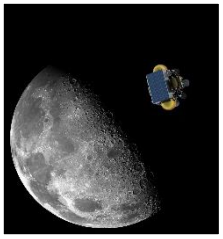
XL-1 +

A block upgrade for the XL-1 lander, XL-1+ incorporates additional services and technology to increase landed mass, expand landing areas, and expand surface services. Key learning from initial missions will be incorporated while keeping the incremental cost low. Specific upgrade decisions are based on market demand and TRL of additional technology.



XL-2

XL-2 Lunar is Masten's evolved lunar lander that will be designed to survive the lunar night and deliver 500kg (0.5mT) to the lunar surface. This spacecraft leverages learning from XL-1, and other Masten advanced technology programs including its 4k LOX-Methane engine and E-Pump. XL-2 is under conceptual design with IOC expected sometime in the mid-2020s.



Xeus

Xeus is a heavy lift lunar lander that will be capable of delivering 1500kg (1.5mT) to the lunar surface. The spacecraft features an innovative dual thrust-axis design allowing for landing on steep slopes, improved reliability, and heavier payloads. Conceptual design for the vehicle began in 2011 in partnership with ULA. Current development includes continued conceptual design and initial component trade studies with IOC expected in the late 2020s.

Overview: Masten Lunar Delivery Service Baseline Capability

Table 1: Vehicle Overview and Payload Accommodations

XL-1 Vehicle Overview	
Vehicle Dry Mass	675 kg
Vehicle Wet Mass	2,675 kg
Dimensions	3.47 m (length) x 3.02 m (width) x 2.08 m (height)
Spacecraft Propulsion Type	Low-toxicity bipropellant
Number of Main Engines	4
Number of RCS Engines	16
Structural Composition	Lightweight aluminum
Power Distribution System	Batteries, solar panels

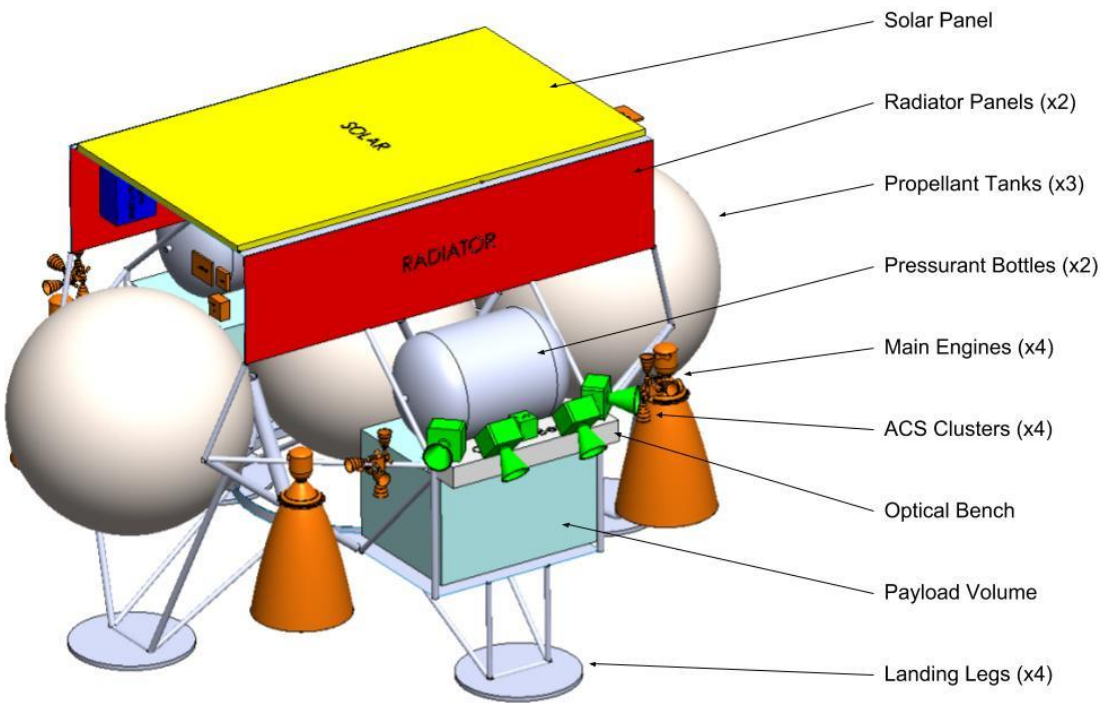


Figure 1: XL-1 Lander Overview

Table 2: Baseline Payload Accommodation

XL-1 Baseline Payload Accommodations	
Total Payload Mass Capacity	100 kg
Number of Payload Bays	2
Payload Mass Limit per Bay	50 kg
Payload Bay Envelope	787 x 610 x 610 mm (31.0" x 24.0" x 24.0")
Payload Power Limit per Bay	50 W, 28 VDC
Total Payload Power Capacity	100 W, 28 VDC
Payload Power per Mass	0.5-1.0 W/kg, varying by landing location and time
Structural Interface	Fastened to regularly spaced grid pattern
Power Interface	28 VDC (AIAA S-133-5-2013)
Thermal Control	Passive (Conductive, Radiative)
Data Interfaces	RS-422 (EIA-422-B), SpaceWire (ECSS-E-ST-50-12C)
Communications	5 MB/s comms link for instrument data transmission after landing
Payload Mechanical Interface	Direct attachment to payload bay structure using a regularly spaced bolt hole pattern; custom mounting locations available

Masten Differentiation

Masten was born for this Masten has a unique combination of experience and approach	Masten's mission is to lower the barriers of access to space. Over the last 15 years, the company has shown how reusability, nimble development, and small teams will change how space is accessed. Experience with space customers and landing technology unlocked the *capability driven* approach that is essential to lowering the barrier of access to the Moon.
Experienced Collaborative Payload Service Unparalleled history of payload integration into rocket powered landing vehicles	Deep collaboration with payload partners, refined over dozens of iterations, is a hallmark of Masten's partner focus. The result of this focus is improved program outcomes and official NASA recognition in multiple Group Achievement Awards. Masten's payload experience applied to Lunar Delivery Services will enable improved value from the landed payloads.
Cultivated Engineering Approach Capability driven engineering developed over 15 years Iterated and matured	Commercialization requires expansion of lunar access from bespoke mission systems to capability driven platforms. Masten's capability driven engineering has delivered substantial value to NASA and payload developers. Example: collaboration with Flight Opportunities and JPL for LVS eliminated two-year drive across Mars for Mars 2020, worth $200 million. For Lunar Delivery Service, this approach reduces cost risk and market risk.
Working Tech Successful performance of propulsive landing	Masten's demonstrated landing technology suite assures customers that Masten has the core ability to perform controlled, powered landing. The company's technology has been demonstrated as the winner of the NASA Centennial Lunar Lander Challenge, in over 600 operations, and 12 customer landing campaigns.
Informed Plan Vetted lunar design	The maturity of Masten's lunar delivery service plan, vehicle designs, and operational methods substantially benefits from NASA collaboration, critique, and iteration through the NASA CATALYST program.

National Aeronautics and Space Administration
Presents the
Group Achievement Award
to
Autonomous Descent/Ascent Powered-Flt Testbed Team
For the successful development and demonstration of a cost-effective flight testbed for rapid validation of new technologies for future Mars landing.

Lunar Delivery Service

Introduction

Masten Lunar Delivery Service transports customer payload from Earth to the surface of the Moon. Using landing technology developed and demonstrated over a decade, Masten provides lunar access for customers pursuing science, technology, and commercialization of the Moon.

Masten is manifesting moon landing missions to mid-latitude, near-side landing location. The primary customer will specify the date and landing site within the mission constraints listed in this guide. The XL-1 lander can support mission durations of up to 12 days after landing, depending on landing site and time.

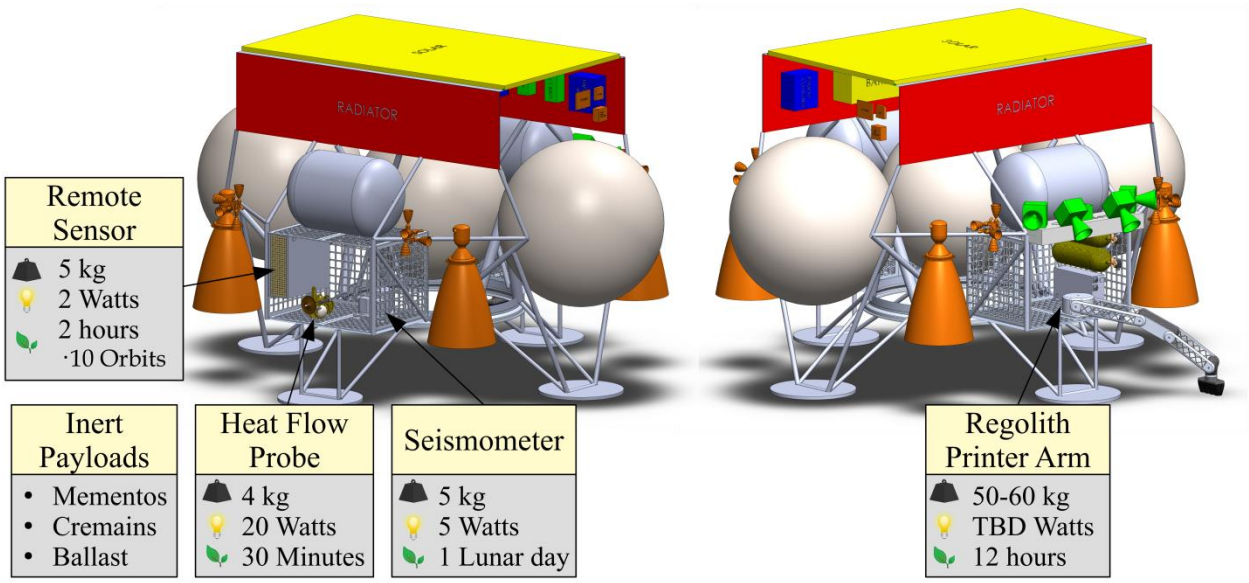


Figure 2: XL-1 Example Payload

Pricing

Masten's pricing model factors in the mass, electrical, and data requirements of each payload. For example, a 1kg payload requiring a 2.5 Mbps real-time downlink will be priced similarly to a 50kg payload with minimal data requirements. Because of the unique requirements of each payload, Masten must provide an individualized quote. Contact Masten sales for more information at moon@masten.aero.

Landing Location

Customer requirements will drive the landing site selection within the XL-1 Lunar Lander's capabilities and constraints, as shown in Table 3.

Table 3: Landing Site Constraints

Constraint	Value
Latitude	50° S to 50° N
Sun angle at landing	> 10° above horizon
Line of sight to Earth duration (after landing)	Full mission
Maximum Obstacle Height	50 cm (19.7 in)
Boulder Abundance	< 10%
Slope	< 15°
Landing Ellipse	TBD
Mission Duration	<12 Days

Additional constraints come from compliance with Planetary Protection requirements. Landing near existing landing sites (including Apollo, Luna, and Chang'e sites) will require additional analysis, mission rules, and cost to protect these heritage sites and avoid an international incident.

Payload Interfaces

Mechanical

A total of 100kg for payload is available, in two payload bays that can each handle up to 50kg (110 lb.) payload mass distributed throughout the bay. Each payload bay measures 787 x 610 x 610 mm (31.0" x 24.0" x 24.0"). Payloads attach directly to the payload bay's orthogrid-style structure using its integral 2" on-center bolt hole pattern. A payload adapter plate can be provided to match a payload's attachment method. The payload may use various sized machine screws as appropriate for the payload, from M3 to M6 or #4 to ¼".

For payloads desiring access to the lunar surface, the payload can be positioned in the payload bay to allow the payload to reach down to the surface or otherwise deploy itself to the surface.

Electrical

The electrical interface is a standard 28VDC bus (AIAA S-133-5-2013). 50W total power is available for each payload bay across all phases of the mission.

Maximum power for each payload will depend on phase of mission and needs of other payloads. Masten engineers will work with the customer to determine the appropriate connections to interface with the XL-1 power systems.

Data and Communications

XL-1 uses two standard types of data connection: RS-422 (EIA-422-B) and SpaceWire (ECSS-E-ST-50-12C). A total data rate of 5Mbps on the downlink is available during ground station contact. Instruments may transmit bursts of data at greater data rates to be stored on the lander and forwarded as radio time is available. These burst data rates are, of course, limited by the RS-422

or SpaceWire data rates as applicable. The total data to be transmitted is likewise limited and depends on individual mission details including ground station availability. There will not be data services to payloads during maneuvers, including correction maneuvers, lunar orbit insertion, and from deorbit to landing.

Spacecraft telemetry can be made available to the payload, the user segment or both.

Real-time data streams on the user segment interface are standard TCP/IP via an IPSec Tunnel to the designated user terminal. Downlinked data may also be stored on Masten ground segment servers to be forwarded later through any common file transfer or file sharing method.

Specific data flow instructions will be detailed in the Interface Control Document.

Environments

Atmospheric Environment

The standard atmospheric environment consists of temperature, humidity, and cleanliness. On receipt of the payload, Masten will conduct integration, test, and launch prep in class 100,000 (ISO class 8) clean rooms with temperature controlled to 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 45% ± 15%. Of course, after launch the payload will be going to an extremely dusty and dry place with large temperature swings.

Mechanical Environment

The limiting load case for the mechanical environment occurs during launch. As such the mechanical environment is given in the appropriate launch vehicle's user guides. The mechanical environment is described in the "Falcon User's Guide" and "Atlas V Launch Services User's Guide. The XL-1 Lander is a "standard mass" payload for determining load factors on the Falcon 9 launch vehicle and a less than 7000 lb. payload for Atlas V.

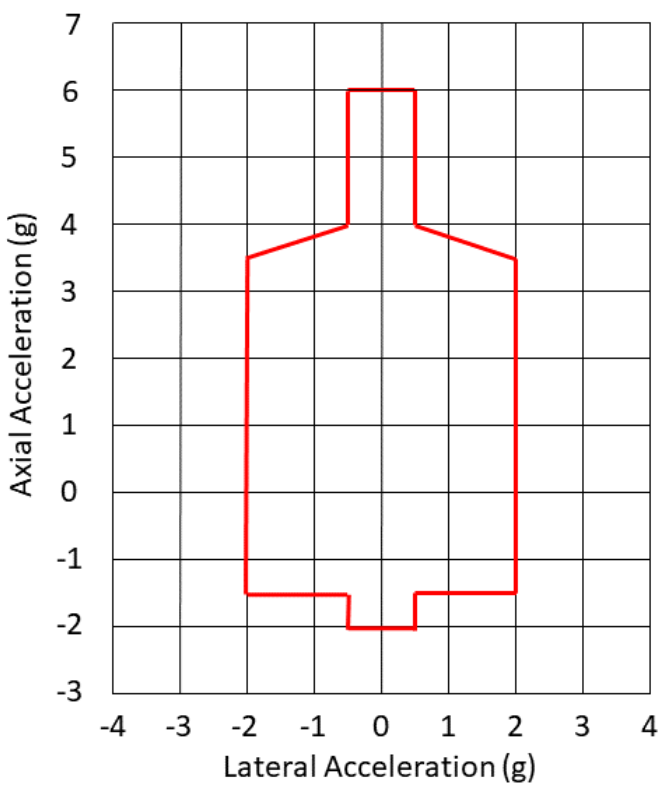


Figure 3: Falcon 9 load factors envelope (standard mass payload)

Electromagnetic Environment

XL-1 and the launch vehicle have several radio frequency systems. For the launch vehicle RF system characteristics, use the appropriate launch vehicle user's guide. XL-1 RF systems are summarized below in Table 4. Once the appropriate FCC licenses and frequency allocations are received, this guide will be updated with the specific frequencies used.

Table 4: RF Systems and Frequencies

Part Description	TX/RX (transmitter/receiver)	Frequency (MHz)
S-band TT&C	RX	2025-2120
S-band TT&C	TX	2200-2300
X-band downlink*	TX	8025-8450
Ka-band downlink*	TX	25250-27500
Radar Altimeter	TX/RX	4200-4400 (TBR)

* X-band is the baseline downlink. Ka-band is under consideration as an upgrade.

Thermal Environment

The preliminary estimate of the temperature environment of the payload bays is given in Table 5. These values are preliminary and will change both as the spacecraft design matures and as specific payloads and operations are determined.

Table 5: Payload Bay Expected Temperatures

Payload Envelope Temperature Environments [°C]						
	Payload Bay 1			Payload Bay 2		
Analysis Case Set	Max [°C]	Min [°C]	Avg [°C]	Max [°C]	Min [°C]	Avg [°C]
Low Earth Orbit Hot	-39.9	-39.1	-39.0	-42.0	-42.2	-42.1
Low Earth Orbit Cold	-37.9	-39.3	-38.1	-39.2	-39.5	-39.3
Lunar Transit Hot (Steady State)	-72.3	-	-	-	-77.9	-
Lunar Transit Cold (Steady State)	-78.8	-	-	-	-84.5	-
Lunar Orbit Hot	-30.0	-30.3	-30.1	-32.7	-32.9	-32.8
Lunar Orbit Cold	-37.5	-37.7	-37.6	-38.9	-39.2	-39.1
Lunar Surface	25.2	-37.6	11.2	85.5	-39.1	55.9

As illustrated in Table 5, payloads will be cold during the transit to the lunar vicinity. This is due to the arrangement of the bays, putting the payload bays in shadow.

The thermal environment for each payload can vary with the payload's position within each payload bay and with the thermal characteristics of the payload and nearby payloads. As part of

the payload integration process, Masten will analyze the thermal environment and work with the customer to ensure that the thermal environment will accommodate the payload

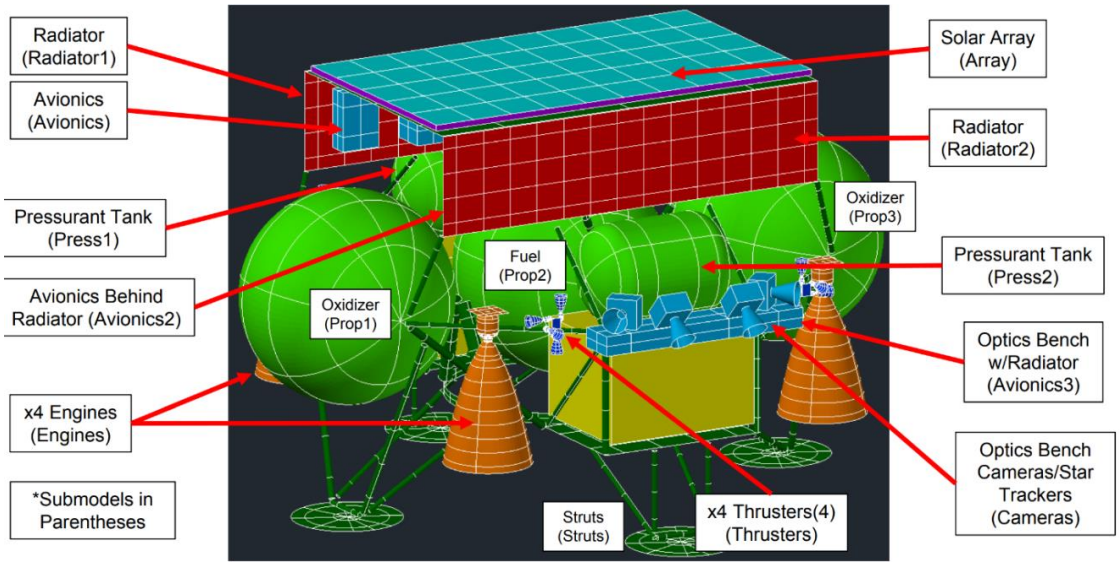


Figure 4: XL-1 Thermal Model

Payload Integration Process

Process Overview

The payload integration process consists of a series of steps culminating in the launch and injection into a trans-lunar trajectory. The high-level steps are:

- Interface Definition
- Analysis
- Payload Integration and Test
- Launch Vehicle Integration and Test

In the interface definition phase an interface requirements document is produced, and interfaces are defined and put into control in an Interface Control Document (ICD). The analysis phase consists of the various analyses that are required to ensure that the payload and lander are compatible, and that the fully integrated lander with payloads will work with the launch vehicle. Once the analyses are complete, the payload is shipped to Masten's facilities, where it is integrated on the lander and the integrated lander is tested. Finally, the lander with payloads is shipped to Cape Canaveral for integration to the launch vehicle and launch.

Interface Definition

The customer provides an interface requirements document (IRD) to define the requirements imposed by the payload on the lander. Masten will review and assist the customer in refining this document. The information in the IRD typically includes:

- mission requirements

- payload characteristics
- mechanical, electrical, and data interfaces
- mechanical and electrical requirements for the integration process
- test operations

Once the IRD is complete, Masten will produce an Interface Control Document (ICD) defining all interfaces between the payload, lander, and integration facilities. Once the ICD is agreed to and signed off by Masten and the customer, it is placed into configuration control and any changes require agreement by both Masten and the customer.

Integration Analysis

Masten is responsible for the integrated lander-payload analyses for each mission, covering all environments preceding launch and following launch vehicle separation. The launch vehicle provider is responsible for the integrated launch vehicle and spacecraft analyses for the launch environment. Masten is thereby responsible for providing the launch vehicle provider with the provider's requested spacecraft data to allow the launch provider to perform their analyses on the integrated spacecraft. A list of the required analyses is provided in Table 6.

Table 6: Required Payload Analyses

Masten Integrated Lander-Payload Analyses		
Analysis	Requested Payload Input	Analysis Products
Reference Mission Loads Analysis	Payload finite element model (FEM)	Results of reference mission finite element model load cases specific to the payload, from low Earth orbit to the reference mission landing site.
Reference Mission Integrated Thermal Analysis	Payload thermal model	Results of reference mission thermal model analysis cases specific to the payload, from low Earth orbit to the reference mission landing site.
Reference Mission Analysis and Performance	Payload mass properties	Results of reference mission trajectory analysis, including the landing accuracy for the reference mission landing site.
Reference Mission Integrated Power Analysis	Payload power and electrical requirements	Results of reference mission power analysis cases specific to the payload, from low Earth orbit to the reference mission landing site.
Reference Mission Concept of Operations	Payload operational requirements and mission timeline relative to the reference mission	Integrated Concept of Operations (ConOps) for the lander and payload, including a complete timeline of the mission events during the reference mission.

The customer should submit finite element model(s), thermal model(s), mechanical computer-aided design (CAD) model(s), and mass model(s) of the payload to Masten to complete payload and primary system analysis of the integrated lander. A summary of the requested documents is outlined in Table 7.

Table 7: Required Payload Models and Documentation

Payload-Provided Documents to Masten		
Payload Document	Request	Rationale
Mechanical CAD Model	The customer shall provide Mechanical CAD models in a file format compatible with the Masten-specified CAD applications or in a neutral file format, such as IGES or STEP.	Masten Space Systems will need Mechanical CAD models for hosted payload analysis cases, and the development of payload-specific structural interfaces.
Finite Element Model	The customer shall provide Masten Space Systems with a Finite Element Model.	Masten Space Systems will need the Finite Element Models for hosted payload analysis cases, and the development of payload-specific structural interfaces.
Thermal Model	The customer shall provide Masten Space Systems with a reduced node geometric and thermal math model.	Masten Space Systems will need the Thermal Math Model for hosted payload analysis cases, and the development of payload-specific thermal interfaces.
Mass Model	The customer shall provide Masten Space Systems with all physical mass models required for spacecraft mechanical testing.	Masten Space Systems may test with the mass model of the payload in the event that the payload delivery is delayed during critical integrated-vehicle testing.

Payload Integration and Test

In advance of receipt of the payload(s), Masten will work with the customer to define detailed handling procedures to ensure physical security of the payload. These procedures will govern all interactions with the payload, including all installation/integration steps, transportation requirements, and safe storage.

Immediately following payload selection, but prior to payload integration and test, Masten will assemble a working group which includes the customer(s), our testing partner NTS, and a launch vehicle integration representative. This group will jointly review the standard Masten Assembly, Integration, Test, & Validation (AITV) plan (MSS-TST-0910-001), the V&V process and where necessary for a specific mission, a tailored AITV plan will be drafted. The customized AITV

document will be informed in part by relevant standards such as: GSFC-STD-7000A, “General Environmental Verification Standard (GEVS) For GSFC Flight Programs and Projects”; GSFC-STD-1000F, “Rules for the Design, Development, Verification, and Operation of Flight Systems”; and ECSS-E-ST-10-02C, “Space Engineering: Verification”.

Payload(s) are expected to be independently qualified prior to delivery to Masten. Following payload integration on the spacecraft, the integrated vehicle testing will be conducted in accordance with NASA Standard 7002B, tailored to ensure compliance with the spacecraft test requirements from the launch services provider. In the case of any conflicts or ambiguities in individual criteria, the more stringent standard shall be adopted. Testing will be conducted at National Technical Systems facilities in the greater Los Angeles, CA area; facility descriptions are presented in the following section.

The NASA 7002B standard requires testing in excess of any expected mission operations limits by varying safety factors. This mission envelope is determined by the launch and landing profiles and guides the test definition. The shock, vibration, and acoustic loads are driven by the launch environment, which are defined in the appropriate launch vehicle user’s guide.

The driving thermal test requirements will be the space environment during transit to the moon and the environment in the landing region where surface temperatures range from approximately -180°C to +115°C (-290°F to +240°F).

Simple and or static payloads and experiments (i.e. retroreflectors) may be tested at the component level and may not require complete integrated spacecraft testing. Payloads with deployable components, actuators, or highly complex experiments should be tested as part of the integrated system. Where possible, signal or subsystem simulations may be inserted for items which would be difficult to test at full scale but have been validated at the component level. As systems become more complex, multi-input issues may arise and these will be mitigated and tested for as much as practical.

Masten’s assembly, integration, and test process is presented schematically in Figure 5: Masten’s assembly, integration, and test process. Assembly and integration of the payload(s) and spacecraft will take place in a ~750ft^2 class 100k clean room at Masten’s headquarters in Mojave, CA. An adjacent ~300ft^2 class 10k clean room will also be available as needed. If needed, Masten has access to additional clean room capacity through our integration test partner, National Technical Systems (NTS). NTS has multiple class 10k and better clean rooms available for use on this program.

To ensure safe transport of the spacecraft between the different integration and test facilities, Masten has engaged various partners to provide specialized spacecraft transportation.

At the completion of integrated vehicle testing, the vehicle will be transported, in coordination with the launch services provider, to the appropriate launch vehicle integration facility for integration on the launch vehicle.

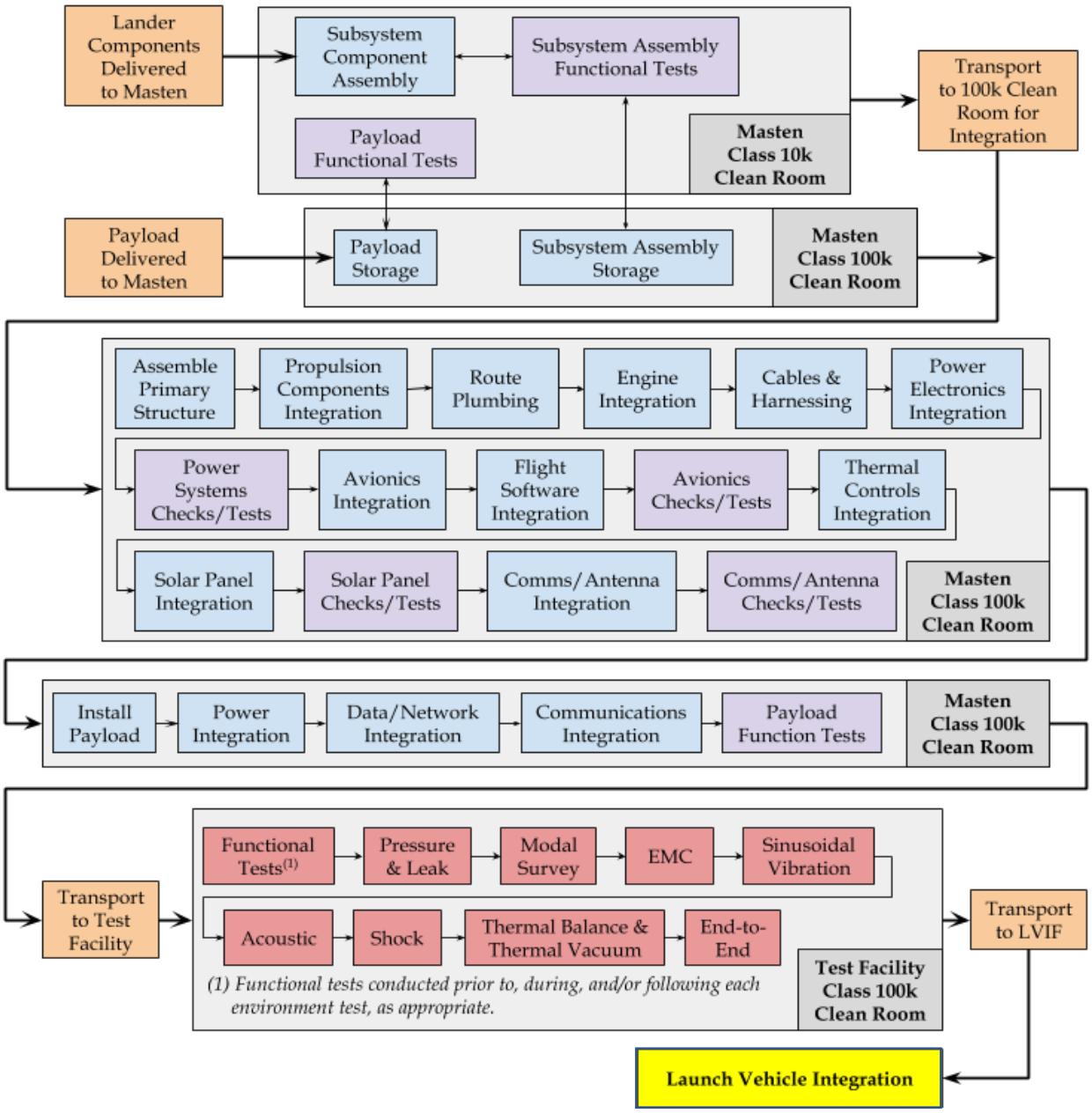


Figure 5: Masten's assembly, integration, and test process

Payload Integration and Test Facilities

Masten is installing ~750 ft^2 class 100k (ISO class 8) and ~300 ft^2 class 10k (ISO class 7) clean room facilities at its Mojave, CA headquarters for use in spacecraft final assembly (class 100k) and sub-system assembly and checkout testing (class 10k). Entry into our facilities is secured using code-locked doors and access to all facilities, including the integration facility, is restricted to authorized personnel only. In addition, a 24hr active security patrol program is in place. Masten also has a CCTV security system available for use in the assembly and integration facility.

Masten has arranged for integrated vibration, shock, acoustic, EMI/EMC, and thermal vacuum testing through National Technical Systems (NTS) at their Santa Clarita, Los Angeles, and Fullerton, CA facilities. Masten has toured the NTS facilities and worked with their engineers to validate that NTS can meet the testing needs for the XL-1 lunar lander and is currently working with them to develop an initial testing plan.

Vibration, shock, and acoustic tests will be conducted at the NTS Santa Clarita Lab, which also has multiple clean rooms ranging from class 100k (ISO class 8) up to class 100 (ISO class 5). Thermal vacuum testing will be conducted in Los Angeles at the NTS TV-25 facility, a 15'x25' test chamber capable of temperatures ranging from -292°F to 392°F under a 10^{-7} Torr vacuum. There are also associated class 100k and 10k clean rooms on site. EMI/EMC testing will occur at the NTS facility in Fullerton, which has a full suite of EMI/EMC test capabilities supporting testing to the relevant MIL-STD-461.

Expanded Lunar Landing Location Service

For 10 years, Masten has been developing and maturing additional technology to enable more robust landings in more difficult lunar locations. The Masten Lunar Architecture and XL-1 system are designed to integrate enhanced landing technologies including terrain relative navigation, real time hazard avoidance, and dynamic trajectory generation . Available initially only as an additional service, Expanded Lunar Landing Location is an option for specific missions.

Lunar Surface Capabilities

Once on the surface, there are a wide array of capabilities that will help unlock the scientific and commercial treasures of the moon. As the transportation backbone provider, Masten executes on the delivery to the surface. On this backbone, Masten, in cooperation with Masten partners, developed additional services for the lunar surface. These capabilities are packaged to reduce or remove barriers to accomplishing lunar science, technology, and commercialization goals.

Refer to the Masten Lunar Catalog of Services for solutions.

Cis-Lunar Orbit Delivery Service

Introduction

In addition to the lunar surface, Masten provides access to points along the trajectory from Earth to the Moon. The needs and uses of this service are widely varied. To develop solutions, Masten draws from partner organizations that will connect the science, technology, or commercial interest to an executable plan.

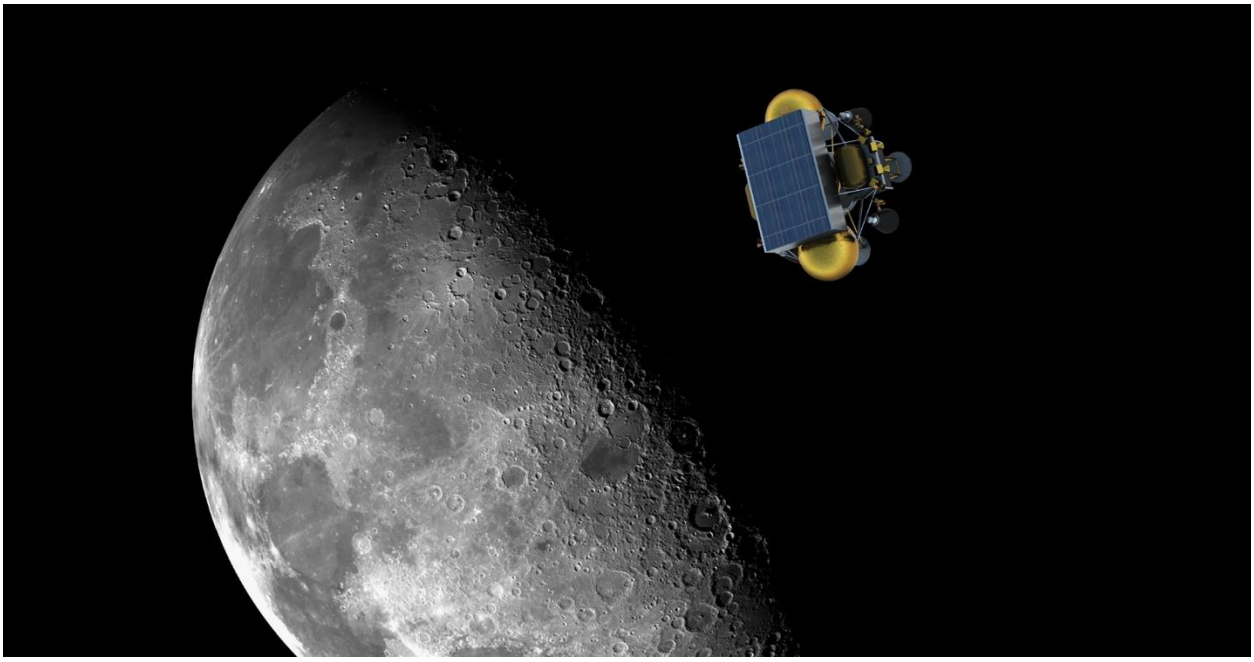


Figure 6: XL-1 in Lunar Orbit

Pricing

Pricing for delivery to locations between Earth and the lunar surface will be priced based on the objectives of the customer. Masten will work together with the customer to optimize for specific customer priorities, crafting solutions from Masten and Masten Partners to meet the budget and technical objectives.

Deployment Location

There are three mission phases for deployment of small satellites or to gather data in flight; during trans-lunar coast, lunar orbit insertion, and lunar orbit

To ensure accurate navigation during landing, XL-1 will orbit the Moon at least 10 times. The orbital parameters are flexible with respect to inclination, semi-major axis, and eccentricity. The major constraint is that the orbital parameters chosen must support a landing at the mission landing site.

Payload Interfaces

Mechanical

For payloads that will be operating in lunar orbit, Masten engineers will work with the customer to ensure that their instruments are integrated into a useable position.

Payloads deploying during flight, such as CubeSats, will require a standard, qualified deployment mechanism. The deployment device is considered as part of the payload mass. Masten engineers may integrate these payloads into other areas of the lander at their discretion.

Electrical

Based on project solution.

Data

Based on project solution.

Environments

Atmospheric Environment

As listed in Landed Services

Mechanical Environment

As listed in Landed Services

Electromagnetic Environment

As listed in Landed Services

Thermal Environment

As listed in Landed Services

Payload Integration Process

Process Overview

As listed in Landed Services

Interface Definition

As listed in Landed Services

Integration Analysis

As listed in Landed Services

Payload Integration and Test

As listed in Landed Services

Payload Integration and Test Facilities

As listed in Landed Services

CLPS Task Order 1 Evaluation Criteria

Task Order 1 Technical Evaluation Criteria	Value			Page
1) Payload mass (capability to the lunar surface) –				
User's Guide must outline how much mass is available for NASA payloads.	100 kg			Mass
2) Payload power –				
The User's Guide must describe how much power is available to NASA payloads across all phases of the mission.				Power
Translunar coast	50W total power per payload bay			
Injection burn	50W total power per payload bay			
Low lunar orbit	50W total power per payload bay			
Deorbit and landing	50W total power per payload bay			
Lunar surface	50W total power per payload bay			
the physical interface(s) to the lander power system.	standard 28VDC bus			
3) Payload volume –				
The User's Guide must describe the volume(s) available for NASA payloads and the relative location of those volumes on the lander.	787 x 610 x 610 mm (31.0" x 24.0" x 24.0") per bay			Volume
4) Payload mounting structure				
The User's Guide must describe how NASA payloads will be mounted on the lander, including any specific mounting instructions.	2" square grid bolt-hole pattern			Mounting
5) Payload communications –				
The User's Guide must describe what communication capabilities are available to NASA payloads, including... for all phases on the mission.				Comms
	interface connections	bandwidth capabilities	data flow instructions	
Translunar coast	RS-422, Spacewire	5 Mbps during contacts	TBD in ICD	
Lunar orbit injection burn	RS-422, Spacewire	On vehicle storage only.	TBD in ICD	
Low lunar orbit	RS-422, Spacewire	5 Mbps during contacts	TBD in ICD	
Deorbit and landing	RS-422, Spacewire	On vehicle storage only.	Not Applicable	
Lunar surface	RS-422, Spacewire	5 Mbps during contacts	TBD in ICD	