



# APEX Lunar Lander Payload User's Guide

REVISION 4 – MARCH 2025

## Preface

The APEX Lander Payload User's Guide (PUG) provides key information pertaining to descriptions and capabilities of the Lander as a part of ispace-U.S.' standard services. This document is intended to be an initial reference for payload customers to aid in preliminary design and interface assessment. Please contact us to collaborate on further assessment and mission launch opportunities.

## About ispace-U.S.

ispace-U.S. is an American lunar exploration company providing cis-lunar transportation, data services, and infrastructure capabilities from Earth to lunar orbit and the surface of the Moon for government, civil, and commercial customers.

ispace-U.S. leads the development of the APEX 1.0 Lander and Alpine & Lupine Relay Satellites – all designed, manufactured, and launched from the United States. In partnership with Draper, this Lander will deliver a suite of NASA-sponsored science payloads to the lunar surface as part of the NASA Commercial Lunar Payload Services (CLPS) program.

Under the grand vision of "Expand our Planet, Expand our Future," ispace-U.S. leverages the expertise of ispace-inc., its parent company, ispace-EUROPE, the center of excellence for rover development in Luxembourg. The APEX Lander leverages heritage and capabilities from the precedent missions and global collaborations.

## Contact ispace-U.S.

To learn more about the APEX Lander and other services offered by ispace-US or ispace, inc., reach out to our Business Development team: [businessdevelopment@ispace-us.io](mailto:businessdevelopment@ispace-us.io).

# Table of Contents

1. LANDER OVERVIEW	1
2. MISSION DESIGN OVERVIEW	2
3. INTERFACES & ACCOMMODATIONS	4
3.1 Structural Accommodations	4
3.1.1 Payload Mass Allocation	4
3.1.2 Mechanical Interface	4
3.2 Thermal Accommodations	5
3.2.1 Thermal Interface	5
3.2.2 Thermal Management	5
3.3 Electrical Accommodations	5
3.3.1 Payload Power Allocation	5
3.3.2 Electrical Interfaces	5
3.4 Data Accommodations	6
3.4.1 Payload Data Allocation	6
3.4.2 Communication Interfaces	6
3.5 Software Accommodations	6
4. ENVIRONMENTS	7
4.1 Humidity and Cleanliness	7
4.2 Sine Vibration and Random Vibration	7
4.3 Acoustic	7
4.4 Fairing Pressure Profile	8
4.5 Vehicle-Induced Shock	8
4.6 Thermal Environment	8
4.7 Radiation Environment	8
4.8 Regolith and Plume Impingement	8
5. PAYLOAD INTEGRATION AND TESTING	9
5.1 Payload Integration Timeline	9
5.2 Payload Deliverables	9
6. MISSION OPERATIONS	12
6.1 Flight Segment	12
6.2 Ground Segment	12
APPENDIX A: ACRONYMS	1

# List of Figures

Figure 2 - 1: APEX Lander Structure	1
Figure 3 - 1: Representative Mission Trajectory and Mission Phases	1
Figure 4 - 1: APEX Payload Mounting Locations	1
Figure 7 - 1: Falcon 9 Payload Fairing with Lunar Lander Payload	1
Figure 7 - 2: Payload Data Flow	1
Figure 7 - 3: ispace-U.S. Summit Mission Control Center	1

# List of Tables

Table 3 - 1: Mission Phase Duration, Description, Key Advantage, and Transitions	1
Table 6 - 1: Nominal Payload Integration Schedule	1
Table 6 - 2: Payload Deliverables and Input Documentation	1
Table 6 - 3: Payload Testing Requirements	1
Table A-1. Acronyms	1



ispace-U.S.' APEX Lander (Figure 2-1) is ispace's next-generation lander, leveraging lessons learned from the company's Hakuto-R Mission 1 (M1) lander and the Mission 2 (M2), the RESILIENCE lunar lander to deliver enhanced mass-to-surface capabilities in its initial configuration. APEX 1.0 has 300 kg of lunar surface payload capacity. The APEX Lander serves as a multi-purpose platform capable of delivering customer payloads to the lunar surface or to lunar orbit.

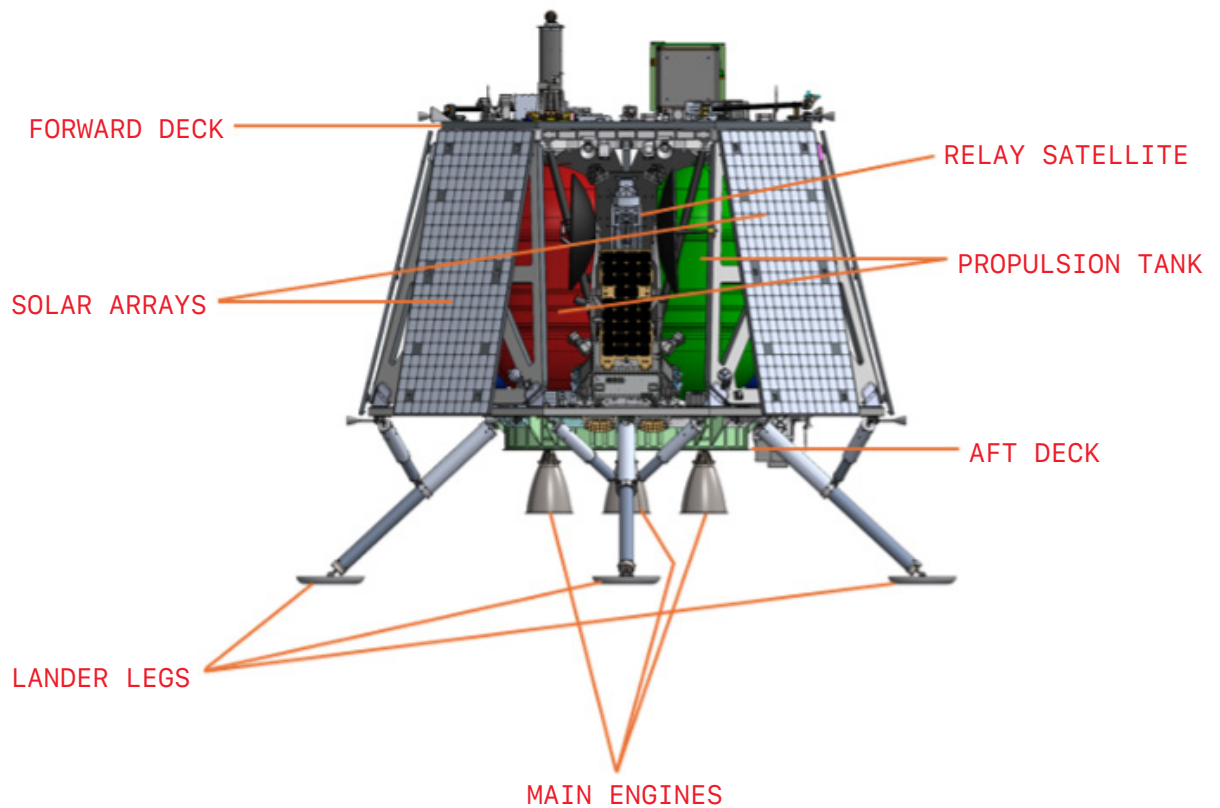


FIGURE 2-1: APEX LANDER STRUCTURE



Each APEX mission is designed to follow a standard set of mission phases (See Table 3 1). These phases align with standard offering services across different parts of a mission to ensure ease of customer understanding, and alignment with key customer objectives that may occur at different points across the mission.

The mission design includes several consecutive launch opportunities per month with a dedicated launch on the flight-proven Falcon 9 launch vehicle; staging in a Geosynchronous Transfer Orbit (GTO); a direct lunar transfer, staging in low lunar orbit (LLO); descent and landing, and lunar surface operations. Deployable assets are able to be accommodated across all mission phases after launch vehicle separation. A visual representation of the trajectories of these phases is shown in Figure 3-1.

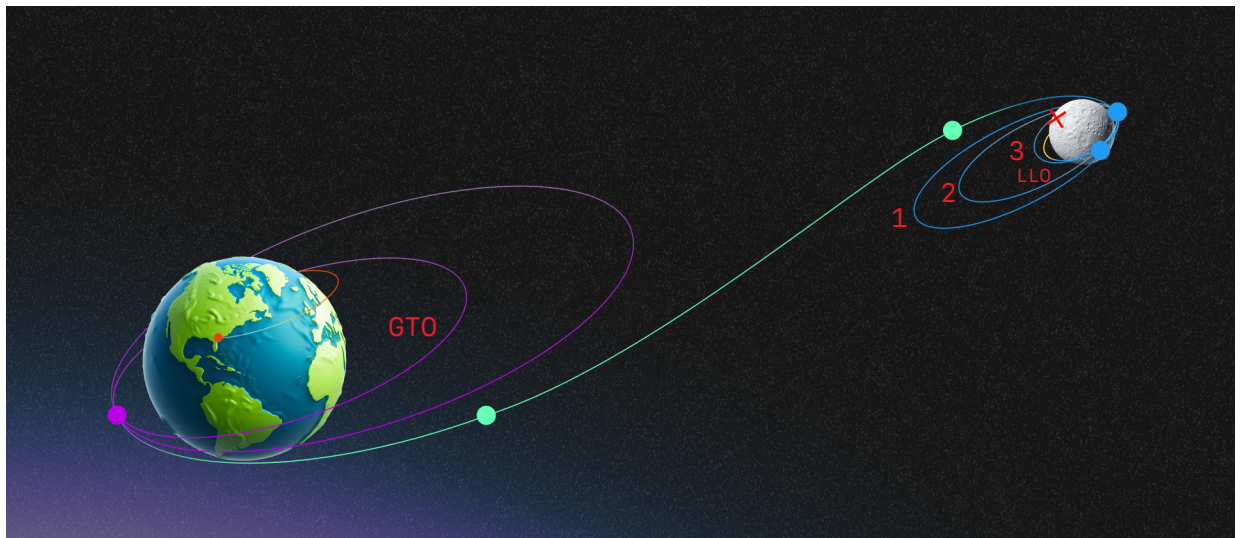


FIGURE 3 1: REPRESENTATIVE MISSION TRAJECTORY AND MISSION PHASES.

**Table 3-1: Mission Phase Duration, Description, Key Advantage, and Transitions.**

MISSION PHASE	PHASE DESCRIPTION	KEY CUSTOMER ADVANTAGES
Pre-Launch	<ul style="list-style-type: none"> <li>Duration represents the time from payload receipt for integration until launch.</li> <li>Pre-launch includes time for payload integration and vehicle-level environmental testing.                             <ul style="list-style-type: none"> <li>o Payloads that opt for integration after environmental testing may have payload simulators installed during vehicle-level environmental testing if required.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Flexibility offered based on payload requirements and schedule considerations for flight integration.</li> <li>Environmental and cleanliness controls are in place for lander processing</li> </ul>
Launch	<ul style="list-style-type: none"> <li>Falcon 9 reusable launch vehicle injects the APEX Lander into GTO.</li> <li>APEX launch window is determined by ispace-U.S. as the primary Launch Vehicle customer.</li> <li>Launch window is designed by ispace-U.S. to maximize launch opportunities in a given month (5+ days in a given window) in case of delays due to scrubbed launch attempts.</li> <li>Standard GTO offers lower injection uncertainty/higher accuracy relative to direct deployment from the launch vehicle in TLI.</li> </ul>	<ul style="list-style-type: none"> <li>All customer payloads nominally powered off during launch</li> </ul>
Geostationary Transfer Orbit (GTO)	<ul style="list-style-type: none"> <li>This approach ensures all launch opportunities have the same TLI state and, thus, the same arrival time at the lunar surface.</li> </ul>	<ul style="list-style-type: none"> <li>Incremental checkouts of payloads and lander systems in GTO offer greater flexibility for implementing contingency plans, if necessary.</li> </ul>
Direct Lunar Transfer	<ul style="list-style-type: none"> <li>The APEX Lander conducts its own Trans Lunar Injection (TLI) maneuver from Earth orbit to optimize mass-to-lunar surface capability..</li> </ul>	<ul style="list-style-type: none"> <li>Direct lunar transfers optimize the transfer time from Earth to the Moon, ensuring we are timely to meet customer mission operations needs after launch.</li> <li>Incremental checkouts and/or payload operations available during lunar transfer</li> </ul>
Low Lunar Orbit (LLO)	<ul style="list-style-type: none"> <li>A Lunar Orbit Insertion (LOI) maneuver is performed, followed by additional maneuvers to lower the apolune until a circular Low Lunar Orbit (LLO) is achieved.</li> <li>The lander stages in LLO as it prepares for Descent Orbit Insertion (DOI), allowing for final checkouts of the lander and payload systems.</li> <li>The exact duration in lunar orbit changes for each mission.</li> <li>The Lander's lunar orbit design allows ispace-U.S. to access the majority of the lunar surface.</li> </ul>	<ul style="list-style-type: none"> <li>Checkouts, operations, and/or deployment opportunities offered to customers during this phase as needed</li> </ul>
Landing	<ul style="list-style-type: none"> <li>Leveraging heritage Descent Guidance Navigation Control (DGNC) algorithms from Hakuto-R M1 and M2 Lander missions.</li> <li>M2 DGNC includes hazard detection and avoidance capability for obstructions smaller than 1ft in diameter.</li> <li>Landing legs include shock absorbing elements designed to limit the forces of landing in any axis to loads less than those experienced during the launch event.</li> </ul>	<ul style="list-style-type: none"> <li>Meets any sun or viewing angle requirements the payloads have once on the lunar surface.</li> </ul>
Surface	<ul style="list-style-type: none"> <li>The Apex 1.0 Lander mission design ensures the optimal landing site approach and maximizes time on the lunar surface, given mission constraints.</li> </ul>	<ul style="list-style-type: none"> <li>Landing at the beginning of the lunar day for each mission allows for maximum data collection before local sunset.</li> <li>Post-sunset operations may be accommodated – please inquire directly for more detail.</li> </ul>

\*DEPENDENT ON LAUNCH DATE AND LANDING SITE COORDINATES.



The APEX Lander is designed to service a variety of static and deployable payloads. The following sections describe the key interfaces and standard accommodations and resources provided for each customer. Standard offerings are intended to give customers a design reference point. Further development of accommodations scope and interface requirements are supported upon request to ispace-U.S.

## 3.1 Structural Accommodations

### 3.1.1 Payload Mass Allocation

The list below describes what is in the allocated Not-to-Exceed (NTE) mass included in quote and contract documents:

- Payload Instrument/Experiment Unit(s)
- Secondary Adapters (Provisions for protection against
- Payload Fasteners
- Payload Insulation (Passive Thermal Control)
- Active Thermal Control Provisions
- Internal Payload Harnessing
- Power/Communications Harnessing from the Vehicle to the Payload

Note: Additional hardware not provided, but available for purchase upon request.

Elements are omitted if they are not required to fulfill payload mission objectives. ispace-U.S. may provide design and manufacturing services for elements listed below, to be discussed and defined with the customer on a case-by-case basis.

### 3.1.2 Mechanical Interface

Payloads may be mounted directly to the primary structure if fastener spacing adheres to requirements; otherwise, payloads may require a mounting bracket for attachment to the Lander's composite panel. ispace-U.S. will determine final mounting locations based on payload requirements and keep-out volumes as needed. Available payload mounting regions on the vehicle are summarized in the Figure 4-1 below.

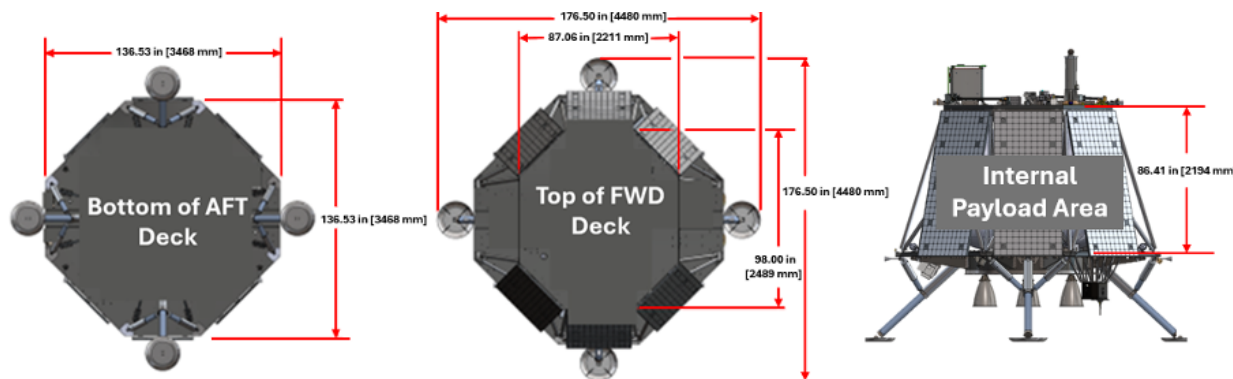


FIGURE 4 1: APEX PAYLOAD MOUNTING LOCATIONS.

## 3.2 Thermal Accommodations

### 3.2.1 Thermal Interface

The standard assumption is that there is no heat exchange from the Lander to a payload or from a payload to the Lander. Depending on payload requirements and operational considerations, thermal conductance and/or radiation requirements are considered on a custom basis.

### 3.2.2 Thermal Management

The vehicle-to-payload interface temperature is monitored and controlled by ispace-U.S. to the required temperature range. Thermal boundary conditions are assessed based on interface design and requirements. As a non-standard service offering, ispace-U.S. may provide payloads with onboard heaters and temperature sensors. Otherwise, the customer is expected to provide ispace-U.S. with any additional thermal control required via the payload design and/or using the electrical interfaces provided.

## 3.3 Electrical Accommodations

### 3.3.1 Payload Power Allocation

Payload power is allocated based on customer needs and availability per existing Lander missions and other payloads. Peak power availability throughout all mission phases is 280W.

#### Situations where power is nominally unavailable:

- Launch until 30 minutes after launch vehicle separation.
- Final descent and landing to the lunar surface (unless a payload has critical science observations during this period).

#### Transit Power (Launch Vehicle Separation (LV Sep) + 30 minutes through Low Lunar Orbit):

- Average power available varies relative to the existing mission operations plan.
- Deployable orbital assets typically have inhibits and are nominally powered off during transit.

#### Surface Power (Touchdown through end of Lunar Surface Operations):

- Power is prioritized during the first Earth Day of observations to support surface commissioning and deployment operations.
- Nominal surface mission power availability is limited to sunlit conditions at the landing site.
  - o Post-sunset operations may be available upon request.

### 3.3.2 Electrical Interfaces

Details of the standard electrical interface provided to payloads are summarized in Table 4-1. Additional interfaces can be negotiated upon request.

Table 4-1: Payload Electrical Interfaces.

INTERFACE	NUMBER OF LINES	VOLTAGE TOLERANCE AVAILABLE
1. Micro-D Style Connector for Power.	Two (2) Power Lines: 1. Operational Power 2. Survival Heaters Line	1. 28 VDC +/- 6 VDC 2. 12 VDC +/- 10% 3. 5 VDC +/- 10%

## 3.4 Data Accommodations

### 3.4.1 Payload Data Allocation

Due to the variable cost of uplink and downlink operations, payload data allocation and associated pricing are negotiated per actual command and telemetry requirements defined by the customer. ispace-U.S. develops the payload operational timeline, which informs the exact timing of communication services throughout the mission. Nominally, data services are unavailable during the mission until 30 minutes after launch vehicle separation. Payload data uplink and downlink can be provided as available throughout the mission duration, with the exception of final descent and landing operations (no payload data can be directly uplinked or downlinked during this period).

### 3.4.2 Communications Interfaces

Details of the standard communications interface options provided to payloads are summarized in Table 4-2.

Table 4-2: Payload Communication Interfaces.

INTERFACE	NUMBER OF LINES	PROTOCOLS AVAILABLE
1. Micro-D Style Connector for Communications.	One (1) Data Line	1. RS-422 2. RS-485 3. RS-232 4. LVDS 5. Discrete GPIO 6. Ethernet (optional upgrade) 7. Custom Protocols, per customer needs

## 3.5 Software Accommodations

The APEX Lander is equipped with a highly capable flight computer for management of the lander systems and payloads. Within the software architecture, power, data, and active thermal control are managed by internal applications. These items are defined between ispace-U.S. and the customer via Interface Control Documentation (ICD) and the Payload Operations Plan (POP), and are implemented into flight software directly by the ispace-U.S. flight software team.

There is also a standardized payload application for customers to implement any unique software for their payload management needs. Further information about this application interface is available upon request.

For information on Ground Software, please see Section 7.2.



The APEX vehicle and customer payloads are exposed to various environmental conditions prior to launch and throughout the duration of the mission. ispace-U.S. provides support to control environments where possible, and mitigates risk of environmental impacts to APEX and payload systems through rigorous design, analysis, and testing.

The types of environmental conditions described within this section can be:

- Ambient – environments that the lander and its payloads are exposed to directly
- APEX-induced – environments that are passed through the interface to a customer payload from the APEX lander
- Payload-induced – environments that are passed to the APEX lander from a customer payload. These must be disclosed by the customer to ispace-U.S.

Requirements including not-to-exceed environmental conditions are defined during the payload onboarding process. Existing for ambient and APEX-induced environmental conditions for a given mission and payload mounting zone, beyond what is included in this PUG, can be provided upon request.

## 4.1 Humidity and Cleanliness

Payload integration, transport, storage, and testing activities take place in facilities designed and operated to meet the requirements of ISO 14644-1 Class 8 cleanliness or better. Climate control and relative humidity are monitored and maintained within defined limits at each facility. Further accommodations may be accommodated should a customer require more strict limitations on humidity and cleanliness.

## 4.2 Sine Vibration and Random Vibration

The maximum predicted flight environments for random vibration and sine vibration at the payload interface(s) are provided during contract period of performance. The duration for random vibration and sweep rate for sine vibration are also provided. Specific accommodations may be provided for payloads requiring random vibration environments specified by GSFC-STD-7000B, a similar standard, or previously as-tested spectra.

## 4.3 Acoustic

Payloads shall be designed to withstand the acoustic environments induced by a Falcon 9 launch vehicle without acoustic blankets given in the Falcon 9 User's Guide. This environment may be enveloped by random vibration environments at the payload interface(s) for payloads with a small surface area and no direct acoustic sensitivities.

## 4.4 Fairing Pressure Profile

Payloads shall be capable of withstanding the launch pressure decay profile outlined in the Falcon 9 Payload User's Guide, without payload structural damage or foreign object debris (FOD) generation. Pressurized payloads are accepted on a case-by-case basis and must adhere to additional safety requirements imposed by ispace-U.S. via the launch vehicle provider.

## 4.5 Vehicle-Induced Shock

The APEX-induced maximum predicted shock environment at the payload interface due to vehicle or adjacent payload operations is provided during the contracted period of performance. Payloads with operations inducing a shock environment may be subject to design requirements to attenuate the payload-induced shock environment if it exceeds the APEX-induced shock and is located near other sensitive components.

## 4.6 Thermal Environment

The ambient thermal environment for the APEX Lander is expected to range from  $-100^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ . Payloads are provided with thermal analysis results at the payload interface(s) to help define payload thermal accommodations design. Further thermal considerations are given in Section 4.2.

## 4.7 Radiation Environment

Due to the mission profile, payloads should be designed to withstand 20 Krad total ionizing dose (TID) and have a minimum linear energy transfer threshold (LET<sub>th</sub>) of  $35\text{ MeV/cm}^2\text{-mg}$ .

## 4.8 Regolith and Plume Impingement

Upon descent, plumes from the descent engine will impinge the lunar surface causing loose regolith to erode and produce a high-velocity spray. Payloads exposed to the ambient environment mounted near the aft end of the APEX lander should expect some degree of regolith exposure upon final descent and landing, pending final mounting location relative to other lander components. Protections may be provisioned by the customer or ispace-U.S. as needed.



## 5.1 Verification Approach

ispace-U.S. offers multiple approaches for customers to ensure their payload is ready for the mission. This ensures payloads are tested appropriately while maintaining ability to optimize required test cadence based on individual cost and schedule considerations. Each option is outlined below:

**1. Payload Qualification / Flight Unit-Level Acceptance:** The customer has a dedicated qualification unit identical to the flight unit that is tested with added margin and not flown. The flight unit is tested to acceptance levels on the assembled flight unit (identical to qualification unit) to demonstrate workmanship. If the flight unit is integrated to the APEX lander prior to vehicle-level environmental testing, the Customer is responsible to ensure the payload is qualified to appropriate margins toward the representative exposure throughout ground test and mission environments.

**2. Payload Qualification / Flight Integrated-Level Acceptance:** The customer has a dedicated qualification unit identical to the flight unit that is tested with added margin and not flown. The flight unit is integrated to the APEX flight vehicle prior to vehicle-level testing, and exposed to the associated environments during vehicle-level testing. The Customer is responsible to ensure the payload is qualified to appropriate margins toward the representative exposure throughout ground test and mission environments.

**3. Payload Unit-Level Protoflight:** The customer flight unit is exposed to protoqualification environments on the assembled flight unit level. With this approach, ispace-U.S. recommends customer assembly unit integration after APEX vehicle-level environmental testing to avoid over-testing prior to the mission. If the flight unit is integrated to the APEX lander prior to vehicle-level environmental testing, the Customer must provide analytical margins toward the representative exposure throughout ground test and mission environments.

## 5.2 Test Requirements

Payloads are required to be qualified or protoflight tested according to the environments unless a waiver is granted. Particularly for fatigue-sensitive environmental exposure, ispace-U.S. and the customer work together to ensure appropriate margins and durations are used for all analysis and testing.

Payloads shall provide ispace-U.S. with acoustic analysis and/or test results or rationale if assuming the acoustic environments on the payload are enveloped by random vibration.

The customer's payload shall be qualified on a representative flight unit and acceptance tested on the flight unit. In the case that a separate representative flight unit is unavailable, protoflight qualification may be accepted on the flight unit. Any payload utilizing the protoflight qualification approach must show a positive margin between exposed test stresses and payload yield

strength, and/or that the yield factor of safety used for structural design exceeds the protoflight test factor. Expected tests are summarized in Table 6-3.

**Table 6-3: Payload Testing Requirements.**

TESTING REQUIRED		DESCRIPTION	DATE DUE
<b>MECHANICAL TESTING</b>			
Strength	Required	Testing shall be conducted in accordance with GSFC-STD-7000B, Section 2.4.2.3 to the environments specified by ispace-U.S. If a separate unit is used for qualification, acceptance testing shall be conducted to acceptance levels. Qualification or protoflight qualification shall be conducted to 3 dB above the maximum predicted flight environments. Unless otherwise agreed upon between the payload provider and ispace-U.S., the duration of testing shall be 60 seconds per axis for acceptance or protoflight qualification, or 180 seconds per axis for qualification.	Test report at payload delivery.
Sinusoidal Sweep Vibration	Required		
Random Vibration	Required		
Acoustics	Test if assessed to be sensitive to the environment. Typically enveloped by random vibration.		
<b>SHOCK (MECHANICAL AND PYRO)</b>			
Self-Induced	Test if assessed to be sensitive to the environment.		Test report at payload delivery.
Externally Induced			
Modal Survey			
Pressure Profile	Test if assessed to be sensitive to the environment.		
Pressure Profile	Required		
<b>THERMAL TESTING</b>			
Thermal Vacuum Thermal Cycle	Required	Testing in accordance with GSFC-STD-7000B, Section 2.6 guidelines for subsystem/instrument.	Test report at payload delivery.
Temperature-Humidity	Test if assessed to be sensitive to the environment.		
Bakeout (Contamination-Sensitive Applications)	Required	The payload will be baked out at the highest temperature possible until the hardware meets $\leq 1\%$ total mass loss (TML) and $\leq 0.1\%$ collected volatile condensable materials (CVCM), when tested per ASTM-E595.	

EMI/EMC TESTING			
Conducted Emissions	Required		Test report at payload delivery.
Radiated Emissions	Required		
Conducted Susceptibility	Required		
Radiated Susceptibility	Required		
FUNCTIONAL TESTING			
Mass Properties Verification	Required	Measured mass required. Analysis may substitute for other mass properties as needed for payloads below 20 kg.	Verification due at payload delivery.
Payload Functional Test	Required	To demonstrate proper functionality and response to lander commands prior to integration onto the lander.	Conducted at ispace-U.S. facility during integration.



ispace-U.S. will work with payload customers to design the lander-to-payload interface. Early milestones serve to provide sign-off on interface design and ensure compliance with requirements.

Payloads will be delivered, along with associated test reports, to ispace-U.S.' integration facility. Payload integration and functional testing onto the APEX Lander will occur after an IRR. The payload will then be subject to the APEX Lander environmental testing. Plans for mission operations will be reviewed prior to the Launch Readiness Review (LRR) between ispace-U.S. and the launch vehicle provider. Nominal mission operations will begin after launch.

## 6.1 Facilities

ispace-U.S. utilizes ISO 8-compliant cleanroom facilities that are humidity-controlled for all its integration and testing processes. The integrated APEX Lander is transported in a temperature, humidity, and cleanliness-controlled container between integration, test, and launch vehicle integration facilities.

## 6.2 Safety

ispace-U.S. requires that all payloads avoid causing harm to either the APEX Lander or other manifested payloads. Precautions include current and power protections, dual fault tolerance for any hazardous system, safe mode and/or dual fault protection, and pressurization and burst testing for pressurized vessels on payloads. ispace-U.S., and the customer will define all hazard mitigations through the development of the Payload ICD based on customer's Payloads Materials Usage List.

ispace-U.S. and its customers are also subject to Range Safety requirements. ispace-U.S. requires its customers to comply with the appropriate Range Safety documentation required for each mission. Range Safety requirement waivers to be negotiated post-contract initiation with a launch provider.

## 6.3 Schedule

The nominal timeline of payload integration after contract initiation is described in Table 6 1 below.

**Table 6-1: Nominal Payload Integration Schedule.**

SCHEDULE	MILESTONE	PURPOSE
ATP	Contract Period of Performance Initiation	Authority to Proceed. Final Payload Services Agreement contract and supplementary contract documentation (including technical Statement of Work) signed by customer and ispace-U.S.
ATP+2 months	Customer Requirements and Architecture Review	Presentation of customer and ispace-U.S. requirements to appropriate audience for payload accommodations, integration, and operation. This may be combined with PDR pending date of ATP relative to ispace-U.S.' mission-level gate reviews.
ATP+6 months	Payload Accommodations Preliminary Design Review (PDR)	ispace-U.S. presents an accommodations design approach to satisfy customer requirements and initial Interface Control Document (ICD*) release. Customer inputs are expected to support PDR and ICD activities.
L-14 months	Payload Accommodations Critical Design Review	ispace-U.S. presents final release of payload accommodation Drawing(s) and ICD*, as well as preliminary release of Payload Integration Plan* and Payload Operations Plan*. Customer and ispace-U.S. agree on approach to verification and validation plans and associated information/documentation exchange.
L-9 months	Requested Payload Delivery to ispace-U.S.	Payload hardware and any associated verification and validation reports required at delivery.
L-8 months	Payload Integration Readiness Review (IRR)	ispace-U.S. to present finalized Payload Installation Plan* and Payload Operations Plan*.
L-7 months	Post Installation and Checkout Conformance Review	Customer inspection to ensure payload installation.
L-2 months	Post Environmental Test Review	ispace-U.S. to present final test reports. Nominally, payloads are subject to integrated environmental testing. If a simulator payload is installed for environmental testing, Payload IRR and Post Installation and Checkout Conformance Review are conducted upon flight payload receipt and integration.
L-1 week	Launch Readiness Review	ispace-U.S. to present a final assessment of payloads and services provided.
L+6 weeks	End of Surface Operations (Mission Complete)	All mission data to be delivered to payload customer.

'ATP' SIGNIFIES AUTHORITY TO PROCEED

'L' SIGNIFIES LAUNCH DATE.

\*INDICATES DOCUMENTATION TO BE DEVELOPED BY ISPACE WITH PAYLOAD INPUTS.

## 6.4 Customer Deliverables

Table 6-2 provides a list of typical documentation that should be expected after a contract award through integration. This list may be subject to change.

Table 6-2: Payload Deliverables and Input Documentation.

DELIVERABLES	PURPOSE
Finite Element Model [FEM]	Required from payload provider, if payload modes are below 100 Hz. Used to decouple induced loads on payload by the APEX Lander.
Computer Aided Design [CAD] Model	Provided by customer to include at least the mass properties, mechanical and electrical interfaces, and the outer envelope.
Payload Materials Usage List [MUL]	Customer to define all the materials used within their payload, hazards and any hazard control required to be defined to satisfy Range Safety requirements.
Payload Specific Interface Control Document	Developed between ispace-U.S. and customer to control interfaces between the APEX Lander and the payload, utilizes delivered mechanical, electrical, and software interface documents.
Payload Emulator	An emulator of the customer's payload to test and develop software and electrical interfaces.
Payload Mass Simulator	A physical mass model of the payload to be integrated with the APEX Lander test article.
Payload Environmental Test Plan	A plan delivered by the customer showing the intent of compliance with Section 6.3 (below). If any tests are requested to be waived, an analysis report will be required in lieu of testing. Waivers will be required before test plans are due and are negotiated during the integration process.
Payload Test Report	A report delivered by the customer showing compliance with Section 6.3 (below).
Payload Installation Plan	A plan developed by ispace-U.S. based on the payload specific ICD, which is comprised of the payload M2 Lander Assembly Drawing, as well as the payload specific test plan.
Payload Operations Plan	ispace-U.S. developed with customer inputs, defines the mission operations of the payload during all mission phases.



Operations for all APEX Lander missions are composed of two functional segments: the Flight Segment and the Ground Segment.

## 7.1 Flight Segment

The Flight Segment refers to the concept of operations of the APEX Lander in flight- from launch through payload decommissioning. This concept of operations describes processes including receipt of ground commanding, autonomous command and control, downlink and review of health and status telemetry, and autonomous FDIR via onboard FSW. Prior to launch, all nominal and contingency payload operations, including power consumption and data downlink allocations will be planned and coordinated with customers in advance.

To exit Earth's atmosphere, ispace-U.S. contracts a launch vehicle provider to inject the APEX Lander into Geosynchronous Transfer Orbit (GTO), as mentioned in Mission Design, Section 3.0. A conceptual image of the APEX Lander inside a Payload Fairing Envelope is shown in Figure 7-1.

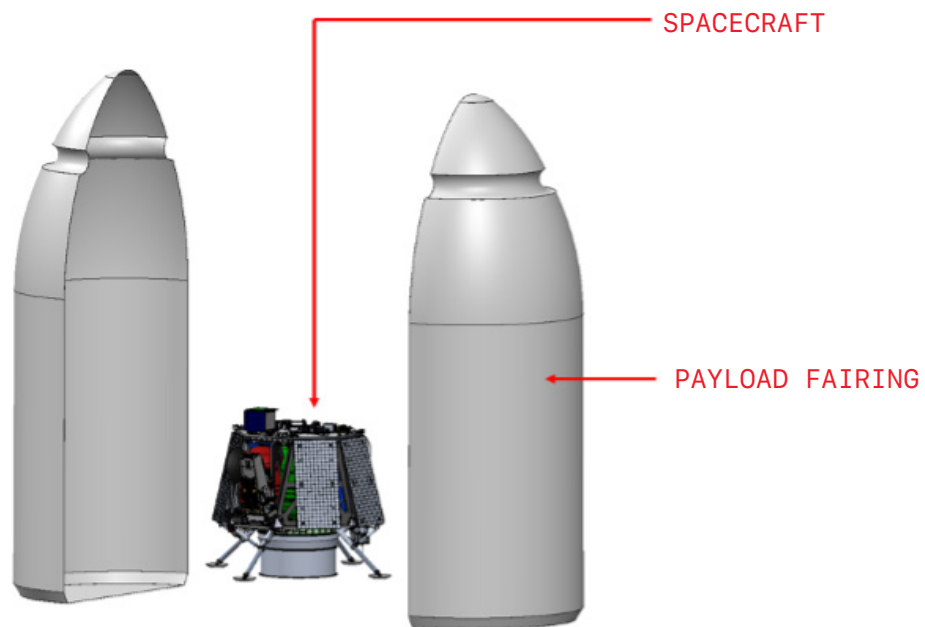


FIGURE 7 1: FALCON 9 PAYLOAD FAIRING WITH LUNAR LANDER PAYLOAD.

Prior to launch, the launch provider also serves as the responsible party for all FAA and Range Safety coordination with inputs from ispace-U.S. and payload customers. Deadlines for Range Safety waivers or tailoring will be coordinated between all parties in advance of launch.

On launch day, the launch provider owns operations until LV Sep. At LV Sep, the ispace Ground Segment assumes responsibility for the Lander operations and begins establishing commanding and telemetry links with the Lander. Unless otherwise coordinated, all payloads are powered off during launch until Lander initialization after separation.

The Lander is designed to send and receive data to the payload via payload interface controllers (see Figure 7 2). When receiving data from the payload, the Lander will store all information onboard until it has received confirmation from the Ground Segment and the associated payload customer Mission Control Center (MCC) that the data received is intact. ispace-U.S. coordinates all planned communication frequencies throughout the mission with the Federal Communications Commission (FCC) prior to the start of operations.

### Payload Data Flow

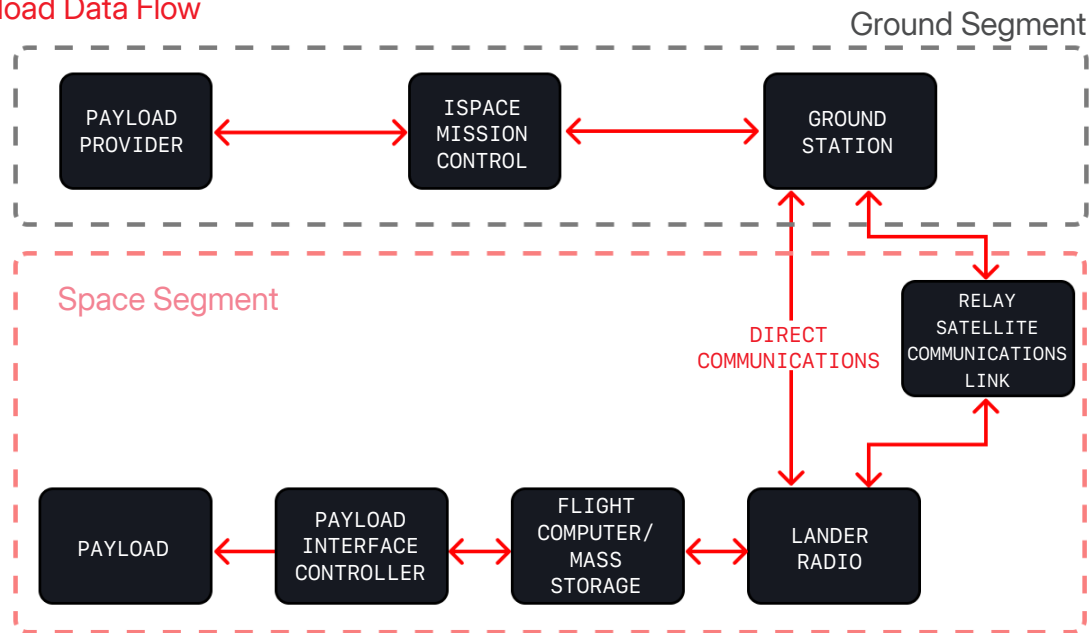


FIGURE 7 2: PAYLOAD DATA FLOW.

## 7.2 Ground Segment

The Ground Segment refers to the Ground Infrastructure, hardware, and software tools that facilitate the operation of the Lander from the ground. Ground infrastructure includes the Ground Station Network, the ispace-U.S. Summit MCC (see Figure 7 3), and the Payload Operations Center. The Ground Station Network intermediates all data transmission to-and-from the lander throughout the mission during predefined periods of availability. This data is then sent to ispace-U.S.' Summit MCC for analysis, processing, and delivery to the applicable customers via secure transfer methods.

Located in the ispace-U.S. office, the Summit MCC includes console positions for Mission Operators to monitor and command the Lander from the ground. All personnel communications are accomplished via a voice loop system that both the Ground Station and each customer team will have access to. On-site accommodations during operations can be made available upon request.

The interface between the ispace-U.S.' Summit MCC and the payload customer consists of:

- Access to a common repository for secure file transfer of all data generated by the payload and transmitted to the Pground.
- Login information to an ispace-U.S. system that allows customers to command to a payload, submit schedule requests, view the Mission Timeline, submit an anomaly report, and view payload telemetry and subsets of Lander telemetry that are relevant to payload health.

The interface between the Summit MCC and both the Ground Station Network and the customer will be validated during the pre-launch simulations compatibility tests. All customers are expected to participate in at least 20 hours of simulations prior to their mission. If anomalies arise during the mission that impact payload requirements, customers will be notified as soon as reasonably possible.



FIGURE 7 3: ISPACE-U.S. SUMMIT MISSION CONTROL CENTER

# Appendix A: Acronyms



Table 6-2: Payload Deliverables and Input Documentation.

ACRONYM	DEFINITION
ACS	Attitude Control System
ATP	Authority to Proceed
ASTM	American Society for Testing and Materials
CAD	Computer-Aided Design
CLPS	Commercial Lunar Payload Services
COTS	Commercial Off the Shelf
CVCM	Collected Volatile Condensable Materials
DGNC	Descent Guidance Navigation Control
DOI	Descent Orbit Insertion
EMI	Electromagnetic Interference
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FDIR	Fault Detection Isolation and Recovery
FOD	Foreign Object Debris
FSW	Flight Software
GPIO	General Purpose Input/Output Standard
GTO	Geosynchronous Transfer Orbit
HDA	Hazard Detection and Avoidance
ICD	Interface Control Document
IMU	Inertial Measurement Unit
IRR	Integration Readiness Review
ISO	International Organization for Standardization
L	Launch
LET <sub>th</sub>	Linear Energy Transfer Threshold
LOI	Lunar Orbit Insertion
LLO	Low Lunar Orbit
LRR	Launch Readiness Review

LV	Launch Vehicle
LV Sep	Launch Vehicle Separation
MCC	Mission Control Center
MLI	Multi-layered Insulation
M1	Mission 1
M2	Mission 2
MUL	Materials Usage List
NTE	Not to Exceed
PDR	Preliminary Design Review
PUG	Payload User's Guide
SB	Software Bus
SBN	Software Bus Network
TID	Total Ionizing Dose
TML	Total Mass Loss
TRN	Terrain Relative Navigation
TTE	Time-Triggered Ethernet

i s p a c e - U . S . 