# LATV: A Portable Testbed for Plant Growth in Off-World Soil

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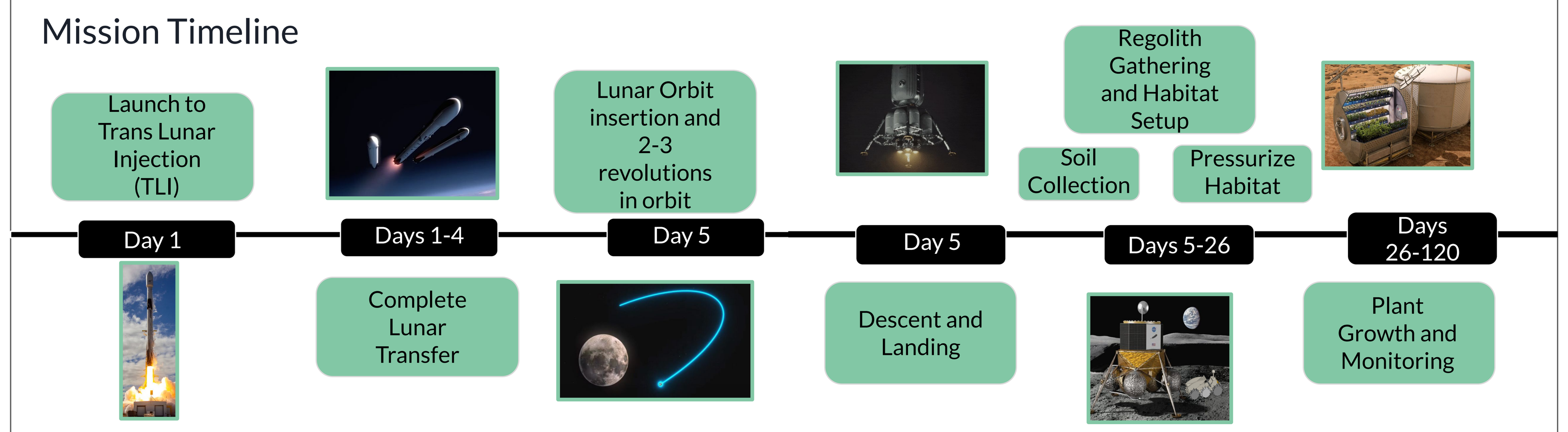
## Primary Mission Objective

To understand requirements of off-planet food crop cultivation using local regolith as a planting medium, by means of a hybrid lander/habitat, a regolith-gathering rover, and a sensor array for monitoring plant health

## Secondary Mission Objective

To contribute to NASA's Commercial Lunar Payload Service (CLPS) program through trajectory analysis and lander design

## Timeline

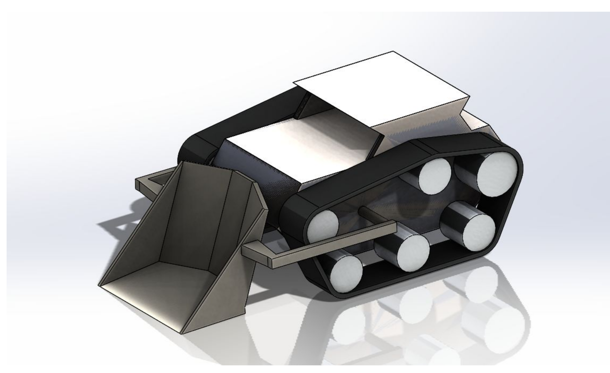



## Rover Configuration

The rover carries out the soil gathering phase of the mission

Shown to the right is the configuration of the rover with its soil carrying capabilities

Rover will prepare planters for seed insertion/germination via transportation of lunar regolith from lunar surface to habitat

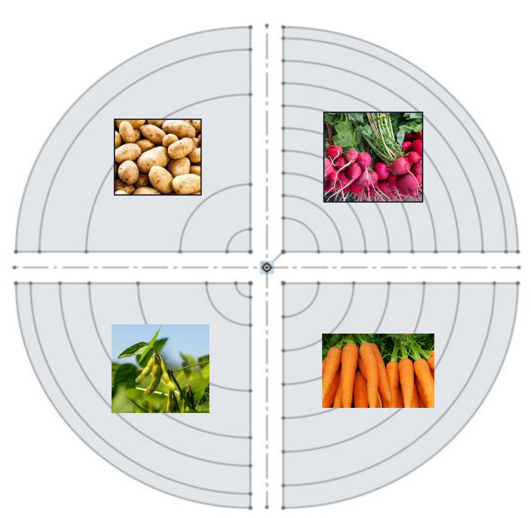


## Payload

Soil preparation is necessary because lunar regolith is not suitable for plant growth

Plant selection was based on water requirement, maturity time, and variety

Seed deployment will be from the habitat ceiling, through a predetermined pattern (see right)



| Plants | Minimum Row Spacing | Height | Plant Spacing in Rows |
|---|---|---|---|
| Potatoes | 26 | 40 | 10 |
| Radishes | 12 | 8 | 2 |
| Carrots | 18 | 18 | 3 |
| Soybeans | 5 | 30 | 5 |

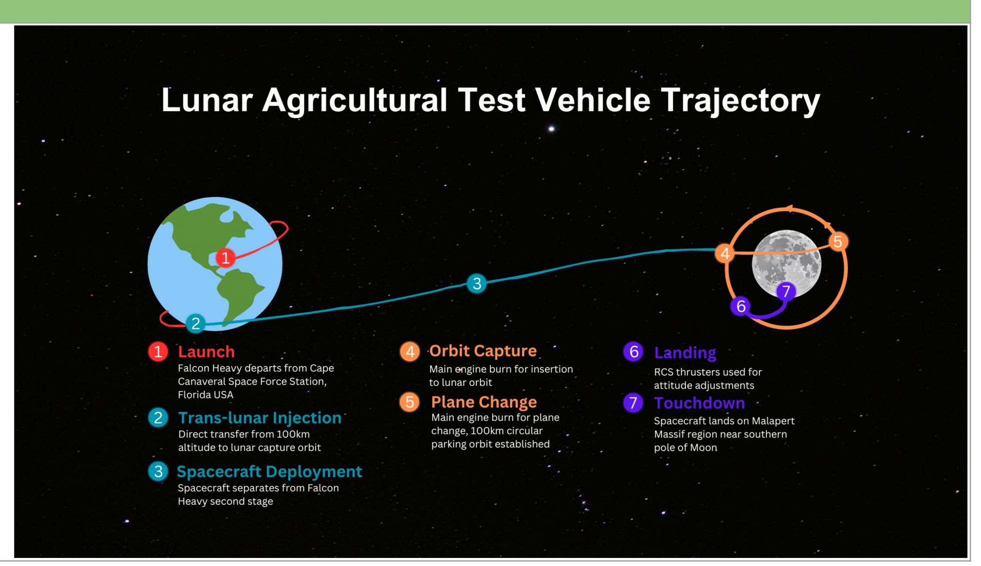

Once the lunar soil is on board the habitat, it is mixed with water, coco coir, and nutrients.

Soil additives allow lunar regolith to support plant life

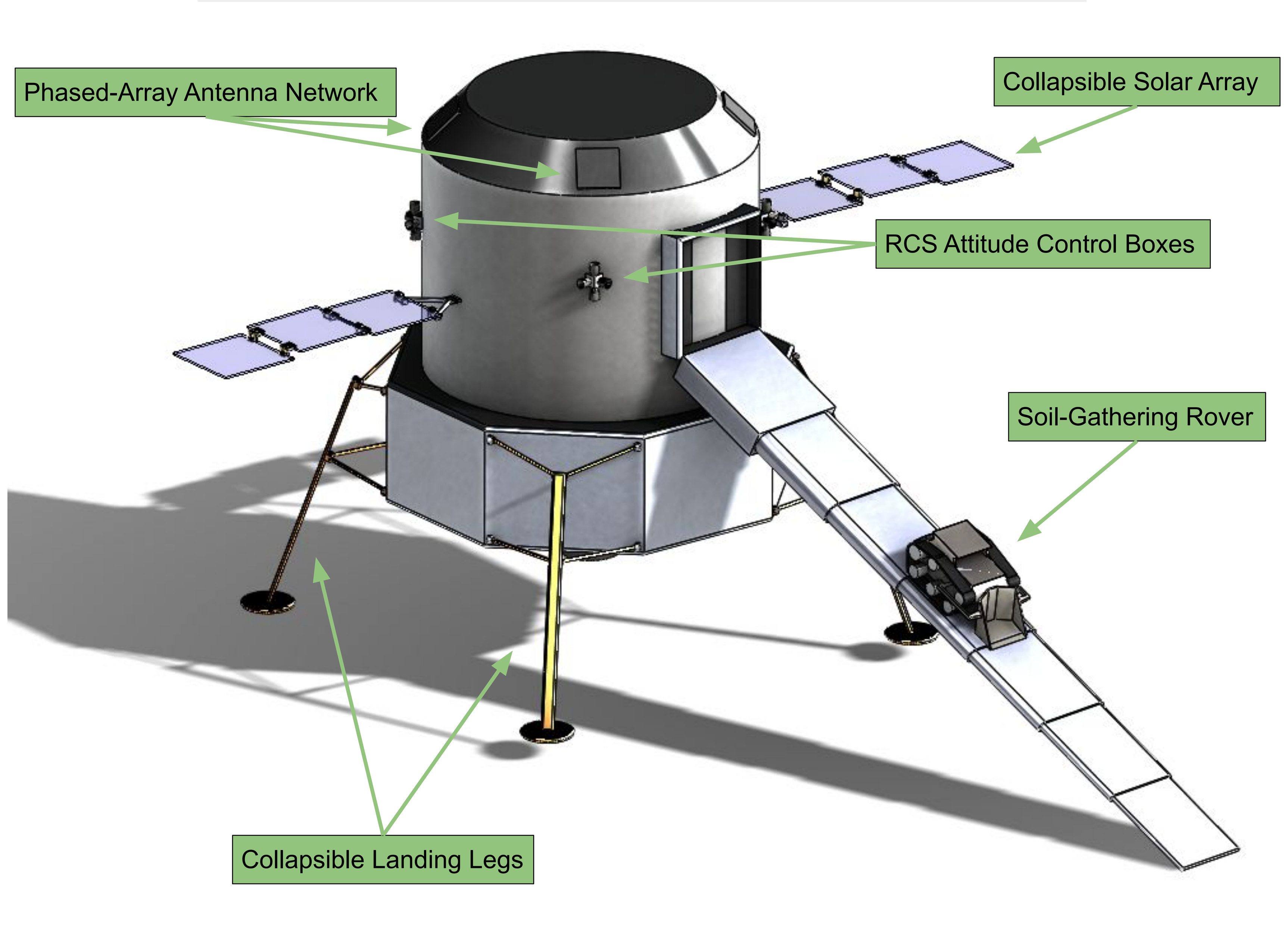
## Trajectory

Shown to the right is the overall trajectory timeline for the LATV lunar transfer

The Launch Window section will detail the best possible launch date for the LATV mission, using this trajectory design




## LUNAR AGRICULTURAL TEST VEHICLE

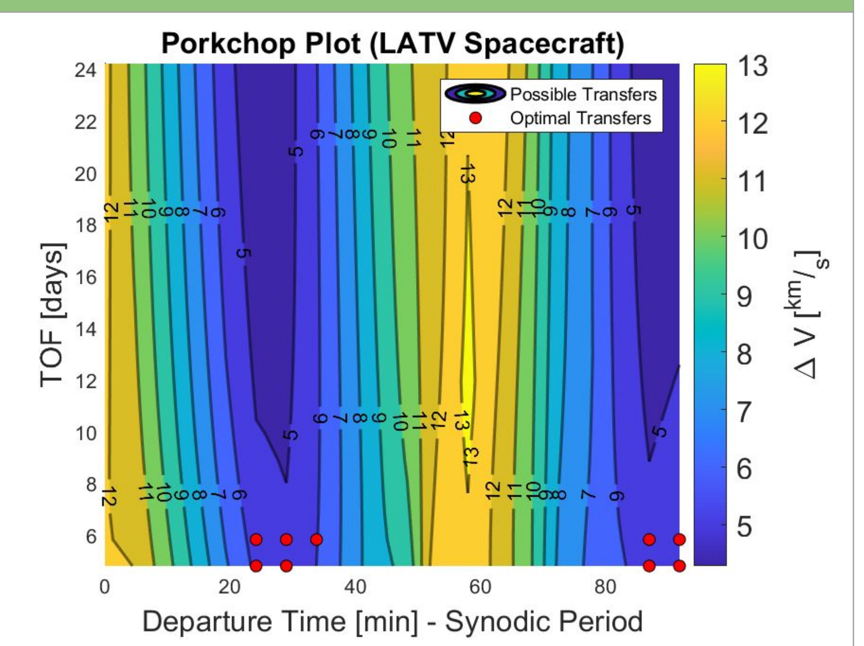



## Launch Window

The LATV spacecraft is carrying biological material, so minimizing time in flight of the transfer as well as change in velocity (i.e., fuel requirements) is essential. We can use Lambert's problem to determine essential characteristics of possible transfer based on a desired time of flight.

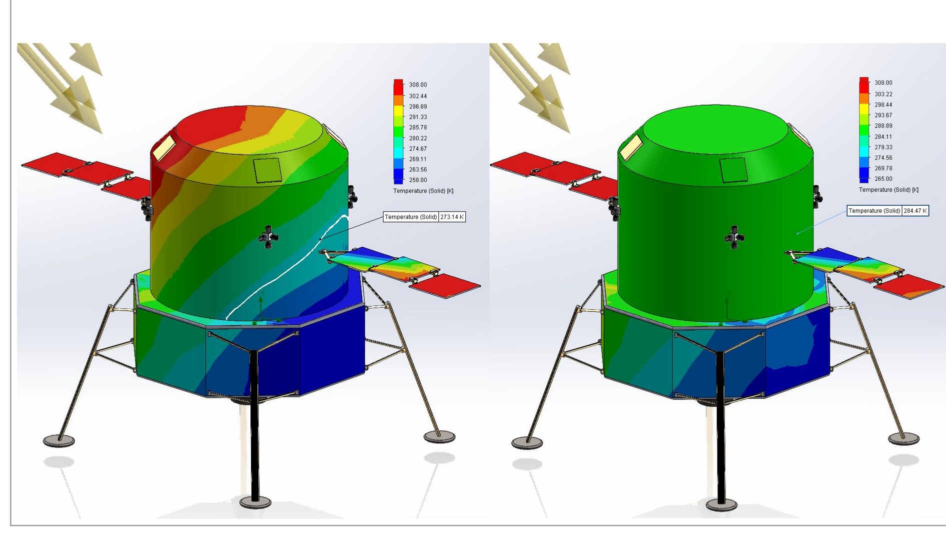
Blue regions in the contour plot on the right show the optimal departure windows for the LATV spacecraft from its initial parking orbit. The red points mark the best possible transfers.

Optimal transfers have a $\Delta V$ of less than 6 km/s, a fuel requirement of around 35000 kg, and a time of flight faster than 6 days



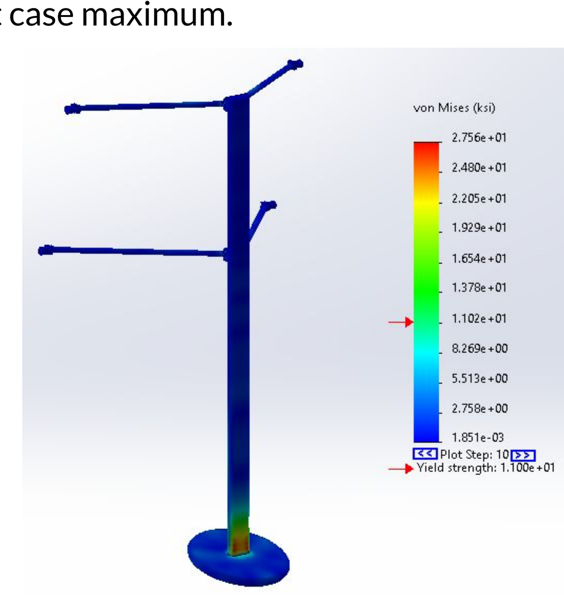

## Thermal Analysis

SOLIDWORKS Flow Simulation with Solar Radiation: Per the following figures, passive thermal solution in the form of heat pipes and reflective paint will be sufficient to keep habitat at 53° F and other components within operating range.



## Stress Analysis

A Solidworks FEA analysis with various drop velocities under lunar gravity shows a maximum touchdown speed of 2.7 m/s. An angled landing leg and a perfectly stiff ground were assumed to give a worst case maximum.



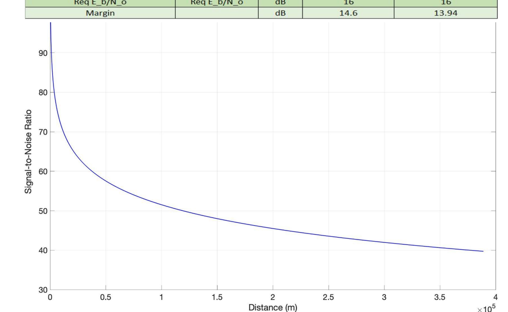
## Communications

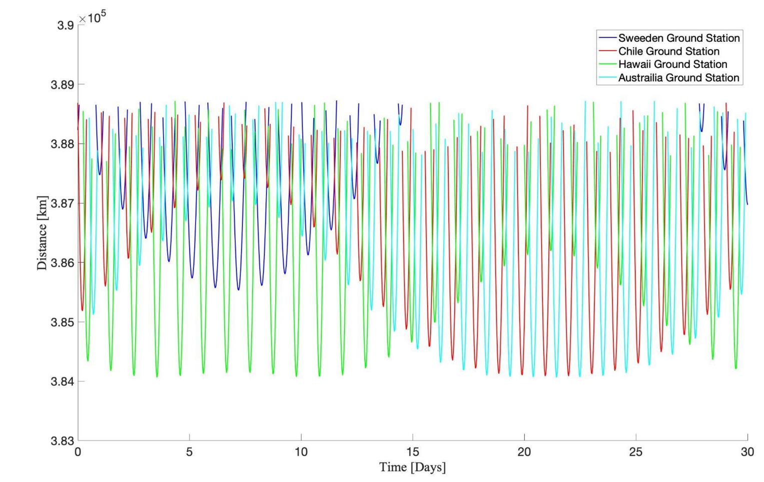
Mission requires constant communication link between LATV Lander and ground stations (Hawaii, Chile, Australia, Sweden). Ground stations provided in collaboration with Swedish Space Corporation. X-Band Phased Array Antennas paired with a Transmitter provided by EnduroSAT deliver videos, photos, and habitat condition to ground stations.

A link budget analysis was completed to size the components and data package, and concluded a phased-array antenna size of 3mx3m, and a receiver power draw of ~10W. MATLAB simulation was conducted to determine link availability for each ground station as well as provide signal-to-noise vs time and distance plots.

Link Budget Analysis

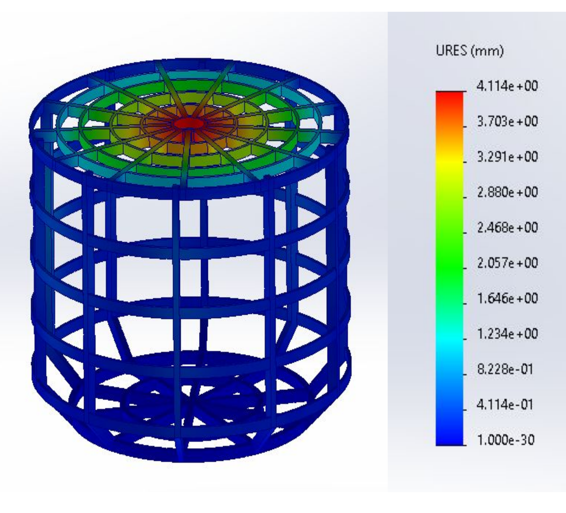
SNR vs Distance





Link Availability Plot

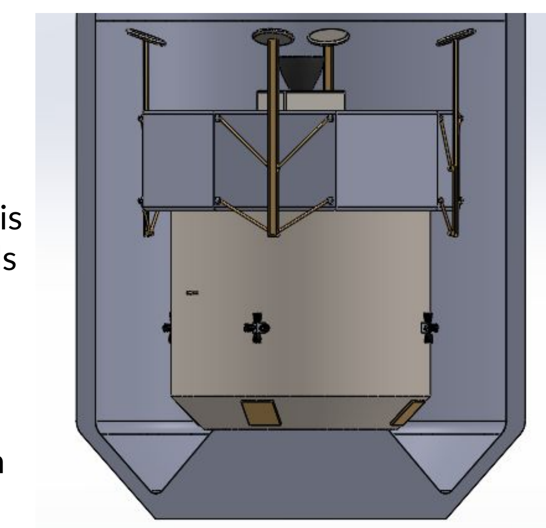
## Launch



Stress analysis of habitat structure

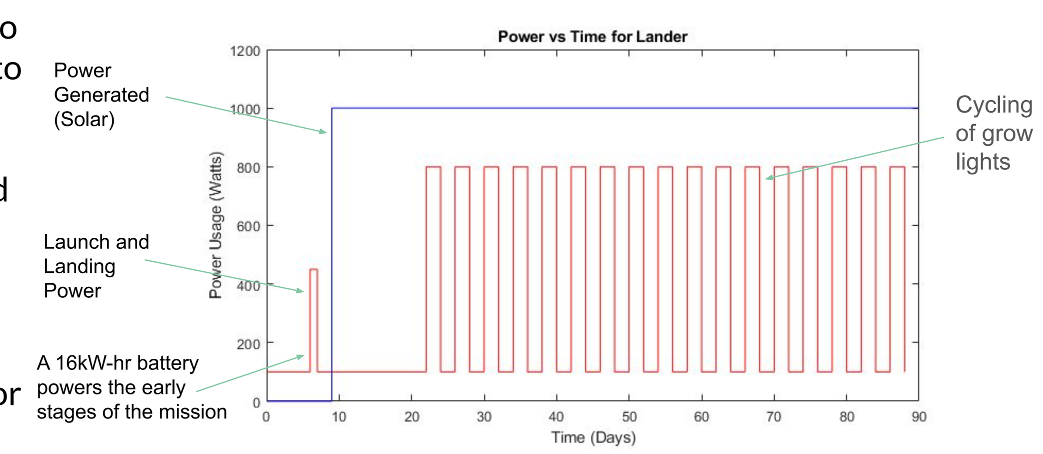
The lander is oriented in the payload fairing as shown on the right

Structural analysis of expected G-loads finds a minimum factor of safety of 1.18, indicating sufficient material strength for launch



## Power

The spacecraft must be able to generate power both en route to the Moon and while landed. A combined use of rechargeable batteries for in-orbit power and solar panels for landed power will keep the spacecraft's instruments on and communicating. A 6 square meter solar array is sufficient for the lander's power needs.




## End-of-Life

Plans for LATV Habitat End-of-Life involve utilizing the Habitat's Earth-Moon communications array as a publicly available communications/data transfer hub for future Lunar missions

Using the linked-ground-station communications system detailed above, the LATV lander enables users to communicate with Earth independent of impacted, overused systems like NASA's Deep Space Network (DSN)

| Total Mass | Max Power Draw | Mission Cost ($Million) |
|---|---|---|
| 15000 kg | 800W | 400-600 |
| **Lander Structure:** 4000kg<br>**Rover:**<br>200kg<br>**Propellant:**<br>8000kg<br>**Science Payload:**<br>2800kg | **Communications:**<br>~60W<br>**Plant Sensors:**<br><50W<br>**Plant Lighting:**<br>700W | **Launch Vehicle:**<br>100<br>**Rover:**<br>~40-60<br>**Lander:**<br>250<br>**Ground Station:**<br><0.300 |

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