San Diego State University

Lunar Survey Mission (LSM)

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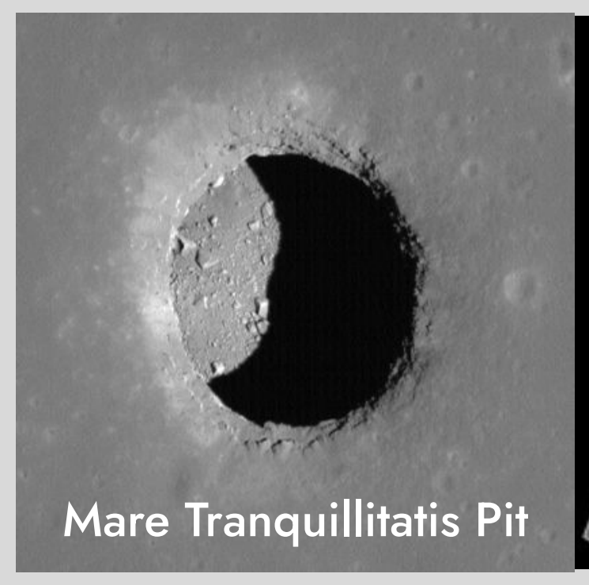
Mission Purpose Statement

The purpose of this mission is to deliver a rover to the surface of the Moon that is capable of measuring environmental values that could have an effect on long term structures or human deployment.

Mission Context

Apropos of Artemis, NASA has expressed its desire to "establish a sustainable presence on the Moon to prepare for human missions to Mars". A stable, safe, and sustainable base of operations on the Moon would greatly forward efforts in preparing the materials, methods, and systems to be used in such future endeavors. NASA concepts projects have proposed the idea of exploring Lunar caves before, and the Lunar Reconnaissance Orbiter has documented several strong candidates for such a purpose. As of this point in time, no missions have been proposed to survey one of these Lunar caves for the purposes of a lunar base.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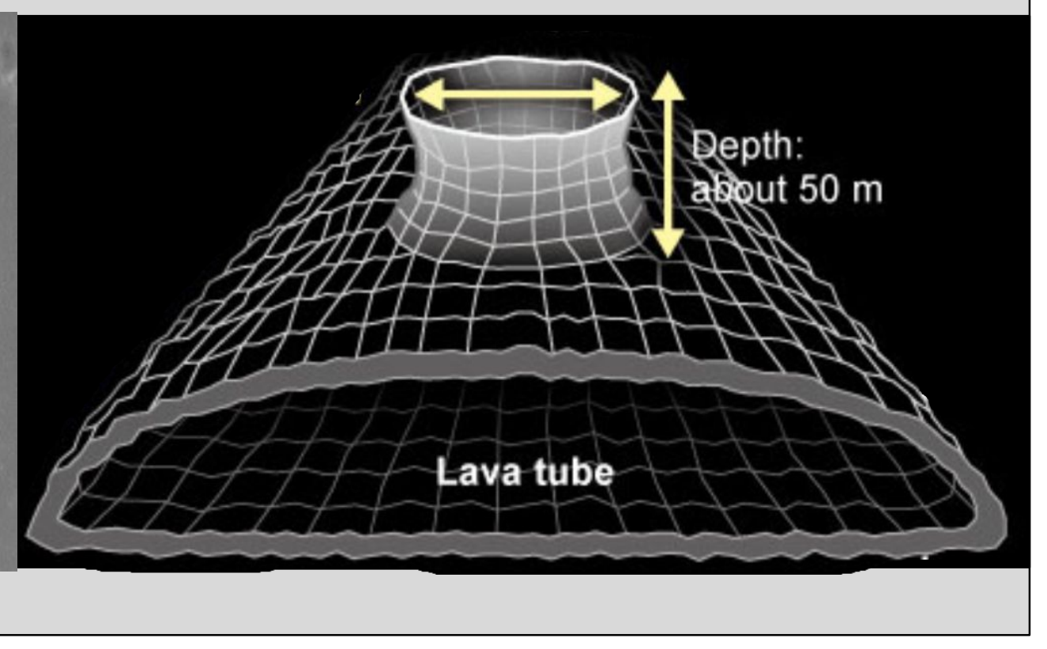
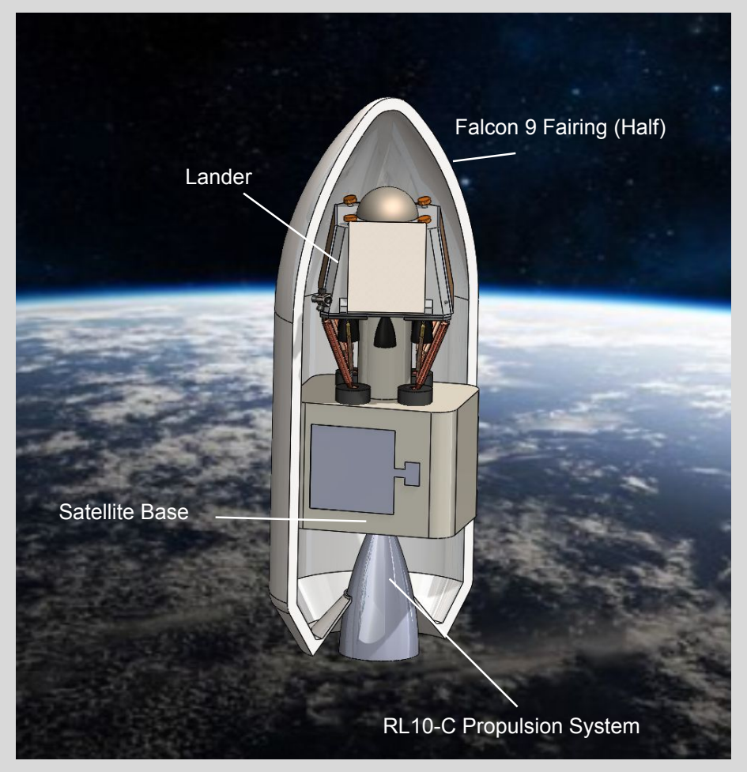


Mission Objective

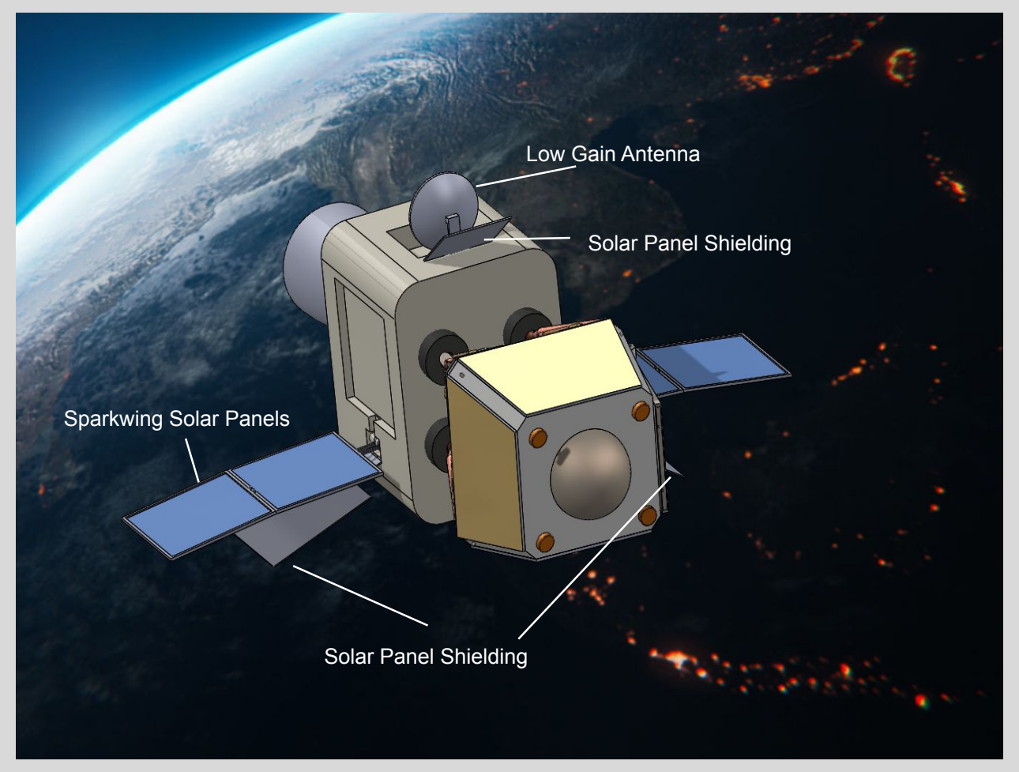
Primary: To deliver a rover to the surface of the Moon equipped with a suite of scientific instruments capable of taking measurements of the luminous intensity, radiation, temperature, seismic activity, and the profile of the terrain above and below the lunar surface simultaneously.

Secondary: To record data on the ambient conditions of the Lunar surface during the traversal from the lander to the subterranean feature of interest to increase the general knowledge of lunar climate.

Satellite Configurations



Our launch vehicle, Falcon 9, separates from our payload, satellite and lander, at GTO orbit before transfer orbit.

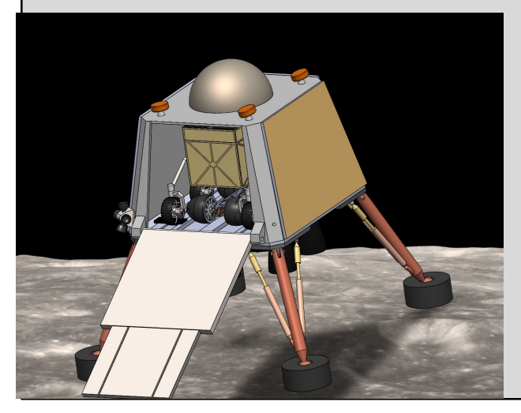


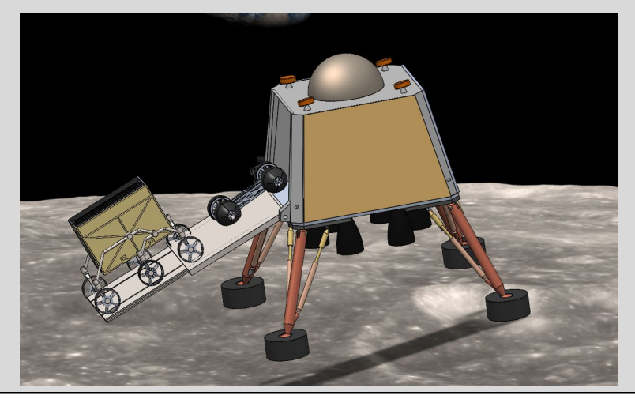
During the transfer, one RL10-C provides enough thrust and has excellent performance for a highly fuel efficient ride to the Moon. The satellite base provides power, communication, and propulsion to deliver the lander and rovers to the Lunar surface.

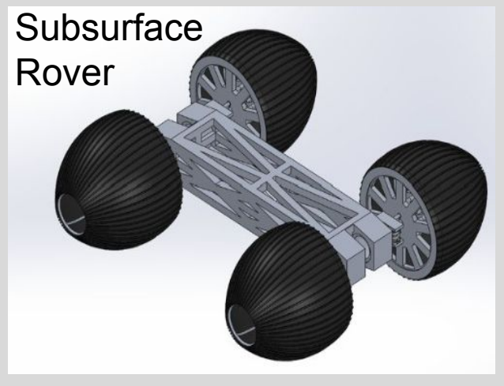
Surface and Subsurface Rover

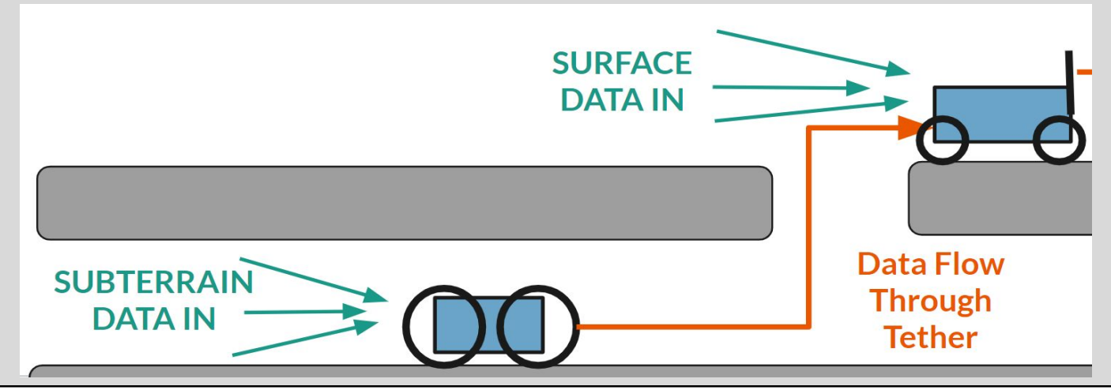
The primary focus of the subsurface rover is to enter down within the lava tube and traverse the subsurface while collecting various environmental data which includes, radiation levels, temperature, humidity, 3D maps of the terrain, and luminosity. This data will then be transmitted to the surface rover through a tether system that will also serve as the rovers main power supply. To ensure the rover's functionality, a flip-car design has been implemented so that the rover can remain operate as intended if it were to flip over.

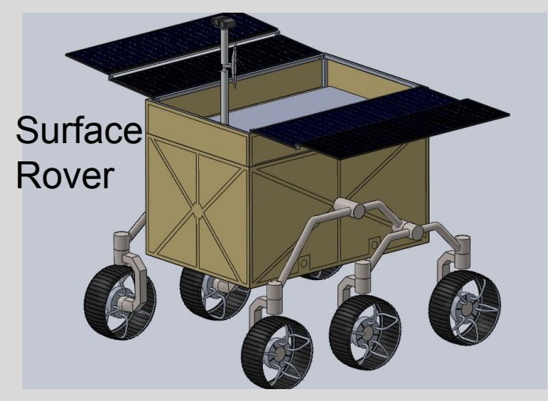
The larger surface rover will serve as the main power source and data storage for the subsurface rover after having been deployed, via tether. Similar to the subsurface rover, the surface rover will be used to collect various data on the surrounding environment above the surface. These values will be used to compare between the two distinct environments in an effort to gauge the feasibility of habitats.











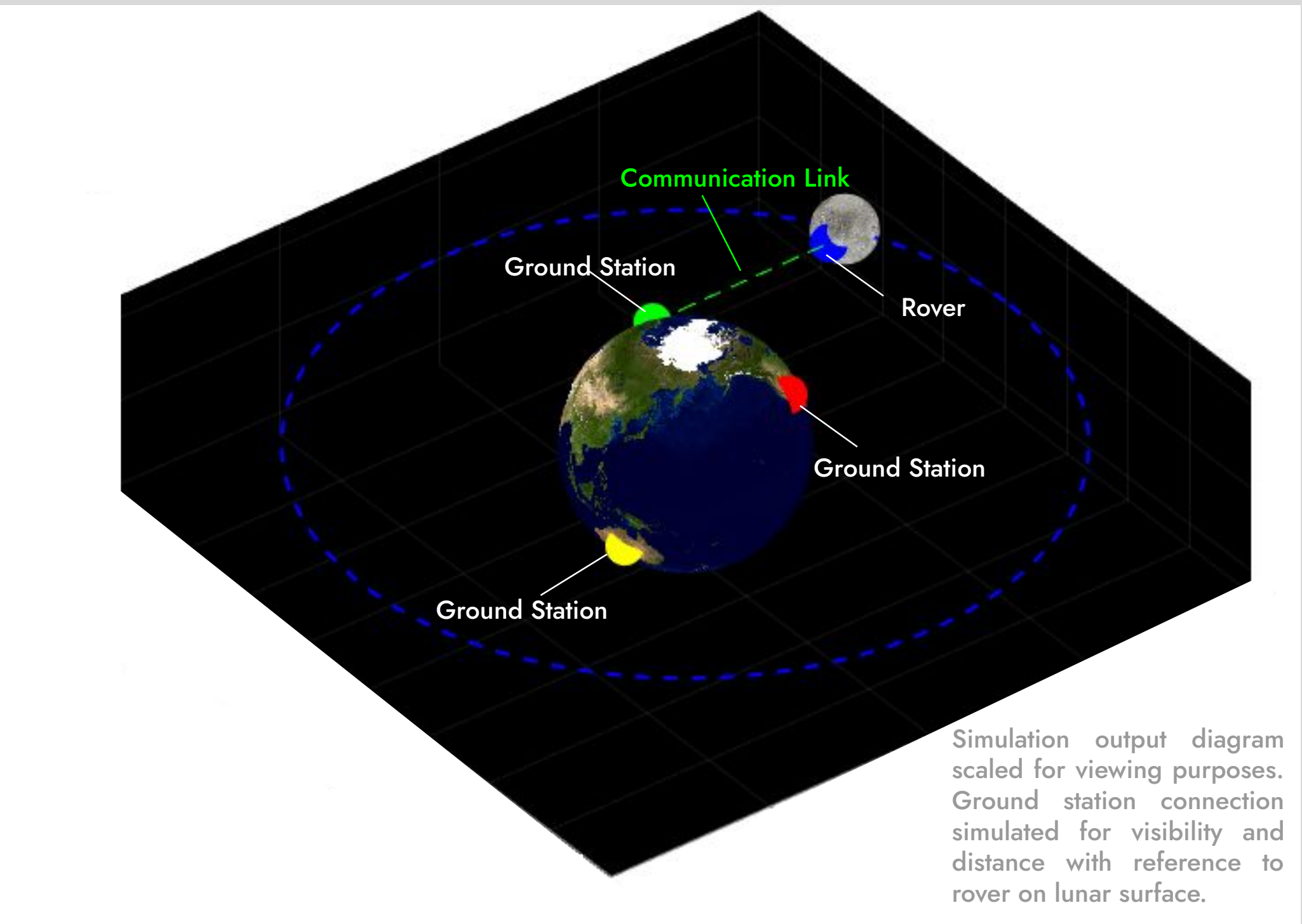
Communication Systems

Requirement: Robust and reliable communication between ground stations on Earth and the rover on the surface of the Moon.

Methodology: A link budget analysis was performed to determine the strength of the communication link and whether or not a ground station has direct line of sight with the rover.

Solution: Our mission will utilize NASA's Deep Space Network facilities located in Goldstone, Madrid, and Canberra. A minimum transmitter power of 20W and a 45 cm antenna on the lander is needed to transmit 60 Mbps of data through an X-band frequency of 10 GHz.

Link Availability between Ground Station and Rover



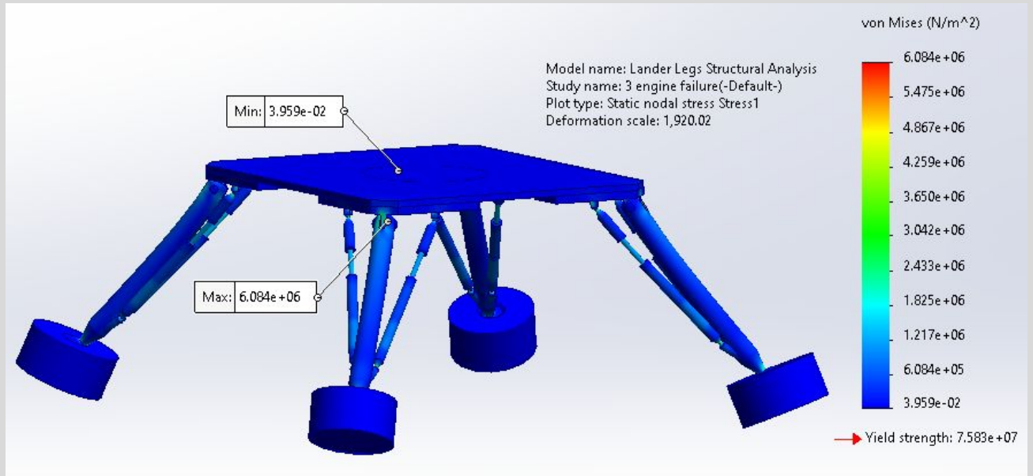
Simulation output diagram scaled for viewing purposes. Ground station connection simulated for visibility and distance with reference to rover on lunar surface.

Lander Legs Structural Analysis

Requirement: The lander is essential for the lunar surveying mission, tasked with safely carrying the rover and scientific instruments to land accurately within the designated site.

Solution: The lander was modified in terms of size, mass, and new leg design using space-grade 2024 Aluminum alloy to ensure it can withstand impact forces and maintain structural integrity.

Methodology: SolidWorks simulation was used to conduct a structural analysis on the legs, confirming their ability to withstand the impact force during touchdown. Detailed results and some important parameters are provided below.


Solidworks Simulation FEA

Failure Mode(s): # of Engine failure	Total Impact force (N)	Iteration: Impact velocity (m/s)	Max Von Mises stress, σ_v (MPa)	Min. Factor of Safety (F.S.)	G - force acceleration (m/s^2)
0	0 N	1	~	~	0
1	1298.3 N	2	1.04 MPa	73	1.667
2	3947.5 N	3	3.161 MPa	24	2.5
3	7596.7 N	4	6.08 MPa	12	3.33

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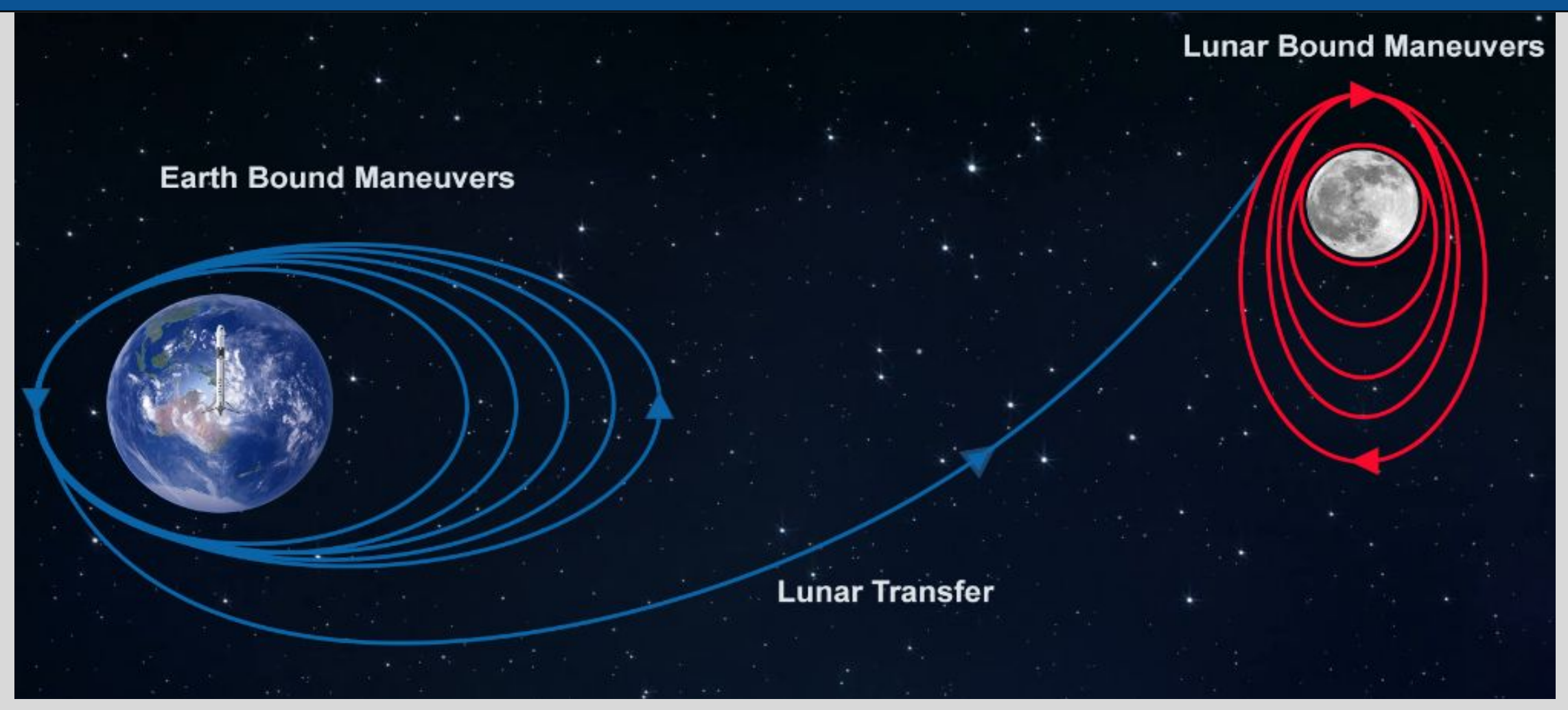
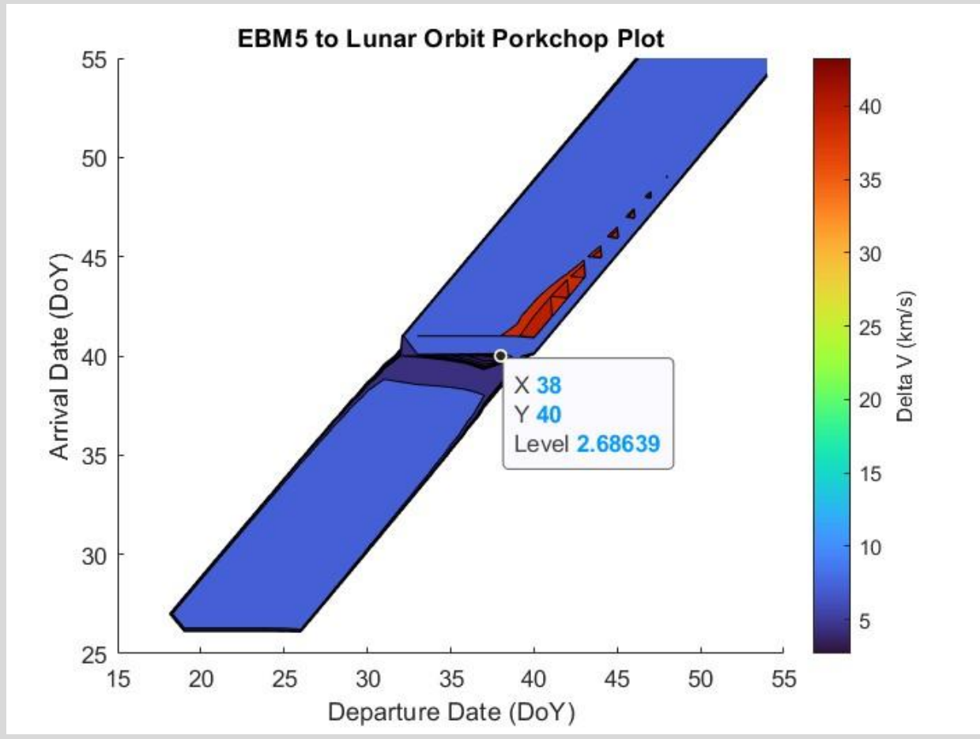
Trajectory Analysis



Requirement: Plan an efficient path and provides correction for orbital perturbations.

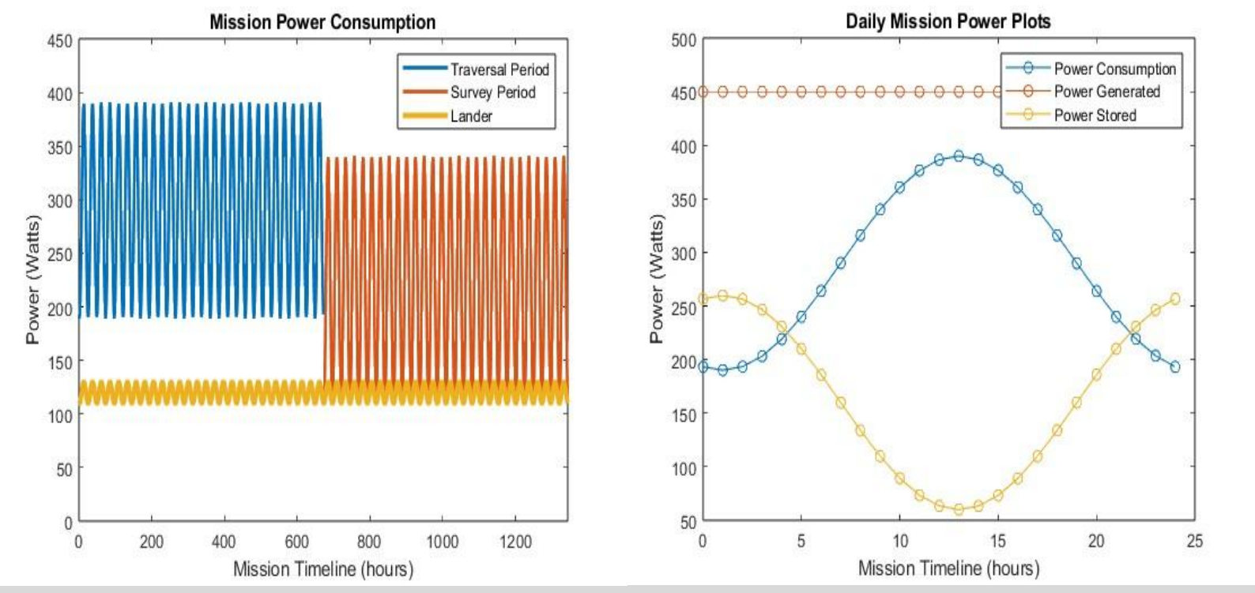
Solution: 5 orbital maneuvers and a Hohmann transfer provide the most efficient result. The ideal transfer is 2 days for a total delta V of 2.7 km/s. Small correction burns and plane change burns are utilized as course corrections for orbit perturbations.



Power Analysis

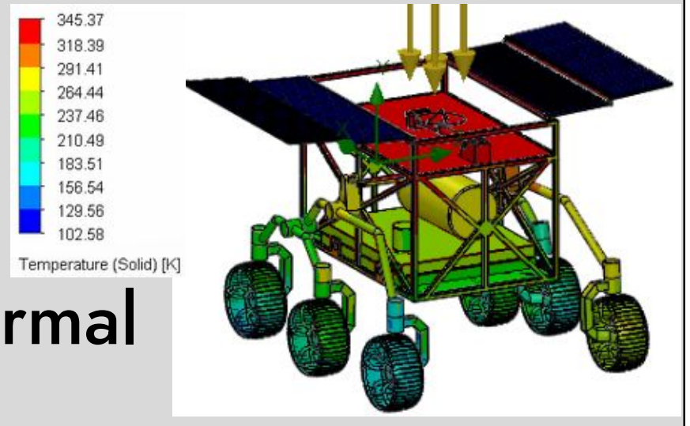
Requirements: The Rover will traverse across the Lunar surface enough for two day and night cycles.

Methodology: Simulated Rover Power Consumption 400W, Generation 450W



Solution: In order to supply the Rover with power during the day it will use 2.23m^2 Silicone Solar Cells, which will be charging the 192kg Lithium Sulfur Dioxide Batteries with surplus. Thus, the Rover will be able to continue the Mission during the night cycle.

Thermal Systems

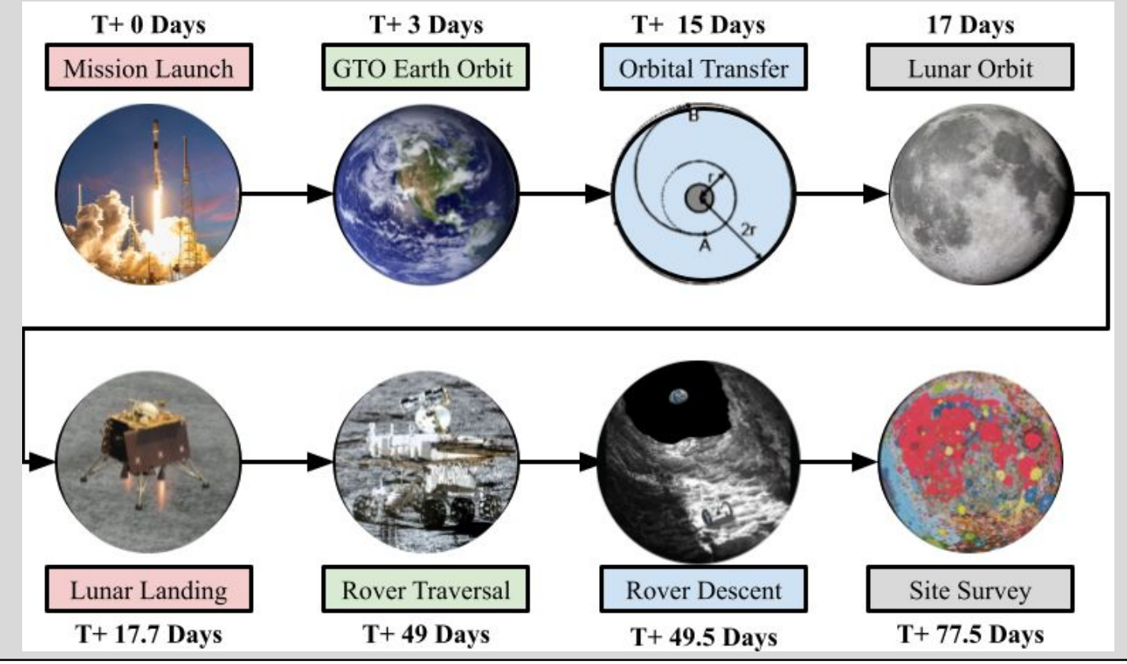


Requirements: Maintain rover systems within operational and survivable temperature ranges during Lunar Night and Day Cycles on surface and subsurface. **Methodology:** SolidWorks Thermal simulation. **Solution:** Heat pipes, radiators, and heaters will be used for thermal control during all mission phases.

Major Values

Total Mission Mass: 3179 kg
Total Rover Cost: $71.4 Million
Rover Traversal Dist. 7km
Power Usage: 390W-450W
Lander Size: 2.75x1.31x3.4m
Total Mission Time: 77.5 Days

Mission Timeline



Spring 2024