

## Context

As humans look to return to the moon and establish a long-term presence, the ability to harness lunar ice is essential for sustaining permanent settlement.

### Benefits of Extracting Lunar Ice:

1. Drinking Water
2. Breathable Air
3. Rocket Fuel

## Mission Objectives

1. Find the locations of ice deposits on the Moon's north and south poles.
2. Map the composition and subsurface structure of each deposit.
3. Quantify the total mass of H<sub>2</sub>O available for future missions

## Orbital Parameters / Mission Timeline

### Orbit Parameters:

- Lunar orbit set at 100 km above lunar surface.
- Polar orbit set at a 90° inclination.
- 117.89-minute lunar period.
- Eclipse: 64 minutes

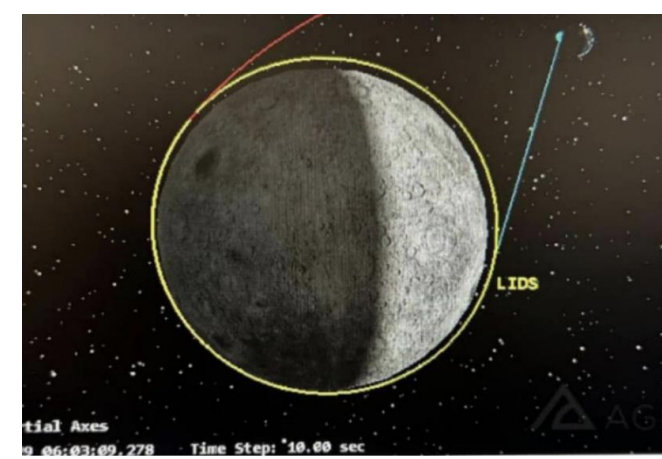


Fig 1. Lunar Orbit Simulation



Fig 2. Mission Timeframe Simulation

### Mission Timeline:

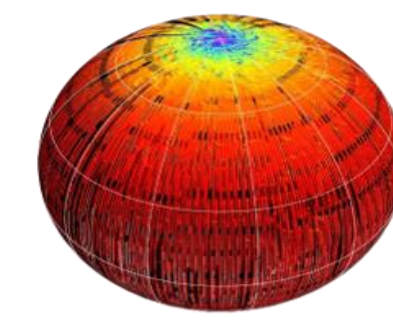
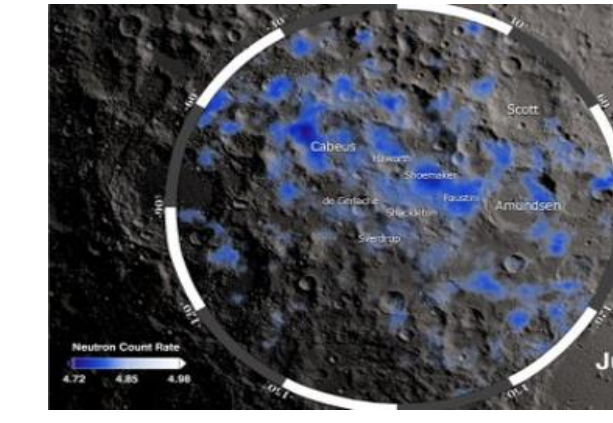
DSS\_13\_Goldstone\_STDN\_VEND-To-LIDS

Access	Start Time (UTC)	Stop Time (UTC)	Duration (sec)
1	1 Jan 2029 05:05:53.597	1 Jan 2029 17:12:59.428	43625.831
2	2 Jan 2029 05:05:30.136	2 Jan 2029 17:38:45.986	45195.850
3	3 Jan 2029 05:27:51.639	3 Jan 2029 17:45:35.455	44263.815
4	4 Jan 2029 05:38:52.225	4 Jan 2029 17:47:26.439	43714.214
5	5 Jan 2029 05:42:22.568	5 Jan 2029 08:29:15.910	10013.342

## Scientific Payload

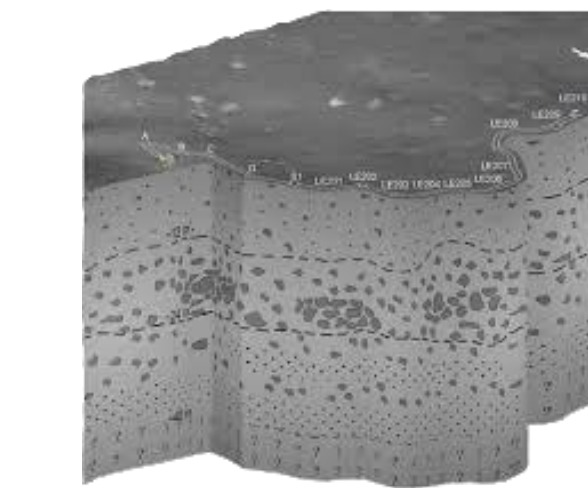
### Lunar Exploration Neutron Detector (LEND):

- Measures the thermal/epithermal neutron emissions and neutron background.
- Cosmic rays strike the surface, exciting neutrons. Interactions with hydrogen atoms lowers epithermal counts.
- Detects the existence of hydrogen within the ice.



### Lunar Thermal Mapper (LTM)

- Measures thermal radiance & IR wavelengths emitted from Moon's surface
- Maps temperature, composition, and physical properties of water on the lunar surface.



### DF – SAR Radar Sounder

- Measures radio waves reflected off of subsurface structures.
- Reflections are converted into a subsurface map of ice structure.
- Utilizes differences in Circular Polarization Ratio (CPR) between rock and ice

## Electrical Power System

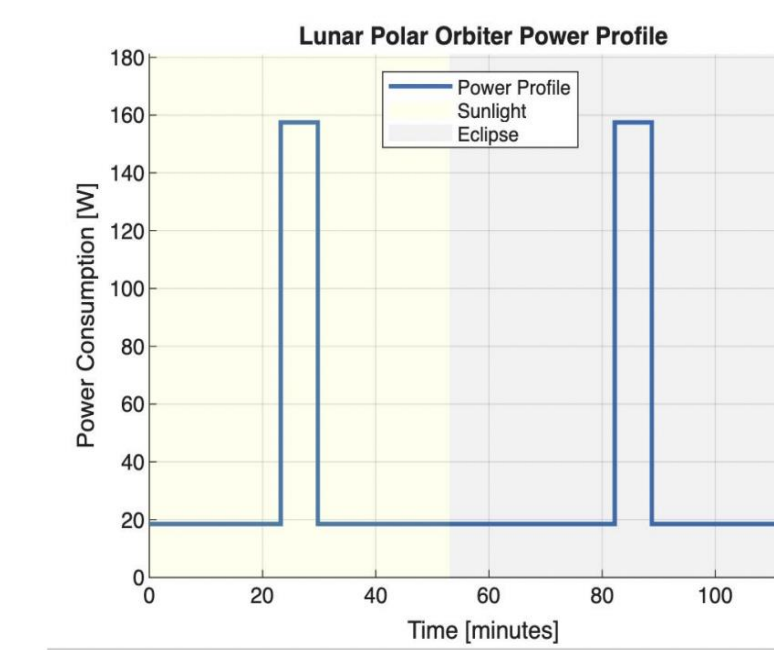
### EPS subsystem:

- The LIDS mission will use NanoAvionics Electrical Power System 2.0
- The system allows for 28 V DC of regulated voltage throughout the bus.
- Maximum output of 600W
  - For the LIDS mission, the peak power consumption with associated margin (1.5) to be 351 W.

Subsystem Power Consumption (Peak)
LEND – 13 W
LTM – 13 W
Radar Sounder - 100W
*RF Ion Thrusters – 80 W
Star Tracker – 5 W
IMU – 10 W
Reaction Wheels – 12 W
OBC – 1 W
<b>TOTAL: 234 W</b>

### Solar Array:

- Design assumptions:
  - 0.1° pointing error
  - 0.02 degradation factor
  - 0.20 geometric efficiency
- Uses Z4J solar cells designed by Rocket Lab
- Solar array area is 4.26 m<sup>2</sup>



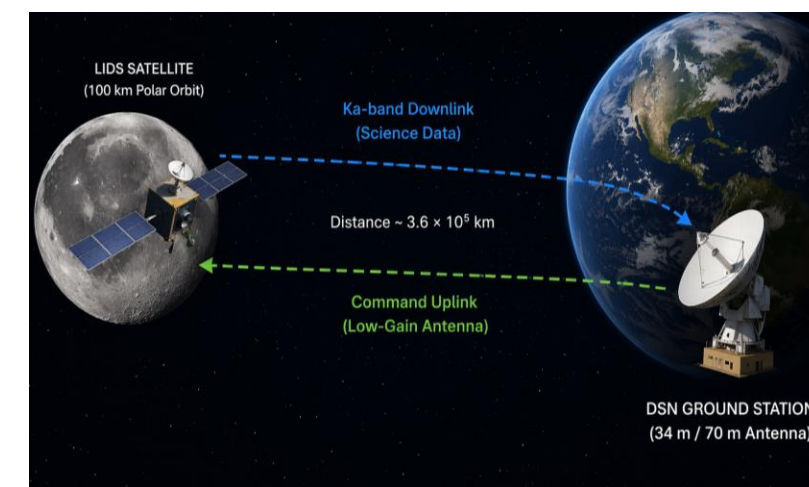
### Power Profile:

The Lunar Polar Orbiter power profile figure, as shown to the right, describes the overall power profile of the LIDS satellite for one complete lunar orbit. The peaks shown in the figure relate to the selected 80° latitude polar regions, by which lunar ice detection and analysis will be done.

## Communications / GCS

### System Overview:

- Ka-band high-rate downlink to Deep Space Network (DSN)
- Low-gain antenna for command uplink
- Supports ~100 GB/day science data return



### Performance:

- Downlink rate: ~111 Mbps
- Link margin: ~5.5 dB
- Frequency: Ka-band (~30 GHz)
- Antenna: 1.5 m high-gain reflector

### Downlink:

Payload → OBC → Comms → Ka Antenna → DSN

### Uplink:

DSN → Low-Gain Antenna → OBC

### Ground Control System (GCS):

- Uses NASA DSN antennas (34 m / 70 m)
- Receives science data and sends commands
- ~2-4 hours/day contact time

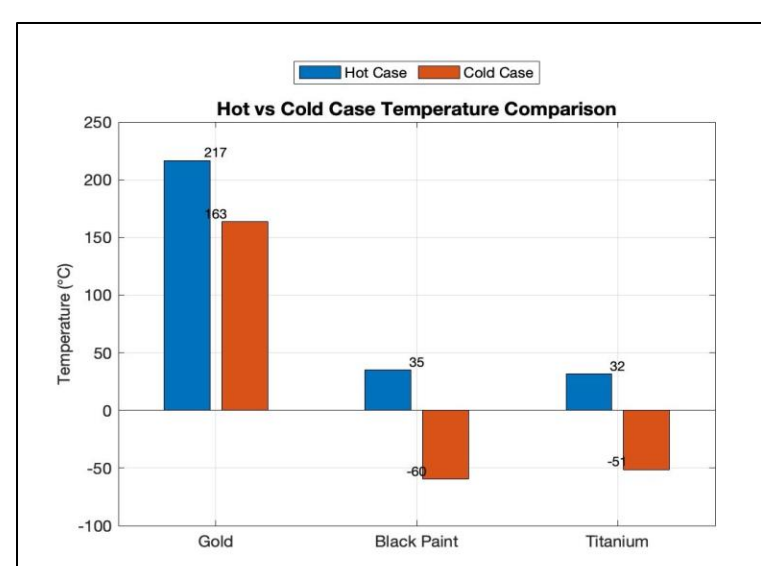
## Thermal

### Thermal Environment & Design Drivers

- 100 km Lunar Polar Orbit, ~ 55% eclipse
- Internal Heat: ~234 W (Peak Dissipation)
- Extreme heat and cold variations

### Hot and Cold Case Thermal Analysis

- Steady state energy balance model (right)
- Worst Case Hot: sunlit + max internal power
- Worst Case Cold: Eclipse (~65 mins)



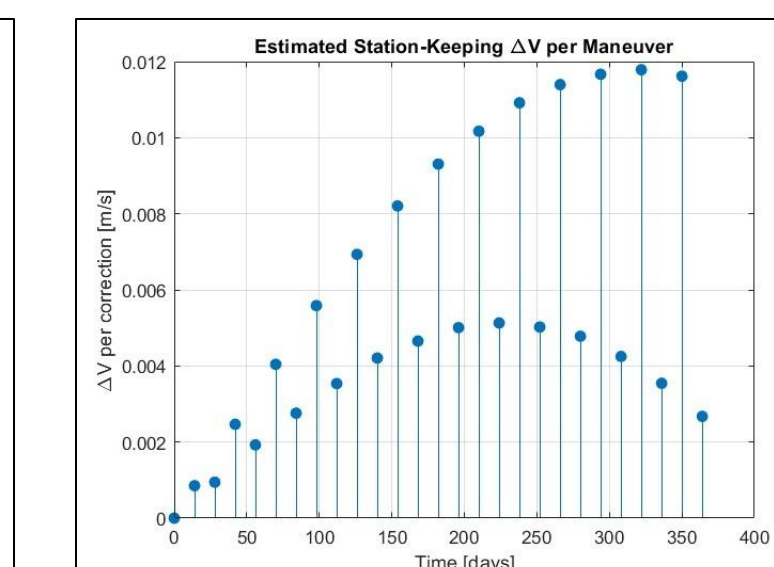
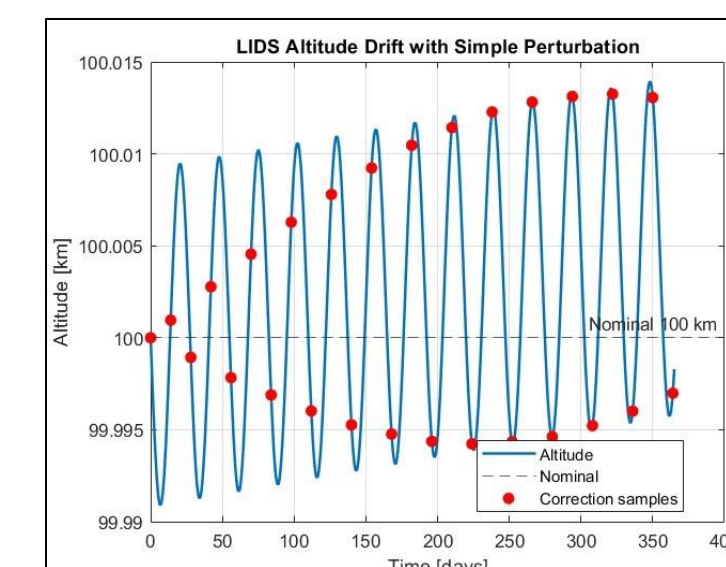
### Interfaces and Risks

- Interface with: Structural Subsystem, Electrical Power System (EPS), Avionics and Payload, and(ADCS)
- Risks:
  - Battery temperature excursions
  - Overheating during hot-case conditions
  - Hot spots, optical uncertainty, reduced heat rejection
- Risks mitigated by:
  - Our thermal control strategy, conservative margins, robust thermal design, and safe-mode altitudes

## Propulsion

### Requirements and Role:

- Maintain 100 km lunar polar orbit
- Correct orbital drift
- Orbit insertion & maneuvering
- Corrections every ~14 days



### Electric Propulsion Selection:

- Low ΔV requirement
  - High Precision & efficiency are prioritized
- 2 BIT-3 RF Ion Thrusters (iodine fuel)

Specifications	
Thrust	~1.1 mN
Isp	~2150 s
Power	56-80 W

### Propulsion System Design and Integration

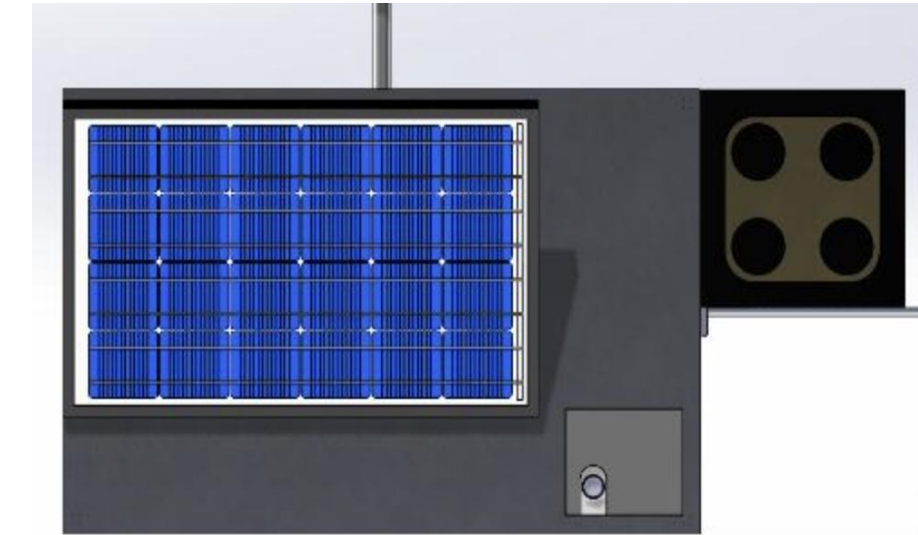
- Thrusters mounted on anti-velocity (-V) face to align thrust & avoid payload contamination
- Mounted on ±10° gimbals to enable precise thrust in all directions
- Interfaces with ADCS for fine control and momentum management
- Interfaces with EPS (~56-80 W)
- Minimal propellant use (~0.01 kg/year)



## Structure

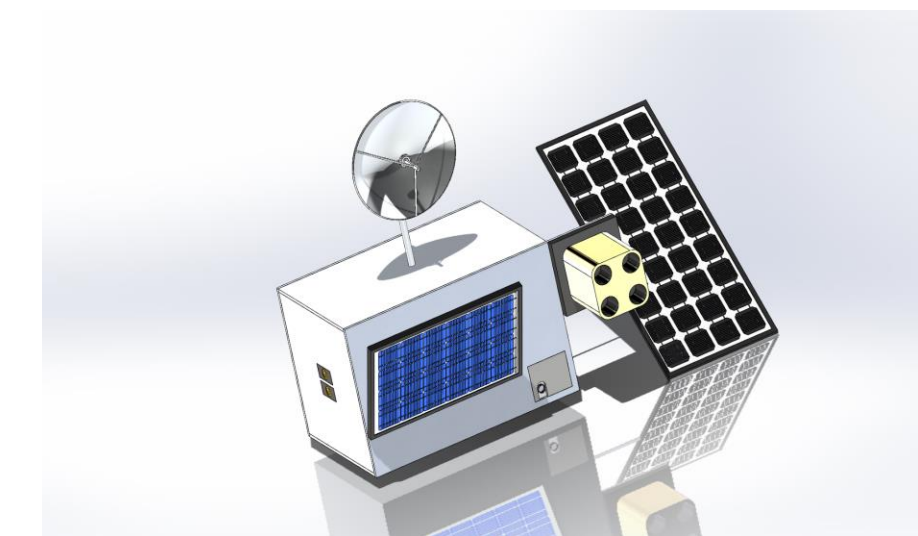
### Bus Design

- 25 x 25 x 25mm aluminum square tube frame
- Face sheets of 20mm of 5052 aluminum honeycomb core
- 0.5mm face sheets of 7075-T73 aluminum over the honeycomb.
- Secured to the square frame and each other using bolts and corner brackets
- Kapton MLI blankets for thermal protection and control



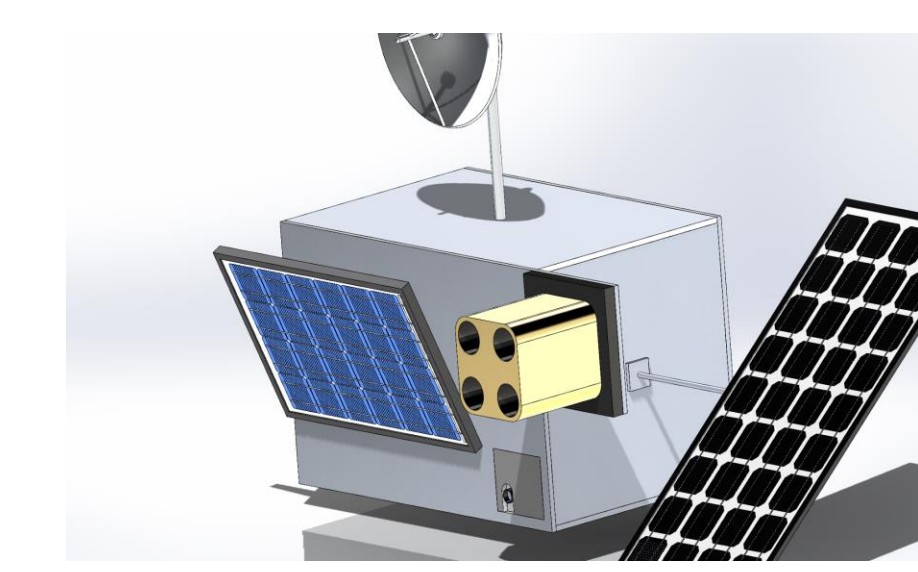
### Payload Design

- Payloads will all be mounted to the nadir-facing side of the satellite
- Lunar Thermal Mapper will be mounted inside of the satellite flush with the nadir face (bottom right)
- Lunar Exploration Neutron Detector will be attached from a boom to avoid other payload obstruction (top right)
- Dual Frequency Synthetic Aperture Radar will be secured on one end with an incidence angle of 25 degrees for an oblique looking geometry (blue panel)



### Secondary Body Design

- Solar Panel will be attached on the right side of the satellite from a boom far enough to not get in the way of the LEND when it rotates
- Two BIT-3 Ion Thrusters sit inside the satellite flush with the left face, 20cm apart and in the center
- Dish placed on top of the satellite for RF communication



## ADCS

### Attitude Determination

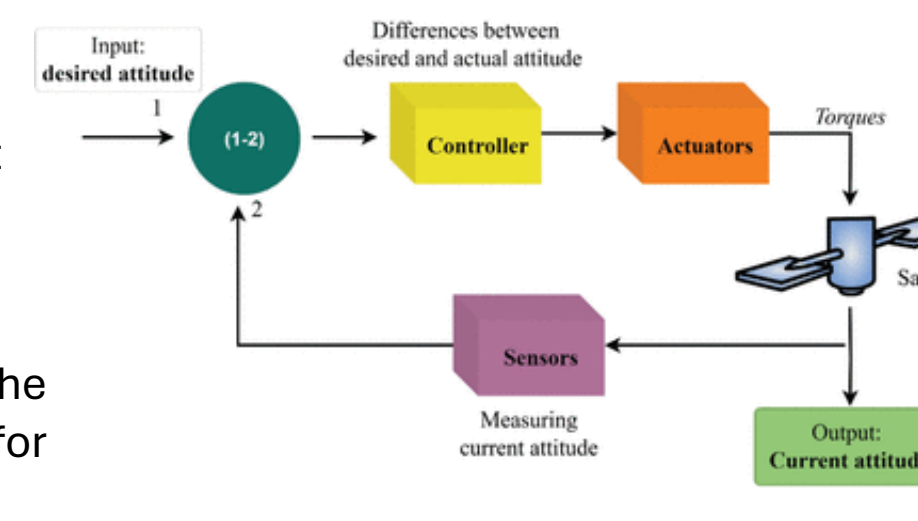
- Star Trackers
  - Primary attitude sensor
  - Orientation determined by tracking star patterns
- Inertial Measurement Unit
  - Gyroscopes and accelerometers tracking motion in sensor gaps
  - Continuous and highly accurate attitude information

### Attitude Control

- Reaction Wheels
  - Precise pointing without propellant - Angular Momentum
  - 4 wheels, each with 3-axis control
  - Ion Thruster
  - Assist trajectory adjustments and momentum dumps
  - Propellant is ionized, and electric fields accelerate ions out to produce thrust

### Performance and Requirements

- Continuous nadir pointing while perpendicular to the lunar surface
- Minimize small errors that may affect the high accuracy of the equipment
- Reduce jitter to ensure stable imaging
- Handle disturbances in lunar orbit versus Earth's gravitational field
- Small closed-loop ADCS feedback loop
  - A looped system where the error between the desired input and the current attitude goes to the controller, which utilizes actuators for correction



## Budget

Category	Description	Estimated Cost (USD)
<b>Payload Instruments</b>	LTM, LEND, DF-SAR (heritage-based estimates)	\$23,000,000
<b>Spacecraft Bus &amp; Subsystems</b>	Structure, ADCS, EPS, propulsion, thermal, OBDR	\$25,000,000
<b>Communications Subsystem</b>	Ka-band system, 1.5 m reflector, 15 W SSPA, avionics integration	\$3,500,000
<b>Integration &amp; Testing (I&amp;T)</b>	Assembly, environmental testing, verification	\$5,000,000
<b>Launch Vehicle</b>	Falcon 9 rideshare to lunar transfer	\$10,000,000
<b>Ground Segment (DSN + Infrastructure)</b>	DSN antenna time, mission control infrastructure, ground software, data storage, operations support	\$10,300,000
<b>Contingency (~15%)</b>	Programmatic + technical margin	\$9,700,000
<b>TOTAL MISSION COST</b>		<b>\$86,500,000</b>

## Acknowledgements

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