

SELENE

A CubeSat constellation for evolving characterization of Lunar regolith and exosphere, with an experimental radiation forecasting system.

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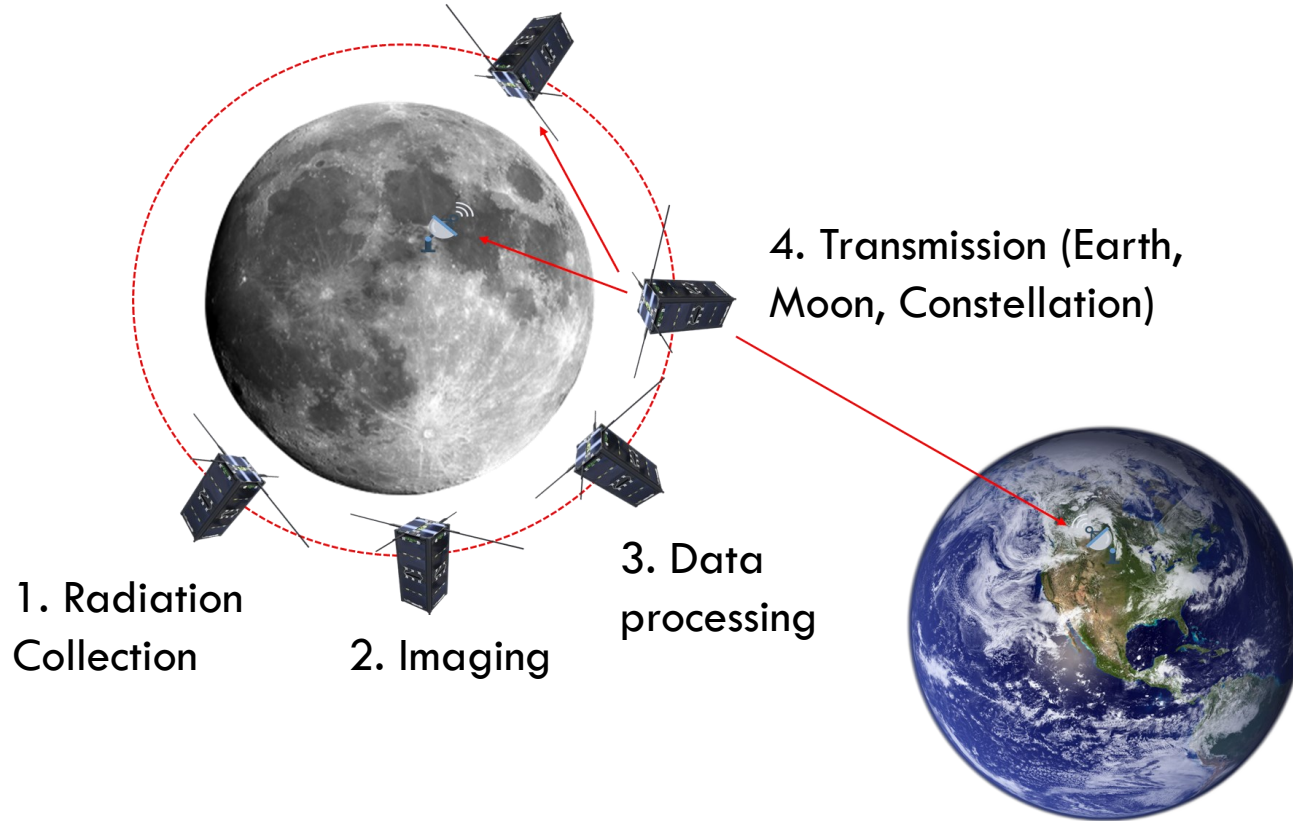
Background and Motivation

- **Sustained lunar presence** - reliable local resource maps
- **De-risk human activity** - lethal solar radiation events
- **Fill current data gap** with frequent, high-resolution measurements
- **Monitoring to prediction** - in-situ forecasting for deep space autonomy
- **Leverage CubeSat economics** - enables high revisit rates

Mission Objectives

1. Map lunar regolith composition
2. Quantify radiation environment inside lunar exosphere
3. Demonstrate constellation-based radiation early-warning capability

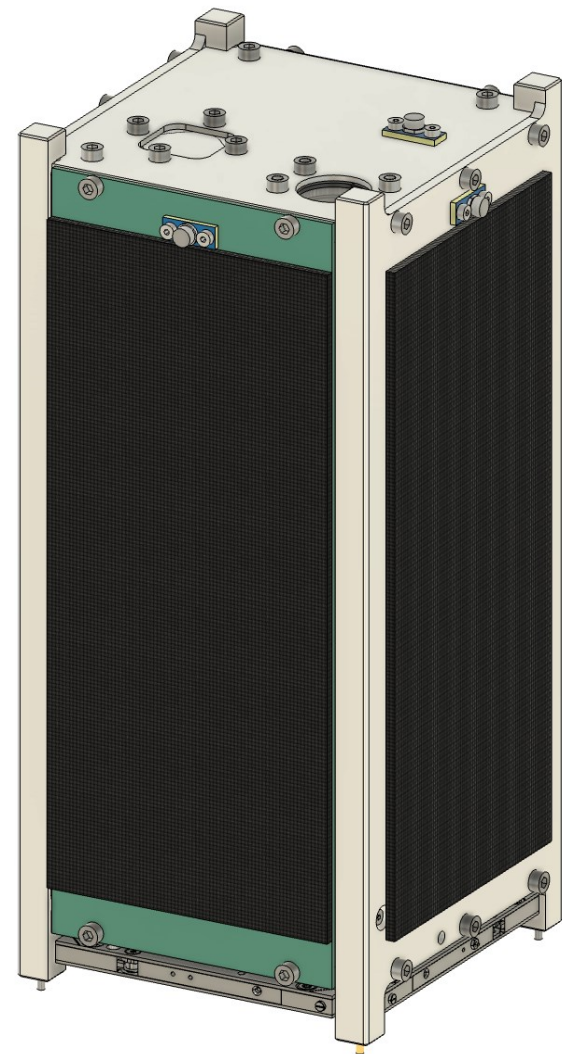
Concept of Operations



Performance Parameters

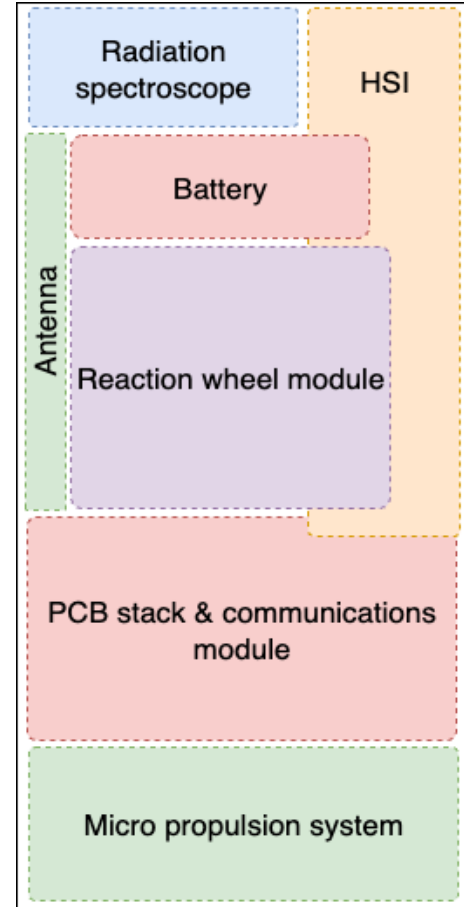
1. **Imaging resolution & coverage:** HSI ≤ 50 m/pixel GSD with ≥ 30 km swath
2. **Spectral fidelity:** HSI has 400–2000 nm and ≤ 10 nm resolution
3. **Downlink capacity:** ≥ 100 Mb/day downlink
4. **Pointing accuracy & stability:** $\leq 0.1^\circ$ absolute pointing and $\leq 0.05^\circ$ /s
5. **Radiation sensing range:** Measure ionising radiation from 0.1–8 MeV

Satellite Design Overview



Satellite Design

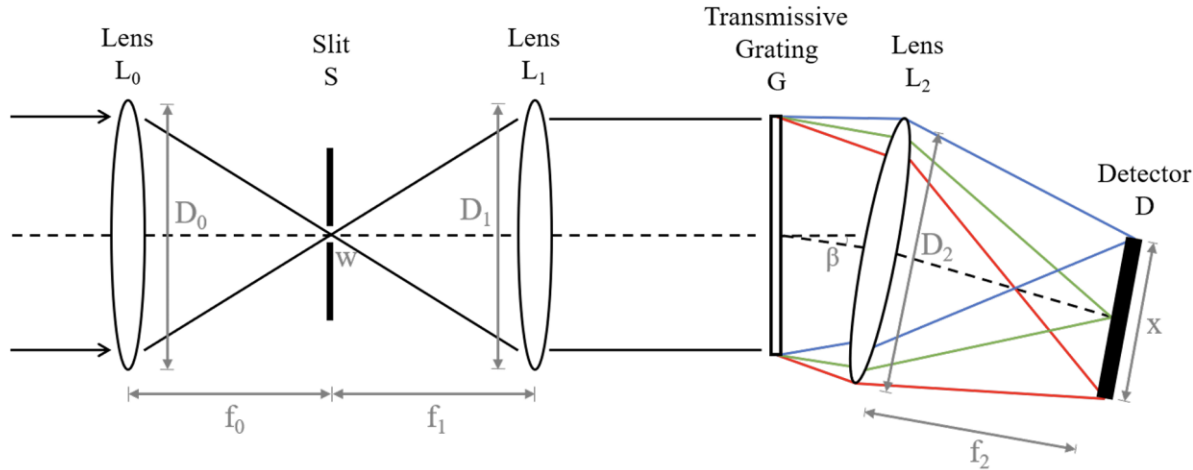
- **2U CubeSat**
 - Equipped with dual payloads
- **Development of 2 models**
 - Flight model with space grade parts: lunar deployment
 - Engineering model: ground-based testing
- **Modular subsystem design**
 - Ease of manufacture and development
- Expected lifespan of **twelve months**



Primary Payload

Design:

- Pushbroom hyperspectral imager – uses spacecraft motion for spatial scanning

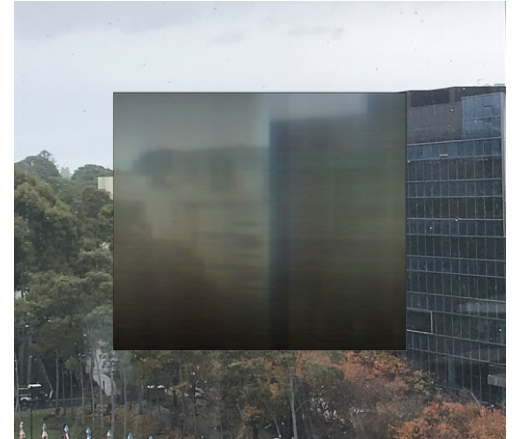
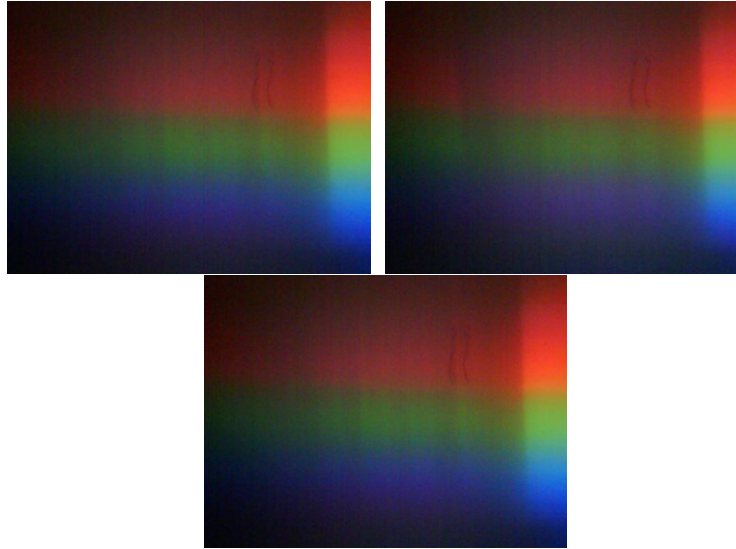


GSD (m)	18.8 x 50.0
Swath (m)	30,000
Spectral FWHM (nm)	2.08
Required FPS	24.7
Data (Mb/s)	14.2

Primary Payload

Application:

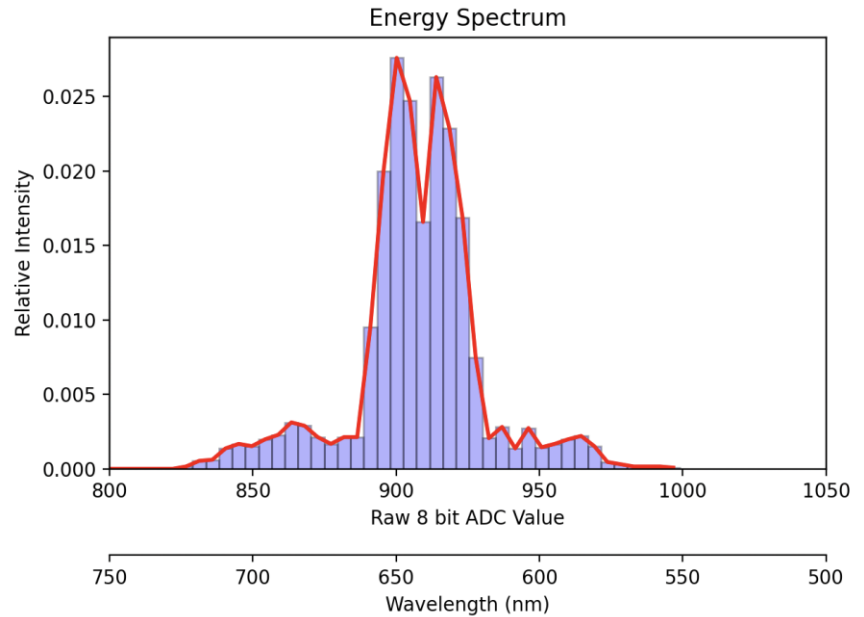
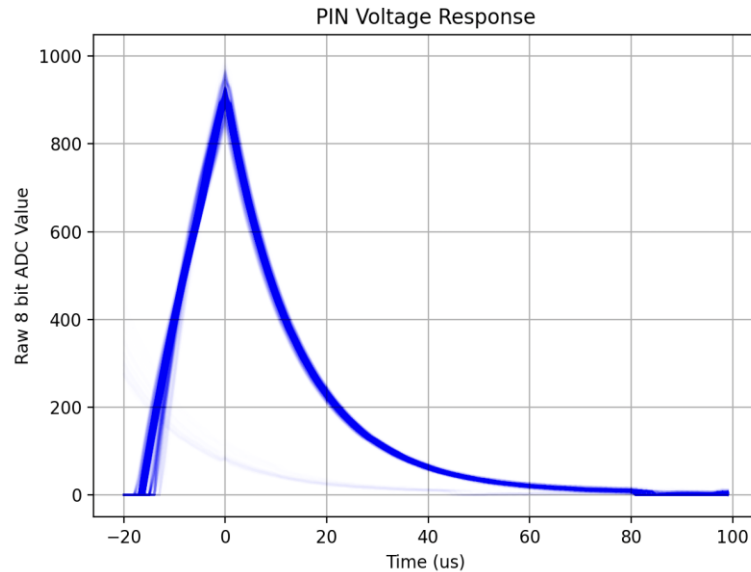
- Mineral composition of regolith



Secondary Payload

Design:

- Silicon PIN-photodiode–based spectrometer



Secondary Payload

Application:

- Isolate exospheric absorption from incident solar flux
- Validate exosphere-radiation models
- Develop radiation early warning / autonomy for Artemis & Mars campaigns

ADCS & OBC

- **Attitude Determination**

- Clyde Space SS200
- Safran STIM318 IMU

- **Attitude Control**

- Rocket Lab RW-0.01 in each axis
- VACCO cold gas Micro Propulsion System

- **OBC**

- ISISPACE On-Board Computer



Rocket Lab RW-0.01 Unit

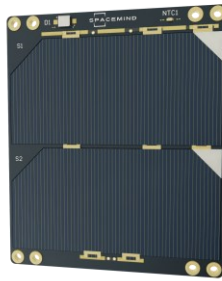


VACCO MPT

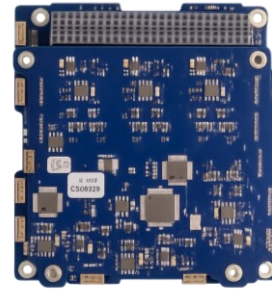
Component	Performance
Sun Sensor	110° FOV
IMU	400°/s, 10g range
Reaction Wheels	10 mNm s torque
VACCO MPT	10 mN thrust

EPS

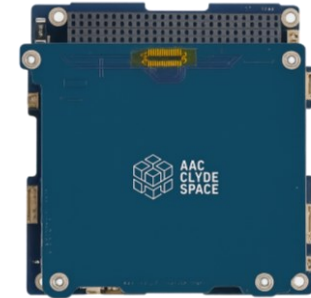
- Solar array: 18.4W maximum power supply BOL
- Power: 3.3V, 5V, and 12V lines
- Battery:
 - 30Wh
 - 12.09W max
 - 0.1W quiescent draw
- Total mass 674g



NPC Spacemind SP1X solar panel



AAC Clyde Space Starbuck-Nano PCDU



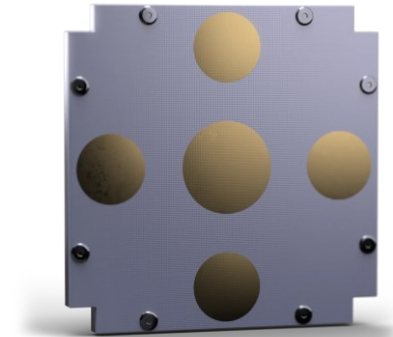
AAC Clyde Space OPTIMUS-30 battery

System	Power Draw by Operating Mode (W)						
	Hibernation	Detumble	Idle	Monitoring	Early Warning	Safe	Desaturate
Internal Subsystems	0.00	7.85	3.83	5.7	8.71	0.83	15.29
Solar Array	0.00	-2.38	-4.11	-4.11	-4.11	-4.11	-4.11
Power Margin (%)	0.00	-229.83	6.87	-38.63	-111.86	79.80	-280.04
Power Required by Battery (W)	0.00	5.47	0.00	1.59	4.60	0.00	11.51

S-Band Transceiver	
Tx Frequency	2200-2290 MHz
Rx Frequency	2025-2110 MHz
Data Rate	0.1-125 kbps
Modulation	GMSK
Max Power Draw	12.2W @ 33dBm
S-Band Antenna	
Frequency Range	2025-2290 MHz
Gain	5+ dBi
HPBW	70°
Type	Wideband
RF Power	4W



Endurosat S-Band Transceiver



Endurosat S-Band Antenna
Wideband

Direct to Earth (DTE) Link Budget



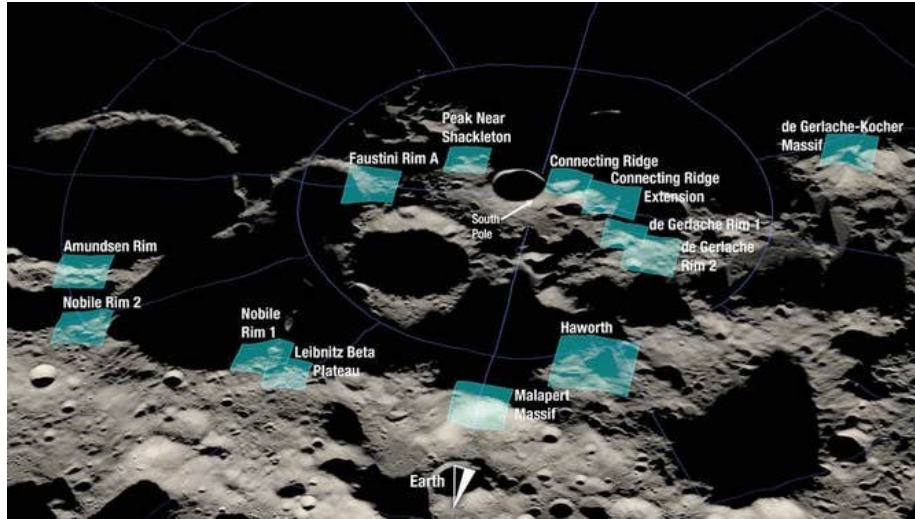
Goldstone (DSS-14)
Canberra (DSS-43)
Madrid (DSS-63)

Specifications:

- 70m
- 100kW S-band Channel
- 63.5dBi gain

Value	Uplink	Downlink	Units
Data rate	9,600	50,000	bps
EIRP	111.95	9.3	dBW
Receiver G/T	33.5	-24.3	dB/K
Total path loss	211.03	211.03	dB
C/N ₀	60.2	91.0	dBHz
Eb/N ₀ (achieved)	51.2	13.2	dB
BER target	1×10^{-5}	1×10^{-5}	
Eb/N ₀ (required)	9.6	9.6	dB
Link margin (dB)	39.6	1.58	dB

Direct to Moon (DTM) Link Budget



Nobile Rim 2

Specifications (Based on Yagi Antenna):

- 20W S-band antenna
- 16.3dBi gain

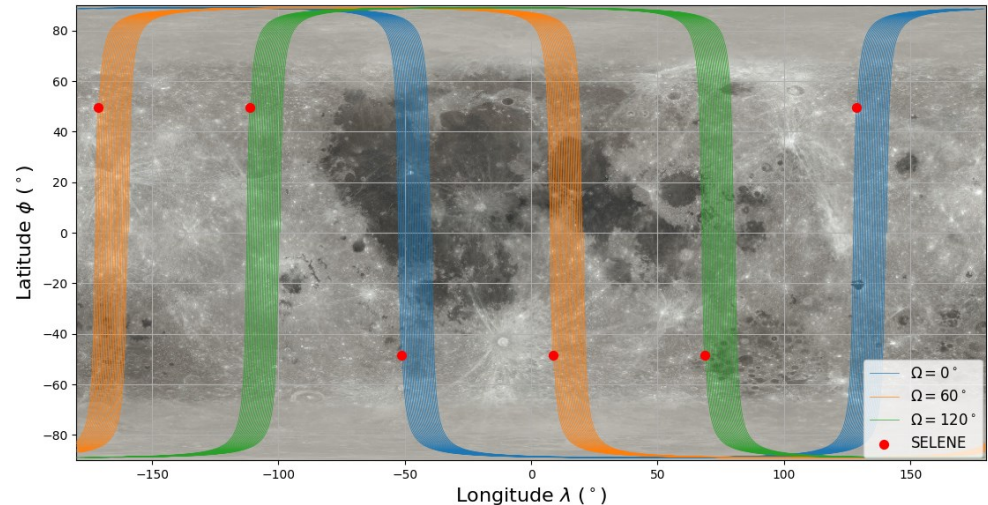
Value	Uplink	Downlink	Units
Data rate	9,600	50,000	bps
EIRP	25.7	9.3	dBW
Receiver G/T	33.5	-14.9	dB/K
Total path loss	150.6	150.6	dB
C/N ₀	78.4	69.8	dBHz
Eb/N ₀ (achieved)	38.5	22.8	dB
BER target	1×10^{-5}	1×10^{-5}	
Eb/N ₀ (required)	9.6	9.6	dB
Link margin (dB)	27.9	12.2	dB

Orbit & Constellation Design

- **Walker-Star constellation**
 - 6 satellites
 - 3 planes
 - Spaced 60° RAAN
- **Full surface coverage** in 9 days
- **Ground station visibility** 6.04 hours per day
- **Data transmission** up to 1.08Gb of data per day.

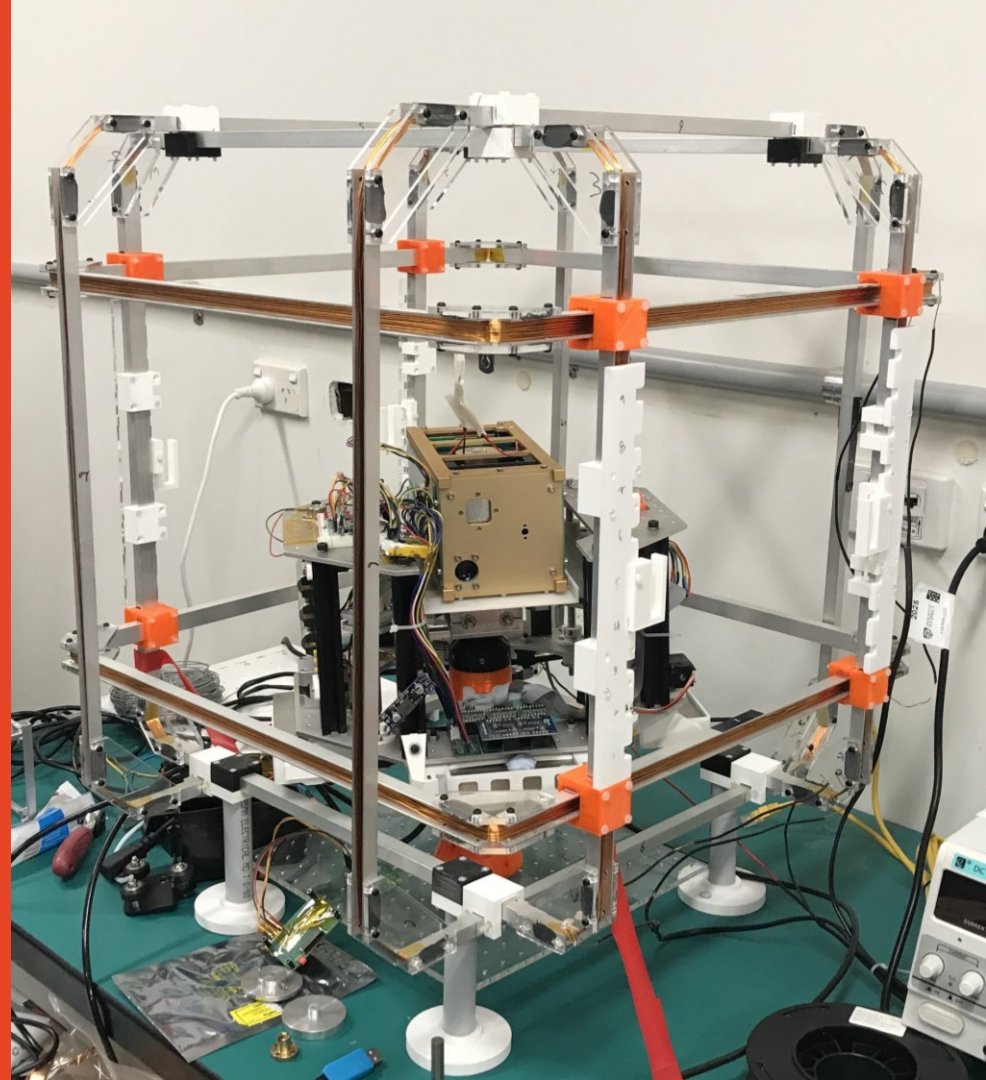
a	e	i	Ω	ω	θ
1846 km	0	90°	0°	0°	0°

SELENE Orbital Elements



Constellation Ground Track over 1 day

Implementation Plan and Risks



Implementation Plan

Project Stage	2025			2026				2027		
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Design Phase										
Authority to proceed										
Mission feasibility study and proposal										
Component analysis, design, and selection										
Development Phase										
COTS component procurement										
Custom component manufacturing										
Assembly and Integration Phase										
CubeSat bus integration										
CubeSat payload integration										
Testing										
Unit testing										
Vibration testing										
Thermal and vacuum testing										
Acceptance review										
Launch and Operation										
Launch										
Commissioning										

- Engineering model and Flight model to validate design with systems engineering approach
- 2.5 year development duration

Subsystem	Cost (AUD \$)
Payload	10,000
ADCS	175,000
OBC	20,000
EPS	40,000*
TT&C	25,000
AIT and Testing	0
Contingency (20%)	46,000
Launch	500,000
Operation	3,000,000
Disposal	0
Total excluding launch, operation, and disposal	316,000
Total cost per satellite	3,816,000

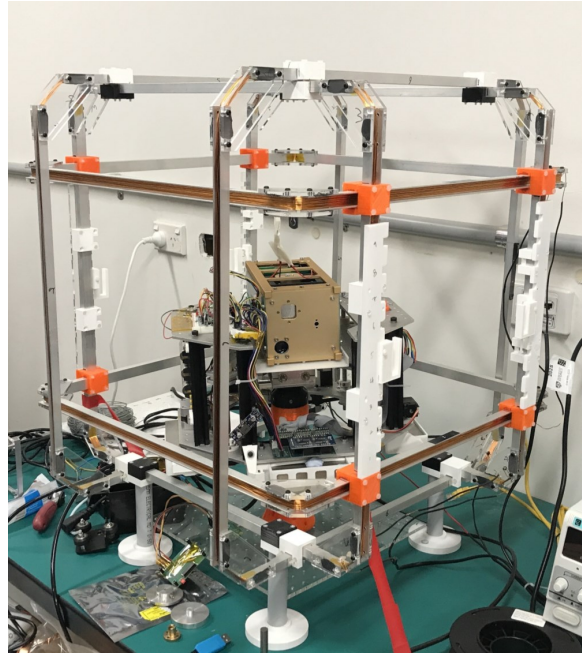
- Government & academic grants and industry partners
- Facilities at the University of Sydney allow in-house testing

Risk Analysis

Risk Description	Mitigation Strategy	Residual Risk
Insufficient project funding delays timeline.	• Additional government grants • Contingency funds reserved	Low
Loss of knowledge and human resources due to team evolution.	• Comprehensive written documentation • Proactively recruit new members	Low
Insufficient propellant to regularly desaturate reaction wheels.	• 1.5x oversized reaction wheels so minimal need to desaturate • Contingency propellant provides additional failure margin	Medium
Insufficient OBC memory leading to OBC hang.	• Separate dedicated payload computer • Watchdog timer will reboot the computer if unresponsive.	Low
Insufficient ADCS accuracy causes misaligned images.	• Attitude orientation data used to align the images	Low

Engineering Model

- Used to validate the design
- Functional equivalents used instead of space-grade hardware



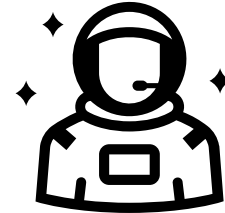
ADCS testing using an air-bearing table



Completed engineering model with side solar panel removed

Conclusion

- **Dual payloads** to support sustained, low-risk, lunar habitation.
- Enable **low-latency, high resolution** radiation characterisation and resource mapping through a cost efficient satellite constellation.



Questions

