Lunaris:
Unveiling the Unknown

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Context

- Numerous upcoming Moon-related missions
- Increased interest in lunar mining
- Need to enhance our understanding of Lunar topography
- Enhance navigational capabilities
- Facilitate the identification of future potential landing and habitation sites
- Locations of interest for space mining

Mission Objectives

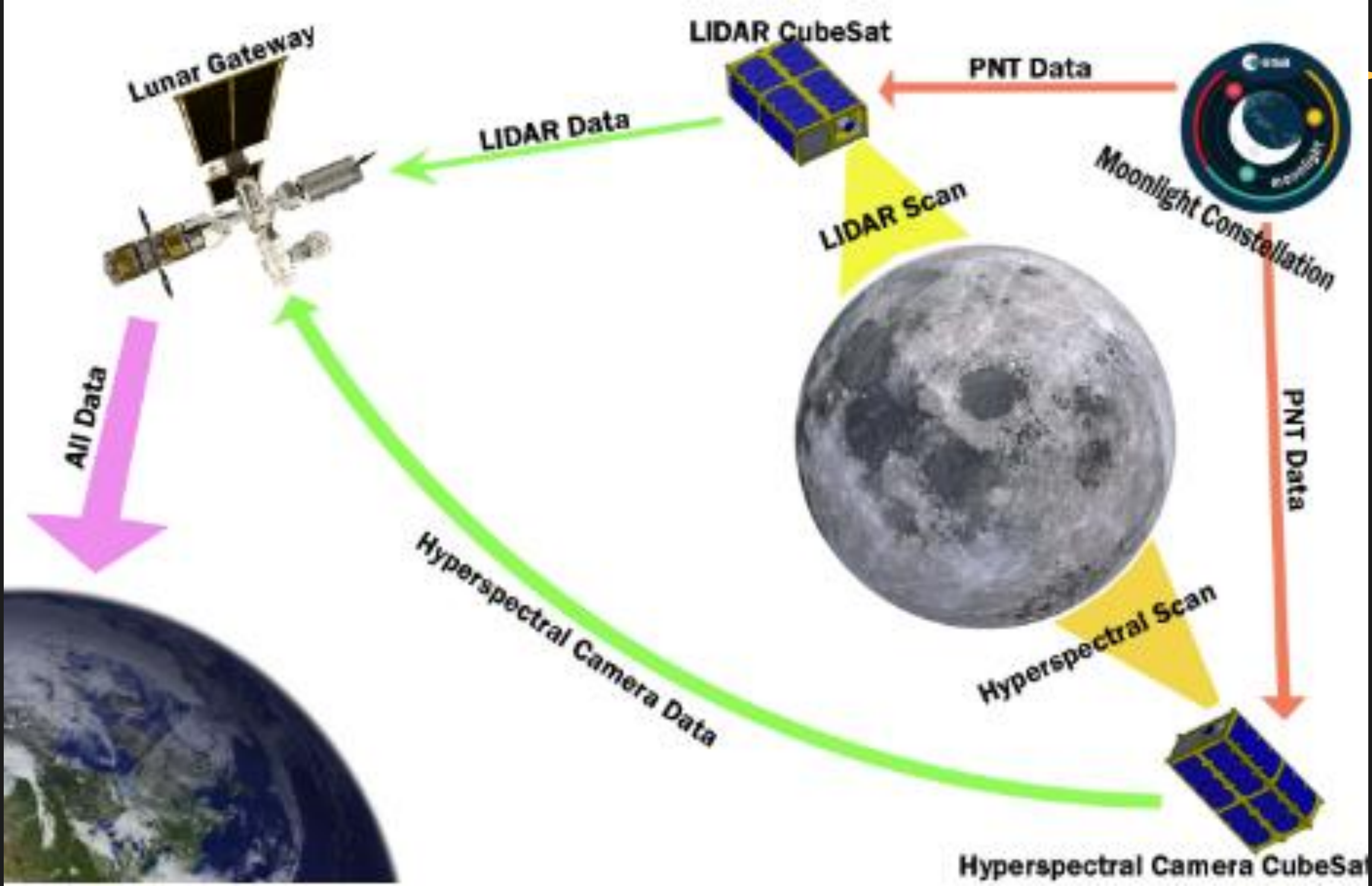
Primary Objectives

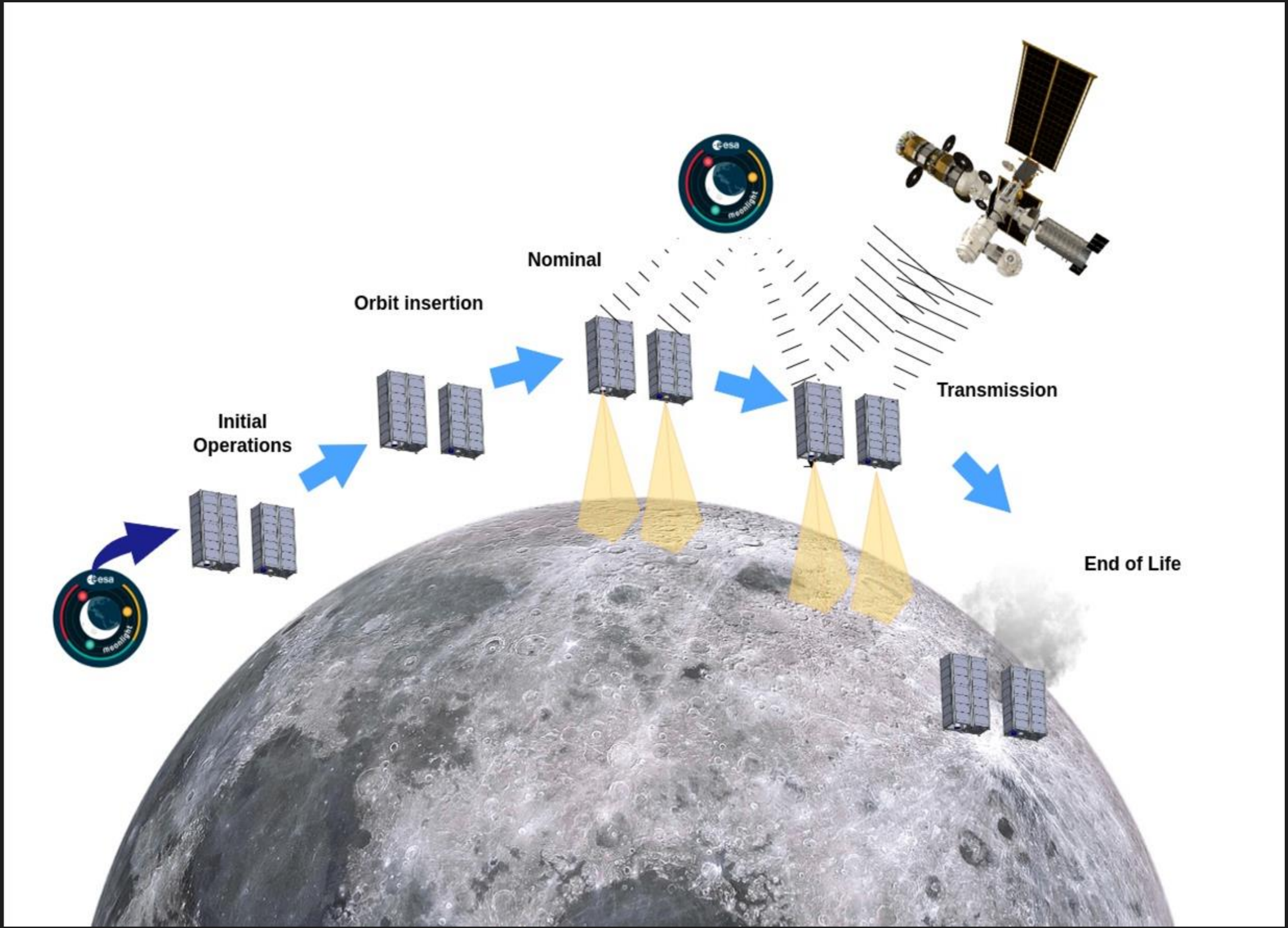
- 3D map of at least 95% of the Lunar surface
- Chemical composition of at least 95% of the Lunar surface.

Secondary Objectives

- Dynamic, up-to-date map of the Moon that will facilitate effective monitoring of changes
- Opportunity for space enthusiasts and radio amateurs to develop their skills by receiving images and data sent from the satellites

Concept of Operations


Lunar Gateway
LIDAR CubeSat
PNT Data
LIDAR Data
LIDAR Scan
Moonlight Constellation
PNT Data
All Data
Hyperspectral Camera Data
Hyperspectral Scan
Hyperspectral Camera CubeSat


Initial
Operations
Orbit insertion
Nominal
Transmission
End of Life
esa
moonlight
esa
moonlight

Key Performance Parameters

Key Parameters:

- Camera Resolution: GSD of 30 or even lower
- Scanning Time: full scanning cycle in approximately one month for a precise scan of the lunar surface
- Stability of Orbital Motion: consistent 100 km altitude for a constant resolution

Solutions:

- HyperScout M from Cosine: GSD of 39 at 350 km altitude
- Using a frozen polar orbit, the mission would complete a full scan in 27.322 days
- Ionic propulsion will be used to correct the change of 2 degrees inclination every Moon rotation cycle

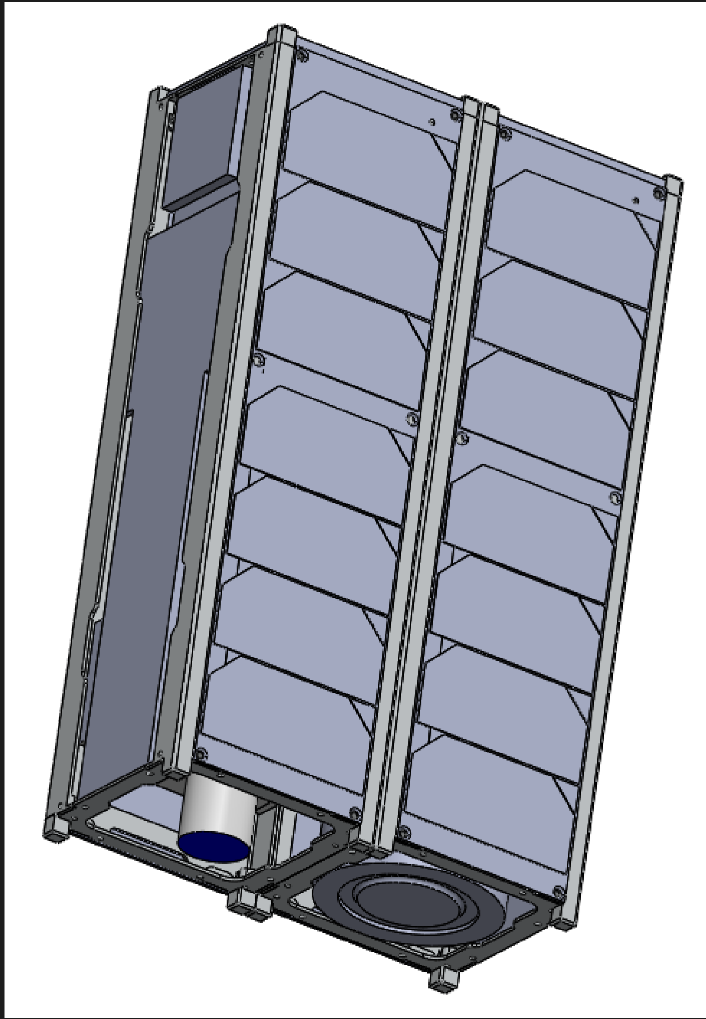
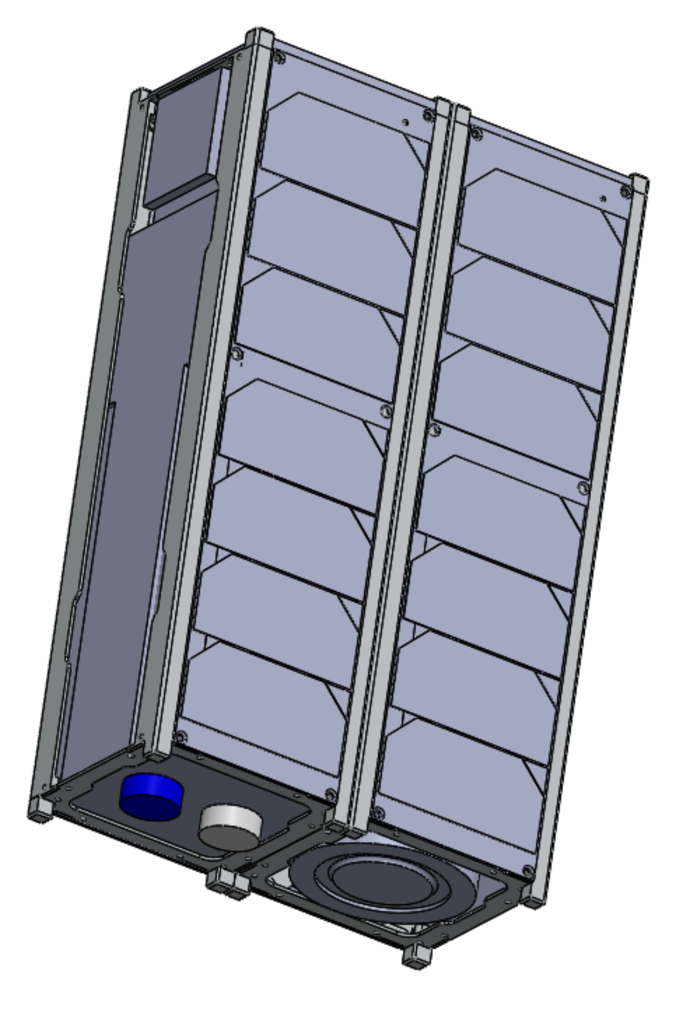
Space Segment

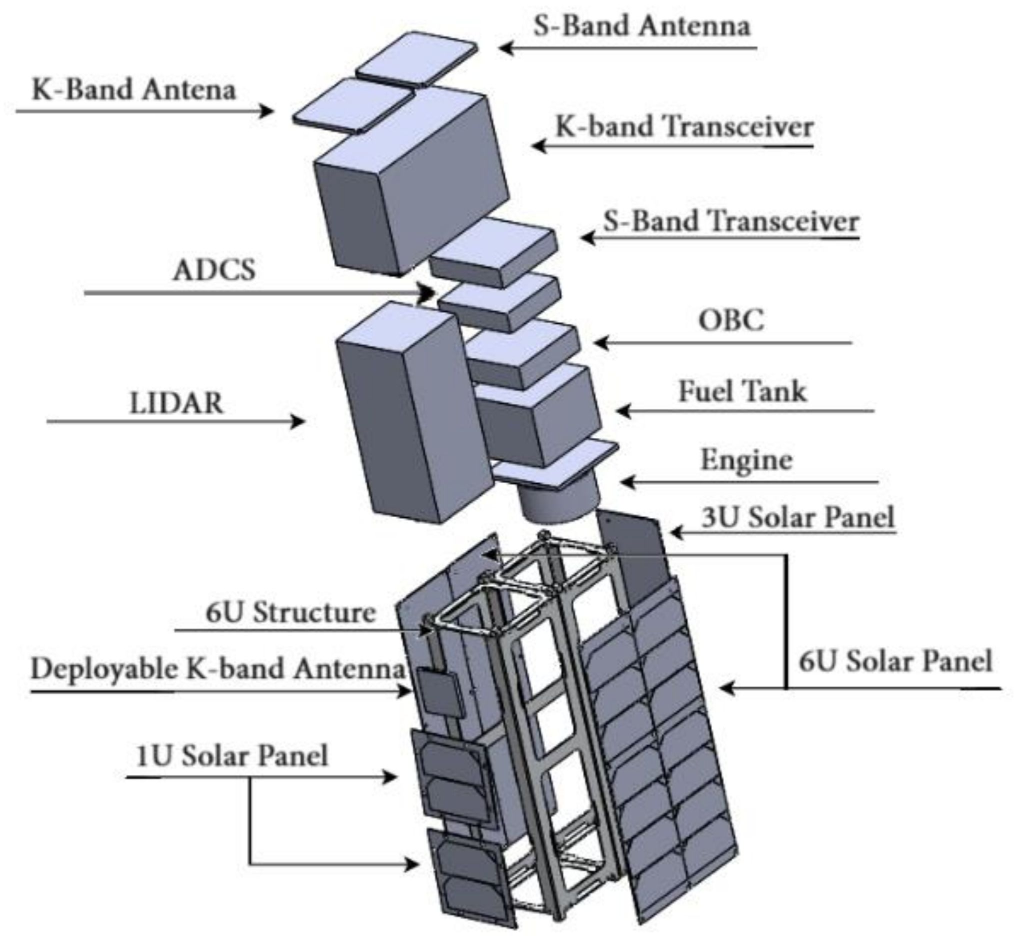
LIDAR

- A size of 2U
- Conducts scan in less than a second
- Promising future developments

Hyperspectral Camera

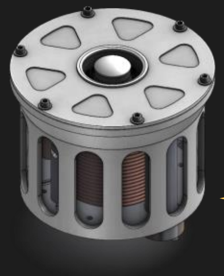
- Size of 1U
- HyperScout M
- Well tested and reliable


S-Band Antenna
K-Band Antena
K-band Transceiver
S-Band Transceiver
ADCS
OBC
LIDAR
Fuel Tank
Engine
3U Solar Panel
6U Structure
6U Solar Panel
Deployable K-band Antenna
1U Solar Panel

Propulsion

- ★ Making use of BHT-100 Hall Effect Thrusters
- ★ Choice influenced by factors such as: size, fuel and power consumption, high specific impulse
- ★ Powered by xenon
- ★ Maximum amount of fuel given by remaining space
- ★ LIDAR: 2.7kg   Hyperspectral: 2.09kg
- ★ Able to maintain orbit for 201 days, over 7 cycles of Moon rotation

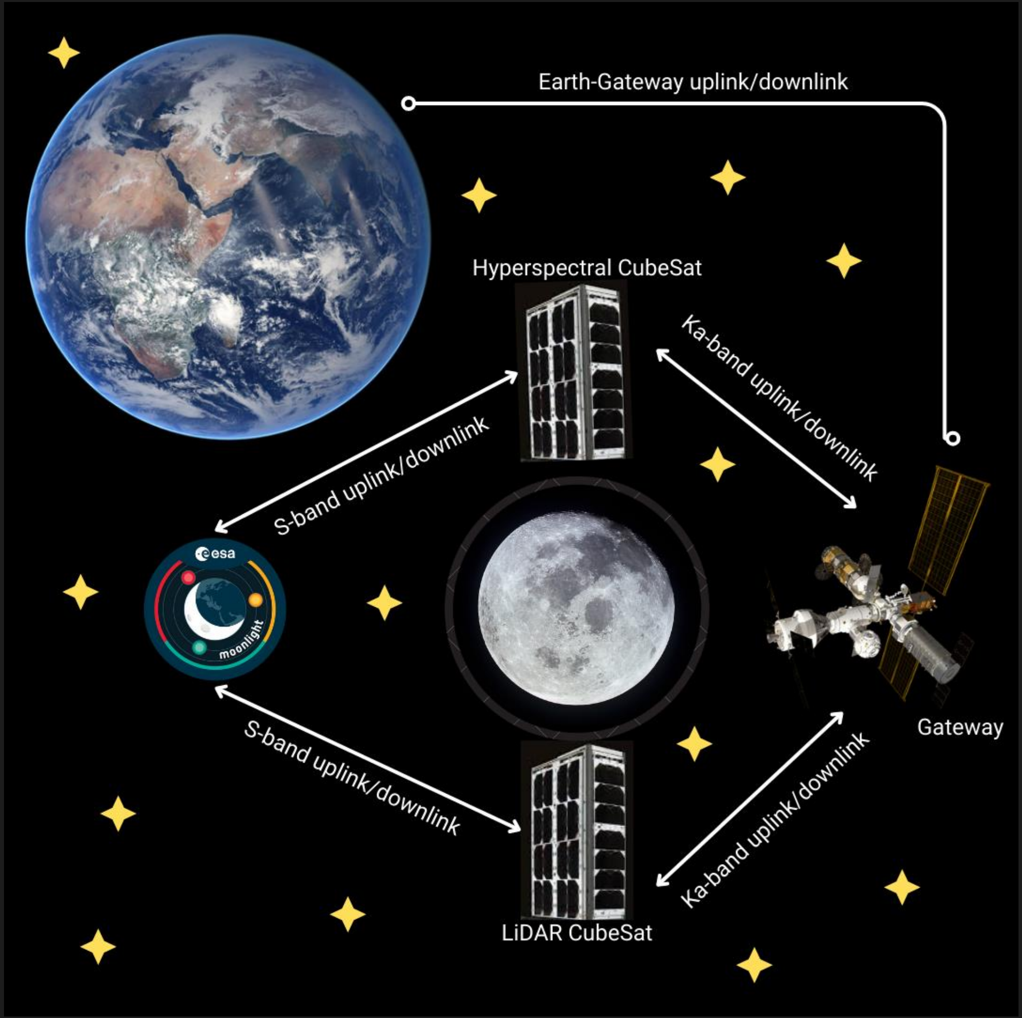


Power consumption

Power Budget

- At worse (while in eclipse for approximately 46.8 minutes) the battery charge reaches 71%
- Largest power consumption is during Orbit Insertion and End of Life modes
- Two 6U and one 3U solar arrays are enough to account for the loss.
- If further calculation require it, deployable solar panels are considered.

Communications



Earth-Gateway uplink/downlink
Hyperspectral CubeSat
Ka-band uplink/downlink
S-band uplink/downlink
esa
moonlight
Gateway
S-band uplink/downlink
Ka-band uplink/downlink
LiDAR CubeSat

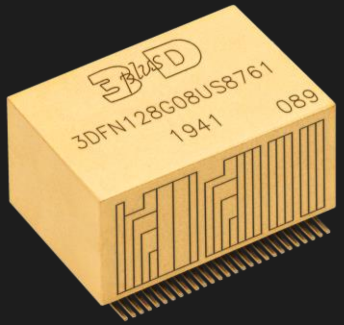
Data Budget

- ★ Housekeeping data
- ★ Telemetry data size for 1 orbit -> 570 MB
- ★ Daily report transmitted to Gateway -> 100 MB
- ★ One 64 GB storage module per each CubeSat

Data Storage

3DPlus non-volatile NAND Flash memory

- ★ Higher storage capacity
- ★ The erase and write operations are quick
- ★ Radiation resistant
- ★ Reduced possibility of bit flips



NAND FLASH

Hyperspectral CubeSat

- The Camera has 192GB storage capability - sufficient for at least 2-3 orbits
- 128GB storage module - for backup
- 128GB storage module - for the lunar map

LIDAR CubeSat

- The equipment is still in development - an exact amount of data could not be computed
- 2 storage modules of 128GB - for data generated by the LIDAR

Data Processing

Hyperspectral CubeSat

- The camera has on-board processing capability.
- The processing capability is possible if a map of the Moon’s surface is stored onboard.

LIDAR CubeSat

In order to avoid a large data flow, an onboard processing unit of LIDAR data is considered to perform lossless compression.

- ★ Radiation-Tolerant Quad-Core ARM Cortex-A72 Microprocessor, LS1046-Space
- ★ Pre-processing steps: data calibration, noise removal, filtering
- ★ Lossless compression techniques based on improved LZW and Huffman algorithm

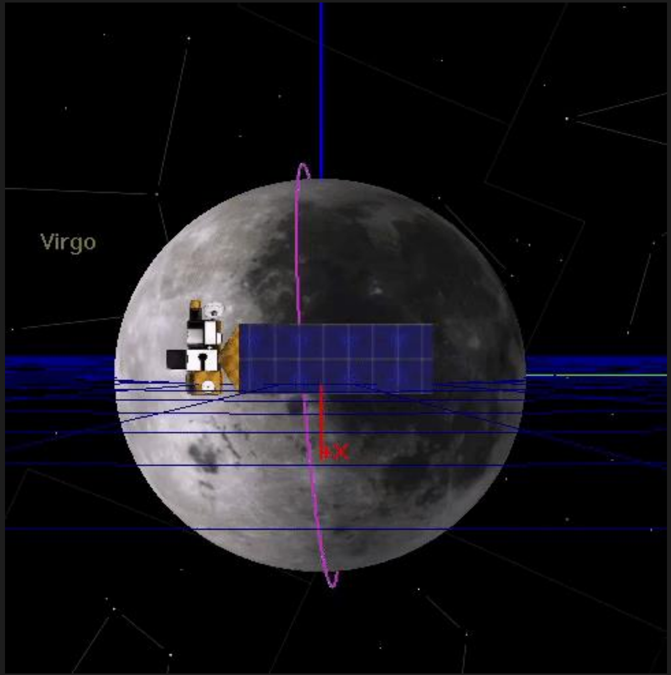
Orbit and Constellation Description

Why a constellation?

- Not enough space in a 6U Cubesat for the necessary payload.
- Using two separate satellites creates more redundancy in the design of the mission

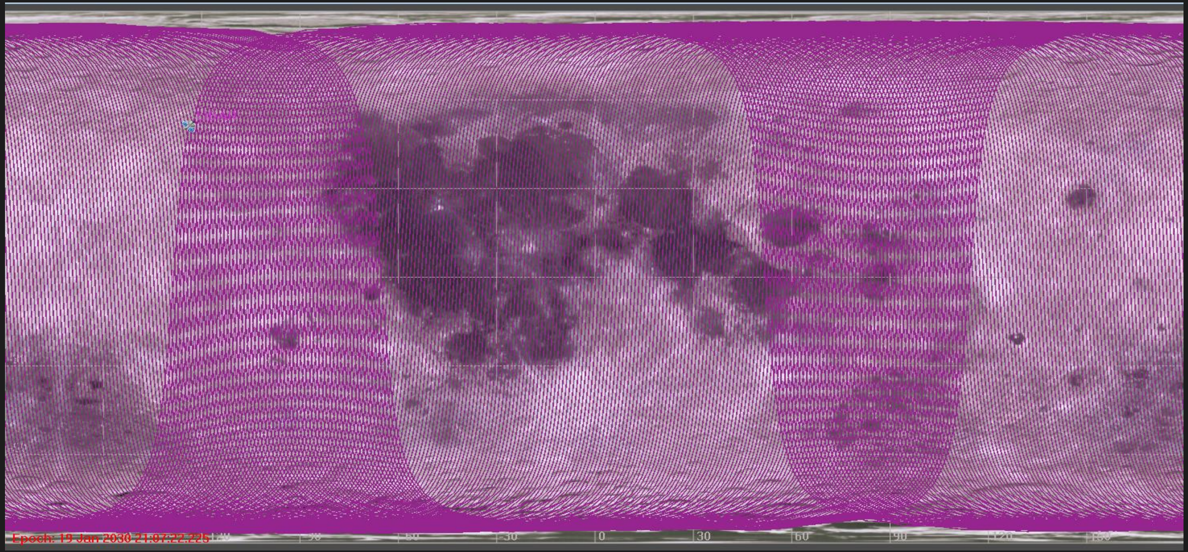
Orbit choice

- Low Lunar Orbit with an altitude of 100 kilometers
- Circular Orbit
- Frozen Orbit of 86 degree inclination
- Same Orbital plane
- Orbital period of approximately 2 hours



Coverage

- ★ Lidar coverage → 99.84% coverage/cycle
- ★ Hyperspectral coverage → 99.92% coverage/cycle



Implementation Plan

gmv
INNOVATING SOLUTIONS

THALES

deimos

INCAS

COMOTI
ROMANIAN RESEARCH & DEVELOPMENT INSTITUTE FOR GAS TURBINES

rise
ROMANIAN INSPACE ENGINEERING

ROSPIN

Subsystem	Component	Cost[euro]		Qty.	Additional costs	Cost[euro]
		LIDAR	Hyperspectral			
ADCS	ADCS	200000		1	Ground Station	750000
PAYLOAD	LIDAR	1200000	-	1	Launch with Moonlight	600000
	Hyperspectral camera	-	1000000	1	Testing facilities	500000
STRUCTURE	6U Structure	64000		1	Facilities Cost	500000
	Harness	-		-	Mission development	500000
EPS	Thermal Hardware	300000		2	Software	1250000
	Solar Panel 6U	137000		2	FlatSat	1000000
	Solar Panel 3U	54000		2		TOTAL
	EPS PDM	235000		1		5100000
	8-cell Battery Pack	50000		2		
Propulsion	Engine	1500000		1		Total Cost
	Fuel Tank	77000	70000	1		15989000
OBC	NAND Flash Memory	50000		3		
	LIDAR data processing microprocessor	200000	-	1		
	OBC	450000		1		
COMMS	Ka-band Antenna	94000		1		
	Ka-band deployable Antenna	60000		1		
	Ka-band Transceiver	224000		1		
	S-band Antenna	50000		1		
	S-band Transceiver	112000		1		
		Total	Total			
		5648000	5241000			

Risk Factors

Number	Risk	Impact	Likelihood	Mitigations/Solutions
1	Delays in the schedule of the Lunar Gateway and Moonlight missions would in turn delay the proposed mission, given the current set-up.	Low	High	We would make arrangements for out satellites to be stored in an appropriate place while waiting for the launch of the Moonlight mission.
2	Malfunctions of the Lunar Gateway and Moonlight constellation during the missions' lifetimes could lead to loss or corruption of vital data. In the worst of scenarios, a complete connection cut-off to the proposed mission's satellites could take place.	High	Unlikely	The mission data will be sent over in archived form, lowering the risks of curruption while also allowing us to store more of it on board until the problem is resolved
3	Lack of funding for building the mission could prove fatal towards the ambition, however several opportunities for sponsorship will be available.	Low	Possible	A crowd funding campaing could provide the additional needed funds.
4	If the data transmission component on one of the CubeSats were to suffer a malfunction, part of the constellation would become unusable.	Medium	Unlikely	To prevent this, redundancies for all crucial equipment will be included during the design process.
5	Failure at launch would lead to the destruction of both satellites.	High	Rare	A good insurance would cover the cost of the satellites and allow us to restart the project

GANTT

Phase	Mission Phases	2023	2024	2025	2026	2027
0	Mission analysis and identification					
A	Feasibility					
B	Preliminary Definition					
C	Detailed Definition					
D	Qualification and Production				*	**
E	Utilisation					
F	Disposal					
*	ESA Moonlight					
**	Lunar Gateway					

End of life

- The satellites will start the end of life procedure if they encounter critical damage or if they finish the lifetime of 201 days of flying on the frozen orbit.
- Crashing on the moon, preferably on a future lunar graveyard

Thank you!

Do you have any questions?