SLINQI

Stellenbosch

Lunar

Interferometric

Network for

Quasi-static

Imaging

The 9th

Mission Idea Contest: to the Moon

Team

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Problem Identification

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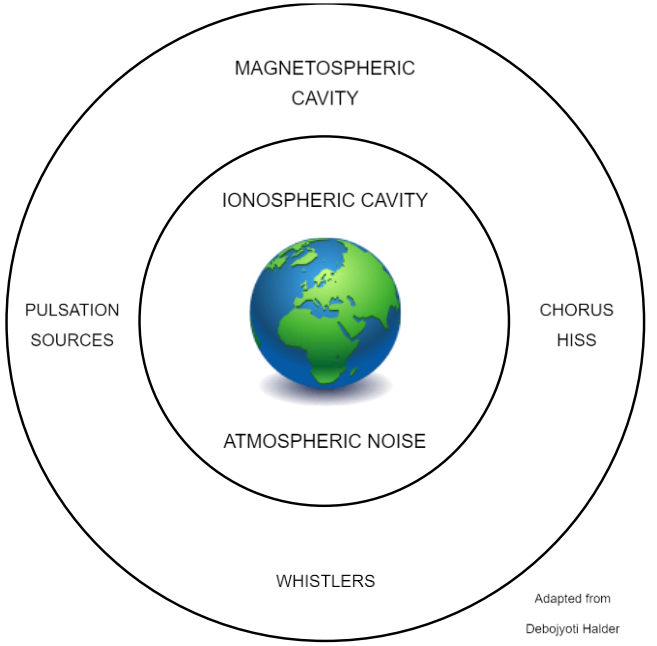
Low Frequency Radio Astronomy -> Very Difficult from Earth

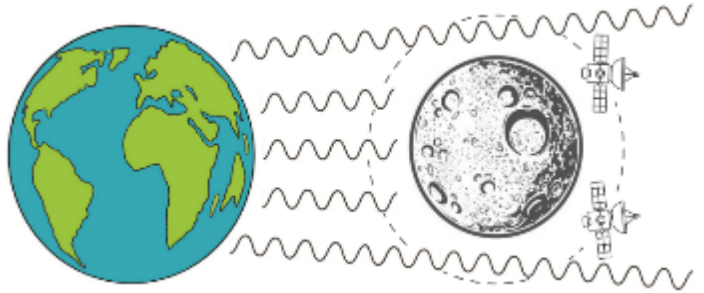
1-30 MHz blocked by interference from Earth

Solar, Planetary & Cosmic Signals -> **Undetected**



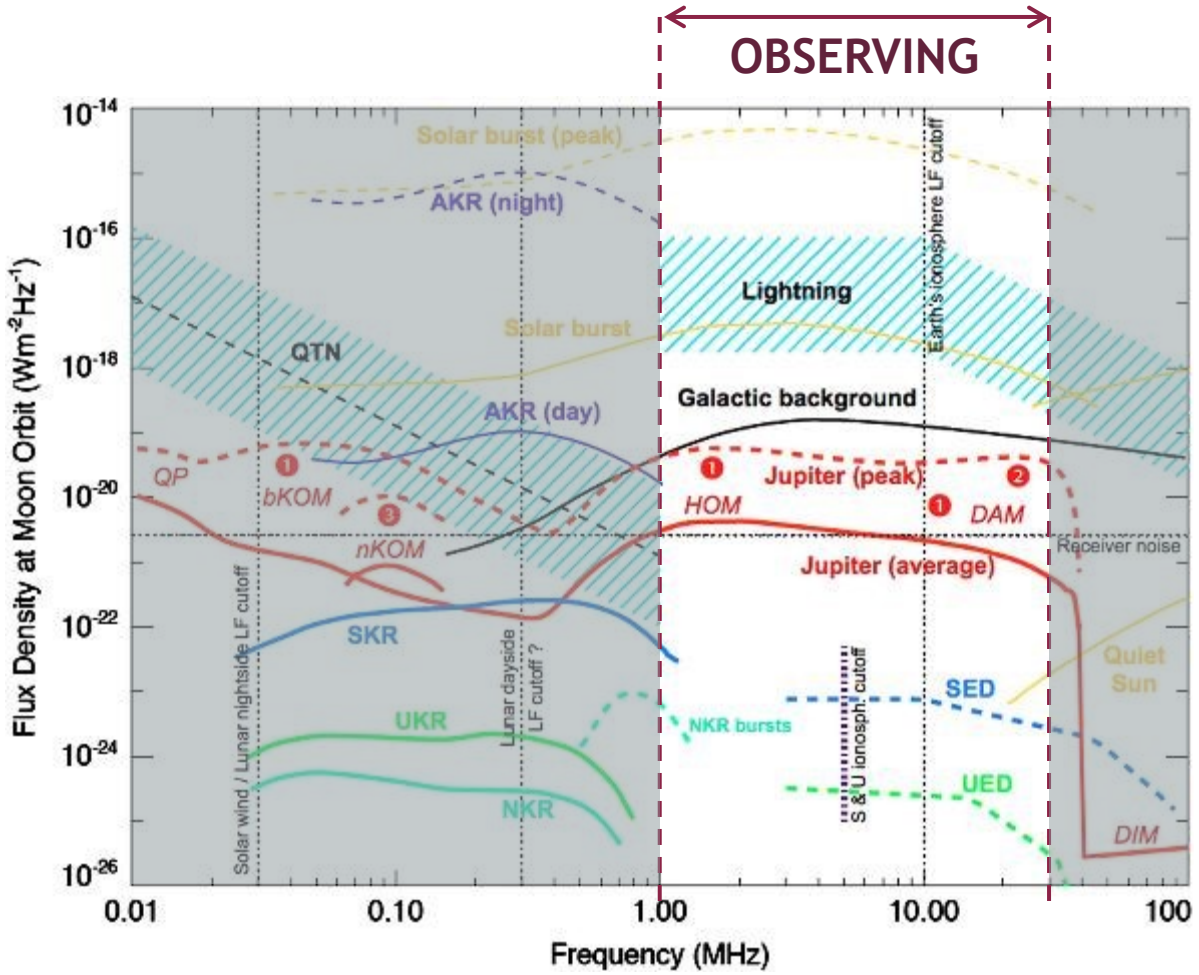
Far side of the Moon -> Interference Free zone

SLINQI enables clear **low-frequency radio astronomy**



Mission Objectives

1. Observe **solar radio emissions** (1–30 MHz)
2. Detect **planetary emissions** (Jupiter, Saturn, Uranus)
3. Investigate **deep-space sources** and early-universe signals
4. Advance **lunar radio astronomy** and **VLBI**



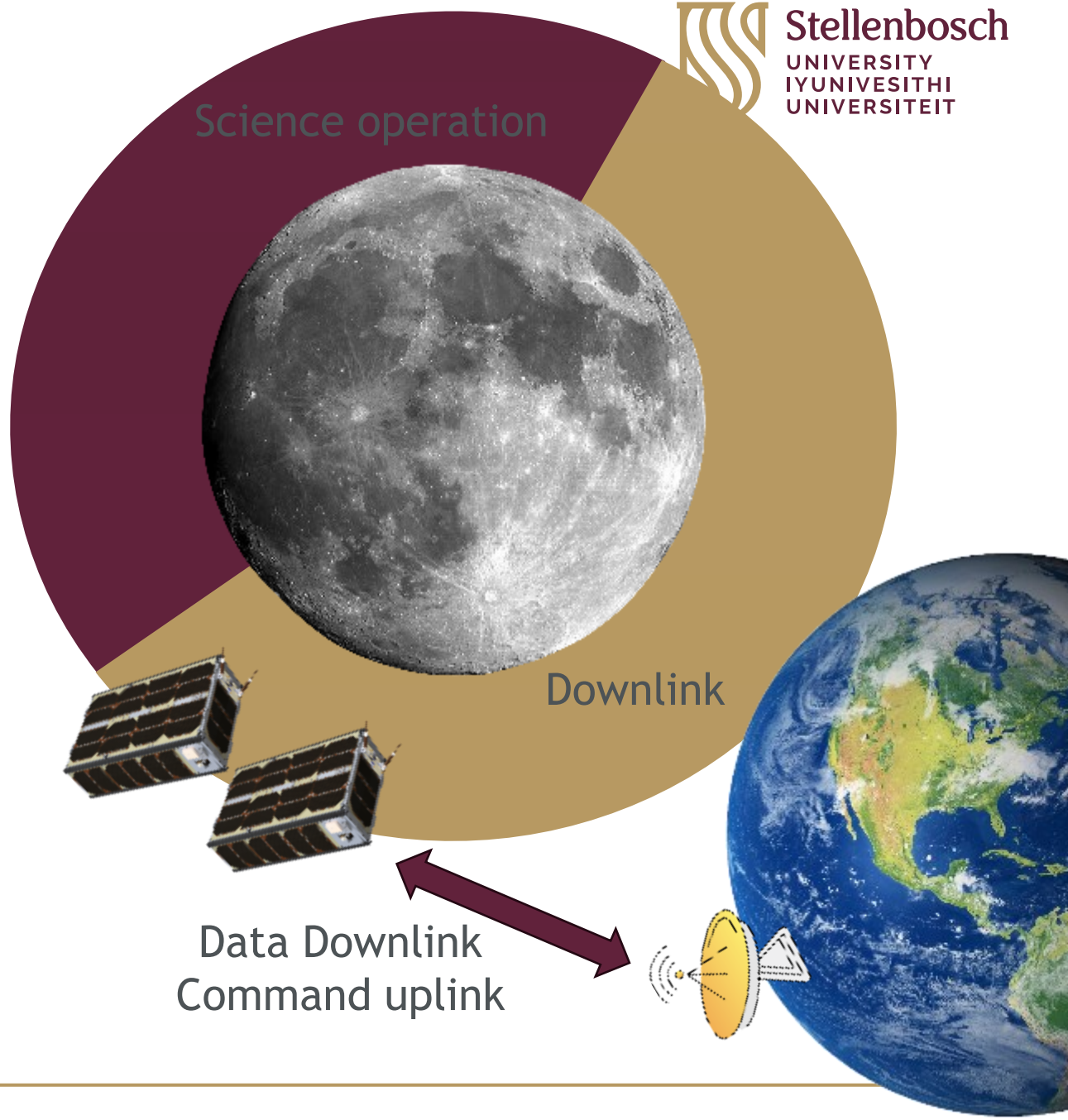
Concept of Operations

Orbit:
Two 6U CubeSats in low lunar polar orbit

Radio-Quiet Phase:
Conduct low-frequency science observations

Earth-Visible Phase:
Downlink data via X-band to NASA DSN
Receive uplink commands

Coordination:
Formation control + atomic clock sync enable interferometric imaging



Key Performance Parameters

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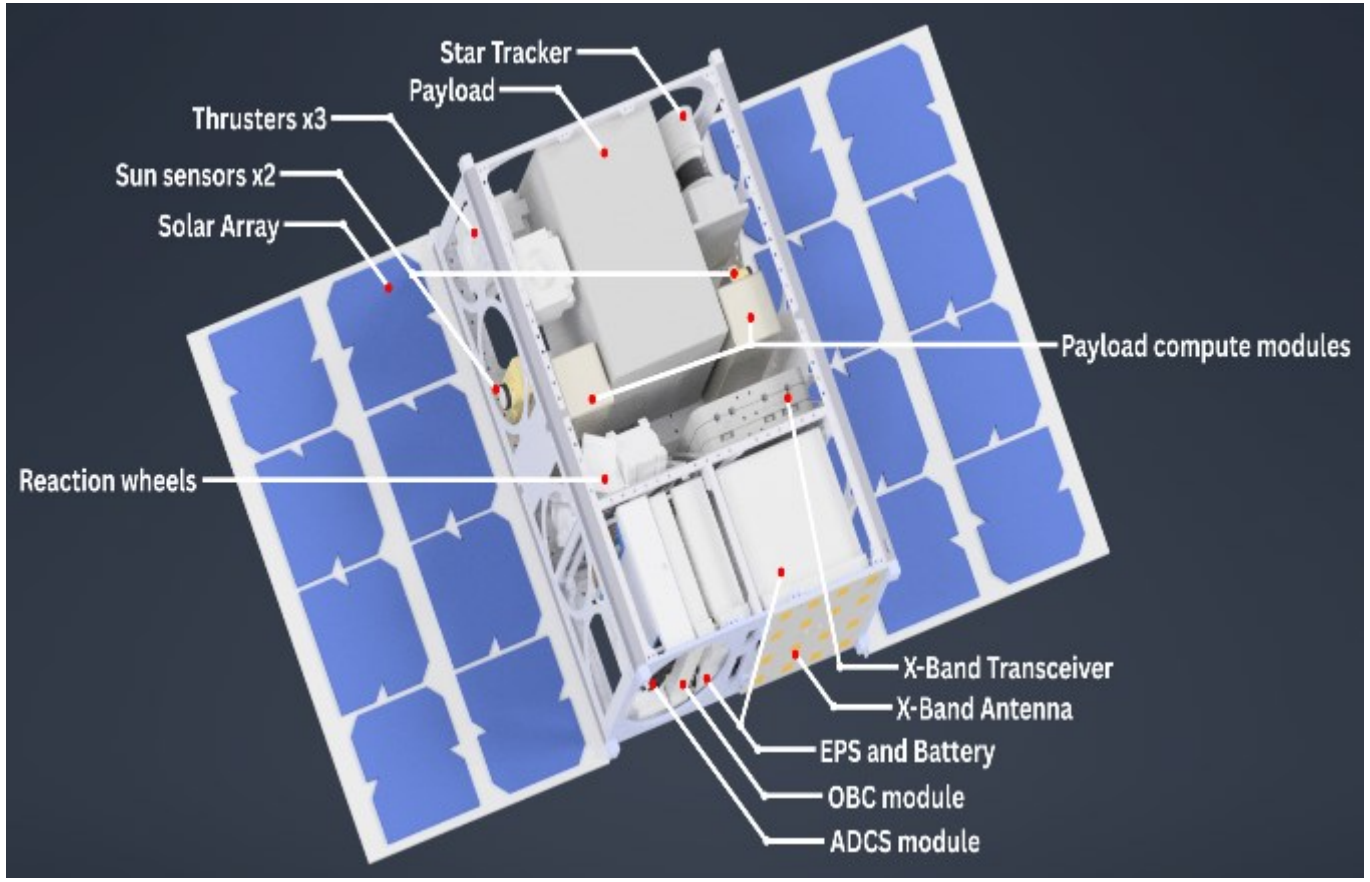
Parameter	Target / Description
Angular Resolution	3.9″ (10 MHz) → 1.3″ (30 MHz)
Synchronization Accuracy	< 1 ns (atomic clocks)
Downlink Rate	2 Mbps X-band
Operational Lifetime	≥ 2 years
Pointing Accuracy (TT&C)	±1°
Payload Calibration	Signal Injection + Celestial Sources

Space Segment Description Overview



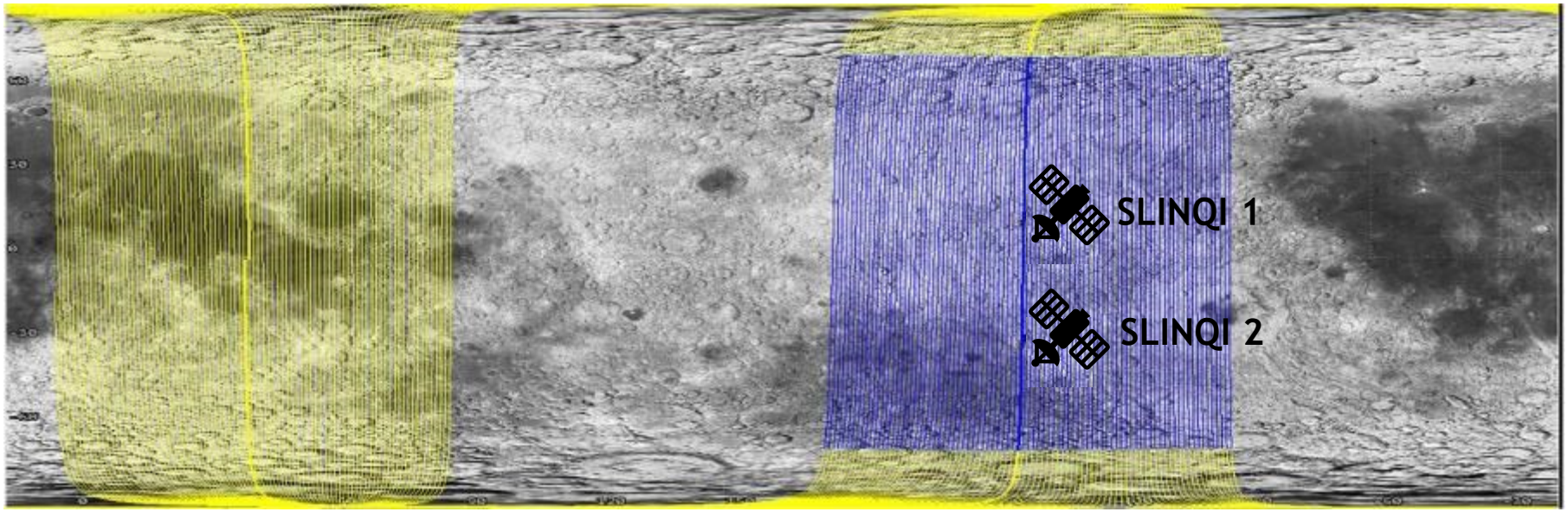
Two identical 6U CubeSats (7.8 kg each).

Mass & Cost: ~7.8 kg, ~USD 777 k (excl. labour) per SLINQI.

Modular Zaphod 6U structure

Passive thermal control with Mult-Layer Insulation and radiators.

Orbit Description



Sunlit Eclipse

100 km polar lunar orbit

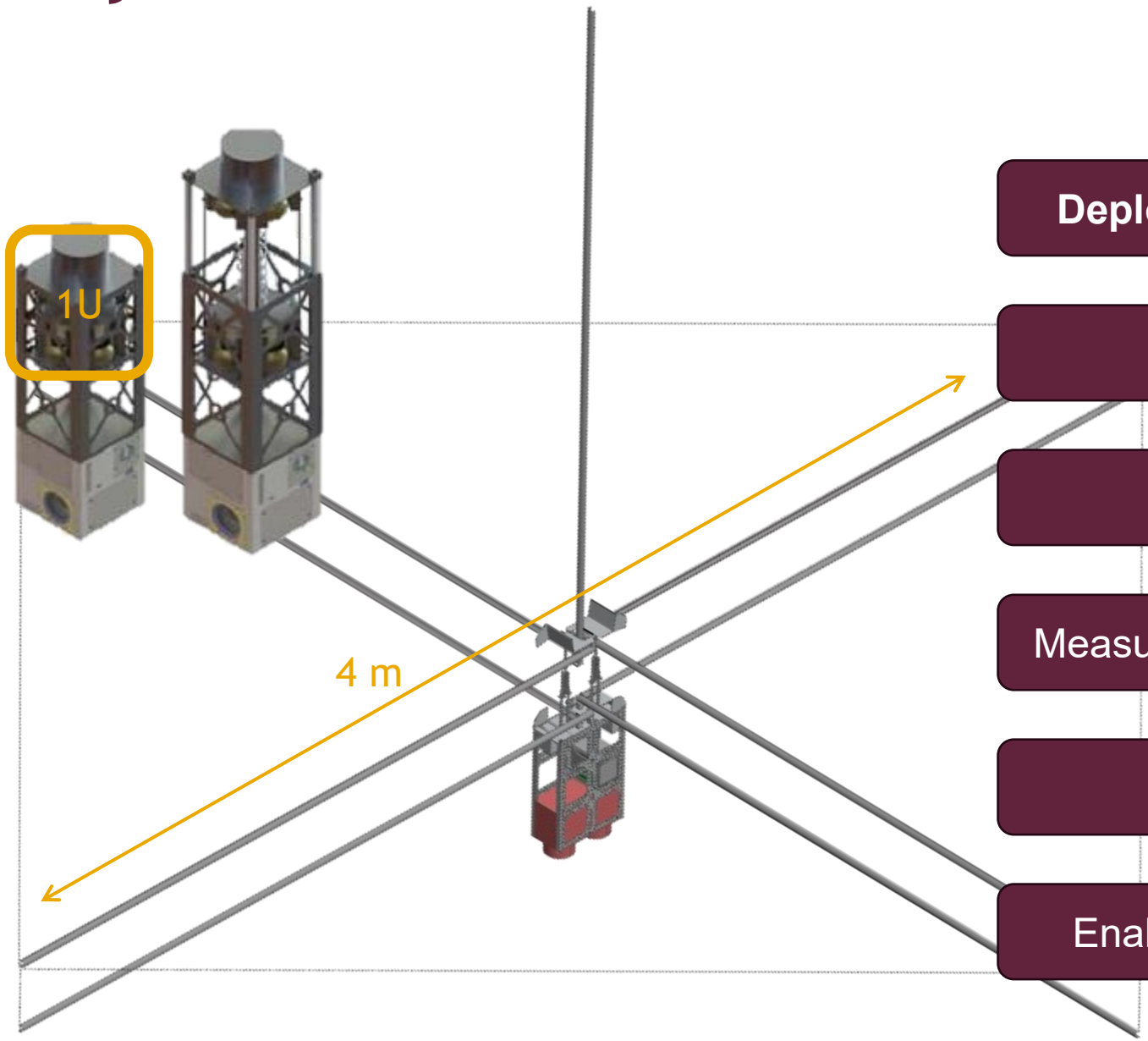
46 min radio-quiet zone per orbit

14 min dual-view window for interferometry

ΔV = 23 m/s for formation & deorbit control

Two 6U CubeSats with variable baseline (50km to 1600km)

Payload: EMVS Antenna



- **Deployable Electromagnetic Vector Sensor (EMVS)**
- **1–30 MHz** frequency range
- **1U stowed → 4 m deployed**
- Measures **full E & B field vectors** (polarization included)
- **Loop + dipole + monopole** configuration
- Enables **precise interferometry** with fewer satellites

Payload Electronics & Data System

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Data Acquisition Chain: LNA → ADC → FPGA

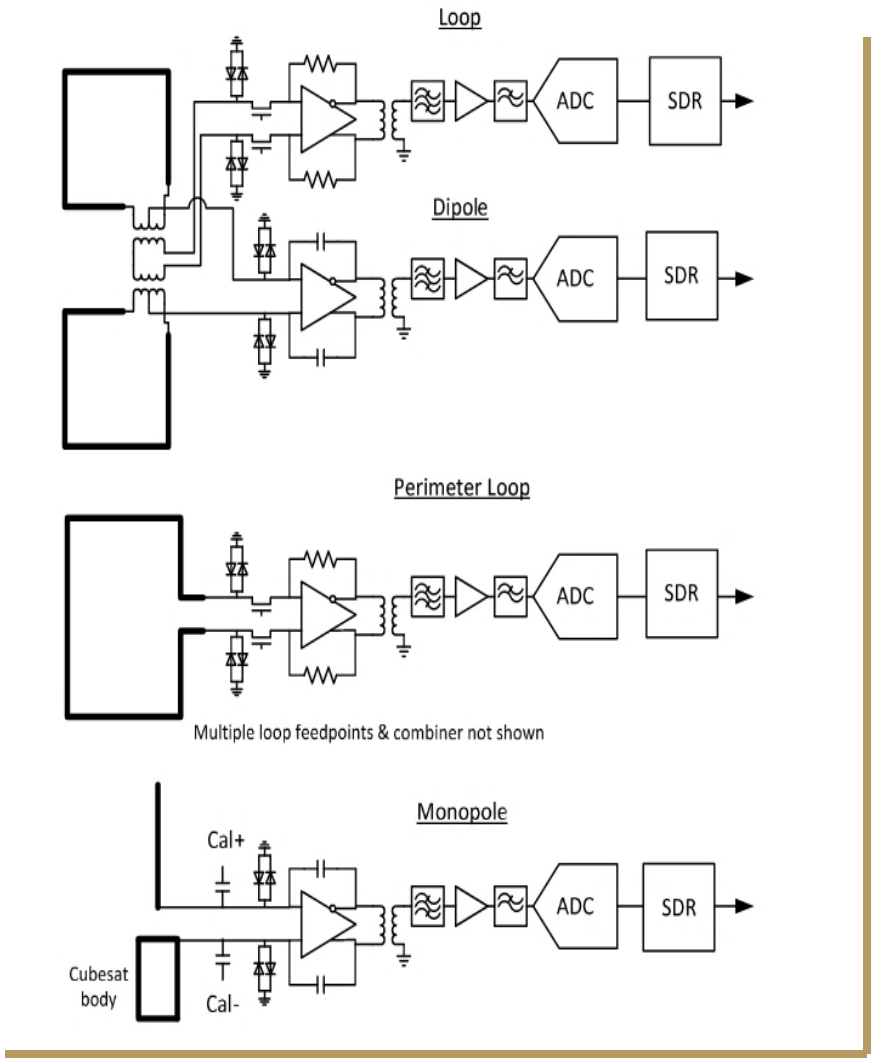
Functions: Filtering, RFI mitigation, compression, ECC

Storage: 1 TB flash

Clock: CSAC atomic clock (< 1 ns sync)

Modes: Wideband (snapshots) / Narrowband (filtered)

Calibration: Signal injection & celestial sources



Communications (TT&C)

IQ Spacecom X-Link SDR Transceiver

X-Band: 8 - 8,4GHz (2kbps to 200Mbps)

+

4×4 X-band patch antenna (18 dBi)

X-Band: 8 - 8,45 GHz

~72 min Downlink/orbit → ~1 GB data returned/orbit

Communications (TT&C)

DSN ground stations: Goldstone (USA), Madrid (Spain), Canberra (Australia)

+

Data rate: 2 Mbps downlink | 500 kbps uplink
BER: ≤ 10^{-9} (downlink)

+

Link margin: +6.8 dB (downlink), +41.9 dB (uplink)

Item	Unit	Uplink	Downlink
Transmitter Power	dBW	43	3.01
Antenna Gain	dBi	73	74
Free Space Loss Downlink	dB	221.30	222.40
Data Rate Downlink	kbps	500	2000
Link Margin	dB	41.9	6.8

Electronic Power System (EPS)

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Power generation: 38.4 W max | 15.6 W average load

Battery capacity: 84 Wh (EnduroSat Li-ion pack)

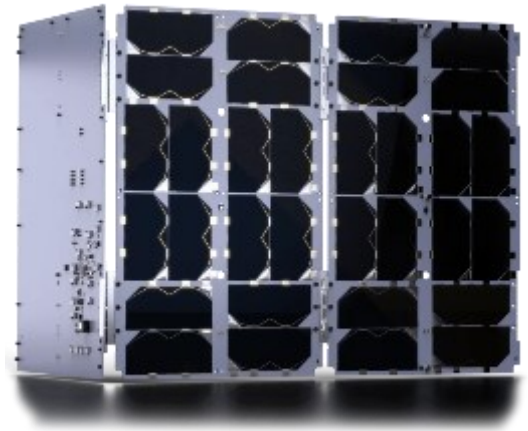
Heated battery pack to survive lunar eclipses (-133 °C)

Eclipse duration: ~1 h (normally), up to 4 h (worst case)

Redundant protection: current limiting, charge control, telemetry

	Power	
	Average [W]	Peak [W]
Total power demand	14.2166	78.19
Total + 10%	15.64	86.01
Total Solar Input [W]	38,4	
Battery Pack DOD [%]	86,03	

EnduroSat EPS II + 2× deployable 6U solar arrays



On-Board Computer (OBC)

EnduroSat OBC II

- **480MHz**
- **Real-time clock**
- **Multi-layer Mass Storage**
- Radiation tolerance **> 20 kRad**

Attitude Determination and Control System (ADCS)

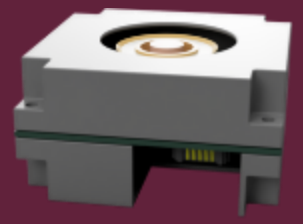
ACTUATORS

CubeSpace CubeWheel

- CW0057 pyramid

SSP “Pocket Rocket” thrusters

- Thrust: 10–200 μN, Isp = 700 s



SENSORS

Sodern Auriga CP Star tracker

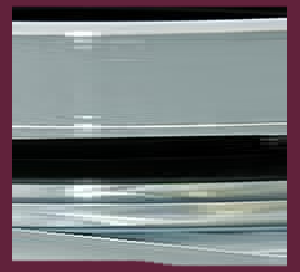
- <9 arcsec (pitch, yaw)
- <51 arcsec (roll)

CubeSpace Fine Sun Sensors

- 170° FOV, 0.2°

MEMS gyros

- Included on CubeSpace CubeComputer



Space Environment Testing

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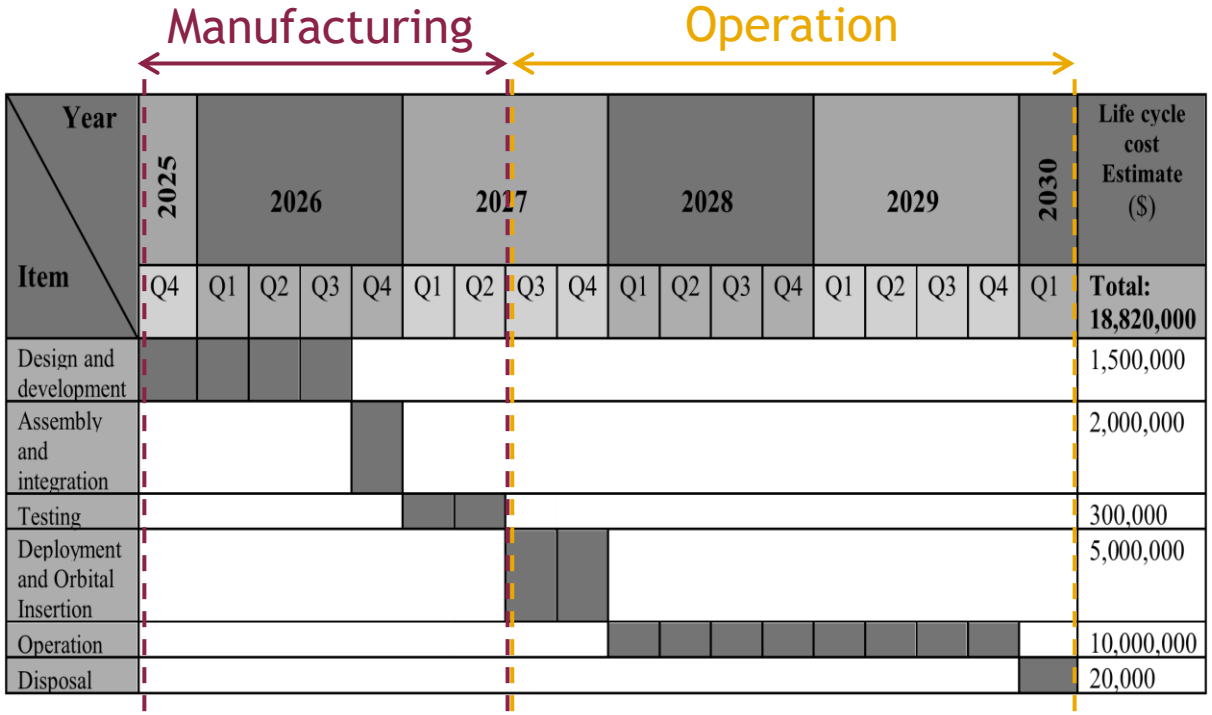
Acceptance:
Vibration, TVAC & EMC at Spaceteq

Radiation:
Radiation Screening (iThemba Labs) & TID (ARC)

Mitigation:
Radiation-tolerant parts, redundancy, shielding

Partners:
MIT, NASA DSN, Spaceteq, iThemba Labs, ARC

Implementation Plan & Risk Analysis



Timeline: ~2 years for design, assembly, testing, and integration

Operations: 2 years + controlled lunar deorbit at EOL

Risk Register		
Description	**Risk Level**	**Mitigation**
TX Failure	**Medium**	Thorough Hardware Testing
Data Corruption	**Medium**	Redundancy & Error Correction + Reconfigurability
Slow Data TX	**Low**	Sufficient Storage
Radiation Damage	**Low**	Adaptive Error Correction+ Redundancy
Interferometric Misalignment	**Medium**	ADCS Calibration & Testing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Thank you
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Photo by Stefan Els

APPENDICES

X-Link SDR Transceiver Key Specifications

X-Band Tx Operation	**8.025 - 8.400 GHz**
X-Band Rx Operation	7.145 – 7.250 GHz
Data Rate Sat2Ground	2 kbps …. 200 Mbps
Data Rate Ground2Sat	56 kbps+
Automatic Doppler Shift Compensation in Rx	≥ 200 kHz

4x4 X-Band Patch Antenna Key Specifications

Tx Center Frequency	**8.0 - 8.45 GHz**
Rx Center Frequency	7.145 – 7.250 GHz
Maximum Gain (Main Direction)	18 dBi
Polarization	RHCP
Connector Type	SMA (f)
Impedance	50 Ω

DTE Link Budget

Item	Unit	Uplink	Downlink
Satellite			
Transmitter Power	dBW	-	3.01
Line Loss	dB	1	1
Antenna Gain	dB	18	18
Ground Station (DSN)			
Transmitter Power	dBW	43	-
Antenna Gain	dBi	73	74
General			
Tx Frequency	MHz	-	8200
Rx Frequency	MHz	7200	-
Propagation Path Length	km	-	-
Miscellaneous Losses	dB	5	5
Polarization Mismatch Losses	dB	1	1
Free Space Loss Downlink	dB	-	222.40
Free Space Loss Uplink	dB	221.30	-
Rx Signal Strength	dBW	-100.3	-141.4
Minimum Receive Power	dBW	-125	-180
Data Rate Downlink	kbps	-	2000
Data Rate Uplink	kbps	500	-
Eb/N0	dB	52.4	16.3
Eb/N0 Required	dB	10.5	9.5
Link Margin	dB	41.9	6.8

APPENDICES

Cost and Mass Budget

Subsystem	Components	Suppliers	Size (LxWxH) [mm]	Mass [g]	TRL	Price [USD]
1.OBC	EnduroSat OBC	EnduroSat	0.12U	123	9	16k
2.COMMS	X-Link SDR Transceiver	IQspacecom	0.2U	365	9	40k
	X-Band Patch Antenna (4x4)	IQspacecom	100x100x2	40	9	10k
3.EPS	EnduroSat EPS II	EnduroSat	1.1U	1300	9	~40k
	6U Double Deployable Solar Array x 2	EnduroSat	(209x342x10) x2	1065 x2	9	88k x2
4.ADCS	Star Tracker - Sodern Auriga CP	Sodern	66x56x94	205	9	59k
	CubeSense Fine Sun Sensor x 2	CubeSpace ADCS	(24x35x22) x2	15 x 2	9	~3.25k x2
	CubeComputer	CubeSpace ADCS	90x96x10	70	9	~10k
	Solid State Propulsion Vacuum Arc Thruster x 3	Solid State Propulsion	(45x45x25) x3	360 x 3	6	~5k x3
	CW0057 CubeWheel Pyramid	CubeSpace ADCS	74x74x43	470		~80k
6.Payload	Radio Telescope Antenna	MIT Haystack	1U	1000	4	~200k
	Payload Compute Module (See section 4)	Developed by ESL	0.5U	300	4	~100k
7.Structure	ZAPHOD 6U Structure	AAC Clyde Space	100x226x341	674	9	~25k
Total				7,787		777,500

Power Budget

Component	Subcomponent	Power	
		Average [W]	Peak [W]
OBC	Endurosat OBC	0.9	1.5
Comms	X-Link SDR Transceiver with RF booster	7.5	20
	X-Link Quad Patch Antenna	-	< 2
EPS	Endurosat EPS	0.074	0.15
ADCS	Sodern Auriga CP	0.8	1.1
	CubeSense Fine Sun Sensor	0.1	0.174
	CubeSpace ADCS compute module	~ 0.5	~ 1
	CW0057 CubeWheel Pyramid	0.336	2.7
	Solid State Propulsion Vacuum Thruster	1	45
Payload	Payload antenna		
	Microchip SA.45s CSAC Atomic Clock	0.0066	0.066
	Xilinx Artix-7 FPGA	3	4.5
Total power demand		14.2166	78.19
Total + 10%		15.64	86.01
Total Solar Input [W]	38.4		
Battery Pack DOD [%]	86.03		