SIRONA

- a low-cost platform for lunar exploration –

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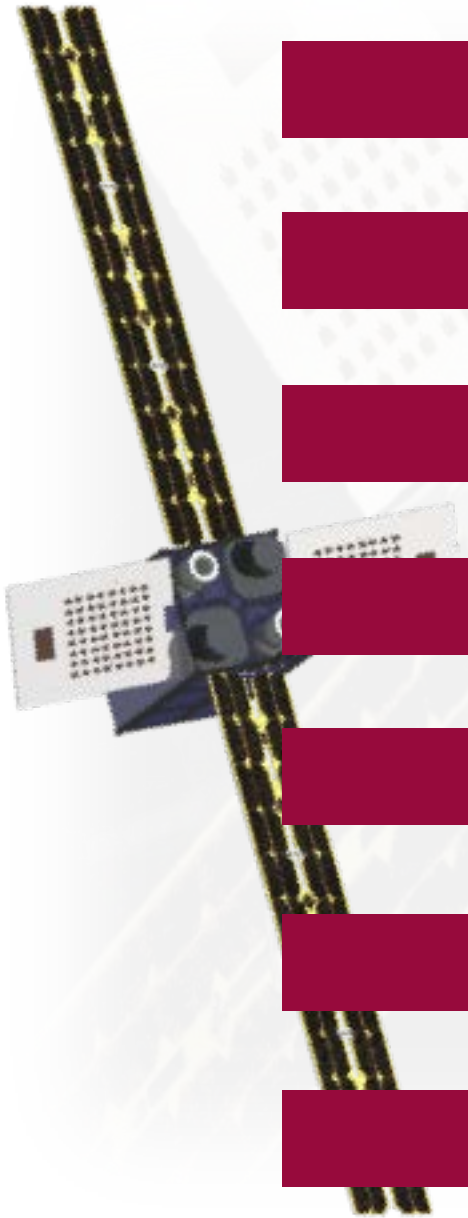
Overview



- Context
- Mission Objectives
- Mission Profile
- Platform Design
- ASTERICS / OBELICS
- Technological Blocks
- Conclusion

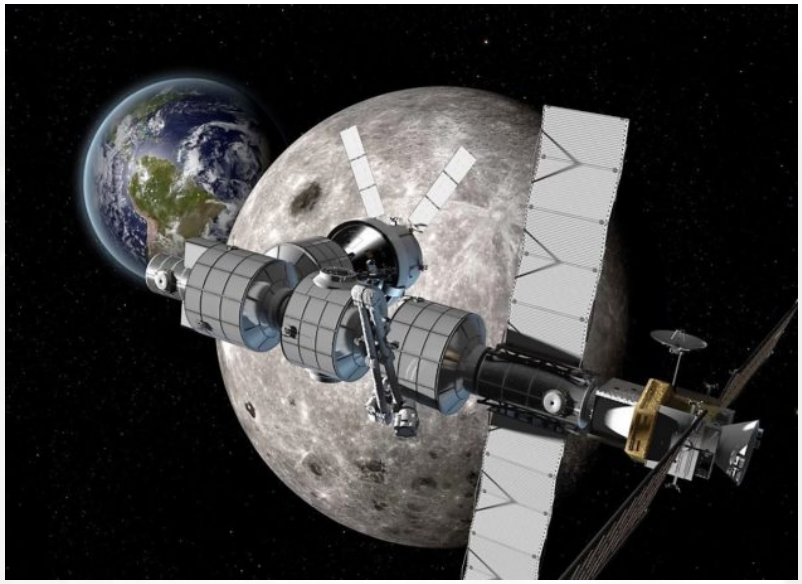
CS³ – Federating Decades of Experience in the Space Field

- Brand new campus located at the south border of Paris, France
- A FabLab/MakerSpace and high level research facilities ranging from Antenna testing to high enthalpy plasma torch
- 5 research labs and 7 departments of CentraleSupélec collaborating for the projects of the Space Center (CS³)
- 2017-2018: 15 students
- On the horizon 2020: 30-40 professors/research engineers
  + 120 students contributing to the CS³ projects

Mission Objectives

Scientific Objective (ASTERICS)

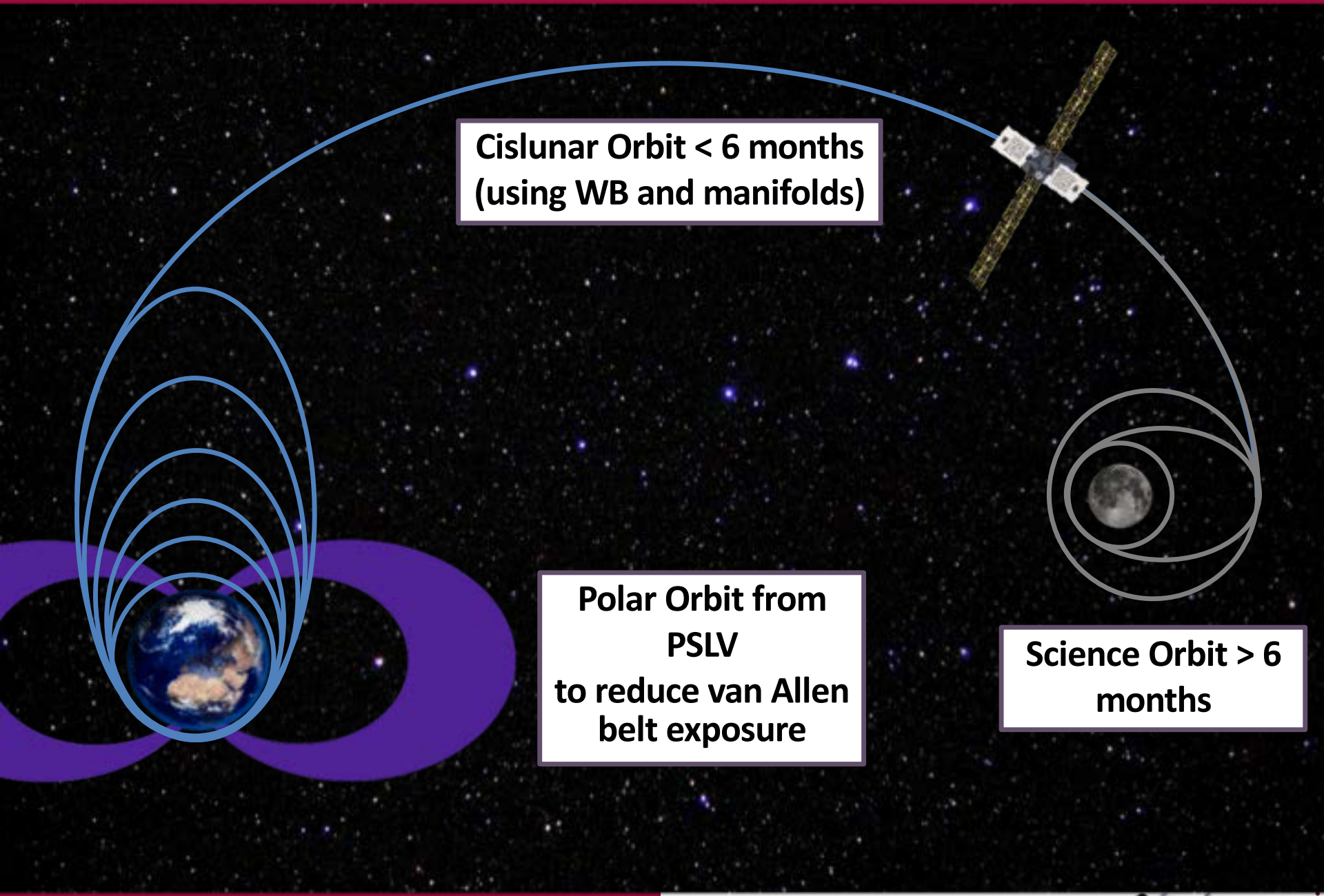
- **Test the hypothesis** of the Lunar Cataclysm
- Demonstrate the capabilities of a deployable telescope for Cube/SmallSats
- **Improve database** of LRO with additional data and different lightning conditions



Industrial Objective (OBELICS)

- **Optimize Radiation Shielding** for future human mission farther than LEO (Cislunar Station, Lunar/Martian colonies…)
- Study the **effect of Radiations** on biological samples
- Gather **long term data** surpassing Apollo program that lasted a maximum of 7 days at a time

Mission Profile



Platform design

SIRONA
Undeployed configuration
(left: scaling reference)

SIRONA
Deployed configuration

Platform design

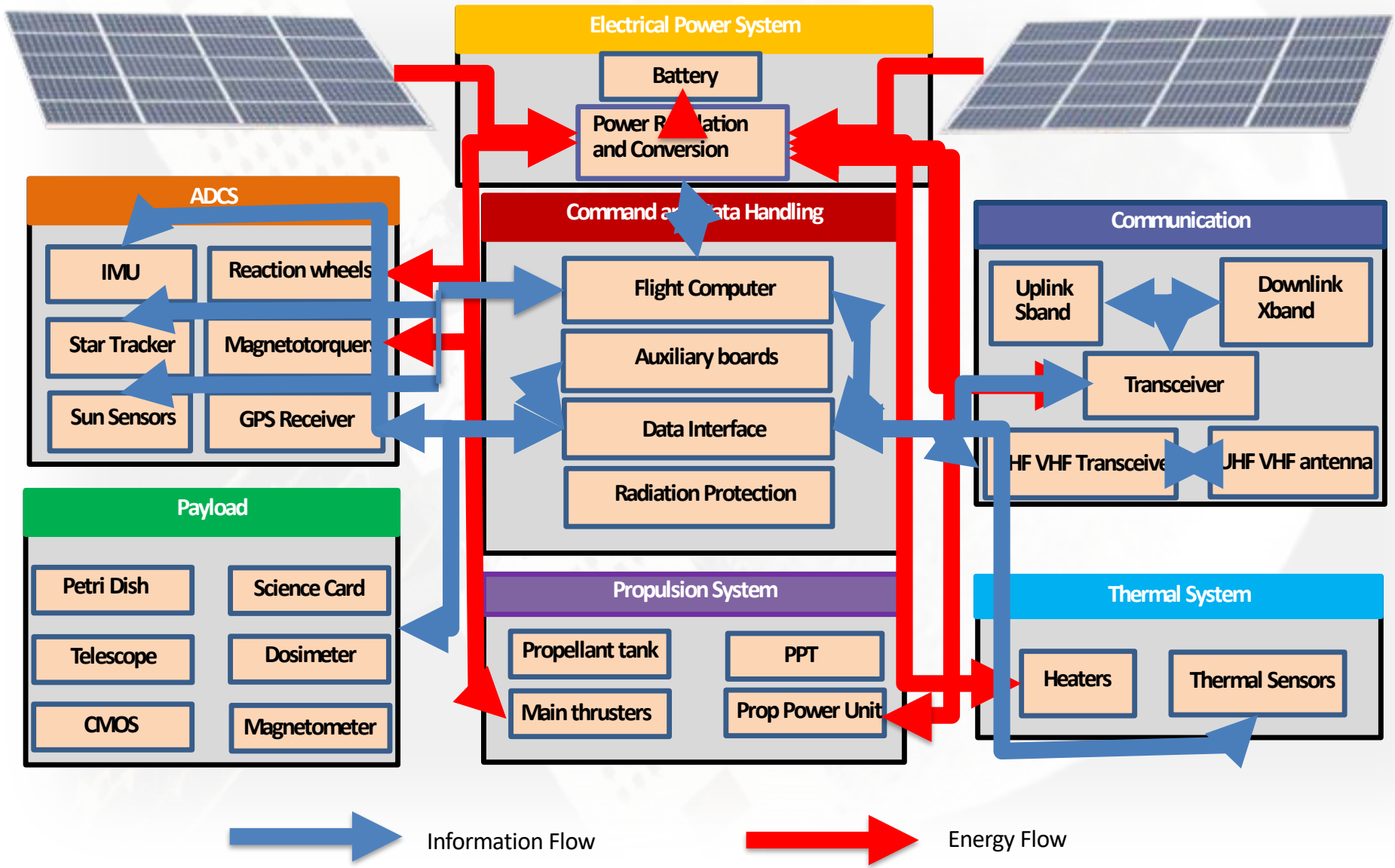
SIRONA
Undeployed configuration

SIRONA
Deployed configuration

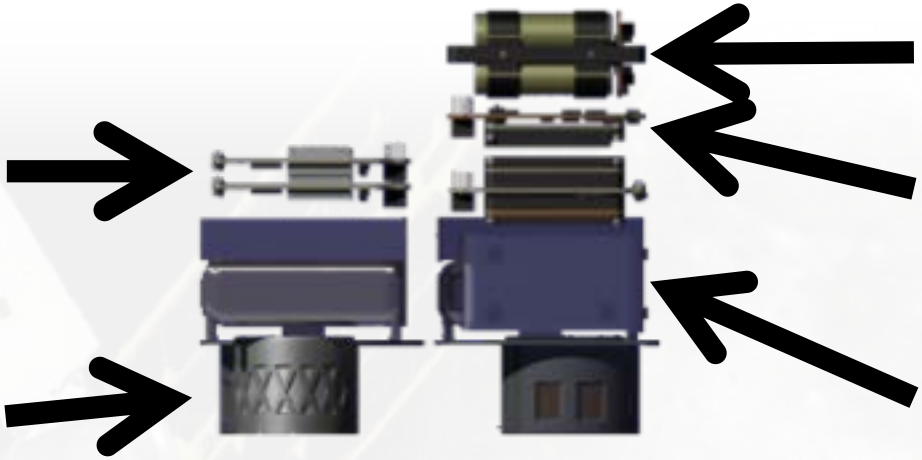
(Saint-Emilion Wine Bottles are for scale purposes and are not intended to promote the amazing french products)

Platform design

System description



Platform design



Command & Data Handling

Electric Propulsion Engine

Batteries

Electric Power System (EPS)

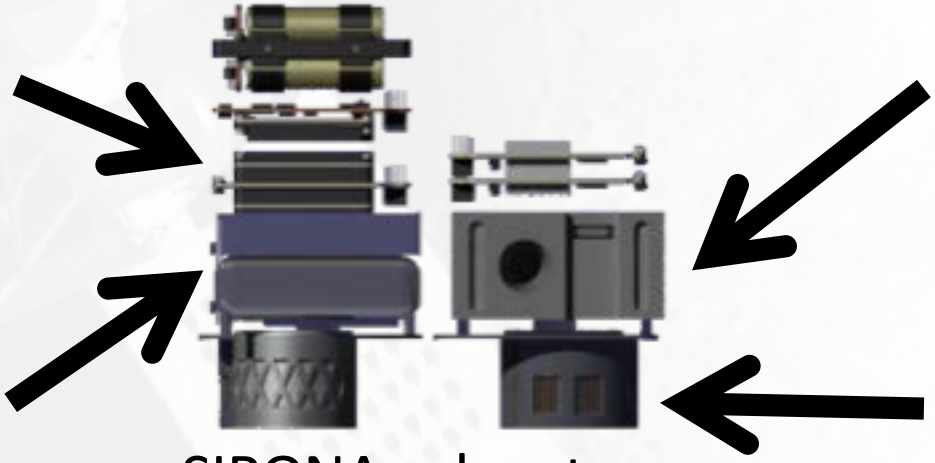
Transceiver

Tx: X-band

Rx: S-band

SIRONA subsystems

(front view)



On Board Computer

Ergol Tank & Propulsion Management Unit

Attitude Determination and Control Unit (ADCS)

Pulsed Plasma Thrusters

(Momentum Wheels desaturation)

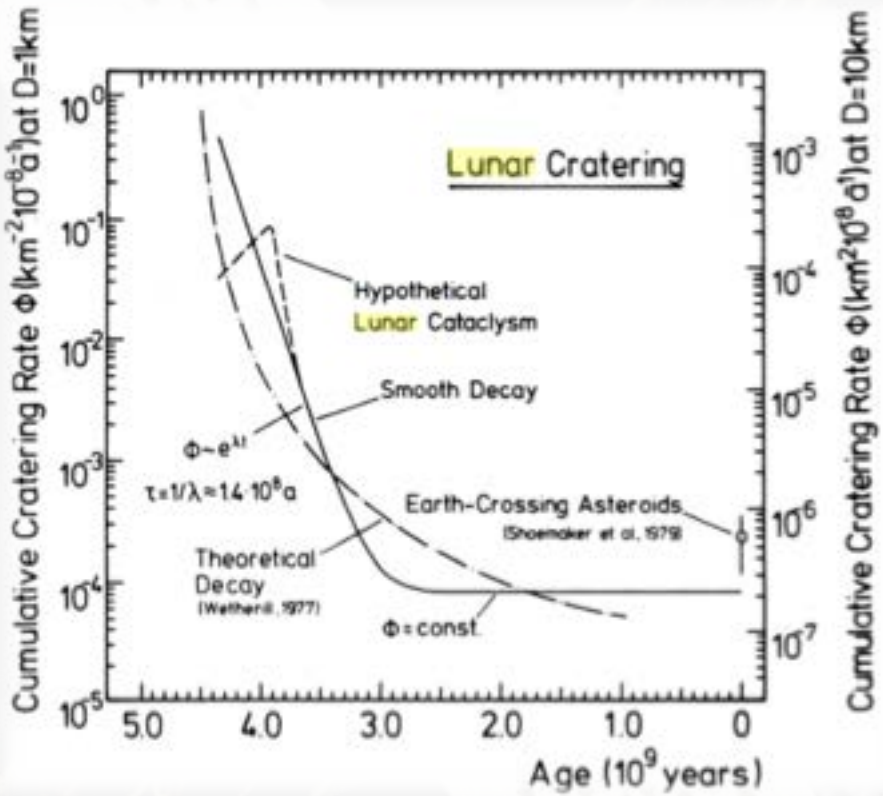
SIRONA subsystems

(back view)

7 units available for payloads and system margins

ASTERICS : Deployable Telescope

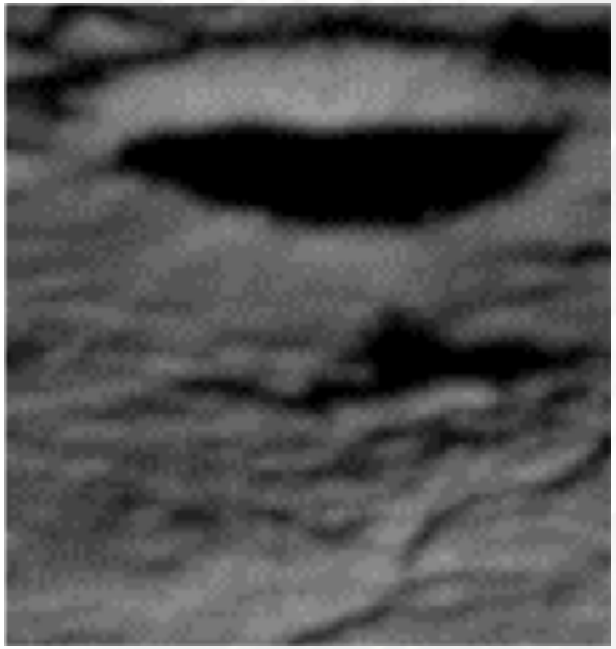
Time dependence of the Lunar cratering rate (Neukum 1983)



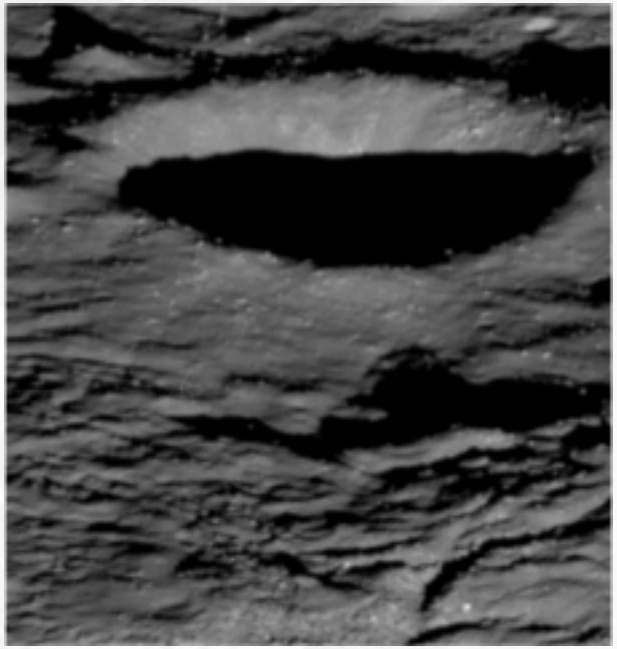
- Test the **cataclysm hypothesis** by providing high resolution images and detect all crater larger than 100 m of diameter

ASTERICS : Deployable Telescope

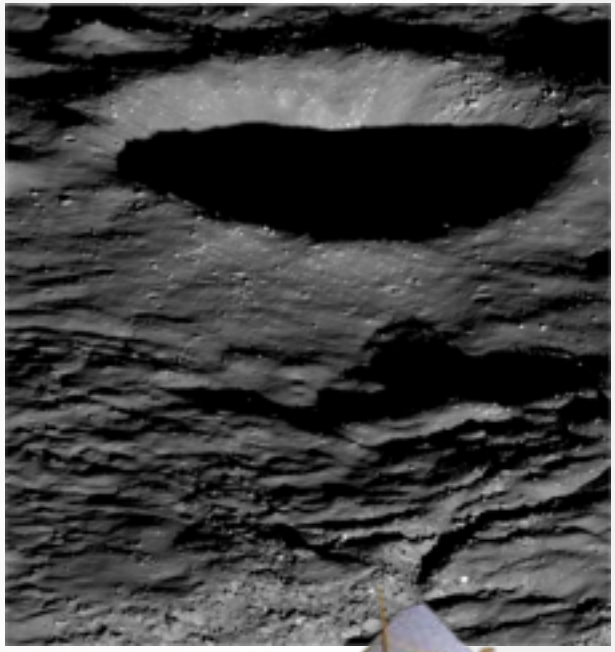
Non deployable CubeSat capabilities (simulated @ 200 km)



SIRONA capabilities (simulated @ 200 km)



Lunar Reconnaissance Orbiter (best data available, @50 km)



ASTERICS : Deployable Telescope

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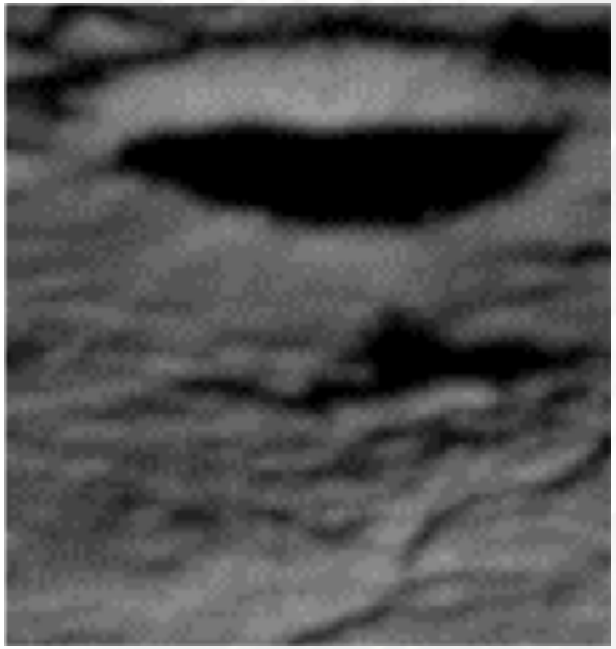

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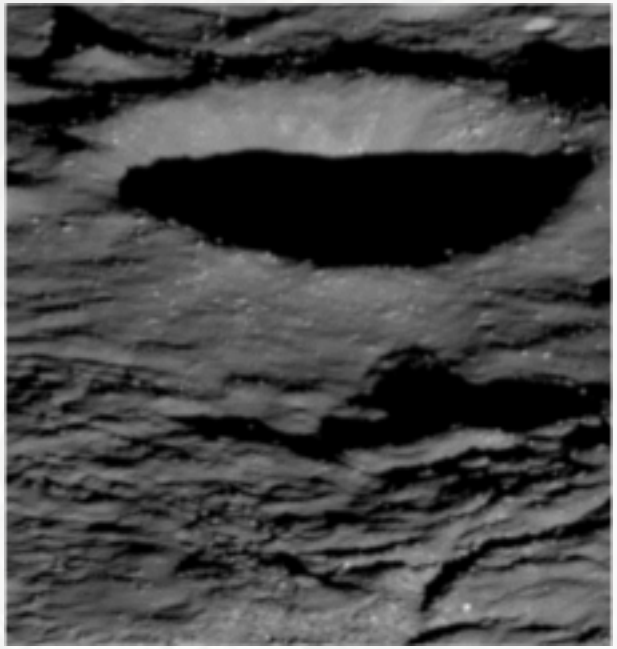

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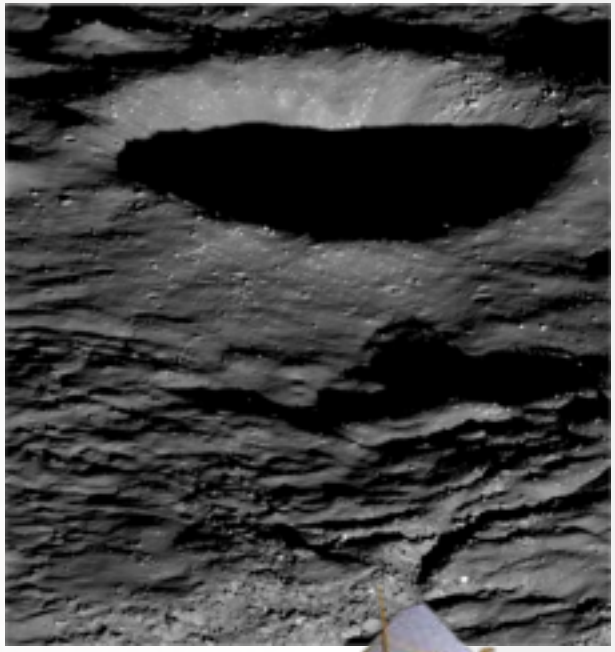

ASTERICS : Deployable Telescope

Deployment strategy

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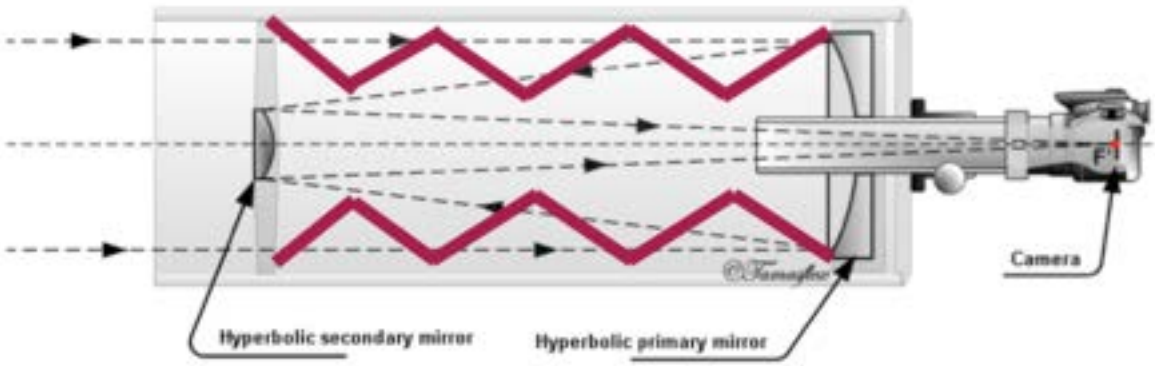
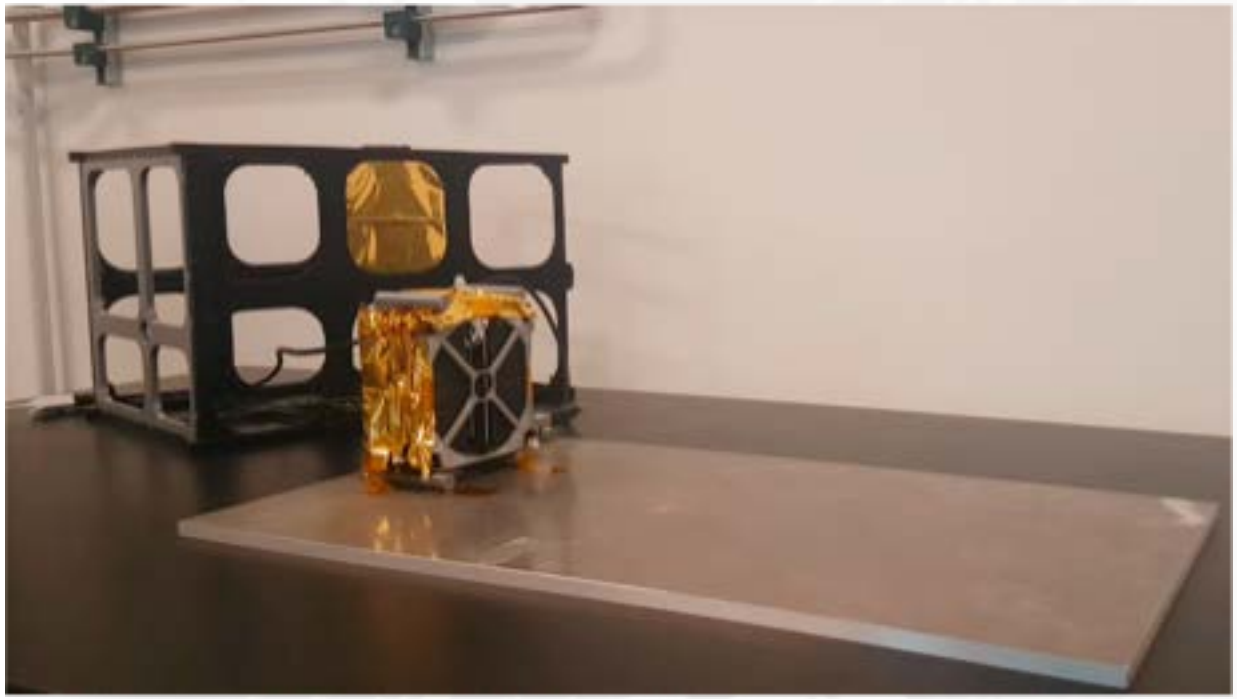
Deployment strategy



- Ritchey-Chrétien architecture
- f/10 design
- Highly compact when stowed
- Scalable for any mission/platform

ASTERICS : Deployable Telescope

Deployment validation of ASTERICS's concept

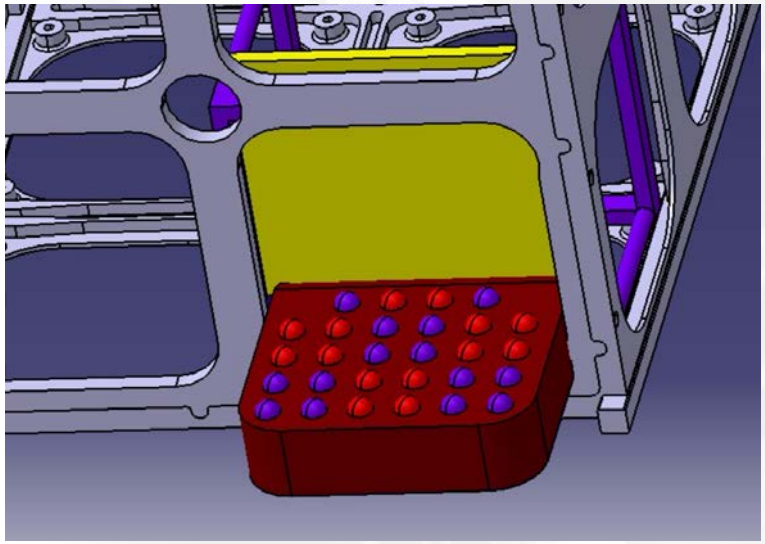


- Low mass/volume (x5 deployment factor, < 500 g)
- Passive deployment method (hot knife)
  - **Next step: Validate alignment (with piezo subtrate) on a Zero-g flight**

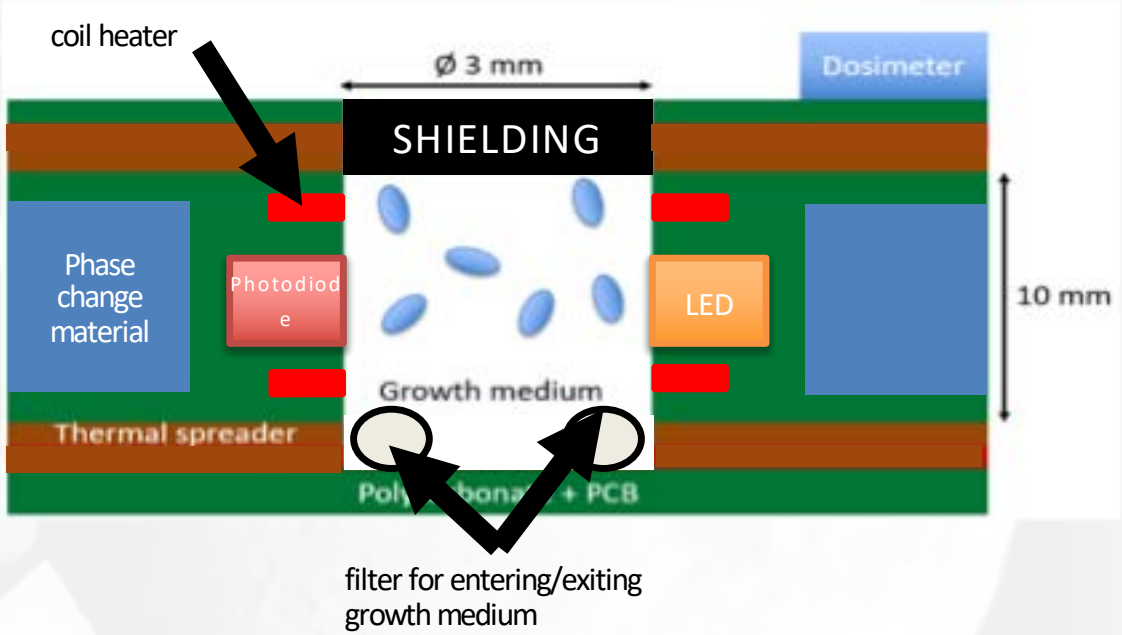
See Tarik Errabih's poster

OBELICS : Biological Experiment

OBELICS' deployment



Wells' design



- Low mass/volume (testing with 10 to 100 wells, < 500 g)
- Passive deployment method (hot knife) allowing higher exposure to the radiation
- Validation of the protocol this summer (with LPGP)

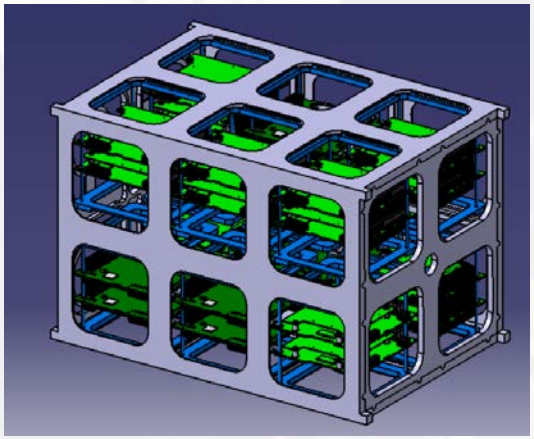
➢ **Next step: Test of the payload in a relevant environment**

(alpha and proton accelerator at CEA)

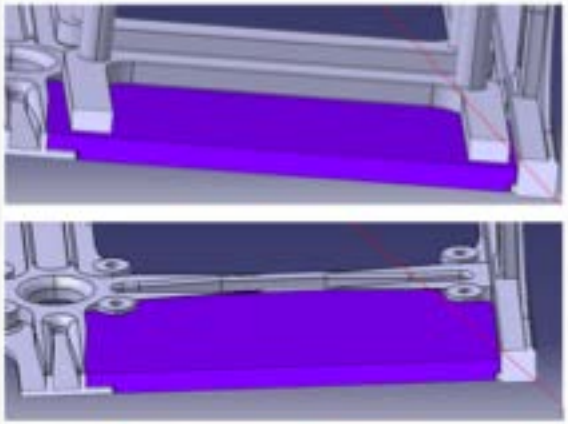
Technological Blocks

Composite structure

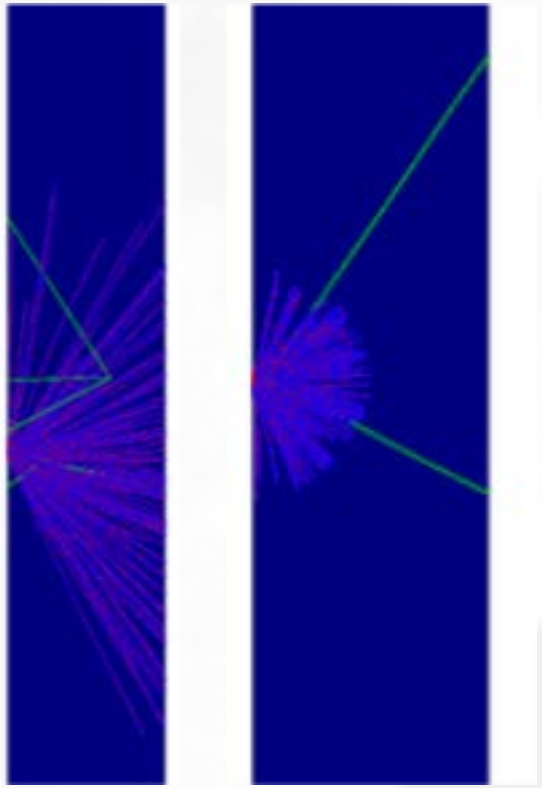
Cells arrangement and optimized structure



Radiation shielding panels



Radiation Shielding using HDPE and Mylar (SPENVIS)



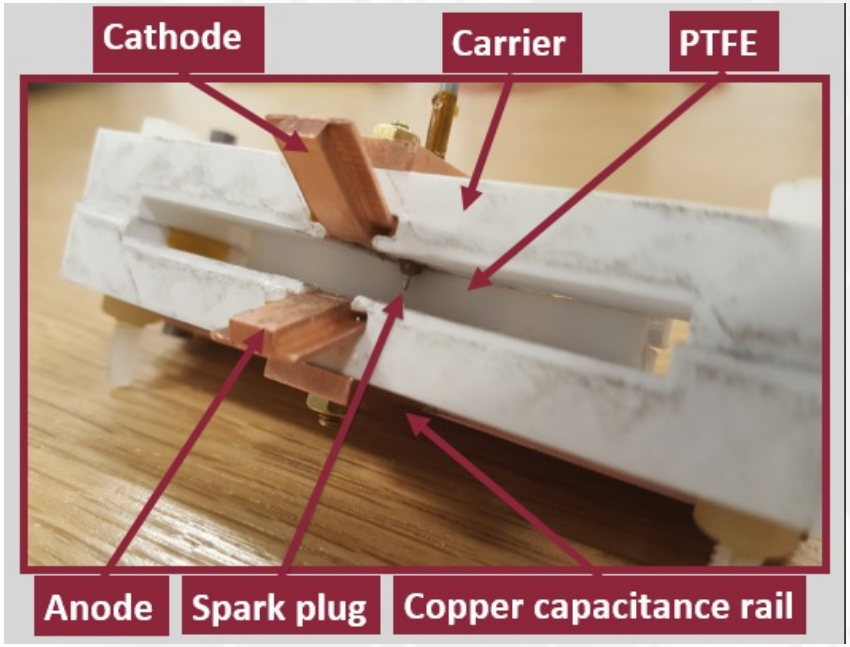
e=1 mm e=4 mm

➢ **Next step: Test of the composite structure in a relevant environment (alpha and proton accelerator at CEA)**

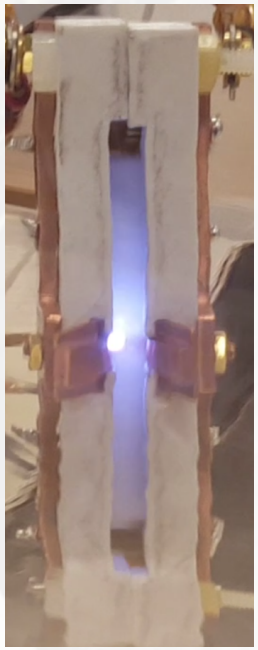
Technological Blocks

Momentum wheel desaturation with small plasma thrusters

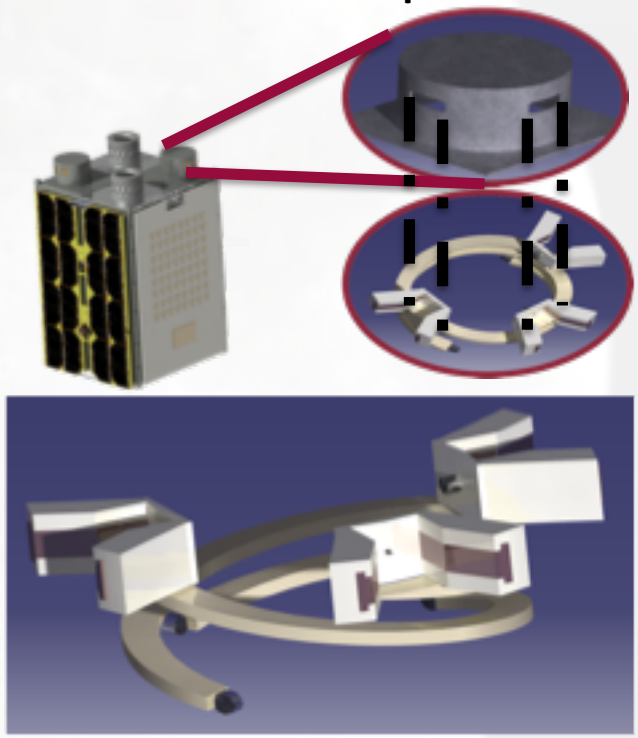
Proof of concept



Successful 1st test campaign



Final Concept



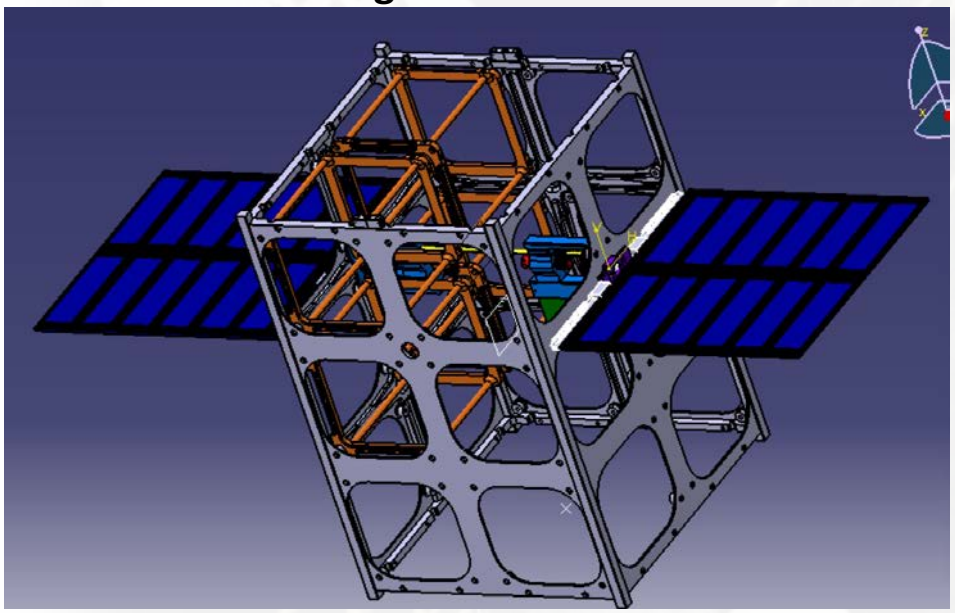
- Compact solution able for desaturation of the wheels around on the 3 axis
- Extend lifetime of the mission
- Increase volume/mass budgets compared to cold gas solutions
- Allows fine maneuvers if needed

➢ **Next step: Reach TRL5 and test @ONERA (µN level performance testing)**

Technological Blocks

Panel Array Drive Assembly

PADA integration on SIRONA



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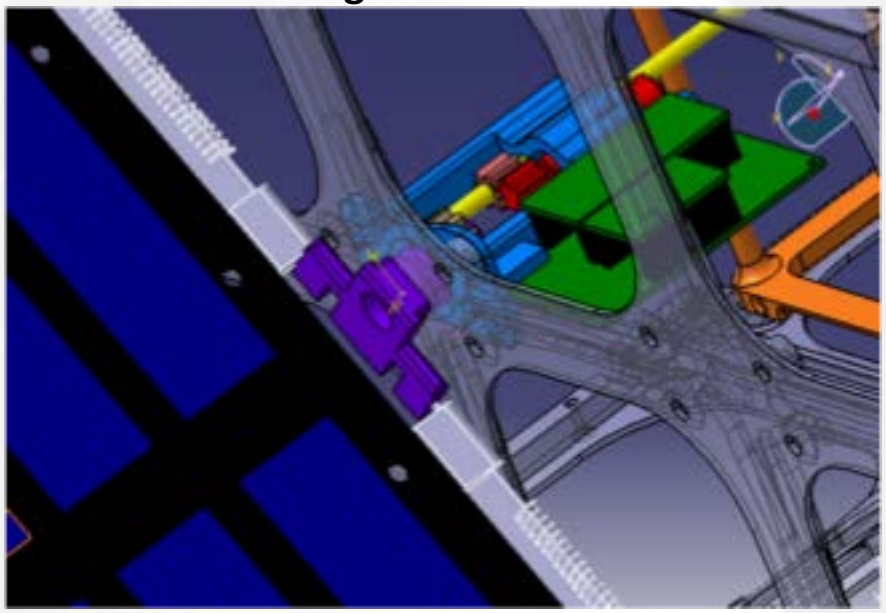

- Allows fine pointing of the Sun (solar panels)
- Allows fine pointing of the Ground Station (S/X-band micro patch array antenna)
- Increase Power and Data budgets
- Use “free volume” for the assembly (no impact on the payload accommodation)
- Increase EPS and COMS redundancy

See Marcus Hott’s poster

➢ **Next step: Refine the design for 3 to 27U and propose it to the CubeSat Missions**

Conclusion

Subsystems	Mass (in g)
Structure	1700
Radiation Shield	150
Thermal Components	150
Solar Panels	900
Power Board (EPS)	110
Solar Panel Motor	20
Battery	1000
Command and Data Handling	300
Antenna 1 (DOWNLINK)	64
Antenna 2 (UPLINK)	65
Beacon UHF/VHF (for AMSATs)	85
Transmitter	50
Receiver	50
IMU	80
Star Trackers	200
Sun Trackers	36
GPS Receiver	45
Reaction wheels	1200
PPT	300
Main Propulsion	4500
Deployable Telescope	500
Biological Experiment	385
Dosimeter	32
TOTAL	11922

- SIRONA is a feasible and realistic low cost platform for lunar exploration
  - ➢ only 12kg (including ASTERICS and OBELICS)
- Industrial interest
  - ➢ Qualifying radiation shielding in relevant environment for future human missions
- Scientific interest
  - ➢ testing the cataclysm hypothesis for research on the solar system history

Large Volume/Mass available (8 kg) for other experiments or technology demonstration in lunar environment

- ➢ **SIRONA** is aiming to become a **space bus** for the lunar exploration community providing with
- **high downlink** capabilities
- **Trouble-free** platform integration and maintenance for the hosted payload

Soutenu par

ThalesAlenia Space

université PARIS-SACLAY

CentraleSupélec

Thank you for your attention

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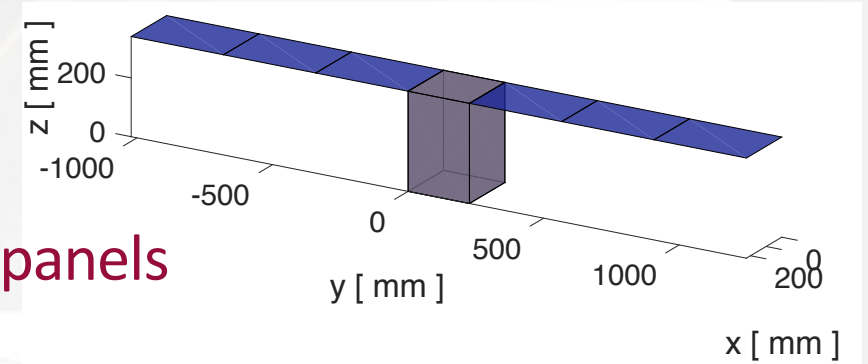
Cécile Oriot and Sylvain Leclercq (Com' CentraleSupélec)

The IPPW comity for accepting this oral presentation

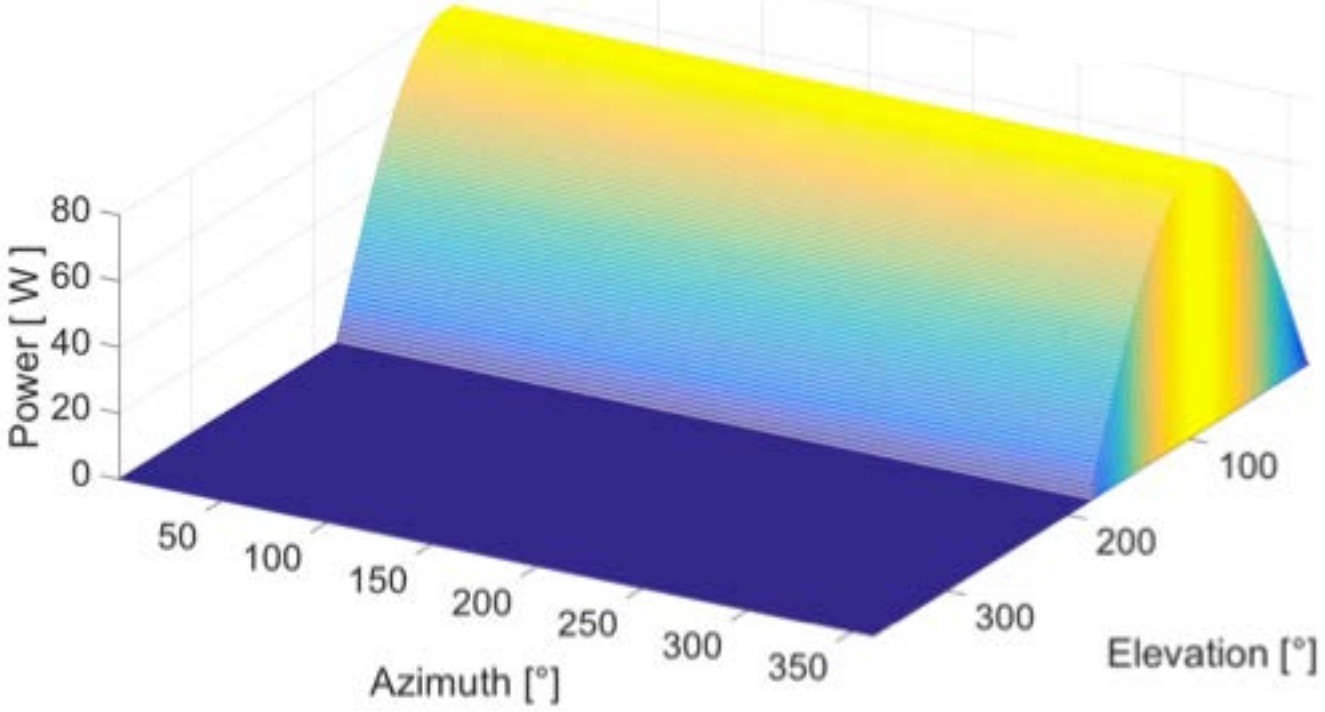
EPS - Electrical Power System

➔ **Large deployable solar panels. Direct them always towards the sun.**

➔ **Development of the <u>PADA</u>**



12U CubeSat with large deployed solar panels



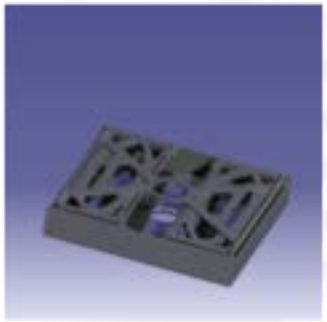
COMS - Communications

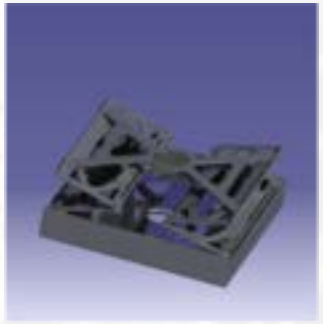
*Summary of SIRONA's parameters in the **lunar phase***

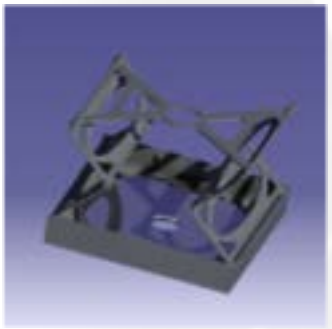
PARAMETER	VALUE
Signal/General	
Downlink Frequency Band	X-Band
Uplink Frequency Band	S-Band
Signal Polarization	Circular polarisation
Modulation Scheme	QPSK
Minimum elevation angle	15°
SIRONA Tx	
Power	5.0W
Antenna Gain	25.0dBi
Antenna type	Micropatch-array
SIRONA Rx	
Antenna Gain	1.0dBi

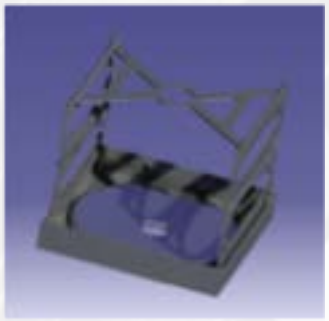
ASTERICS : Deployable Telescope

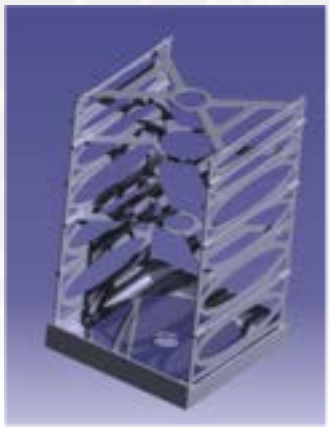
First Stage Deployment





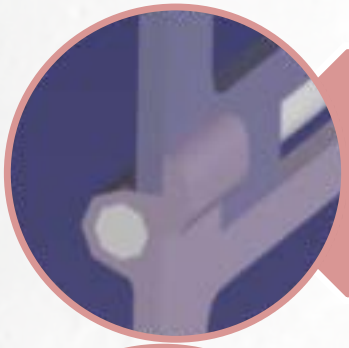




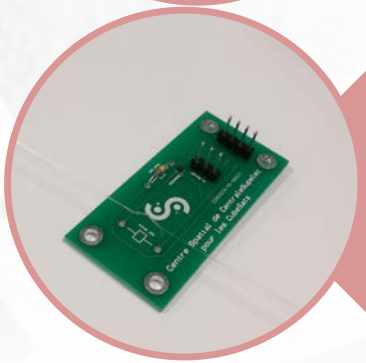


Final Deployed Configuration

Panels deployment by springs



Stops



Release Mechanism