A 3U CUBESAT FOR EARTH OBSERVATION AND ELECTRIC PROPULSION TECHNOLOGY DEMONSTRATION

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United Nations/Brazil Symposium on Basic Space Technology
"Creating Novel Opportunities with Small Satellite Space Missions"

Natal, Brazil – September 11-14, 2018

CONCEPT

- UniPolar: a pioneer project, intended to jumpstart cooperation between
  - Brazil (University of Brasília - UnB, …?)
  - Poland (Warsaw University of Technology, Warsaw Institute of Aviation)
  - UK (University of Southampton)
  - Other international partners…?
- In the field of NanoSats
  - 3U CubeSat
    - Earth Observation
      - Pollution, Climate change
    - Technology Demonstration
      - Electric Propulsion (Ablative Pulsed Plasma Thrusters – APPTs)

PREVIOUS EXPERIENCE

- University of Brasília
  - SERPENS , a 3U CubeSat, deployed from the ISS on September 17th, 2015
  - SERPENS II, another 3U CubeSat, currently being developed
  - Preliminary mission design studies (Acta Astronautica, April 2018)

Acta Astronautica 145 (2018) 11–17

Contents lists available at ScienceDirect

Acta Astronautica

journal homepage: www.elsevier.com/locate/actaastro

CubeSat constellations for disaster management in remote areas

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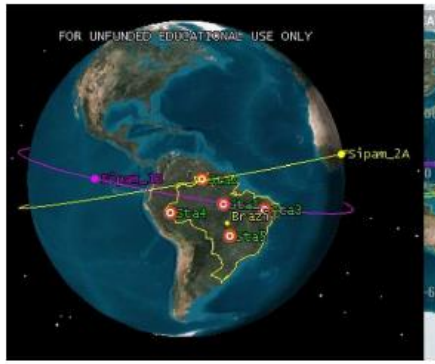
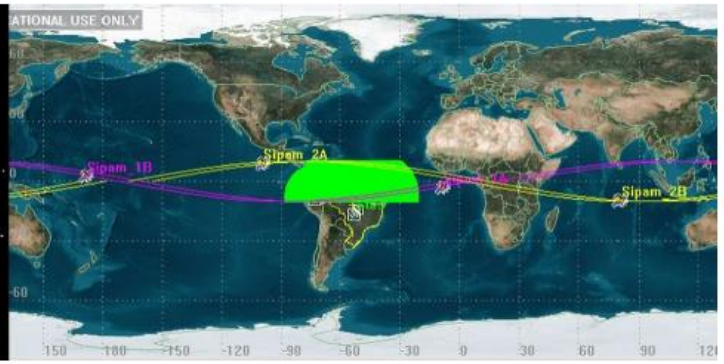
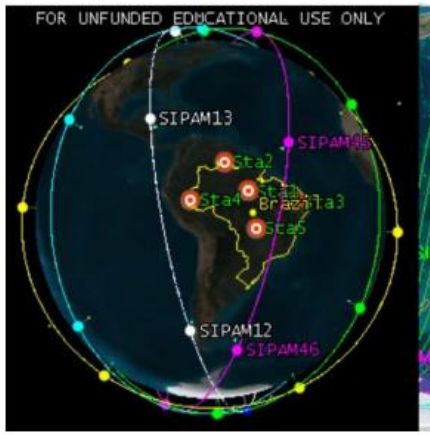
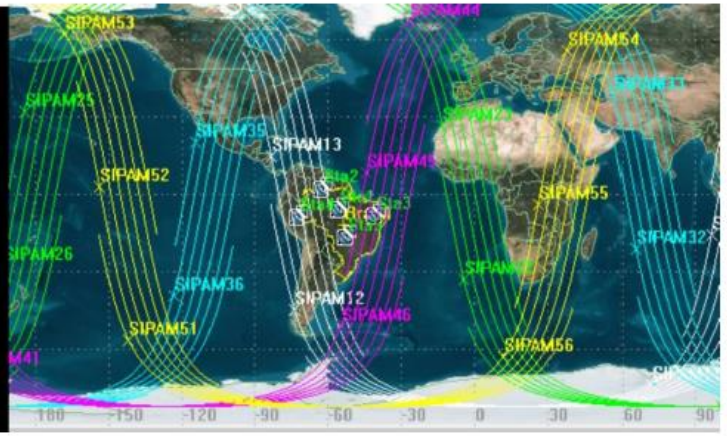


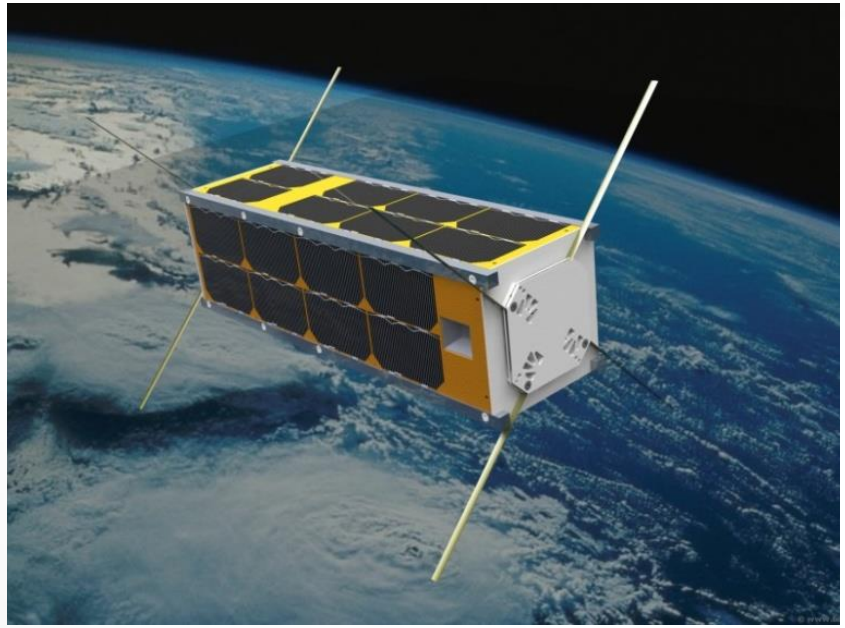






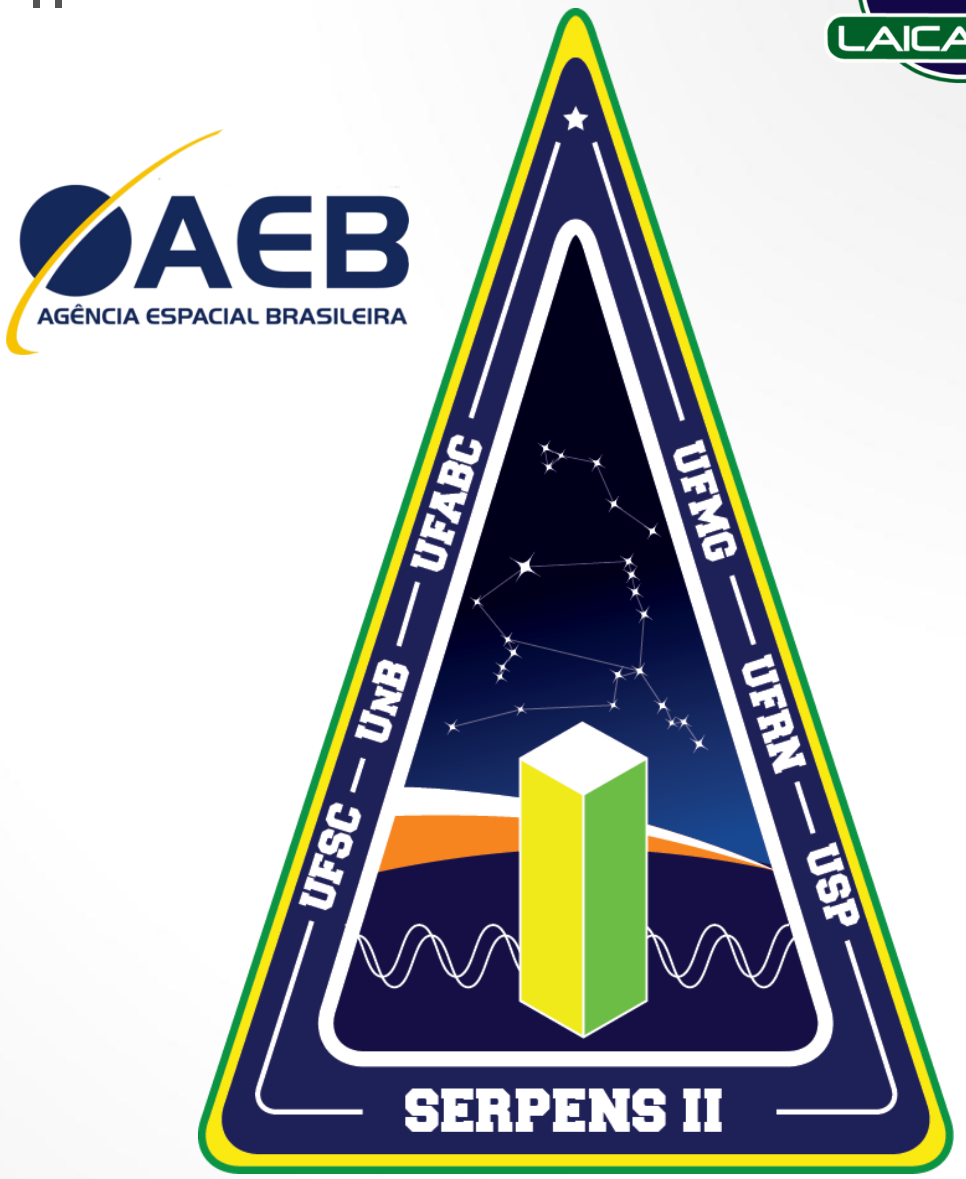
SERPENS

- First satellite in a program, supported by AEB, created to foster nanosatellite development by Brazilian universities
- UnB had leadership of the project
- In cooperation with Universidade de Vigo, CalPoly, Sapienza Università di Roma, Morehead State University



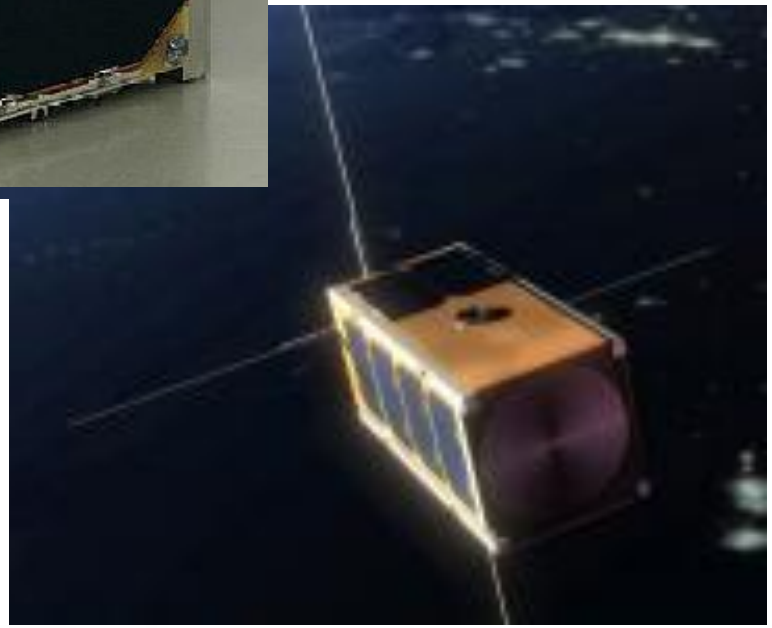
SERPENS II

- Second microsatellite in the program
- UFSC has the leadership of the project
- Many universities involved (UFSC, UFMG, UFABC, UnB, UFRN, UFSM, USP)
- UnB takes care of the APPT and of the orbit determination system



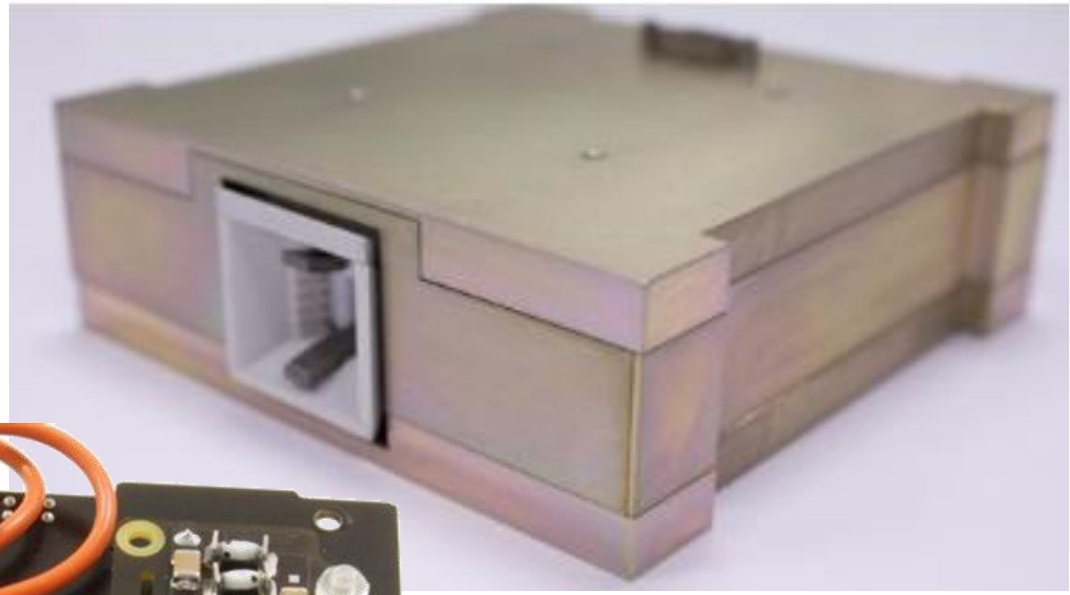
PREVIOUS EXPERIENCE

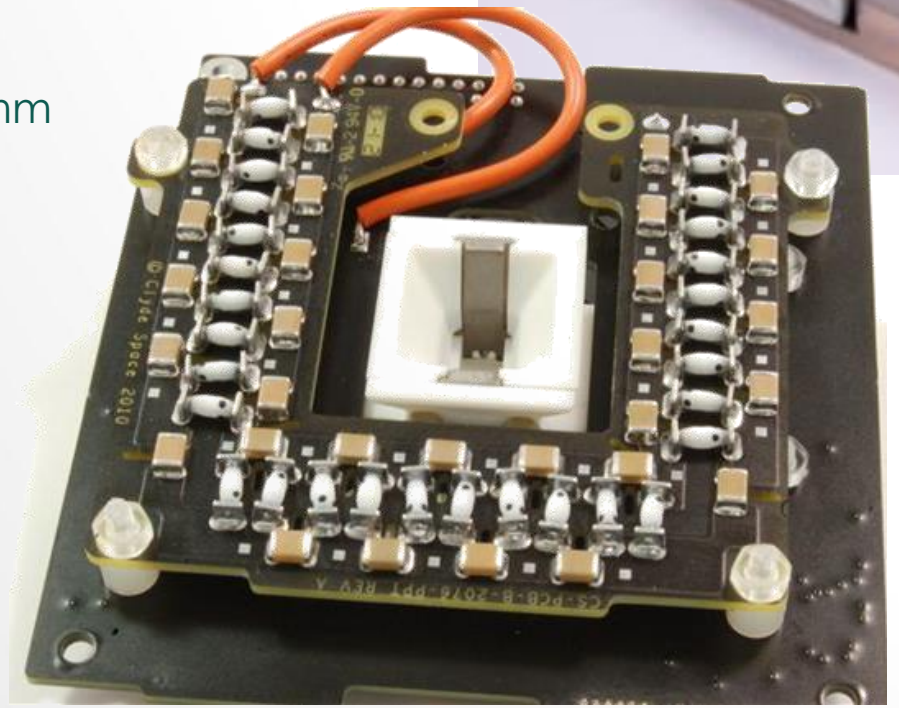
- Warsaw University of Technology
  - Two CubeSats
    - PW-Sat and PW-Sat2
- Warsaw Institute of Aviation
  - Remote Sensing Division
    - Data analysis, image processing
    - Multispectral camera Quercus



PREVIOUS EXPERIENCE

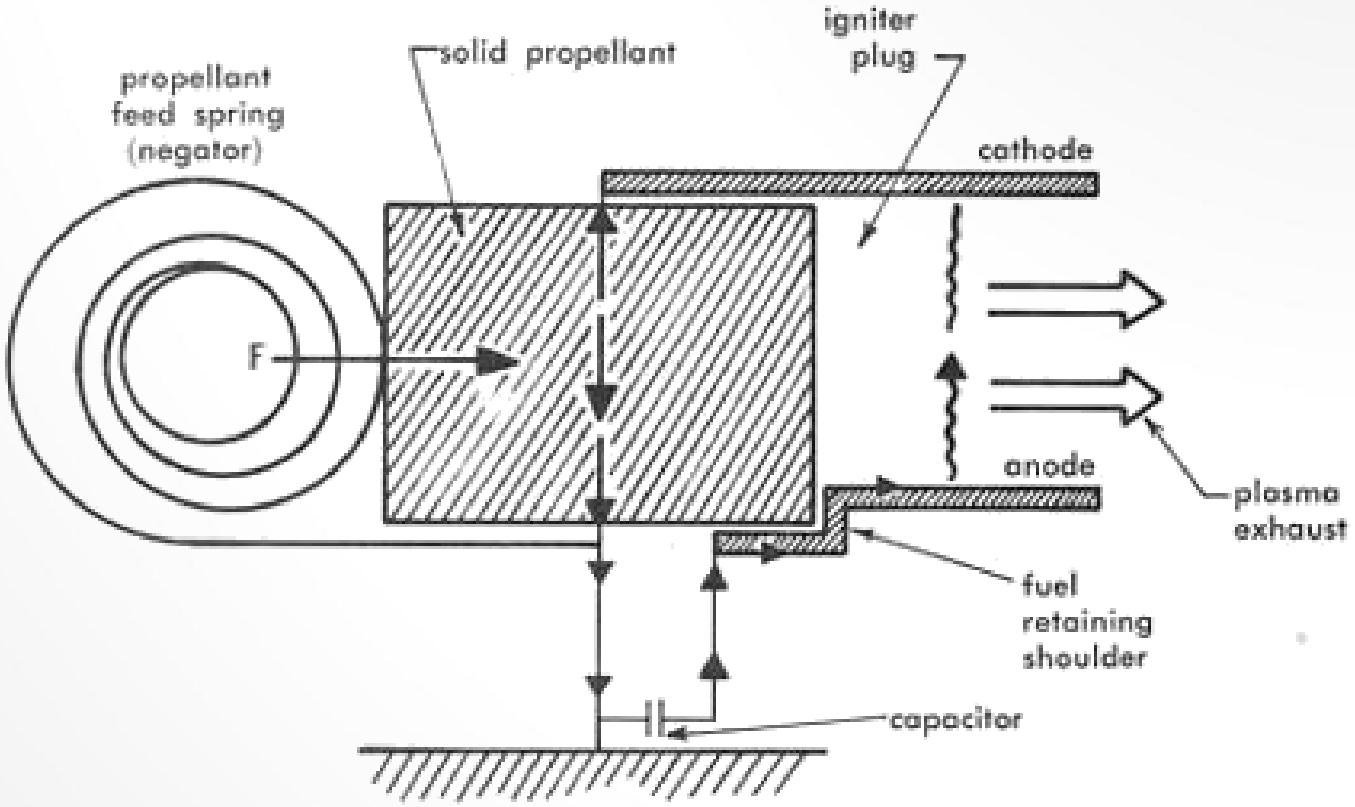
- University of Southampton
  - Electric Propulsion (APPTs)
    - PPTCUP with Mars Space Ltd., a spinoff company established in 2007, and Clyde Space Ltd.
      - Dimensions: 100 mm x 100 mm x 33 mm
      - Mass: 280 g, with EMI shielding
      - Power draw: < 2.7 W
      - Impulse bit: 38 μNs
      - Specific Impulse: 600 s
      - Total Impulse: 42 Ns / 63 Ns
        - Two versions available
        - Further customizable





ABLATIVE PULSED PLASMA THRUSTER - APPT

- Pulsed electric discharge (capacitor charged at high voltage) between two electrodes across the surface of a Polytetrafluoroethylene (PTFE) block
- Propellant ablated and accelerated partly by Lorentz force, partly thermally
- No moving parts, piping, tanks, valves: simple and robust
- Easily scalable to low and high power values
- Because of the above, used in spite of low efficiency
  - Late-time ablation: part of propellant ejected thermally, which decreases specific impulse

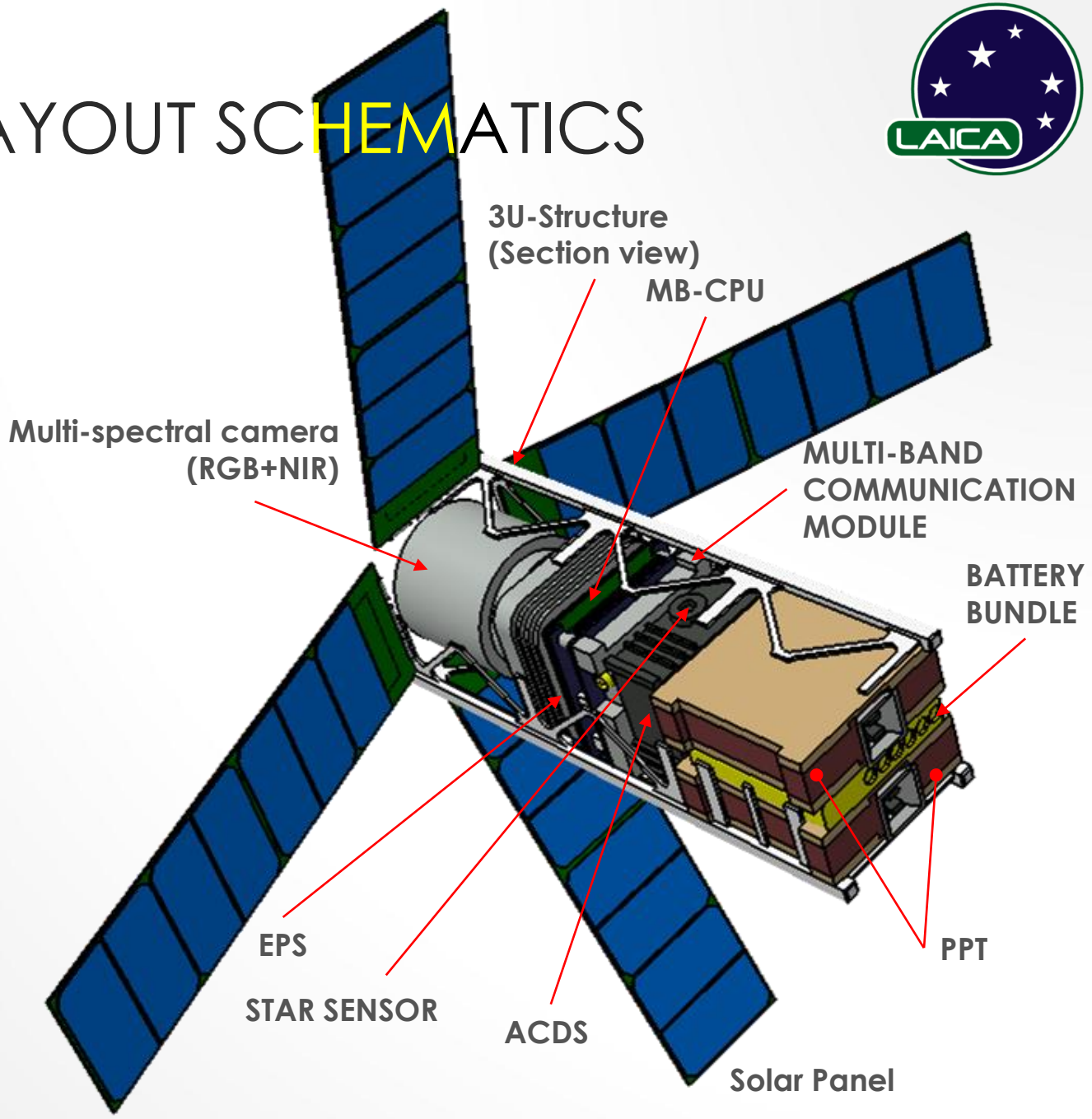


MICROPROPULSION FOR NANOSATS
APPT FOR CUBESAT DRAG COMPENSATION

Altitude	Average orbit power for drag compensation	CubeSat Size	Natural Life	Life with µPPT	Life increase
250 km	2.4 W	1U	5.7d	17d	+200%
		2U	11d	22d	+100%
		3U	17d	28d	+66%
300 km	0.7 W	1U	21.6d	58d	+170%
		2U	1m 13d	2m 19d	+85%
		3U	2m 4d	3m 11d	+56%
350 km	0.26 W	1U	2m 8d	5m 21d	+150%
		2U	4m 16 d	8m	+75%
		3U	6m 24d	10m 8d	+50%
400 km	0.1 W	1U	6m 12d	1y 3m	+140%
		2U	1y 1m	1y 10m	+70%
		3U	1y 7m	2y 4m	+46%
450 km	0.04 W	1U	1y 5m	3y 3m	+133%
		2U	2y 10m	4y 8m	+67%
		3U	4y 2m	6y	+44%

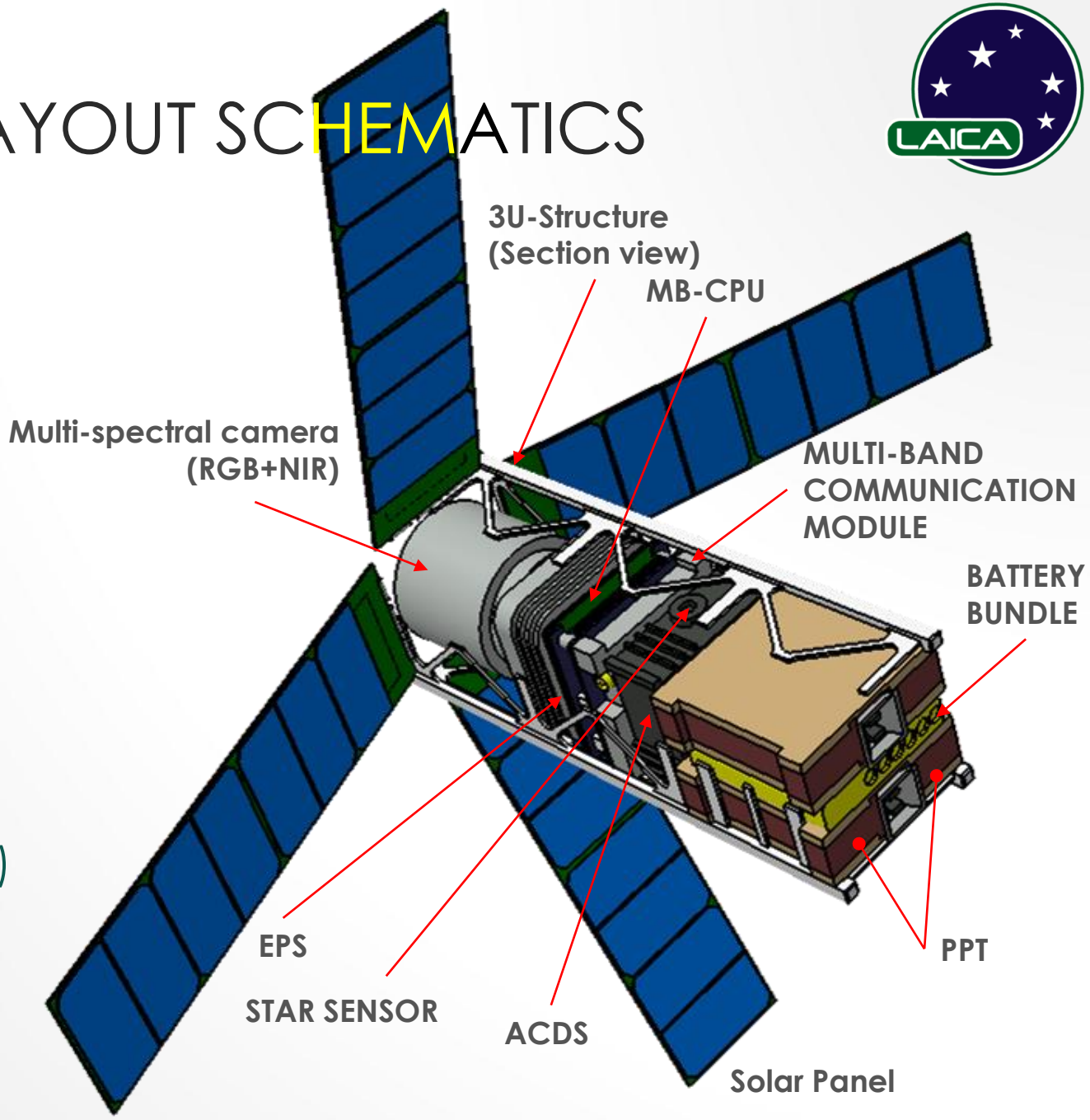
PRELIMINARY LAYOUT SCHEMATICS

- 3U CubeSat platform
  - Onboard power budget < 10 W
    - solar cells on satellite body and on deployable panels
    - Li-Ion battery package
  - A 3-axis ADCS
    - Star sensors
    - Reaction wheels and magnetorquer module
  - An X-band transceiver
    - data download
  - An S-band system
    - telecommunications, tracking and command.



PRELIMINARY LAYOUT SCHEMATICS

- Payload
  - Two PPTCUP electric propulsion systems
    - Both mounted at one end
      - Thrusters can be fired together, for orbit modification, or alternately, to rotate the satellite about one of its principal axes
        - Technology demonstrator
  - A compact multi-spectral camera
    - Four adjacent channels (0.48 – 0.9 μm)
    - Low spatial resolution (<100 m)
      - optical system and CCD detector
        - Already space-tested



MISSION

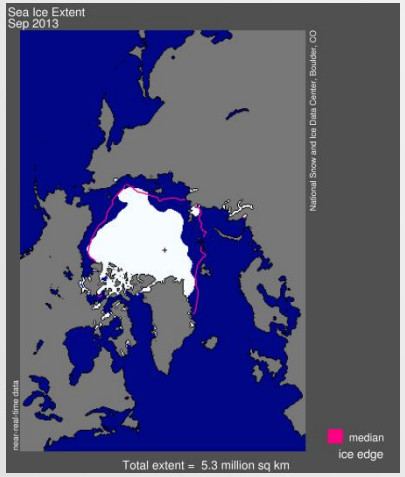
- Technology Demonstration
  - By accurate orbit and attitude tracking the performance of the APPTs can be assessed
    - PPTCUP electric propulsion system will thus be space-qualified
    - Pointing accuracy desirable < 0,1°
- Earth Observation
  - 500 km Low-Earth Orbit, images with a spatial resolution of <100 m
    - By launching the satellite into a high-inclination orbit, the optical payload could be used to monitor the spectral reflectance of polar caps
      - The data thus collected would be extremely useful for the investigation of pollution and climate change
    - Images taken at lower latitudes could also be used, for example to monitor deforestation in remote areas
      - Non-SSO makes corrections necessary for inconsistent lighting conditions

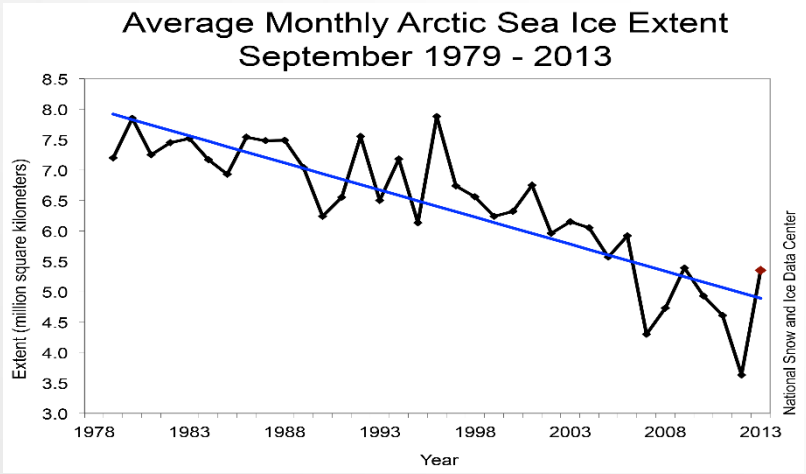
MULTI-SPECTRAL CAMERA FOR POLAR CAPS MONITORING: PROBLEM

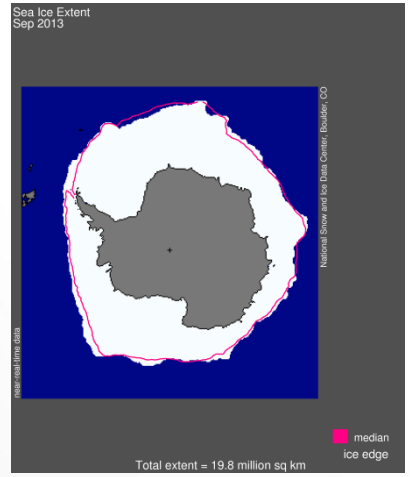
- Polar caps are a sentinel of global change. These regions are influenced by multiple physical and socio-economic drivers and feedbacks, impacting both natural and human environment
  - Air pollution is one such driver, impacting climate change, ecosystems and health
    - Significant uncertainties still surround quantification of these effects
  - Air pollution includes
    - Harmful trace gases (e.g. tropospheric ozone) and particles (e.g. black carbon, sulfates)
    - Toxic substances (e.g. polycyclic aromatic hydrocarbons) that can be transported to the Polar regions from emission sources located far outside the region, or emitted within the Arctic from activities including shipping, power production and other industrial activities

MULTI-SPECTRAL CAMERA FOR POLAR CAPS MONITORING: GOALS

- Estimate the variations of Albedo associated with the precipitation of pollutants in the Polar areas
- Perform spectral classification to distinguish the presence of moss, lichens and other types of surface covering vegetation
- Normalize the data collected on polar regions, in order to integrate with other data from similar missions and so be able to improve time analysis and determine more accurate trends

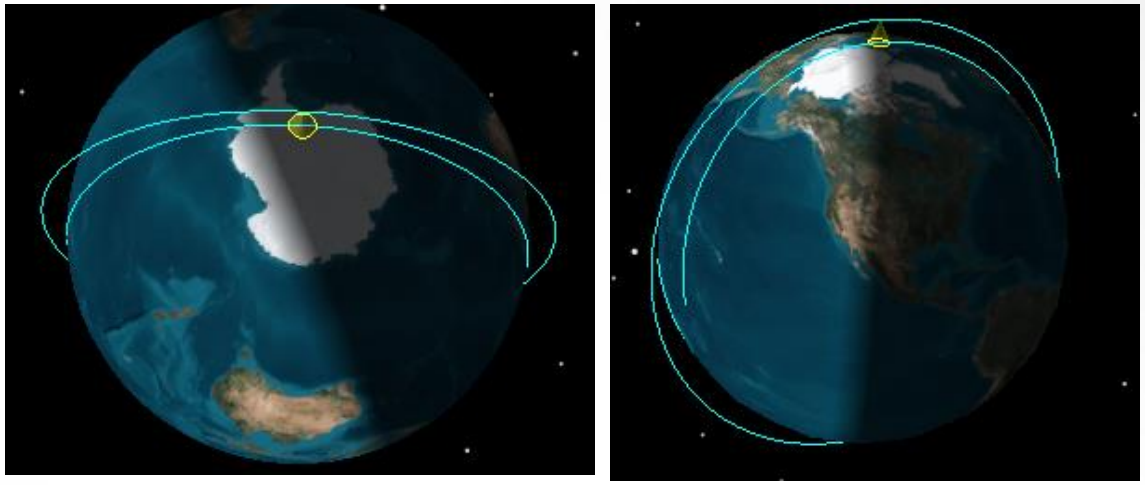






MULTI-SPECTRAL CAMERA FOR POLAR CAPS MONITORING: PAYLOAD AND MISSION ANALYSIS

- Almost polar orbit
- Low spatial resolution and large Swath
- High revisit time



Parameter	Spatial Resolution (m)	Swath (Km)	Revisit Time (days)	Spectral Resolution (bands)
	< 100	1230	< 1	B,G,R,NIR

CONCLUSIONS

- Electric Propulsion onboard NanoSats is not a widespread application yet
- UniPolar will space-qualify PPTCUP, an APPT system developed by UK partners
- Traditionally, EO satellites have been quite large, with masses on the order of hundreds of kg
- Nowadays we have the capability of realizing this specific EO application, with a much lower cost and similar performance, by using NanoSat technology
- This is extremely important in order to make access to space available to low-budget actors, such as academic institutions and organizations in developing countries

Thanks for your attention!
Any questions?

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