HORUS constellation

Pre-4th Mission Idea Contest Workshop

Tokyo, July 3rd - 5th 2015

SAPIENZA
UNIVERSITÀ DI ROMA

TABLE of CONTENT

AIR POLLUTION

CLIMATE CHANGE




HOW CAN THEY BE MONITORED?

Studying top-of-the-atmosphere and bidirectional albedo

Analysing main cloud features

Analysing atmospheric aerosols and dust

Investigating land surface characteristics

EXISTING SOLUTIONS

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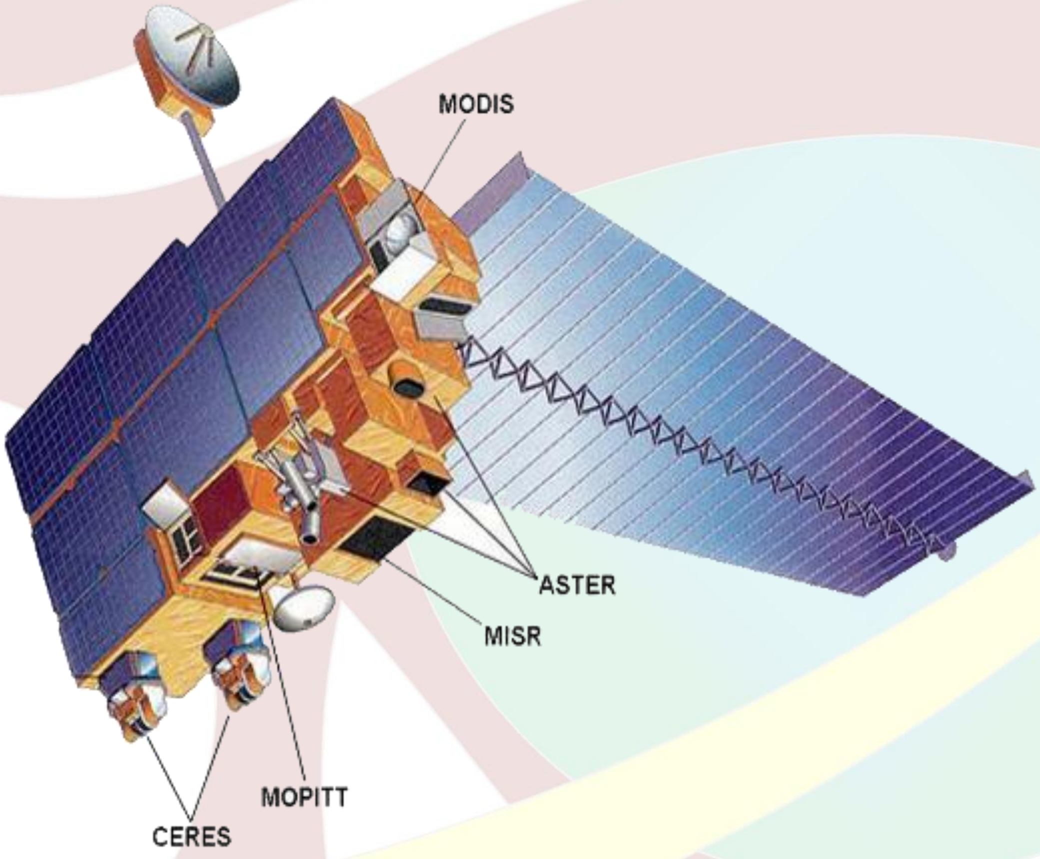
TERRA SATELLITE



ASTER
(*Advanced Spaceborne Thermal Emission and Reflection Radiometer*)

CERES
(*Clouds and the Earth's Radiant Energy System)*

MISR
(Multi-angle Imaging SpectroRadiometer)

MODIS
(*Moderate-resolution Imaging Spectroradiometer*)

MOPITT
(*Measurements of Pollution in the Troposphere*)

NASA launched the Earth Observing System's flagship satellite "**Terra**," named for Earth, on **December 18, 1999**

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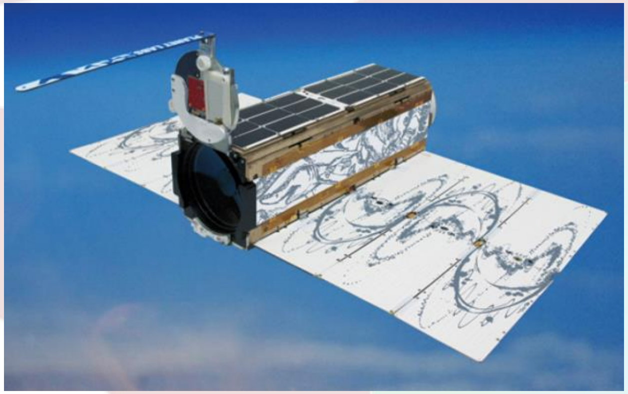
EO CUBESAT CONSTELLATION

FLOCK of DOVES
PLANET LABS

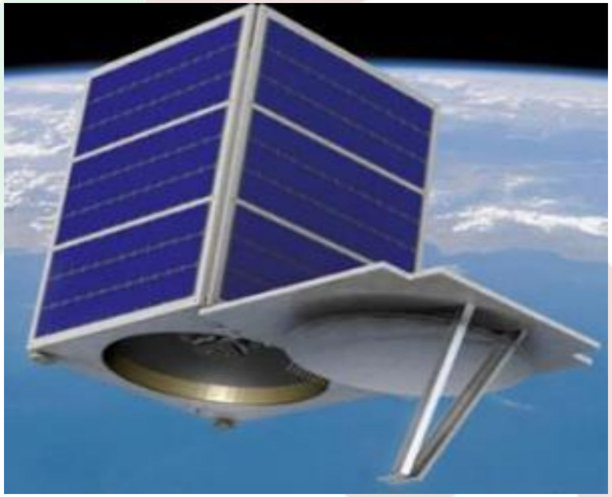


Low cost mission

Nadir–pointing cameras

High resolution imagery

SkySat constellation
Skybox imaging + Google



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From MISR to CAST

Single satellite with MISR sensor

- measurements only along a restrictive plane with respect to the solar phase → insufficient for accurate analyses
- angular measurements separated in time by too many minutes along-track → low data reliability

Small satellites in formation flight

- large angular spreads → faster and better data
- improvements in time of sampling → higher data reliability
- Possibility to use COTS and standardise items and technologies → cheaper mission

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constellation

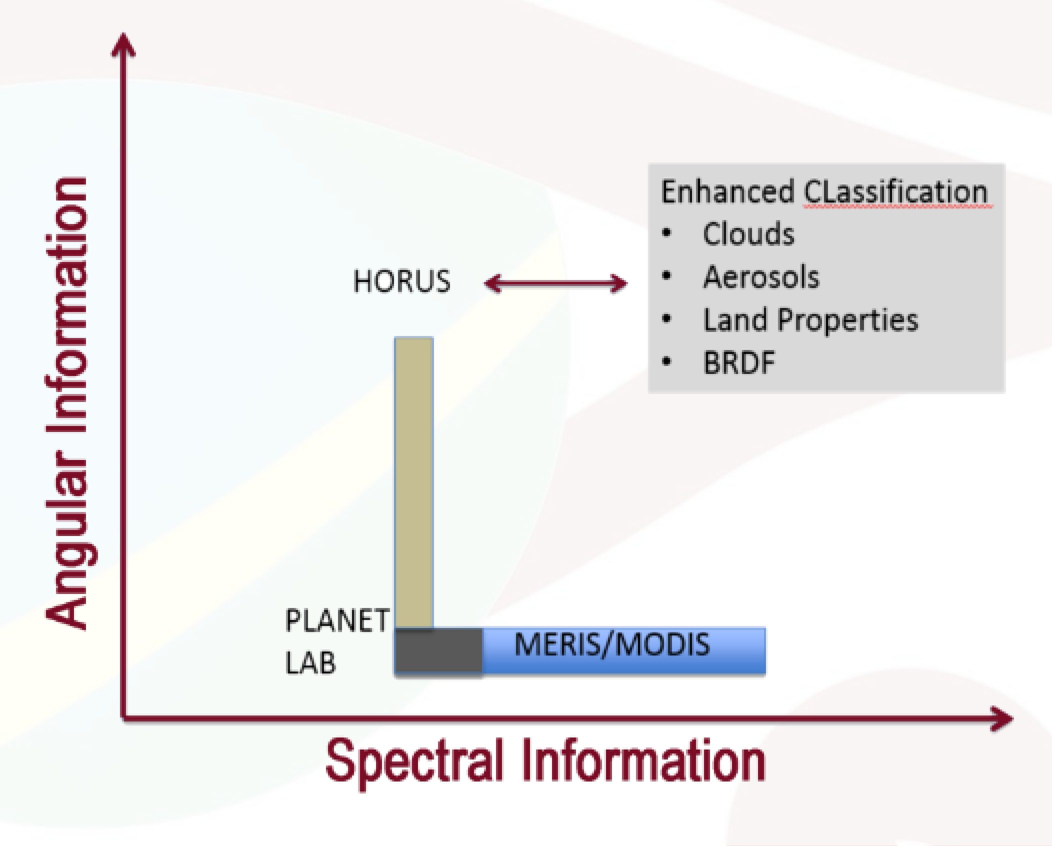
IMPROVEMENTS

1) Off-nadir observation capability

2) Enhanced spatial resolution and revisit time

3) Multiple-perspective and multi-spectral imagery

4) New views for global environmental monitoring



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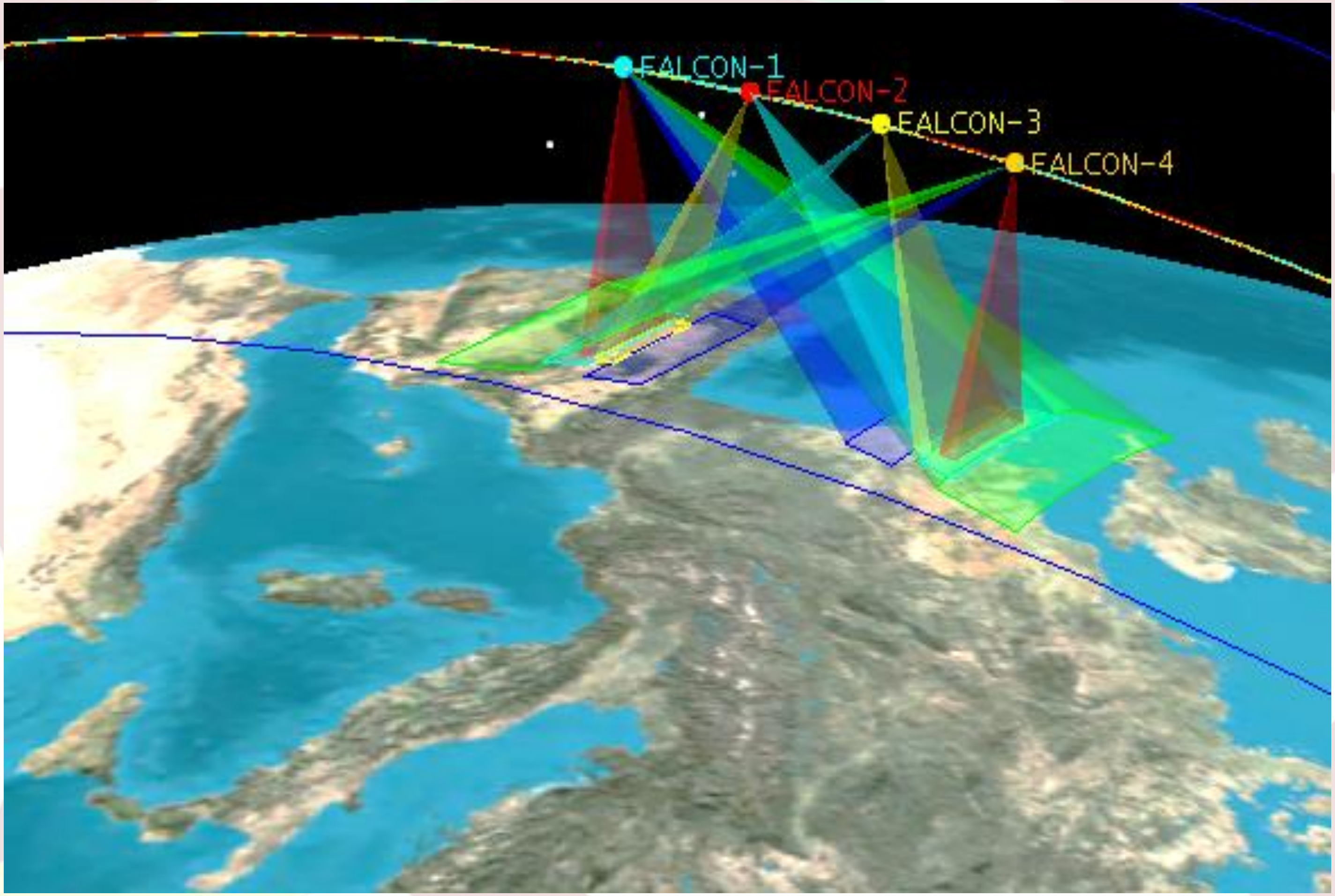
HORUS
CAST



A constellation of **four 3U CubeSats**

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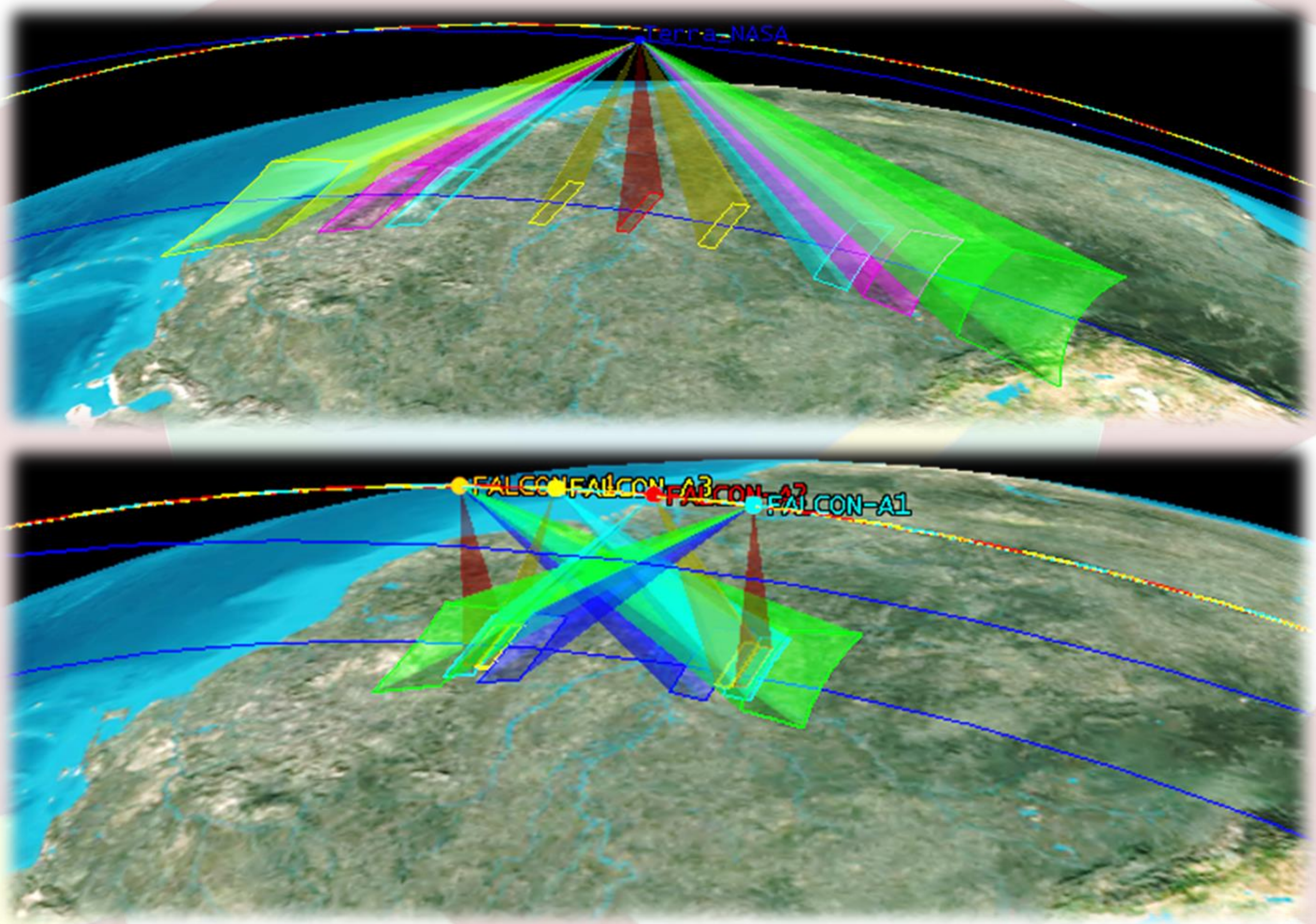
UNIQUENESS

Synthetic mini - MISR



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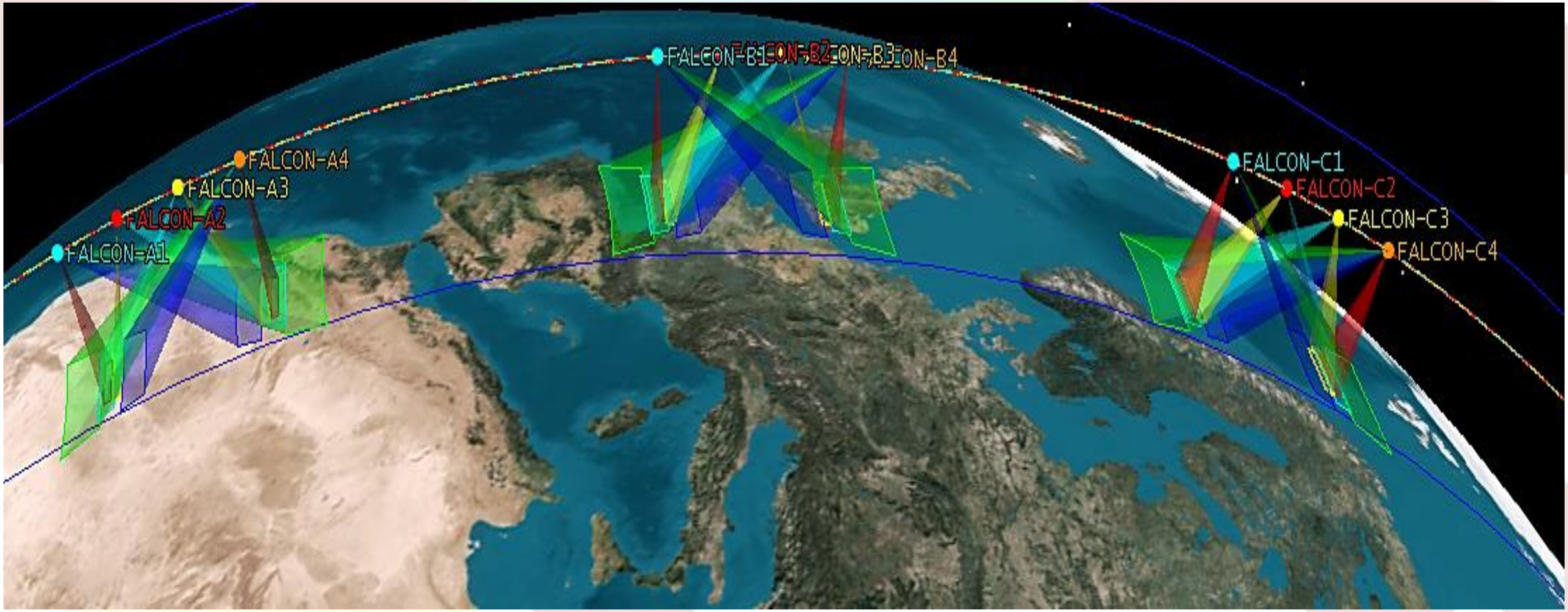
SCALABLE
SYSTEM

The more **"Cast of FALCONS"**…the more **robust and reliable DATA!**



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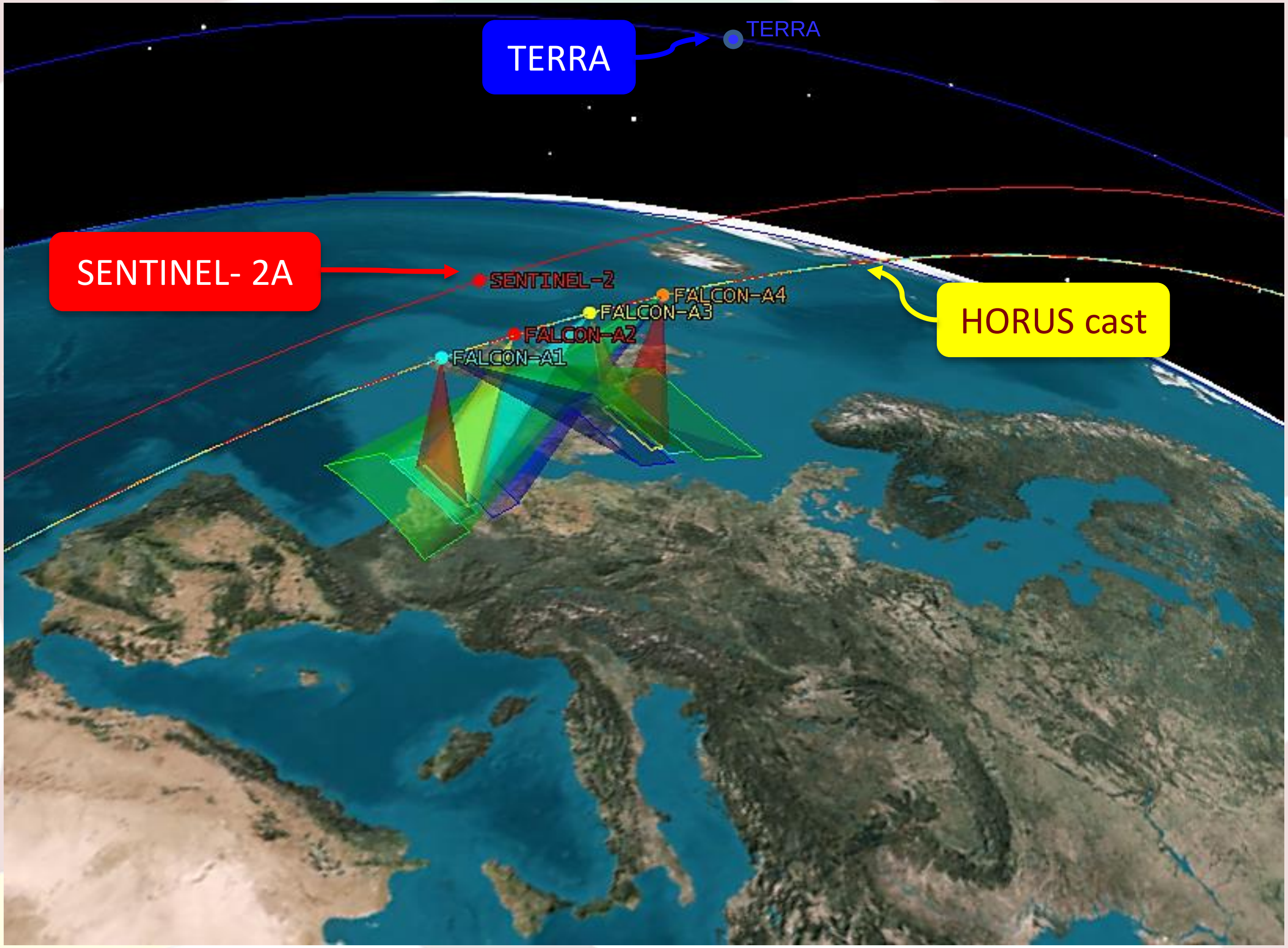
SYNERGY



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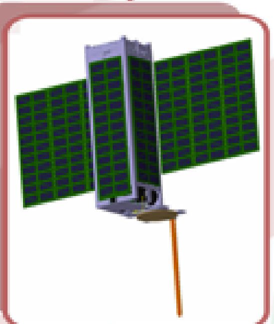
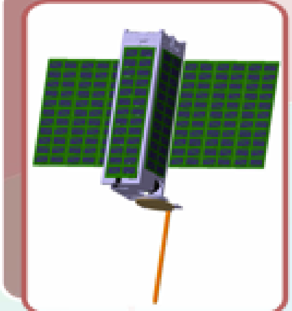
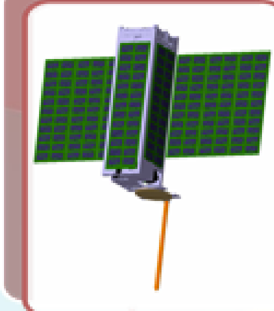
Synthetic mini - MISR



- One Nadir camera
- One -60° off-nadir camera
- One -70,5° off-nadir camera



- One +26,1° off-nadir camera
- One -45,6° off-nadir camera



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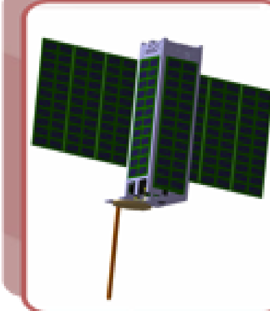

- One Nadir camera
- One +60° off-nadir camera
- One +70,5° off-nadir camera

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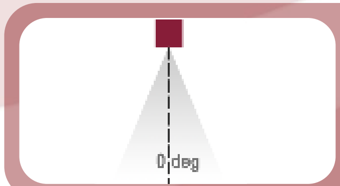
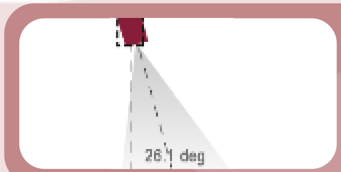
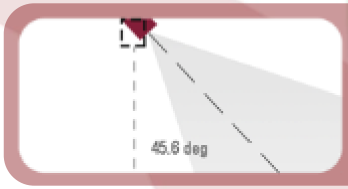
Mini - MISR
VIEW ANGLES



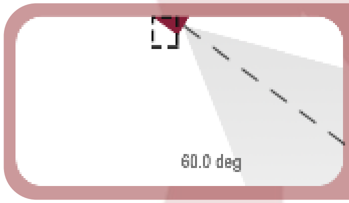
- Imagery less distorted
- Near minimal influence from atmospheric scattering
- Comparison with other cameras' imagery



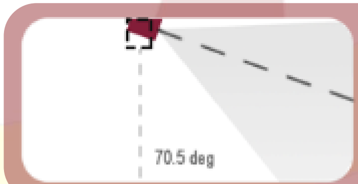
- Optimal base/height ratio
- Indipendent information not distorted by geometric effects



- Optimal aerosol sensitivity
- Optimal groundtrack distance between A-B cameras/ B-C cameras
- Uniform scene lengths for high-resolution targeted observations



- Directionally oriented reflectance variations among many different types of clouds are minimized
- The amount of reflection at each ground point-hemispherical albedo



- Maximal sensitivity to off-nadir effects

Mini - MISR
CAPABILITIES

Mini-MISR will be able to acquire radiometrically and geometrically calibrated images in four spectral bands at each angle:

Estimation of the size distribution of the aerosol particulates
(blue channel – 443 nm)

Broadband-reflecting properties for albedo features estimation
(green band – 555 nm)

Vegetated surface identification and marine aerosol studies
(bands in the red and near-infrared – 670 and 865 nm)

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Mini - MISR
CAMERAS

Cameras	Df	Cf	Bf	Af	An	Aa	Ba	Ca	Da
Angles	70,5	60,5	45,6	26,1	0,0	26,1	45,6	60,0	70,5
443 nm									
555 nm									
670 nm									
865 nm									

- Albedo
- Cloud detection/Features
- Surface classification
- Aerosols
- Comparison

SYSTEM REQUIREMENTS

Multiple sampling of targeted area	the acquisition of a huge imagery allows improvements in data reliability
Sunlight and Cloud Coverage	an optical sensor have limitations in term of diurnal sampling - some of them need daylight - and requirements in terms of cloud fraction statistics
Attitude and Orbit Control System	the central sensor camera has to maintain a nadir-pointing configuration and the high-gain antenna has to be accurately pointed to Earth for communications
Calibration	mini-MISR needs a stable and absolute calibration in order to ensure a synergism between the various sensors operating at the same time

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ORBIT FEATURES

Orbit	SSO - circular
Semiaxis	6856.99 km
Inclination	97.41 deg
Argument of Perigee	68.13 deg
RAAN	200.00 deg
Shift in True Anomaly	2.32 deg
Mean Local Solar Time at DN	10:30 am
Orbital Period	94.18 min
Eclipse Time	35.12 min

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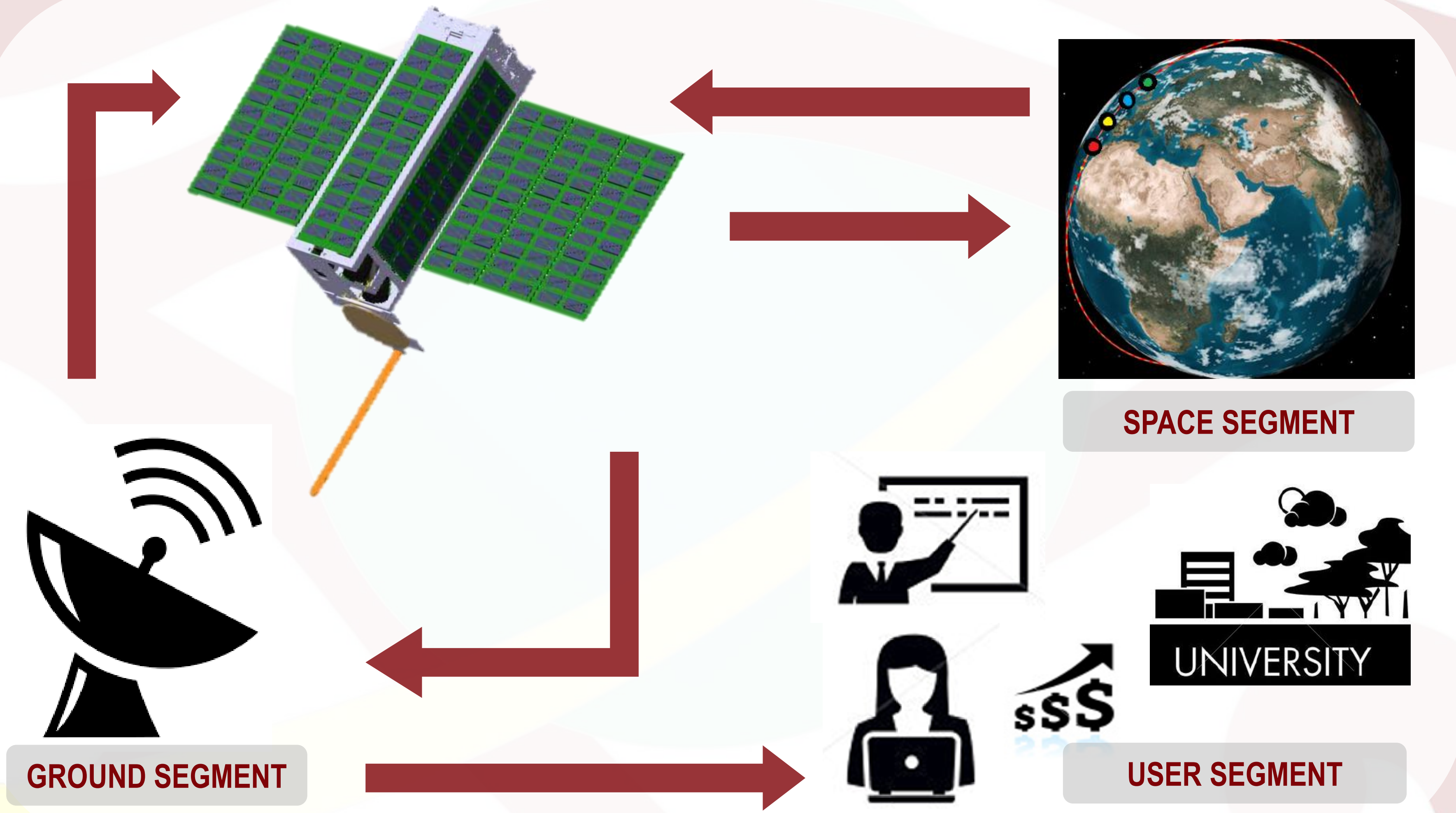
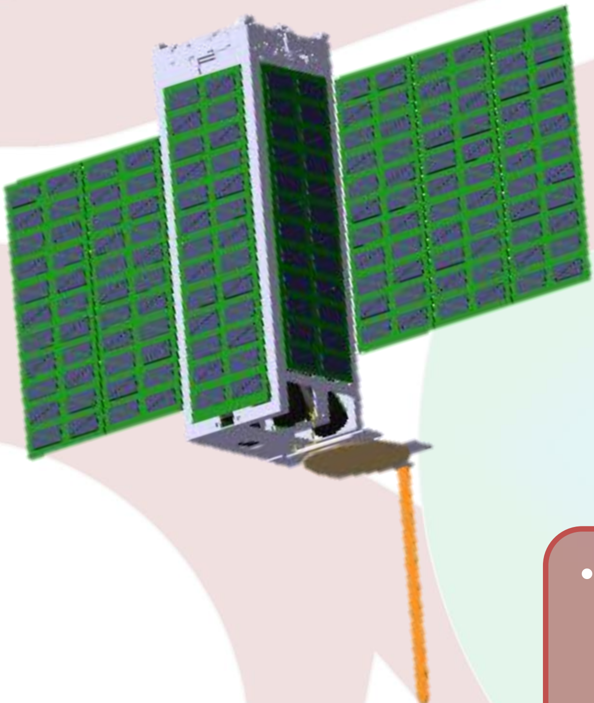
MISSION SEGMENTS



HORUS constellation

MISSION SEGMENTS



Size	300x100x100 mm
Weight	~ 3,8 Kg
Area-to-mass	0.00789
Orbit	SSO (500 Km) – LTAN 10.30 am

COMMUNICATION

- **High speed downlink**: X-BAND (Simple quasi-omnidirectional antenna diagram)
- **High speed uplink**: S-BAND
- **Backup downlink**: S-BAND (minimizing of data losses)
- **Backup uplink TT&C**: UHF

LAUNCH SEGMENT

HORUS CubeSats could be **launched as part of a larger payload** of a nominal launcher, by an aircraft launcher or by expulsion from an orbitant platform (i.e. ISS)

LINK BUDGET

FEATURE	S-Band	X-Band
Frequency	2.2 GHz	8.4 GHz
Transmitter Power / Total RF Power to Antenna	4 W / 4.33 dBW	8.8 W / 7.8 dBW
Antenna Gain TX / RX	10 dB / 45.7 dB	2.15 dB / 57.5 dB
Modulation Type	BPSK	QPSK
Telemetry Eb/No	12.2 dB	10 dB
Requested Telemetry Eb/No	10.7 dB	9.6 dB
System Margin	1.5 dB	0.4 dB
Data Rate	1 Mbit/s	1.1 Mbit/s

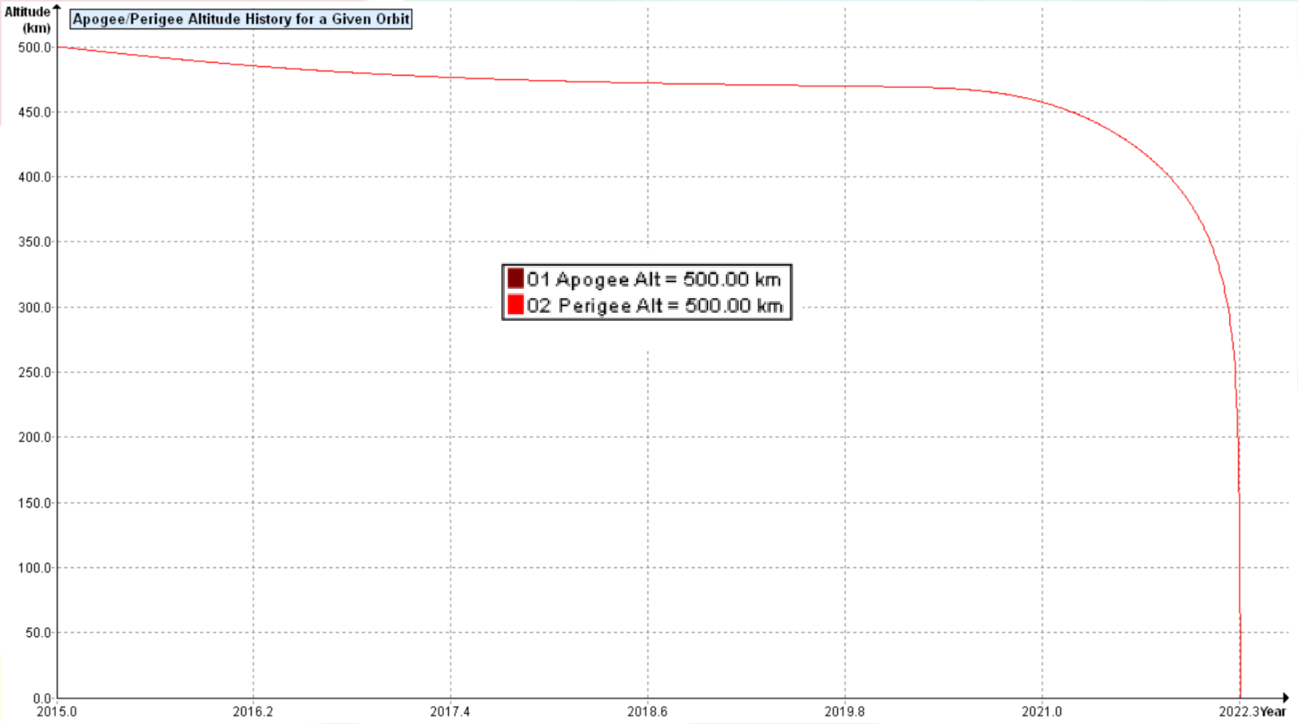
CUBESAT SUBSYSTEM OVERVIEW

OCS	• Orbit Control System
CDHS	• Command & Data-handling System
EPS	• Electric Power System
ADCS	• Attitude, Determination and Control System
TT&CS	• Telemetry, Tracking & Command System

DRAG SAIL FOR CUBESAT DEORBITING

MISSION LIFETIME

- The cubesat will experience a significant decay due to the drag during the period of mission. We performed an **orbit evolution analysis** and the **mission lifetime** is about **7.25 years** with an average **daily decay of 18 meters**



Start Year	2015.00 yr
Inclination	97.40 deg
RAAN	200.00 deg
Arg Peri	68.00 deg
Mean Anomaly	48.00 deg
Area-To-Mass	0.008 m^2/kg

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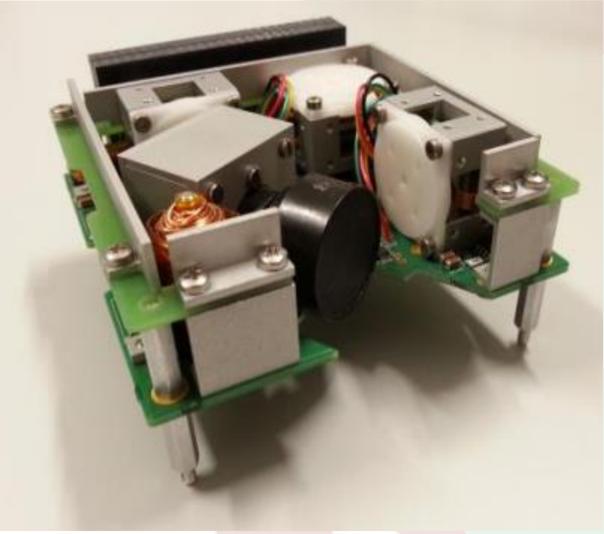
ADCS

- For the «**Attitude and Determination Control System**» we collaborate with HYPERION TECHNOLOGIES (**iADCS100**)



SPECIFICATIONS

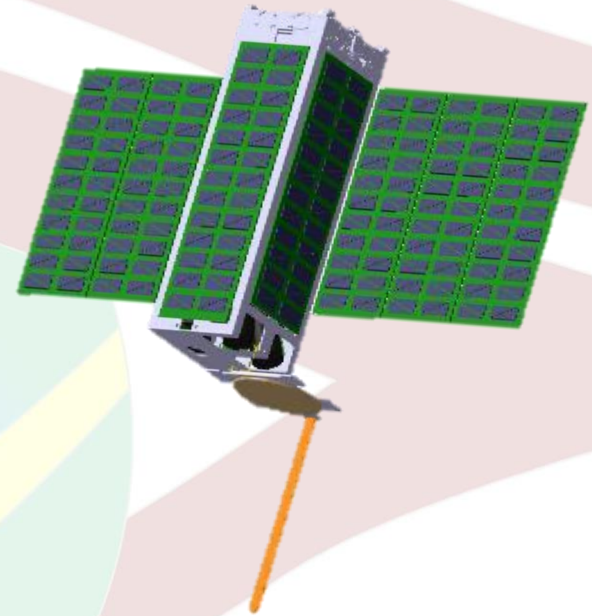
Performance				
Total momentum storage per axis	+/-1.5 to +/- 6.0[1]			mNms
Maximum torque	>0.087			mNm
Nominal magnetic moment	0.2 (X, Y), 0.1 (Z)			Am^2
Attitude determination accuracy	30			arcseconds
Pointing accuracy	<< 1			°
Slew rate	> 1.5[2]			°/s
Electrical specifications				
	Min.	Typ.	Max.	
Supply voltage	4.0	5.0[3]	15[4]	V
Bus logic level voltage	Referenced to Vsys[5]			V
Power consumption:				
Idle	<TBD>	<TBD>	900[6]	mW
Nominal[7]	<TBD>	1400	<TBD>	mW
Peak[8]	<TBD>	2700	4500[6]	mW

HYPERION TECHNOLOGIES

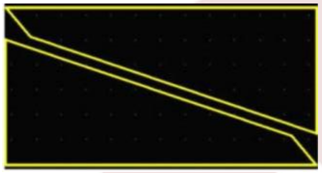
Outer dimensions	95 x 90 x 32 mm
Low mass	250 g
Low power	2.7 W peak

SOLAR PANELS
SIZING

Area available (well-lighted)	0.132 m²	Cells in series:	Cells in parallel:
Tot Power available	48.957 W		
Voltage available	2.100 V	4	121
Bus Voltage	8 V		
Cell Area	1.55 x 3.18 cm		
Solar panels filling factor	0.9		



Area available (non well-lighted)	0.07 m²	Cells in series:	Cells in parallel:
Tot Power available	25.84 W		
Voltage available	2.100 V	4	64
Bus Voltage	8 V		
Cell Area	1.55 x 3.18 cm		
Solar panels filling factor	0.9		



DRAG SAIL

- Each cubesat will have on-board a **drag sail** for deorbiting developed by NPC Spacemind (Bologna – Italy) ready to be tested on URSA MAIOR QB50 cubesat

- The sail is made of a special polymeric material that works like a memory shape or elastic material

NPC NEW PRODUCTION CONCEPT

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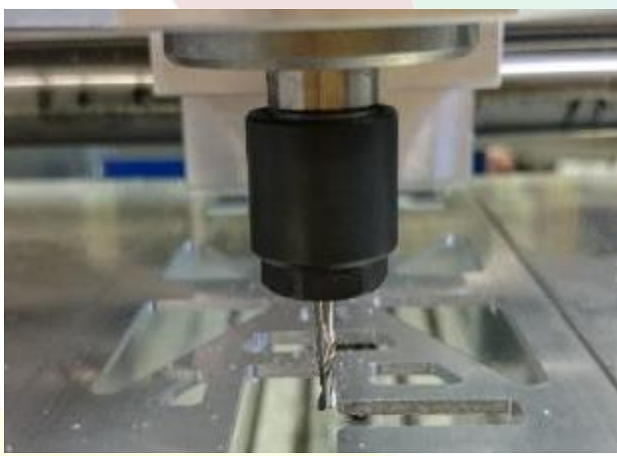
CUBESAT STRUCTURE

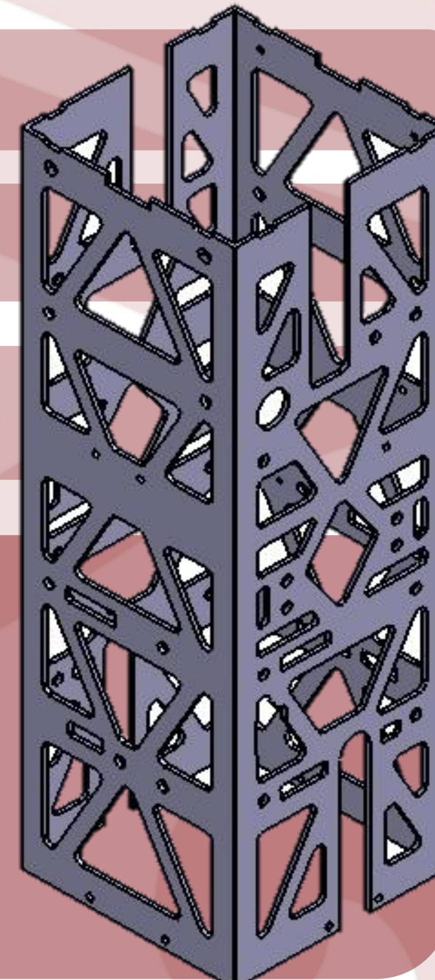
Structural and mass optimization

Integration compatibility

Smart development



MONOLITHIC ALUMINIUM STRUCTURE



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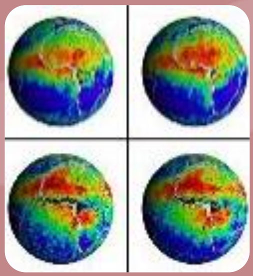
PRELIMINARY
RISK ANALYSIS

RISK	PROBABILITY	PREVENTION
Structure failure	Very low	Vibration and structural tests before the design phase
Sensor calibration failure	Very low	Mini-MISR calibration using state-of-the-art techniques
AOCS failure	Low	HORUS' AOCS has already flown in a CubeSat mission
MISR data collection failure	Low	Synchronization between mini-MISR sensors in data acquisitions over a targeted area
Downlink data loss	Medium	Each CubeSat will be provided with an on-board memory –ranging between 32kB and 8MB – and an additional flash memory up to 8GB

FUTURE IMPROVEMENTS



Enhancement for the optical sensors:

- Spectral range from 1 µm to 1.6 or 2.1 µm (enhancements for the study of both aerosols and clouds)
- Finer spatial resolution (a factor of two refinement)

Collaboration with Resource Providers:

- to design an imager with multi-spectral and multi-angle capabilities
- to gain the cubesat subsystems needed

- **Synergy with other EO operational mission in order to improve the amount and the quality of data**

- **Collaboration with research and data design facilities**

OUTREACH PROGRAMME

WEB

- FACEBOOK
- TWITTER
- YOUTUBE channel
- LA SAPIENZA UNIVERSITY OFFICIAL WEBSITE
- OFFICAL WEBSITE/BLOG
- EDU App

Scientific papers for journals about area of space research

CONFERENCE

- IAC 2016
- AIAA 2016
- AIDAA 2016
- AMOS 2016

LA SAPIENZA University of Rome

- LECTURES during academic courses of Aerospace Engineering (BSC) and Space and Astronautical Engineering (MSC)
- S5Lab Laboratory OPEN DAYS

FUND RAISING

Partnership with local companies

Sponsorship by firms interested in gaining <u>social responsability benefits</u>

CROWDFUNDING

Kickstarter

ACADEMIC SUPPORT

STVDIVM VRBIS

ADVISORS

Dr. Pierre-Philippe Mathieu

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Field of research: Earth Observation Science & Applications

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TEAM

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Federica Zaccardi — Bachelor student in Space Engineering

Federica Angeletti — Master student in Space Engineering

Saverio Cambioni — Master student in Space Engineering

QUESTIONS??

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