

# Characterization and calibration of VIS cameras for space applications – JANUS and HYPSSOS systems

PhD Student: Livio Agostini  
Padua 25/10/2019



# JUICE (Jupiter ICy moons Explorer)

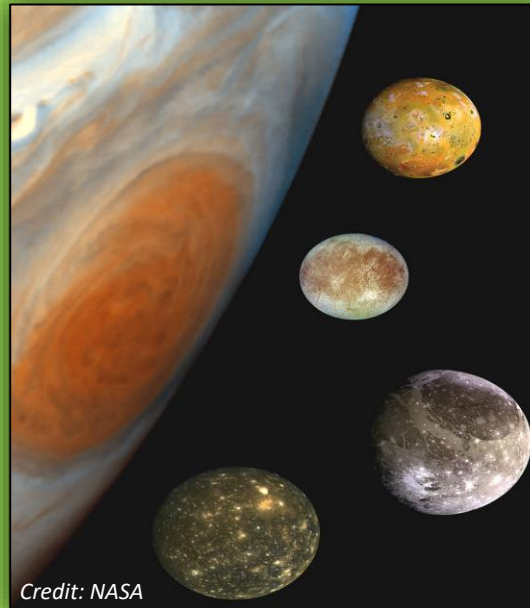


- First large mission (L1) of ESA program Cosmic Vision 2015-2025
- First ESA-led satellite in the outermost solar system
- First S/C to orbit a moon of giant planet
- 3-axis stabilized
- Solar panels-powered

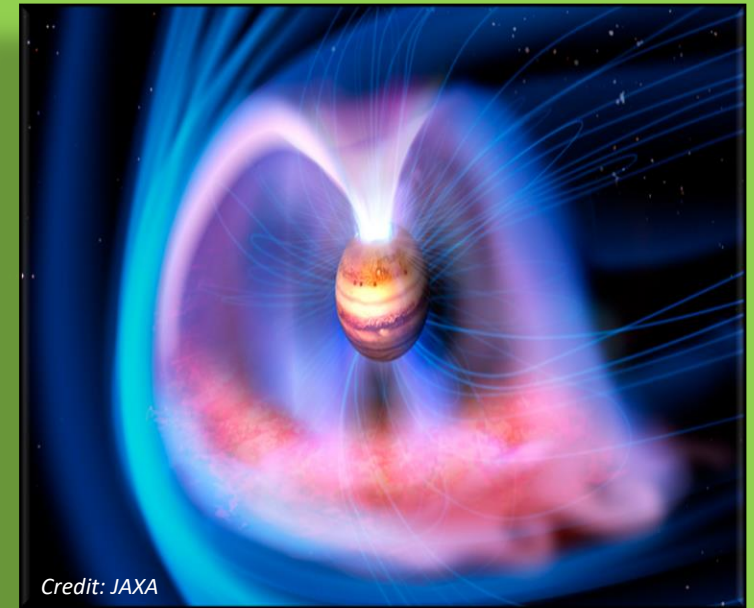
## SOME IMPORTANT FACTS

## T H E M E S

### *Explore the habitable zone*

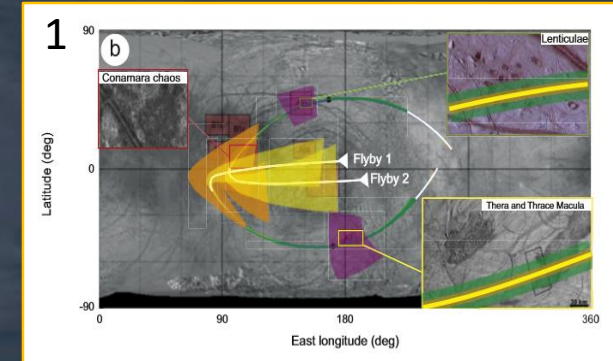
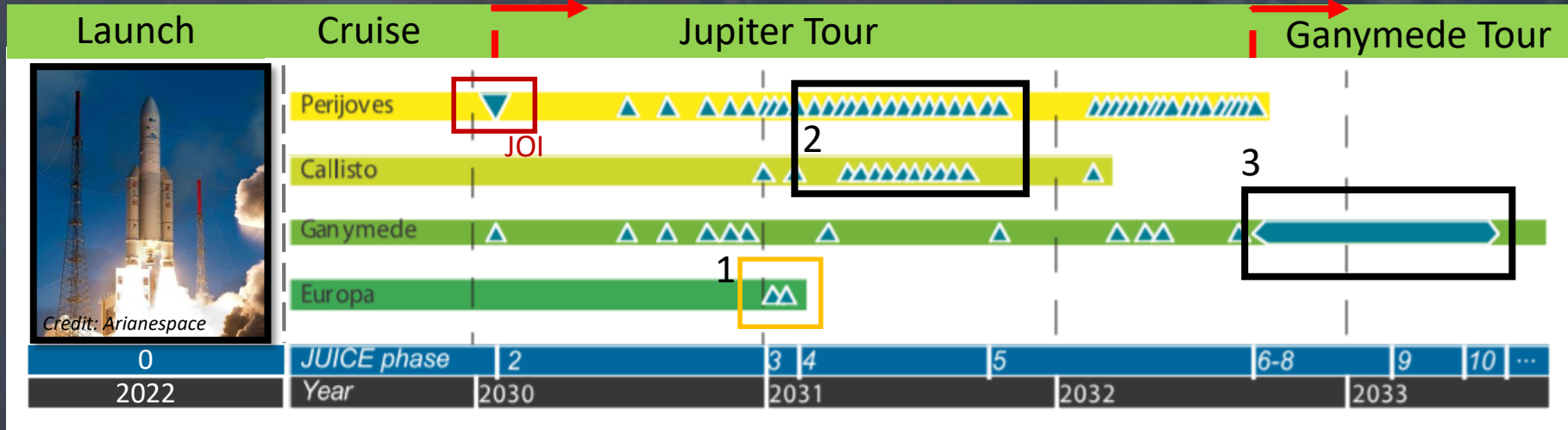


### *Jovian System: gas giant archetype*

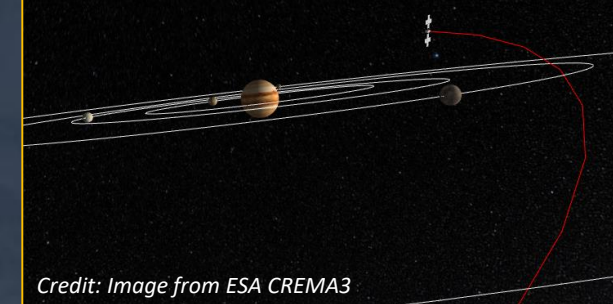




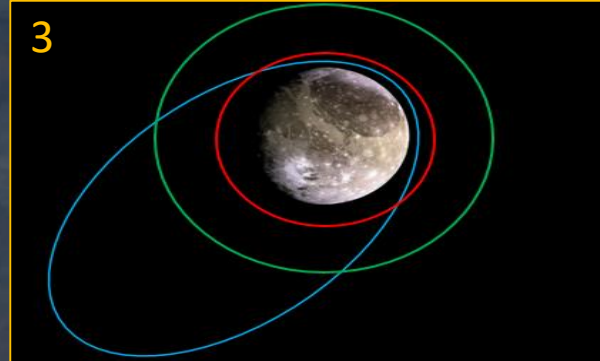
# JUICE MISSION DESIGN



## 2 - High inclinations phase



Credit: Image from ESA CREMA3

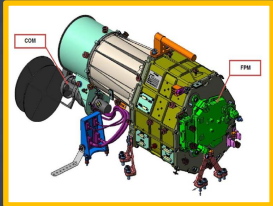


- Very complex mission design
- 2 main mission phases (Jupiter and Ganymede tour)
- ~7.6 year of cruise
- ~8 month at Ganymede
- 2 Europa flybys
- ~3 years of scientific mission

SOME IMPORTANT FACTS

# JUICE INSTRUMENTAL SUITE

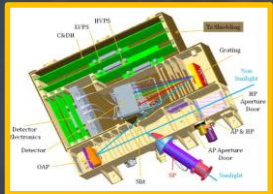
## REMOTE SENSING



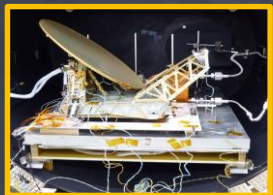
JANUS



MAJIS

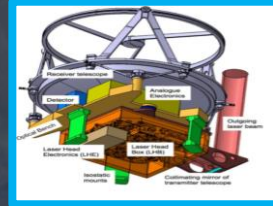


UVS



SWI

## GEOFYSICAL



GALA



RIME

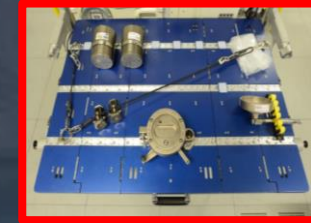


3GM

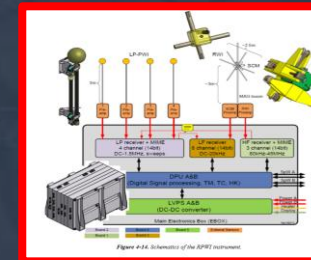


PRIDE

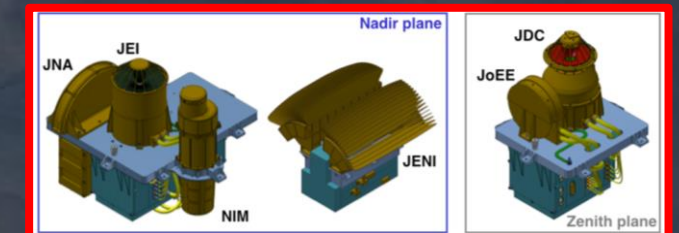
## IN SITU



JMAG



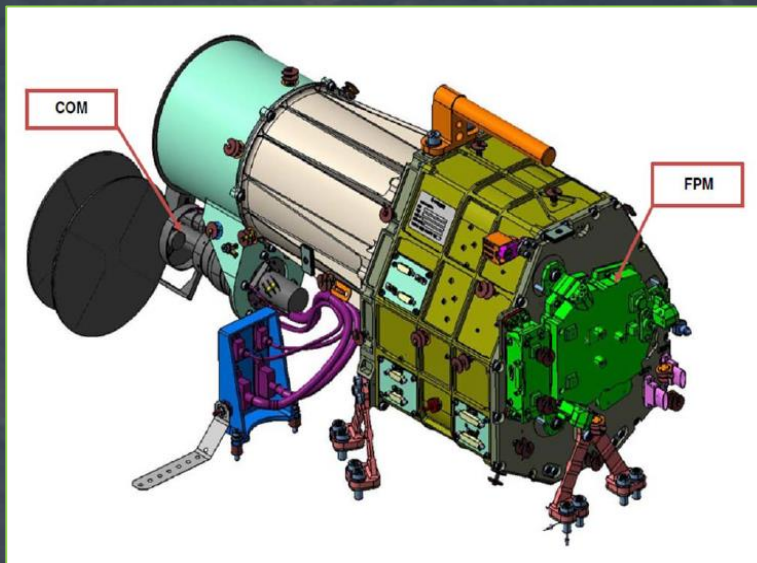
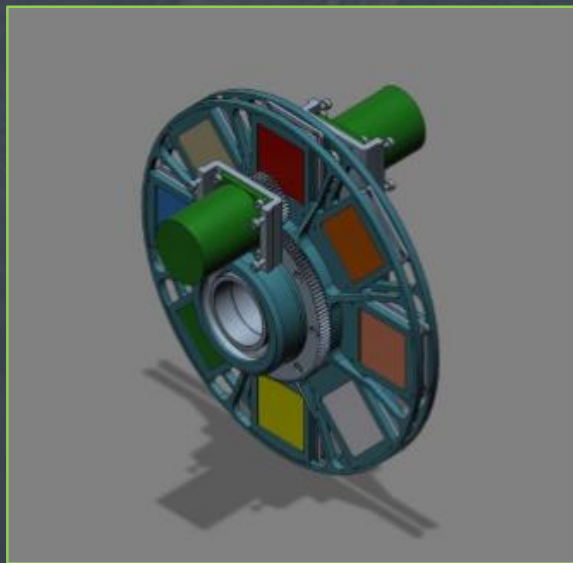
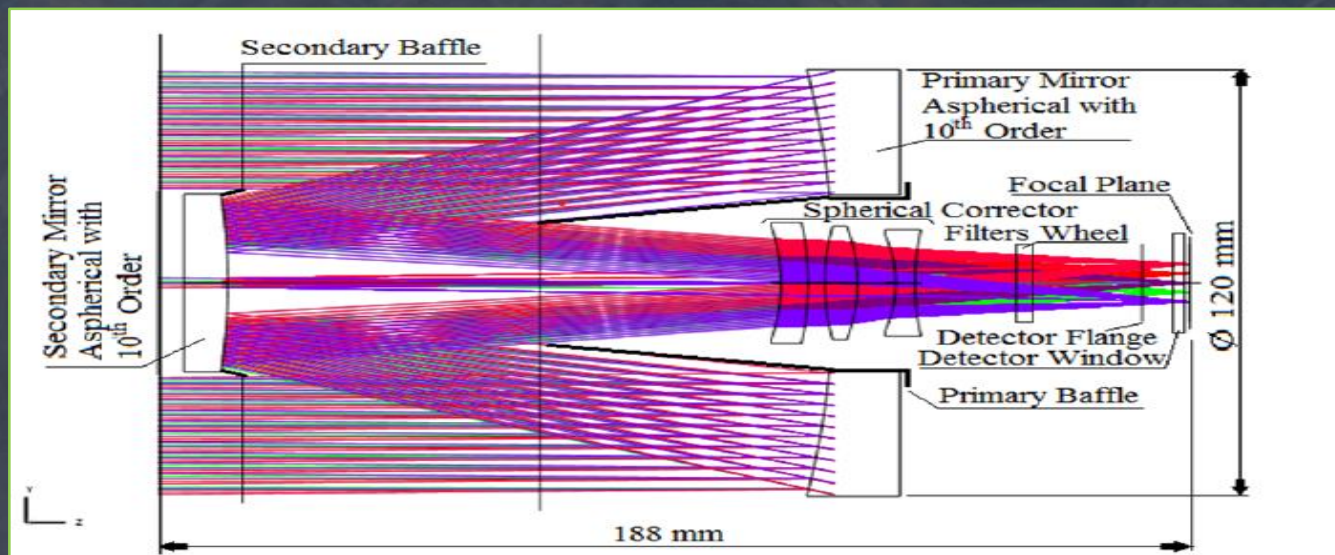
RPWI



PEP



## GENERAL DESIGN



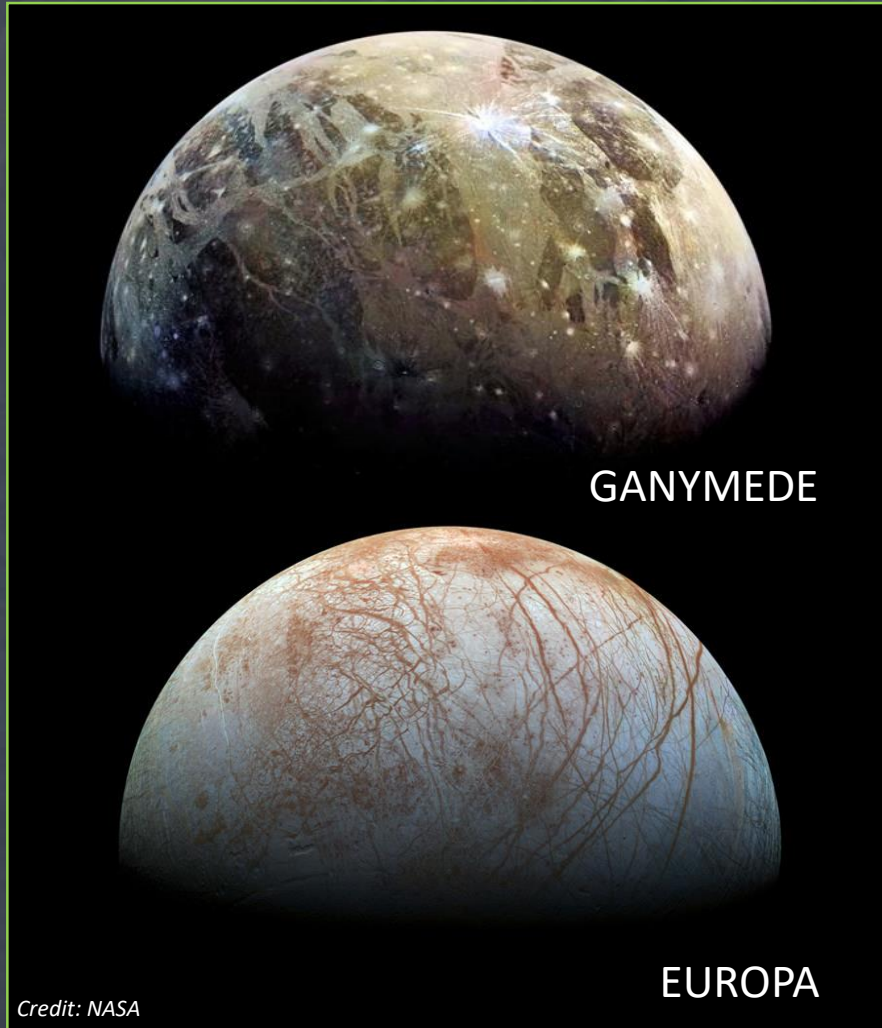
- Modified Ritchey-Chrétien configuration (it includes a dioptric corrector)
- The instrument is made of three parts
  - Main Electronic Unit (in the vault for radiation protection)
  - Proximity Electronic Unit
  - Optical Head Unit
- Spectral Imaging capability thanks to the filter wheel (13 filters – 340nm to 1080 nm)
- Stereo imaging capability
- It provides context for other JUICE instruments
- Sinergy with other instruments
- Scientific and technological heritage from previous missions (e.g. OSIRIS Rosetta, SIMBIO-SYS)

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# MAIN SCIENTIFIC GOALS

*Geological characterization of Ganymede's and Europa's surfaces, with special focus on Ganymede*



## GANYMEDE IMPORTANCE

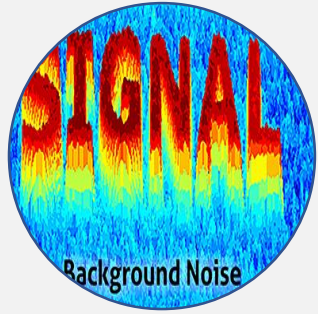
1. Great variety of surface ages
2. Great variety of geologic and geomorphic units
3. Possible Subsurface ocean
4. Active magnetic dynamo

## JANUS MAIN CONTRIBUTION

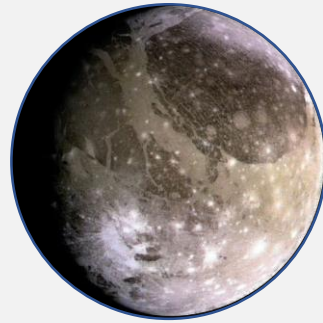
1. Tectonism
2. Cryvolcanism
3. Craters
4. Cosmic weather-altered surfaces
5. Exogenic surfaces alteration processes (micrometeorites, radiation, charged particles, etc...)



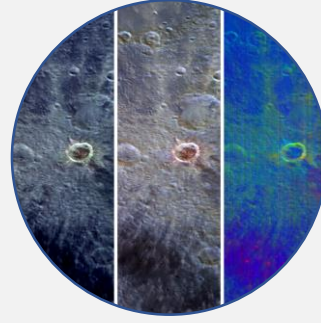
# REQUIREMENTS AND DESIGN DRIVERS



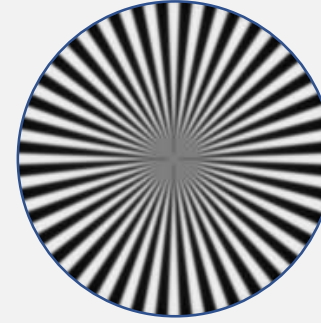
SNR > 100



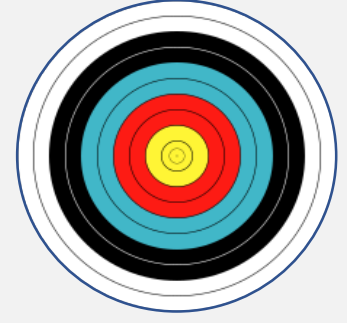
GSD & Coverage



Color Imaging

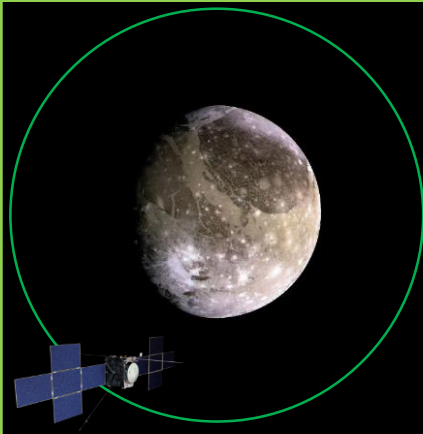


MTF > 0.15  
@Nyquist



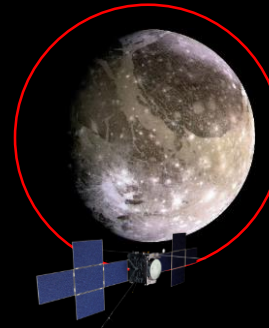
AKE ~ IFOV

Driven directly from icy moons observation objectives



**Ganymede Circular Orbit  
GCO5000**

- 400 m/pix
- 4 colors
- Global coverage



**Ganymede Circular Orbit  
GCO500**

- 5-10 m/pix → Targetted areas
- PAN images

1 - <https://www.cambridgeincolour.com/tutorials/image-noise.htm>  
2 - NASA/JPL/DLR  
3 - ISRO / NASA / Chandrayaan-1 / courtesy Sriram S. Bhiravarasu  
4 - Image from "Optical Transfer Function", Wikipedia  
5 - Image from "<https://it.wiktionary.org/wiki/bersaglio>"

Image credit

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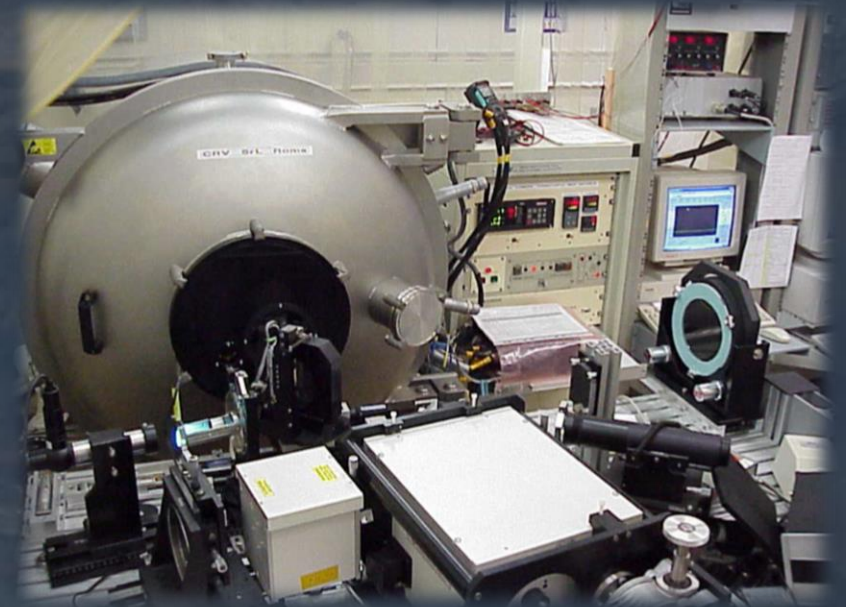
# CHARACTERIZATION and CALIBRATION

PhD Project  
MAIN GOAL

To support the activities of characterization and calibration of JANUS high resolution camera

J  
A  
N  
U  
S

- ▲ Analysis and verification of the optimal compression factor for image transmission
- ▲ Supporting the Acceptance Test of the detector electronics
- ▲ Planning, performing and analyzing the characterization and calibration data
- ▲ Production of the documents about the calibration results
- ▲ Analysis and verification of the performances and parameters during and after the integration of the instrument on the satellite



*Thermo-Vacuum chamber at Galileo Avionica (now Leonardo Spa) during VIRTIS-M calibration. From: Filacchione PhD Thesis, 2006*

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# CHARACTERIZATION and CALIBRATION

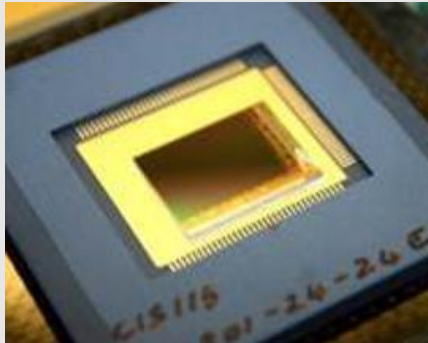
J  
A  
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S

## FOCAL PLANE MODULE (FPM) LEVEL

- Fixed Pattern (FP)
- Dark current
- ReadOut Noise
- Response (e.g. response non uniformity)
- Defects

+

- $QE(\lambda)$
- Full Well
- Gain
- $MTF(\lambda)$



## INSTRUMENT LEVEL

- Boresight
- FoV and distortion map
- PSF and MTF
- Relative response
- Spectral calibration
- Absolute radiometric calibration

+

- Straylight
- Ghost

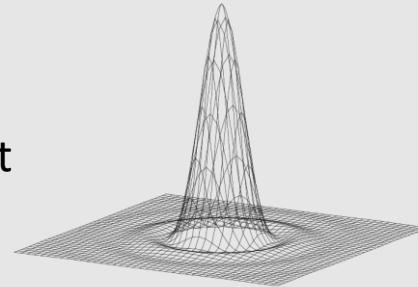


Image from: "PSF" Wikipedia EN

## VERIFICATION

- Functional test
- Science Verification Test



Credit: ESA

Facility:



Institute in charge  
of doing the  
development of  
electronics

Facility:



**LEONARDO**  
JANUS Prime Contractor

NOTE: The OGSE was developed for HRIC/SIMBIO-SYS  
→ heritage from previous instruments

Facility:

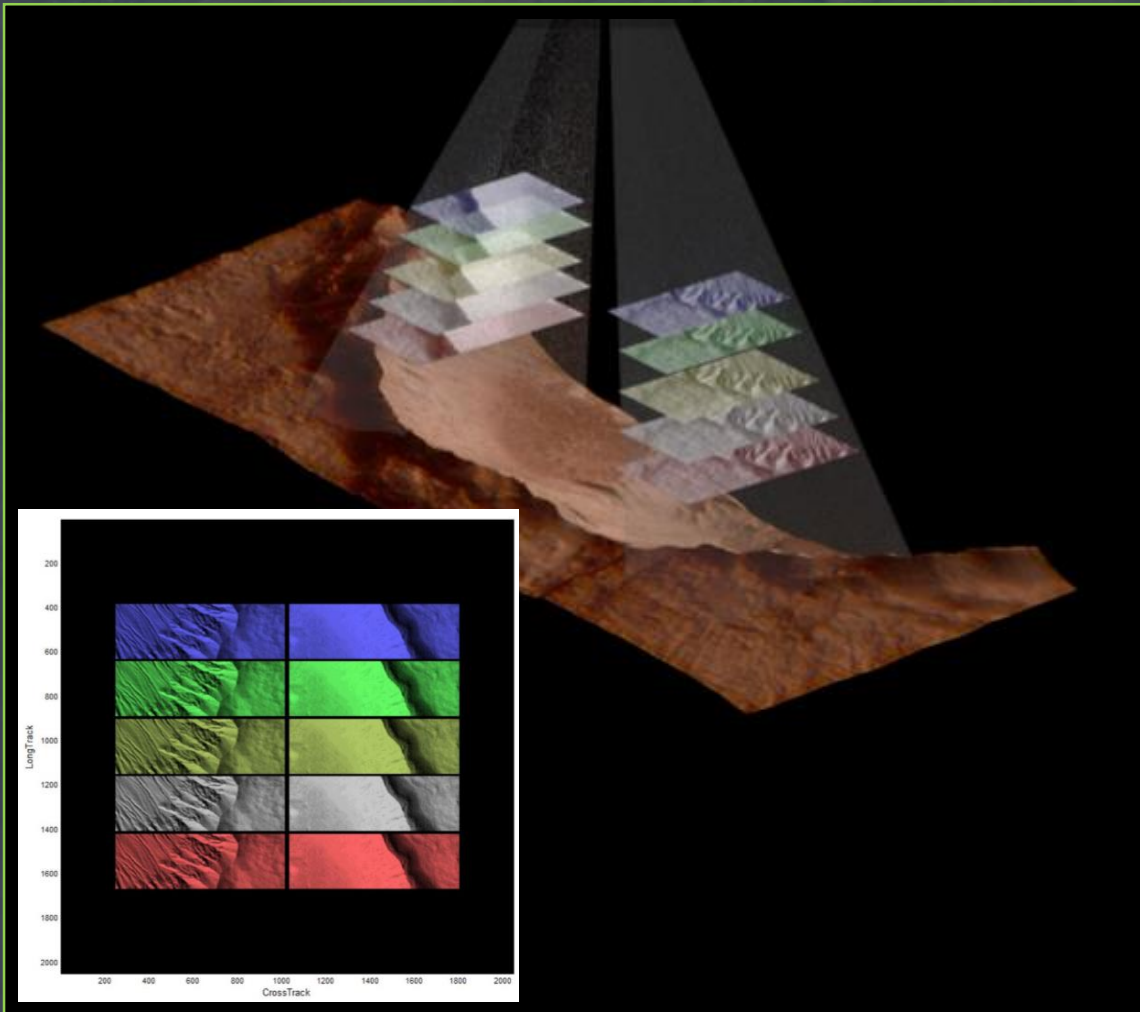


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# HYPSOS

## HYPerspectral Stereo Observing System



STEREO  
Capability

+

HYPERSPECTRAL  
Capability

=

New data  
type

3D

+

1D

=

4D

The instrument is able to produce more than 100 stereo pairs on the same detector

### MAIN BENEFITS

1

Improving DTM models

2

NO instrumental cross-correlation problems

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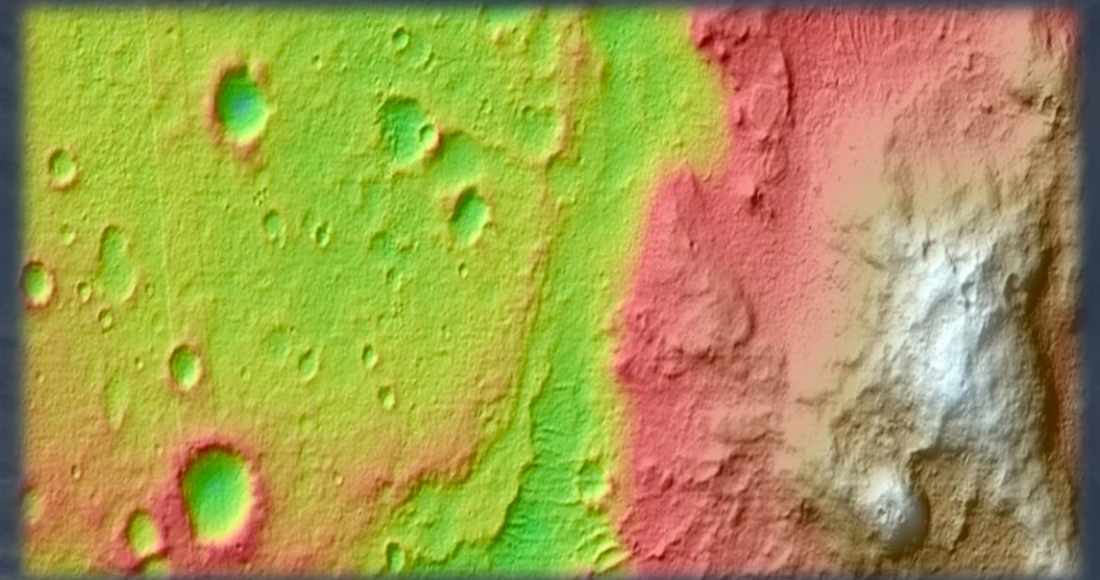


# CHARACTERIZATION

PhD Project  
SECONDARY GOAL

To support the characterization activity on HYPSONS

- ▲ Analysis of data acquired from breadboard model
- ▲ Expected performance verification
- ▲ Supporting the generation of DTM



*Credit: NASA/JPL/University of Arizona/USGS*

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# THANKS FOR YOUR ATTENTION

## References:

- 1 – “The JANUS camera onboard JUICE mission for Jupiter system optical imaging”, V. Della Corte et al., <https://doi.org/10.1117/12.2056353>
- 2 – “JANUS on the JUICE Mission: The Camera to Investigate Ganymede, Europa, Callisto and the Jovian System”, R. Jaumann and al., European Planetary Science Congress 2013
- 3- “JUper Icy moons Explorer (JUICE): An ESA mission to orbit Ganymede and to characterise the Jupiter system”, O. Grasset et al., <https://doi.org/10.1016/j.pss.2012.12.002>
- 4 – “Scientific objectives of JANUS Instrument onboard JUICE mission and key technical solutions for its Optical Head”, V. Della Corte et al., 10.1109/MetroAeroSpace.2019.8869584
- 5 – “Specific Technologies for Planetology, Space Weather and Gravitation oriented instrumentations”, G. Cremonese et al., Giornate INAF / 27-28 marzo 2019, [https://indico.ict.inaf.it/event/775/contributions/3761/attachments/2014/3882/Tecnologie\\_Planetologia\\_Cremonese\\_27Marzo2019\\_1.pdf](https://indico.ict.inaf.it/event/775/contributions/3761/attachments/2014/3882/Tecnologie_Planetologia_Cremonese_27Marzo2019_1.pdf)
- 6 – “HYPSOS, Next generation of a stereo camera”, C. Re et al. Abstract in “SIMP-SGI-SOGEL 2019” congress.

*Image credit: NASA/JPL-Caltech*