JUpiter Icy Moons Explorer (JUICE)

Status report for OPAG

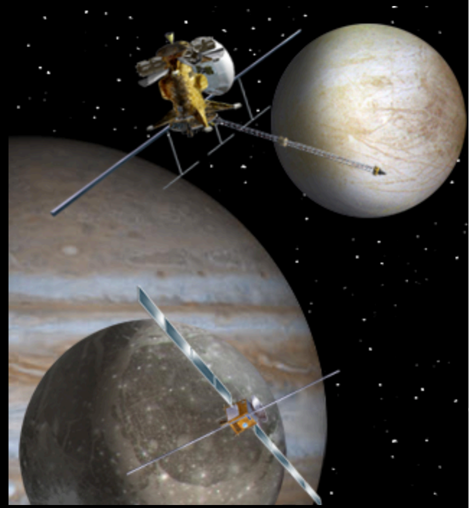
C. Vallat and O. Witasse

The JUICE origins:
Cosmic Vision 2015-2025

→ *Addressing the questions raised by the European scientific community in Astronomy, Solar System exploration and fundamental physics*

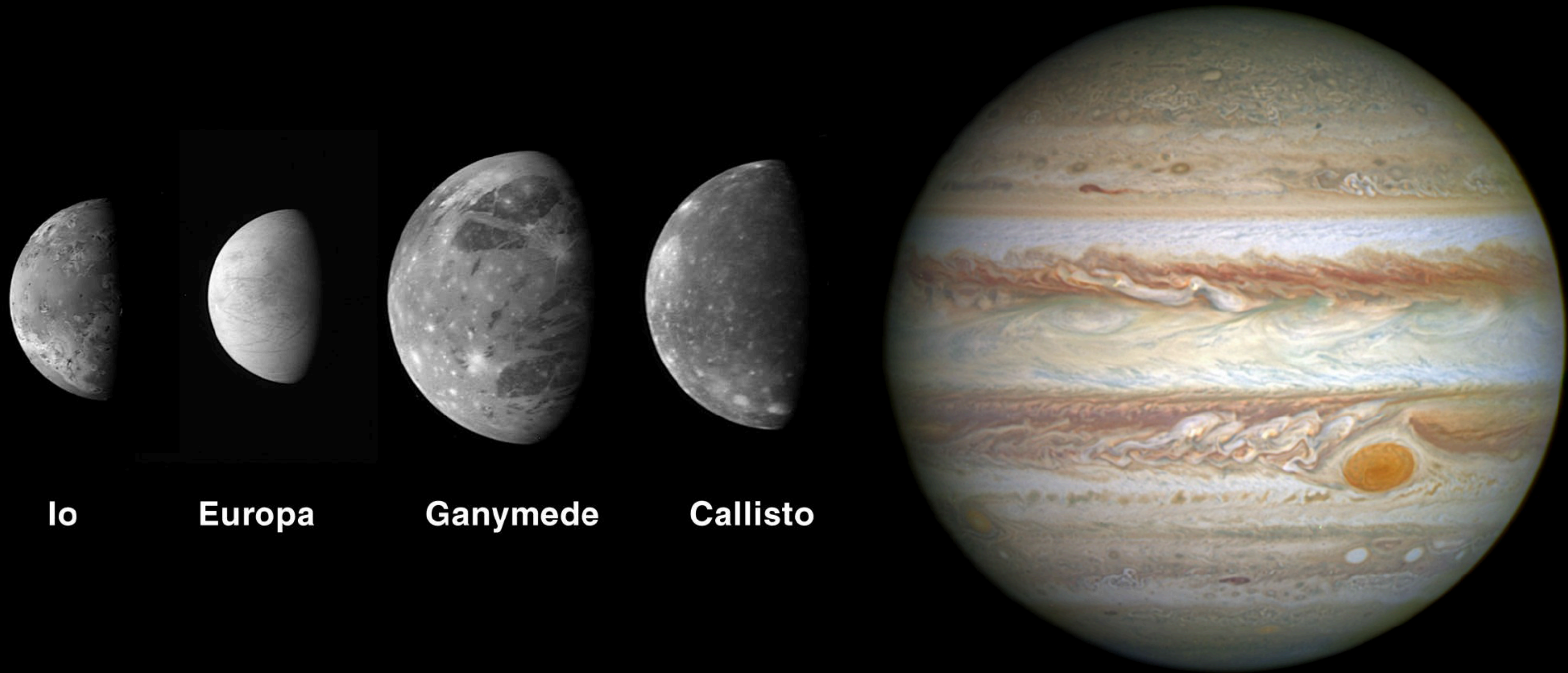
→ *current cycle of ESA's long-term planning for Large, Medium and Small size missions*

→ *JUICE: first L-class mission, adopted by end 2014*



→ *JUICE evolved from former EJSM concept*

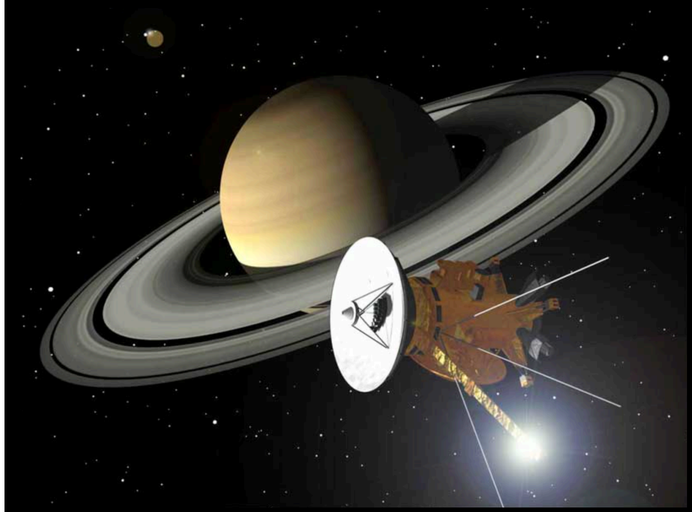
JUICE contribution to Cosmic Vision

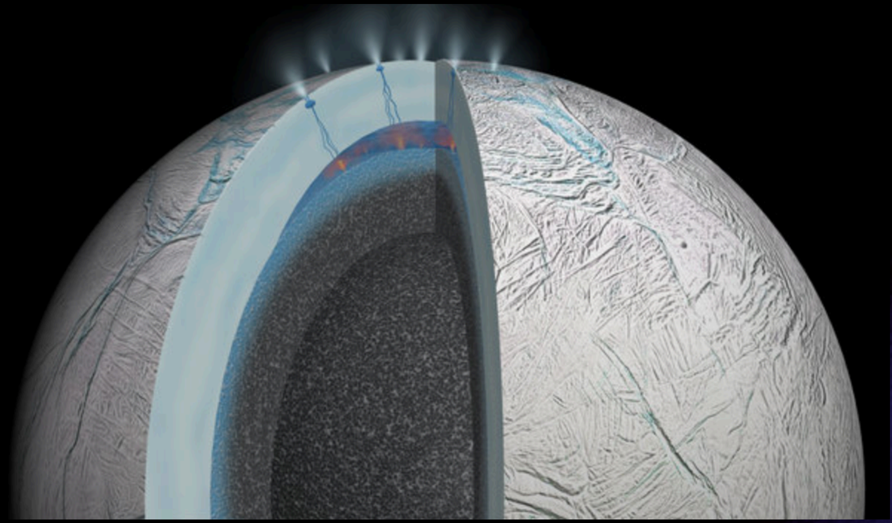


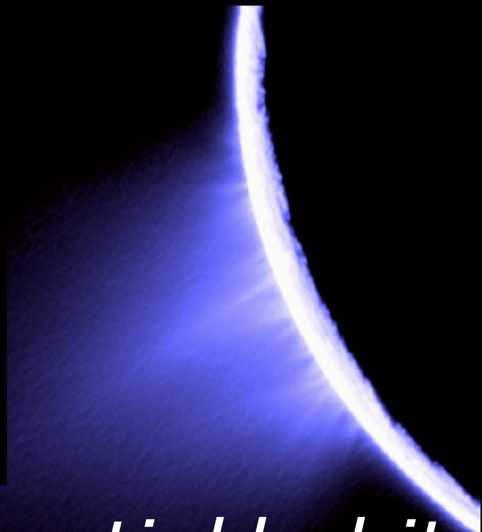
Emergence of habitable worlds around gas giants

Jupiter system as an archetype for gas giants

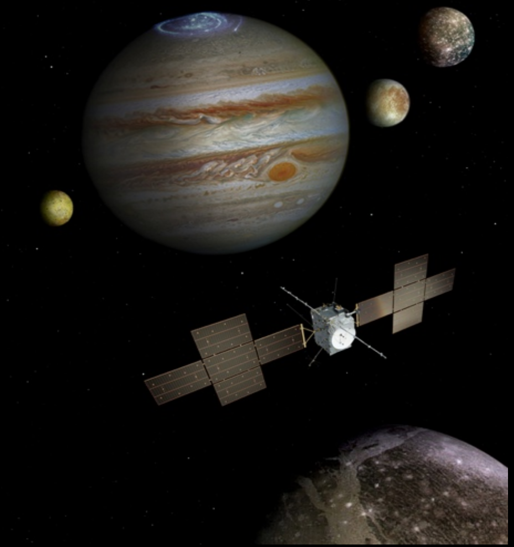
From Cassini to Juice…

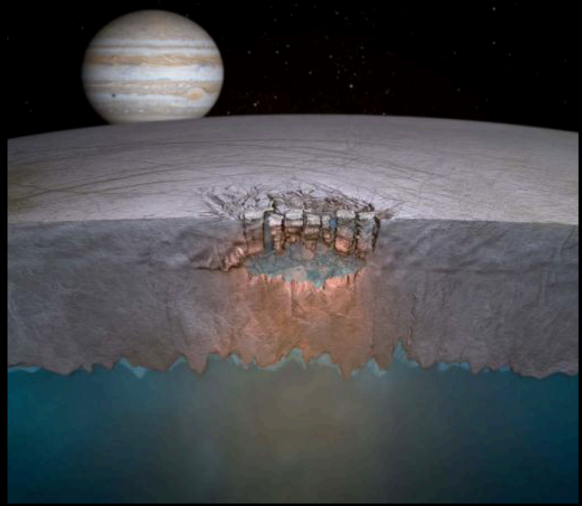


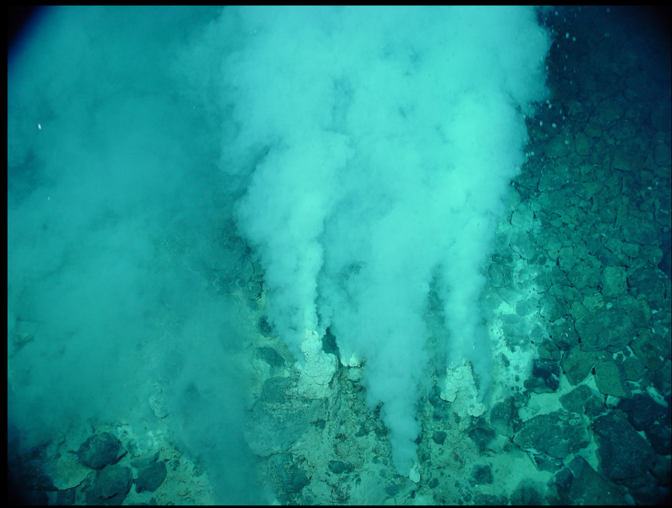




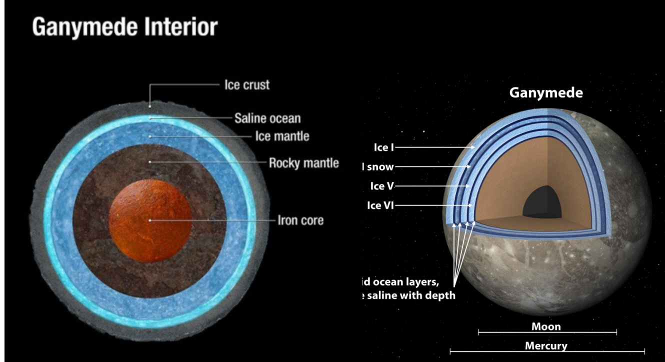
…the icy moons as potential habitat…

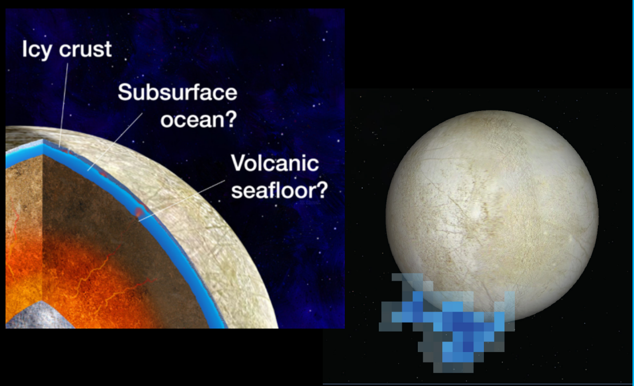


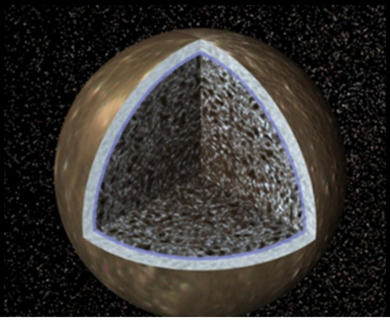




Scientific themes







Emergence of habitable worlds around gas giants

Ganymede as a planetary object and possible habitat

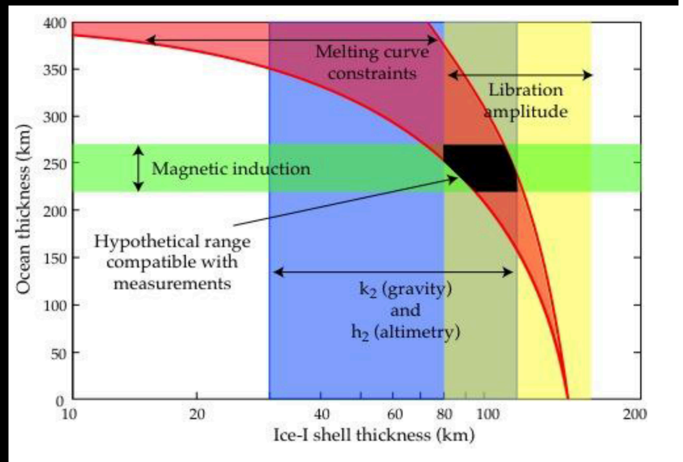
- Largest satellite in the solar system
- Ocean between icy layers
- Internal dynamo
- Richest crater morphologies
- Archetype of waterworlds

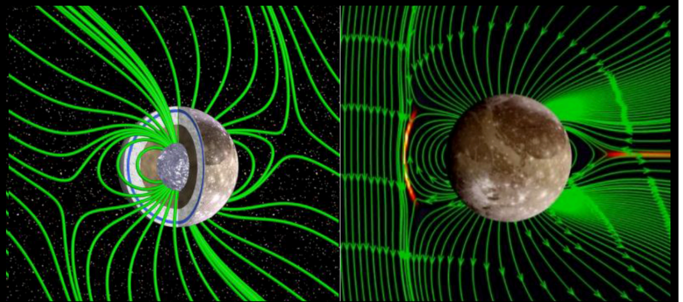
Europa's recently active zones

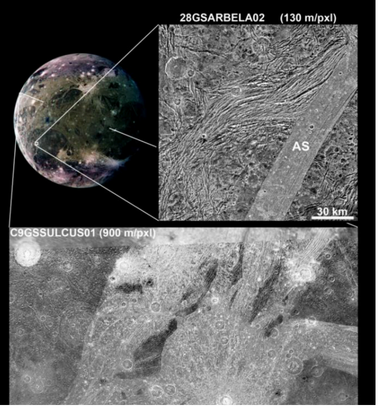
- An active world?
- Ocean in contact with silicates

Callisto as a remnant of the early Jovian system

- Impactor history
- Enigmatic differentiation
- Witness of early ages







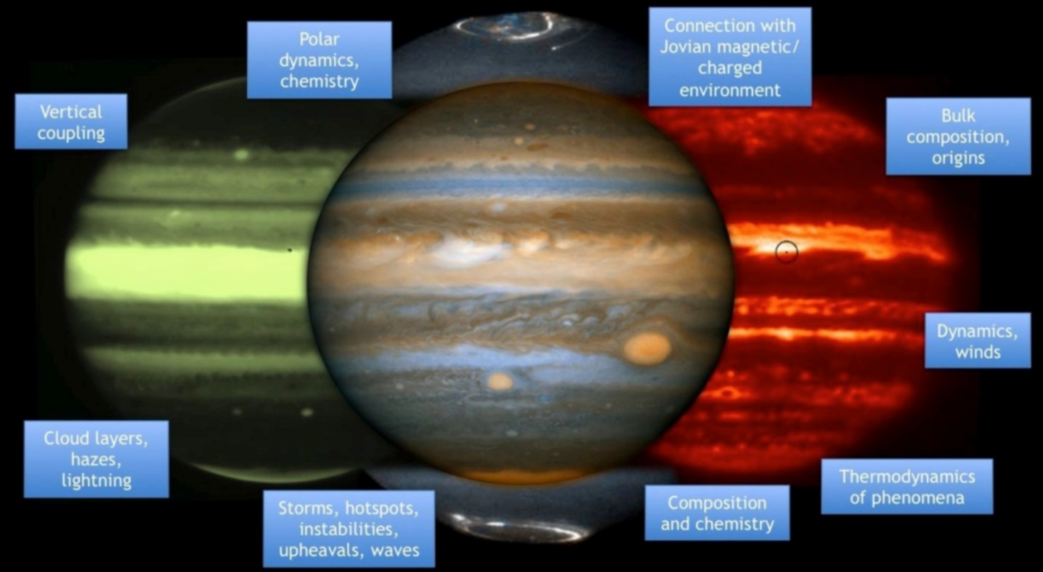
Scientific themes

Jupiter system as an archetype for gas giants

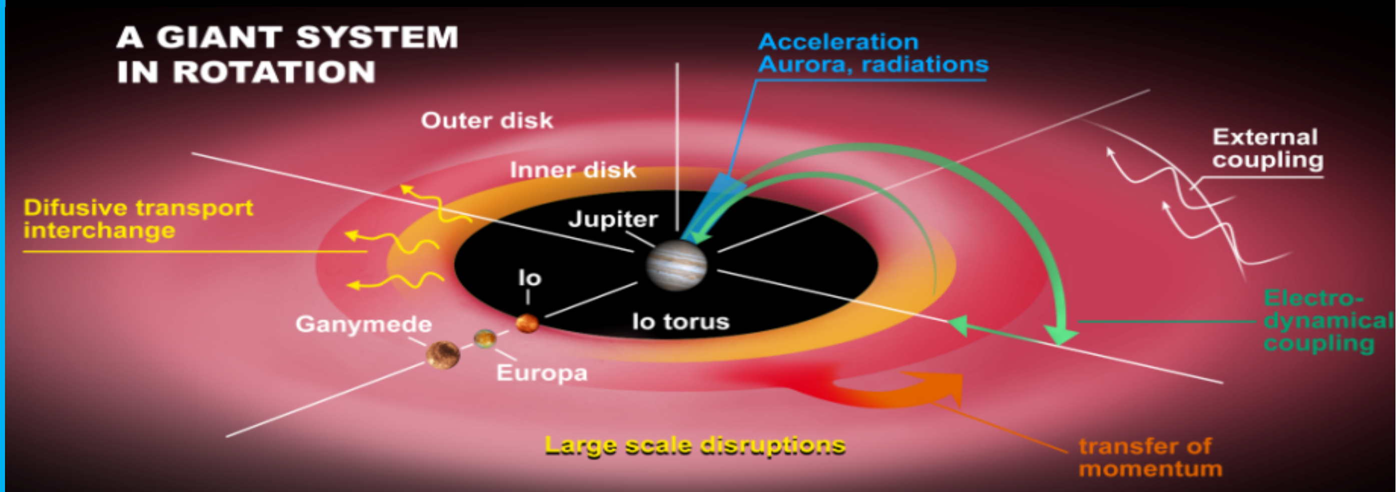
Jovian atmosphere
- Archetype for giant planets
- Fluid dynamics, chemistry, meteorology,...
- Formational history of planetary system

Jovian magnetosphere
- Largest object in our Solar System
- Astrophysical mechanisms at work
- Giant particle accelerator

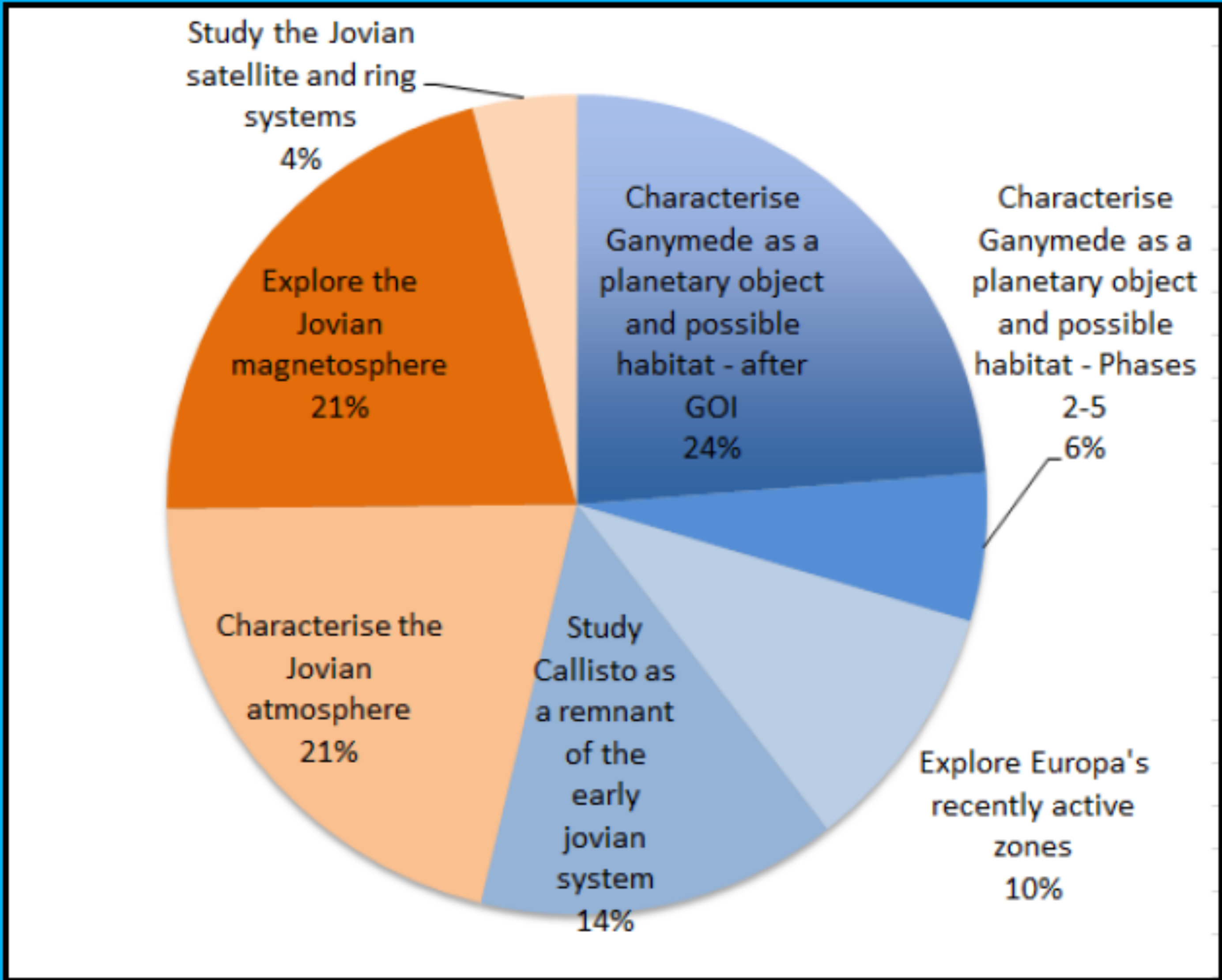
Jovian satellite and ring systems
- Tidal forces: Laplace resonance
- Electromagnetic interactions to magnetosphere and upper atmosphere of Jupiter



Credit: NASA/ESA/J. Clarke.



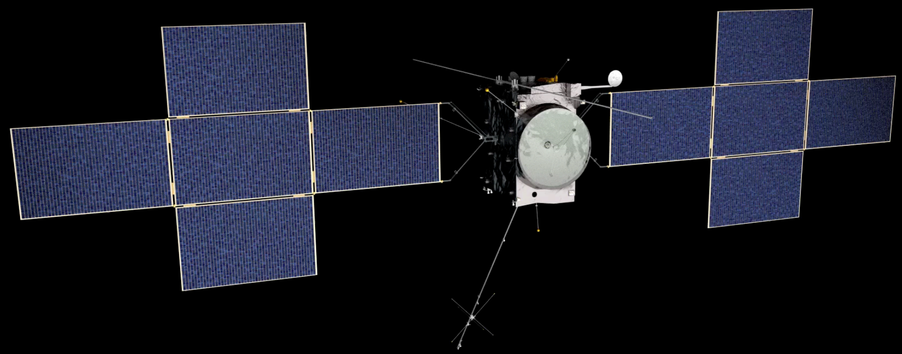
Scientific themes

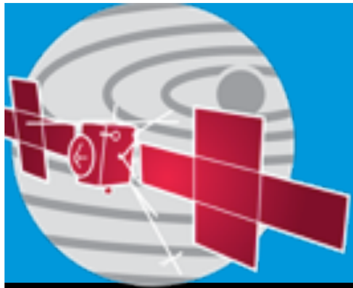


Overall data volume share amongst science objectives

The spacecraft

- 3-axis stabilised
- Launch mass ~5100 kg (instruments ~ 285 kg); Fuel ~ 2900 kg
- Solar array 85 m^2
- Power at Jupiter ~ 725 W EOL
- Fixed High Gain Antenna and steerable Medium Gain Antenna (X, Ka)
- Data Volume ~ minimum 1.4 Gb per day (Malargüe station as baseline)

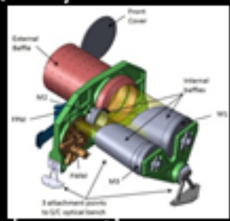




The payload

JANUS: Visible Camera System

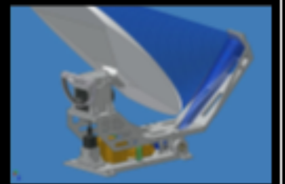
PI: Pasquale Palumbo, Parthenope University, Italy.
Co-PI: Ralf Jaumann, DLR, Germany



- ≥7.5m/pixel
- Multiband imaging, 380 - 1080 nm
- Icy moon geology
- Io activity monitoring and other moons observations
- Jovian atmosphere dynamics

SWI: Sub-mm Wave Instrument

PI: Paul Hartogh, MPS, Germany



- 600 GHz
- Jovian Stratosphere
- Moon atmosphere
- Atmospheric isotopes

MAJIS: Imaging VIS-NIR/IR Spectrograph

PI: Yves Langevin, IAS, France
Co-PI: Guiseppe Piccioni, INAF, Italy

- 0.9-1.9 μm and 1.5-5.7 μm
- ≥62.5 m/pixel
- Surface composition
- Jovian atmosphere

GALA: Laser Altimeter

PI: Hauke Hussmann, DLR, Germany

- ≥40 m spot size
- ≥0.1 m accuracy
- Shape and rotational state
- Tidal deformation
- Slopes, roughness, albedo

UVS: UV Imaging Spectrograph

PI: Randy Gladstone, SwRI, USA

- 55-210 nm
- 0.04°-0.16°
- Aurora and Airglow
- Surface albedos
- Stellar and Solar Occultation

RIME: Ice Penetrating Radar

PI: Lorenzo Bruzzone, Trento, Italy
Co-PI: Jeff Plaut, JPL, USA

- 9 MHz
- Penetration ~9 km
- Vertical resolution 50 m
- Subsurface investigations

The payload

JMAG: JUICE Magnetometer

PI: Michele Dougherty, Imperial, UK

- Dual Fluxgate and Scalar mag
- ±8000 nT range, 0.2 nT accuracy
- Moon interior through induction
- Dynamical plasma processes

3GM: Gravity, Geophysics, Galilean Moons

PI: Luciano Iess, Rome, Italy

Co-PI: David J. Stevenson, CalTech, USA

- Ranging by radio tracking
- 2 µm/s range rate
- 20 cm range accuracy
- Gravity fields and tidal deformation
- Ephemerides
- Bi-static and radio occultation experiments

PEP: Particle Environment Package

PI: Stas Barabash, IRF-K, Sweden

Co-PI: Peter Wurz, UBe, Switzerland

- Six sensor suite
- Ions, electrons, neutral gas (in-situ)
- Remote ENA imaging of plasma and torus

PRIDE: Planetary Radio Interferometer & Doppler Experiment

PI: Leonid Gurvits, JIVE, EU/The Netherlands

- S/C state vector
- Ephemerides
- Bi-static and radio occultation experiments

RPWI: Radio and Plasma Wave Investigation

PI: Jan-Erik Wahlund, IRF-U, Sweden

- Langmuir Probes
- Search Coil Magnetometer
- Tri-axial dipole antenna
- E and B-fields
- Ion, electron and charged dust parameters

Mission Development Status and milestones

✓ **2017:**

- ***Spacecraft Preliminary Design*** Review (PDR).
- ***Instrument PDR*** completed
  - ➪ Start of phase C (Mar. 2017)
- Completed ***Ground Segment Requirement*** Review (Dec. 2017)

- 2018:
  - Start of EM campaign

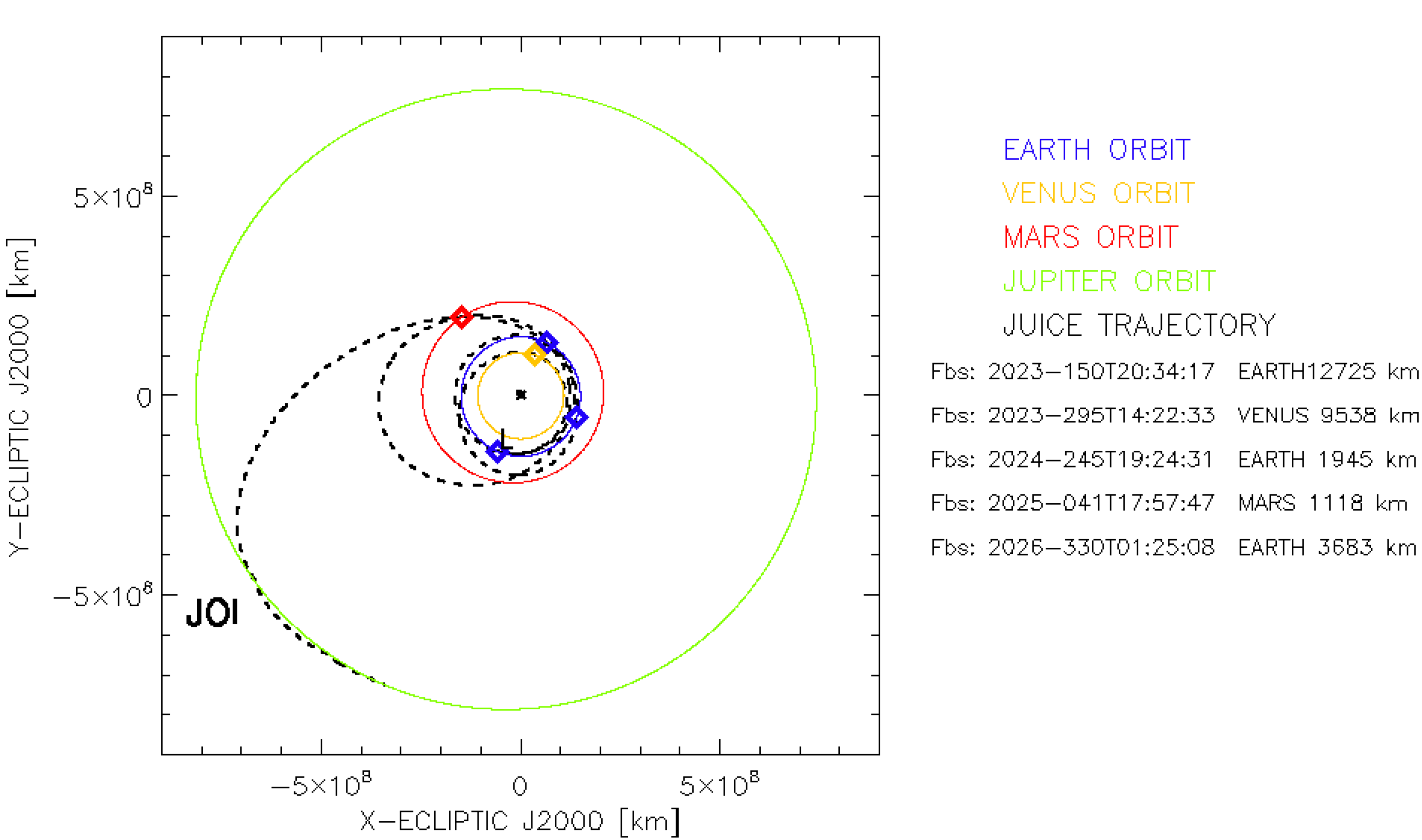
- 2019:
  - ***Spacecraft Critical Design*** Review : board in Mar. 2019 and go ahead for flight model manufacturing.

- 2019/2020:
  - Delivery of instrument Flight Models

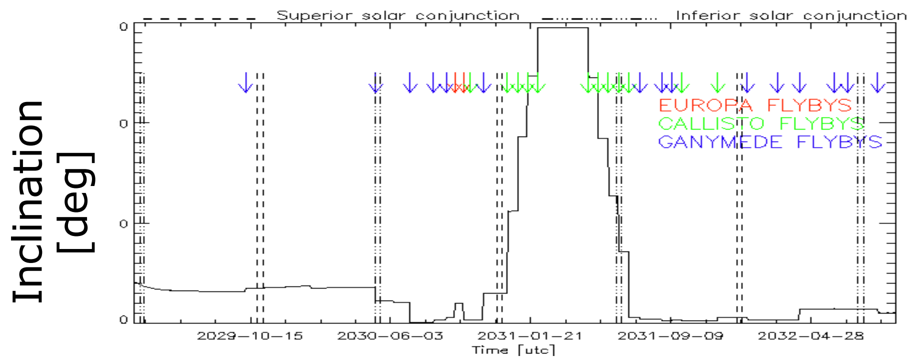
Mission milestones

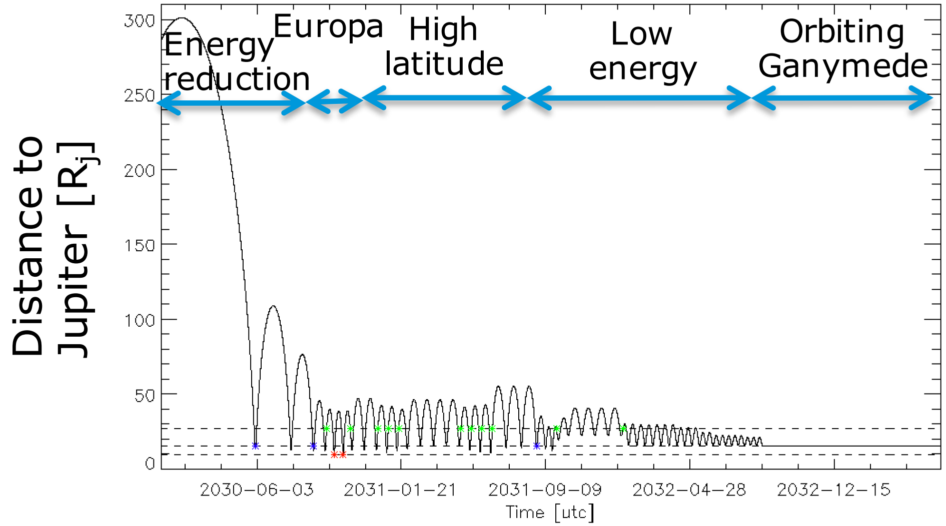
Launch	May 2022
Interplanetary transfer (Earth-Venus-Earth-Mars-Earth)	7.6 years
Jupiter orbit insertion (JOI)	Oct 2029
2 Europa flybys	Sept-Oct 2030
Jupiter high-latitude phase	Nov 2030-Jul 2031
Transfer to Ganymede	Aug 2031-Sept 2032
Ganymede orbit insertion (GOI)	Sept 2032
Ganymede elliptical orbit/5000 km circular orbit	Sept 2032–Jan 2033
Ganymede 500 km Circular Orbit	Feb-June 2033
End of mission	June 2033

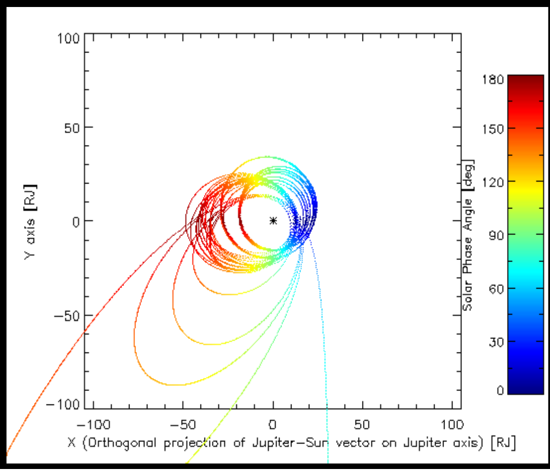
Cruise phase
5 planetary flybys



Jupiter Tour

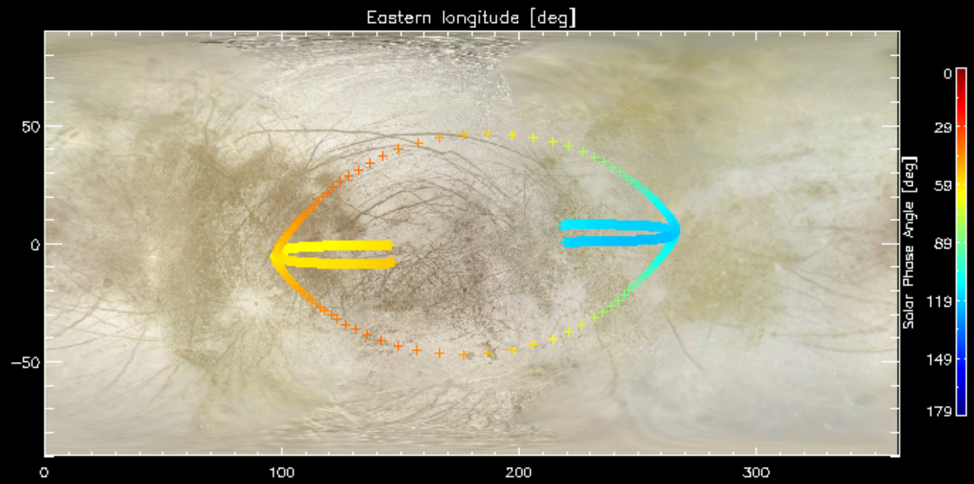




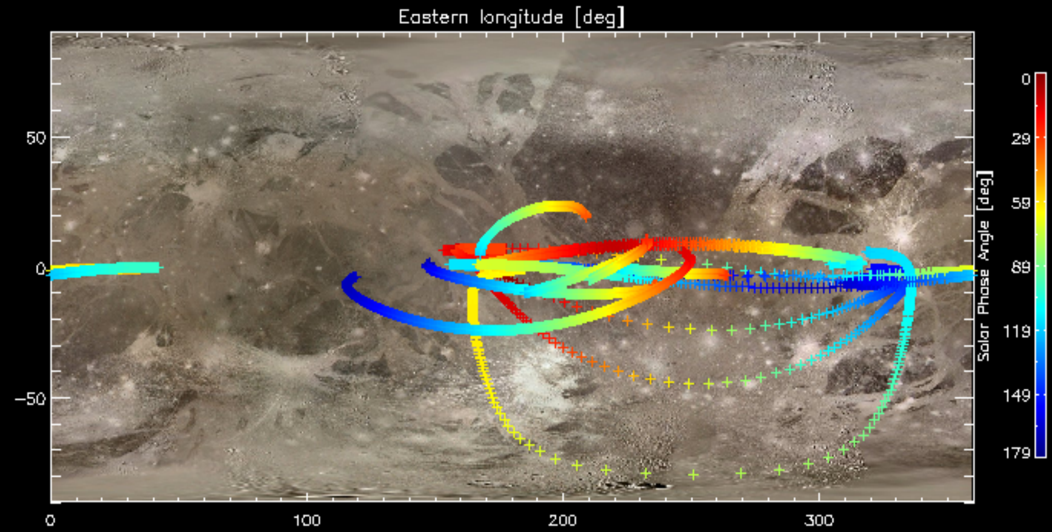


Jupiter Tour: moons flybys

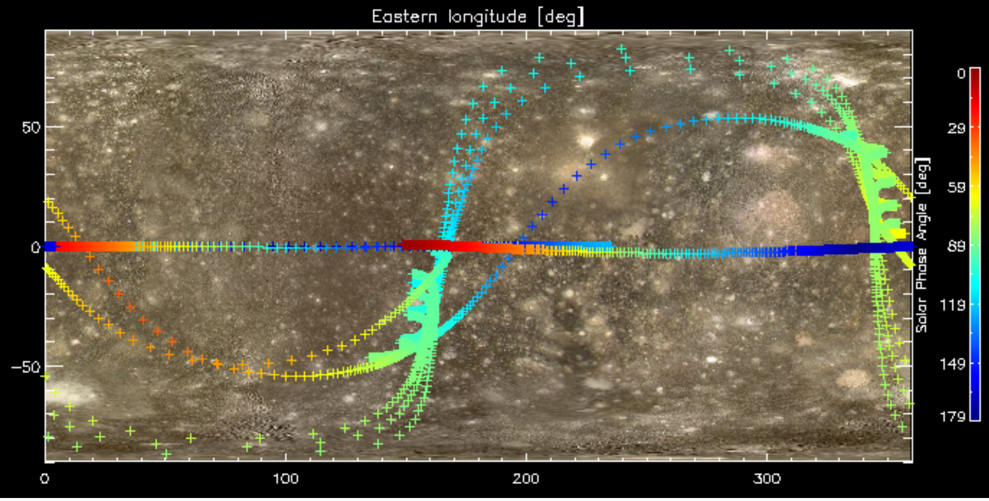
2 EUROPA @ 400 km



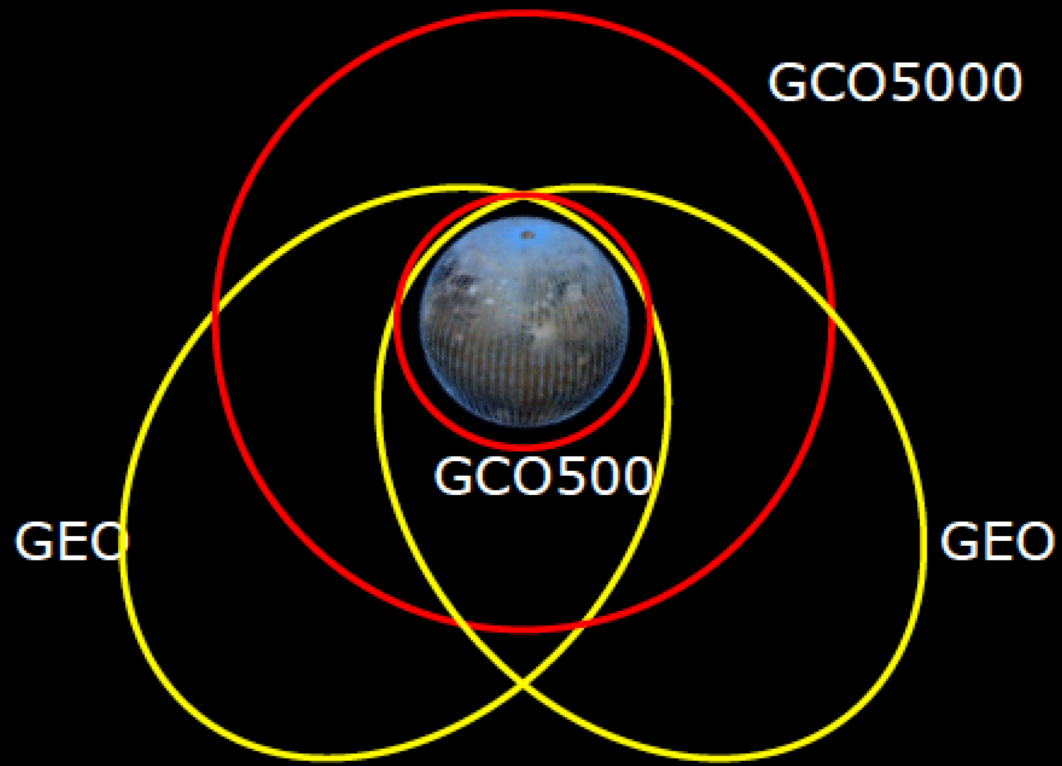
15 GANYMEDE @ 300-50000 km



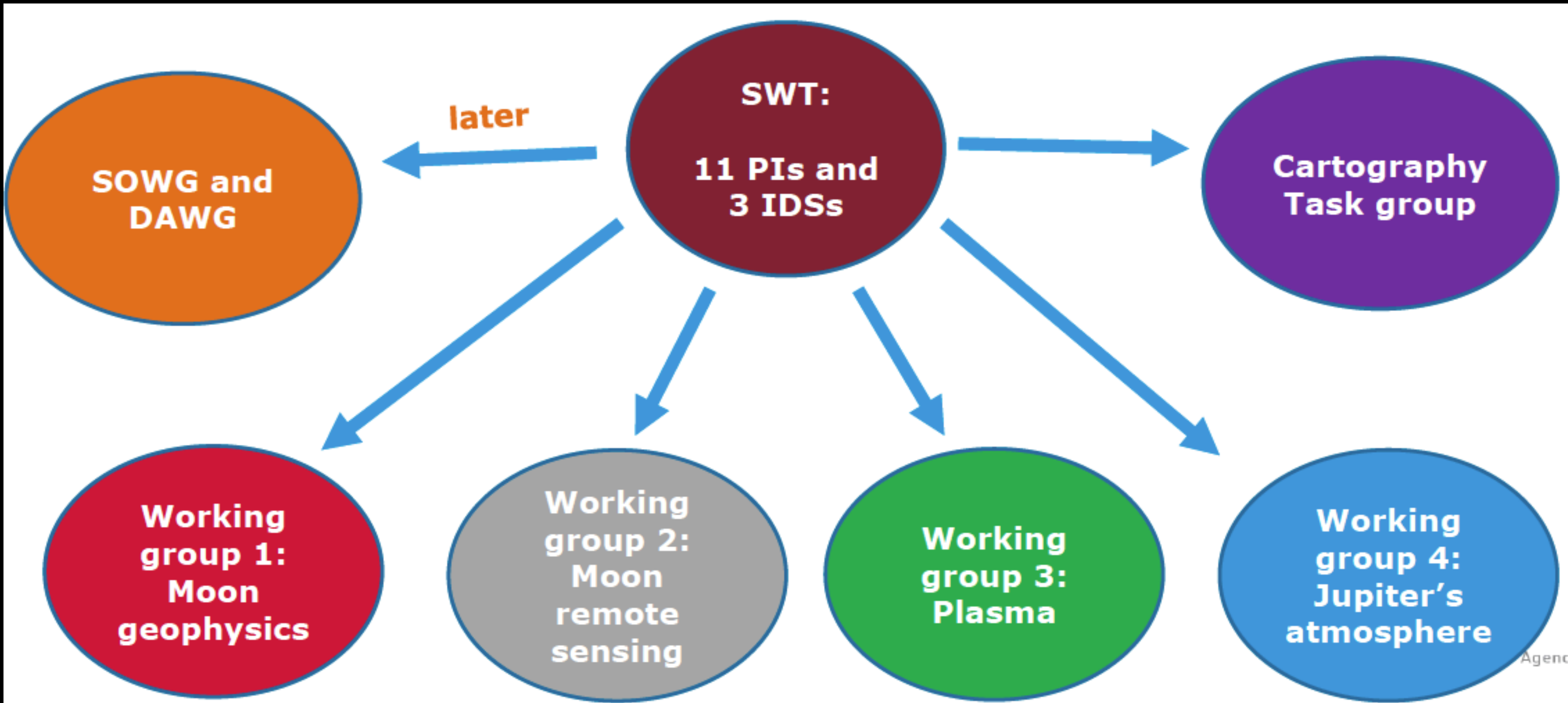
12 CALLISTO @ 200-3,500 km



Ganymede phase



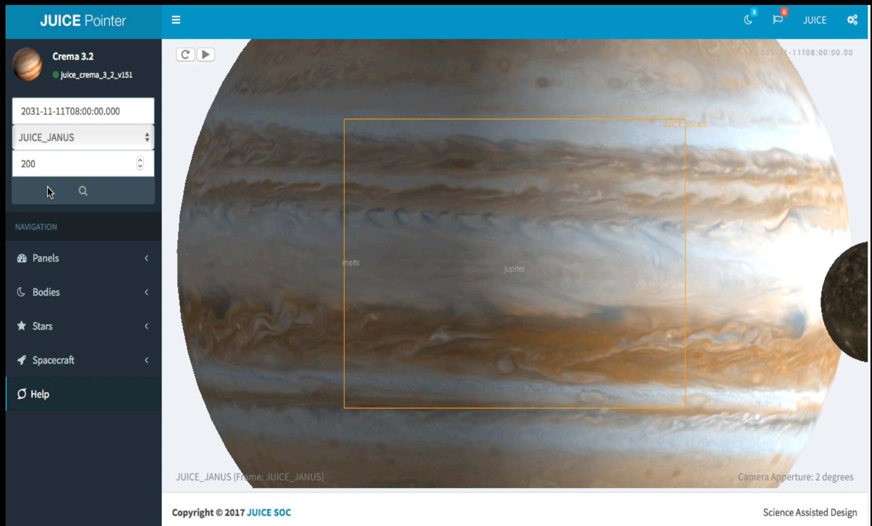
The Science Working Team organization



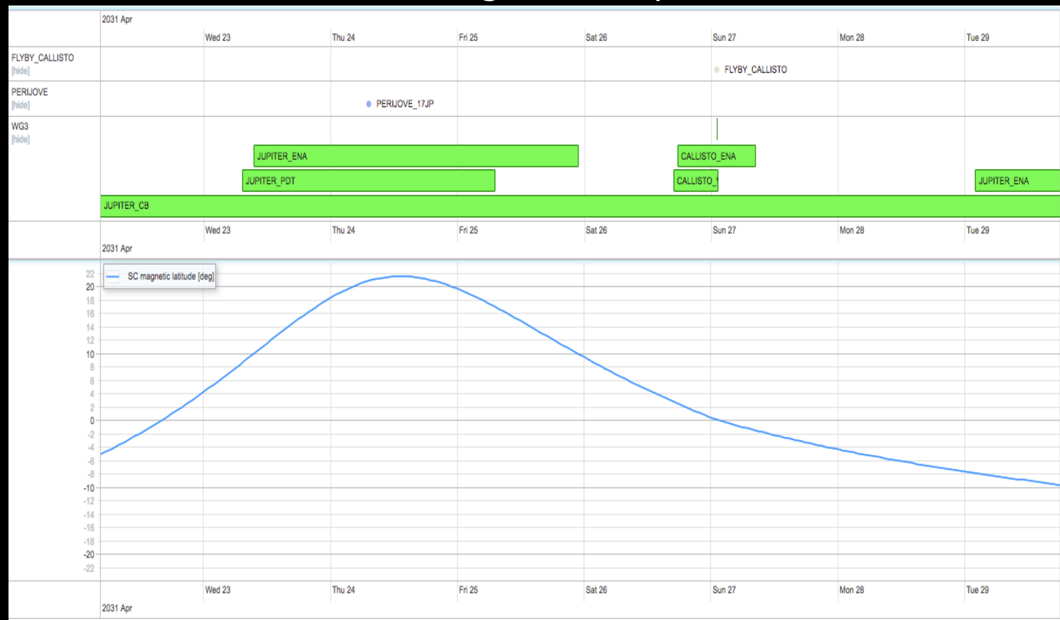
The four WGs are advising on scientific matters, top-level science planning, trajectory segmentation and sharing of mission resources.

Identify science observations opportunities

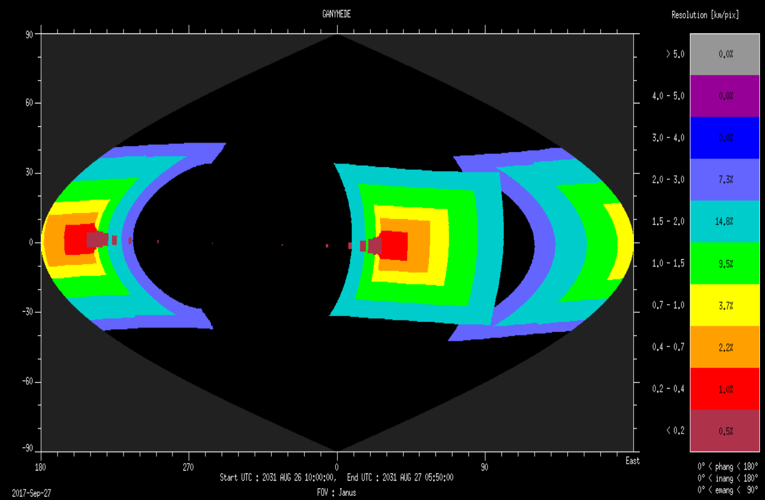
Callisto and Europa in front of Jupiter disk (PR)



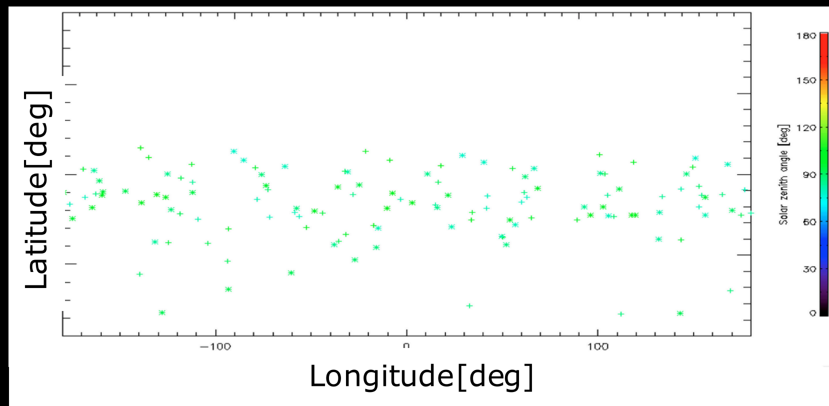
WG3 (Plasma): example of science observations opportunities during inclined phase



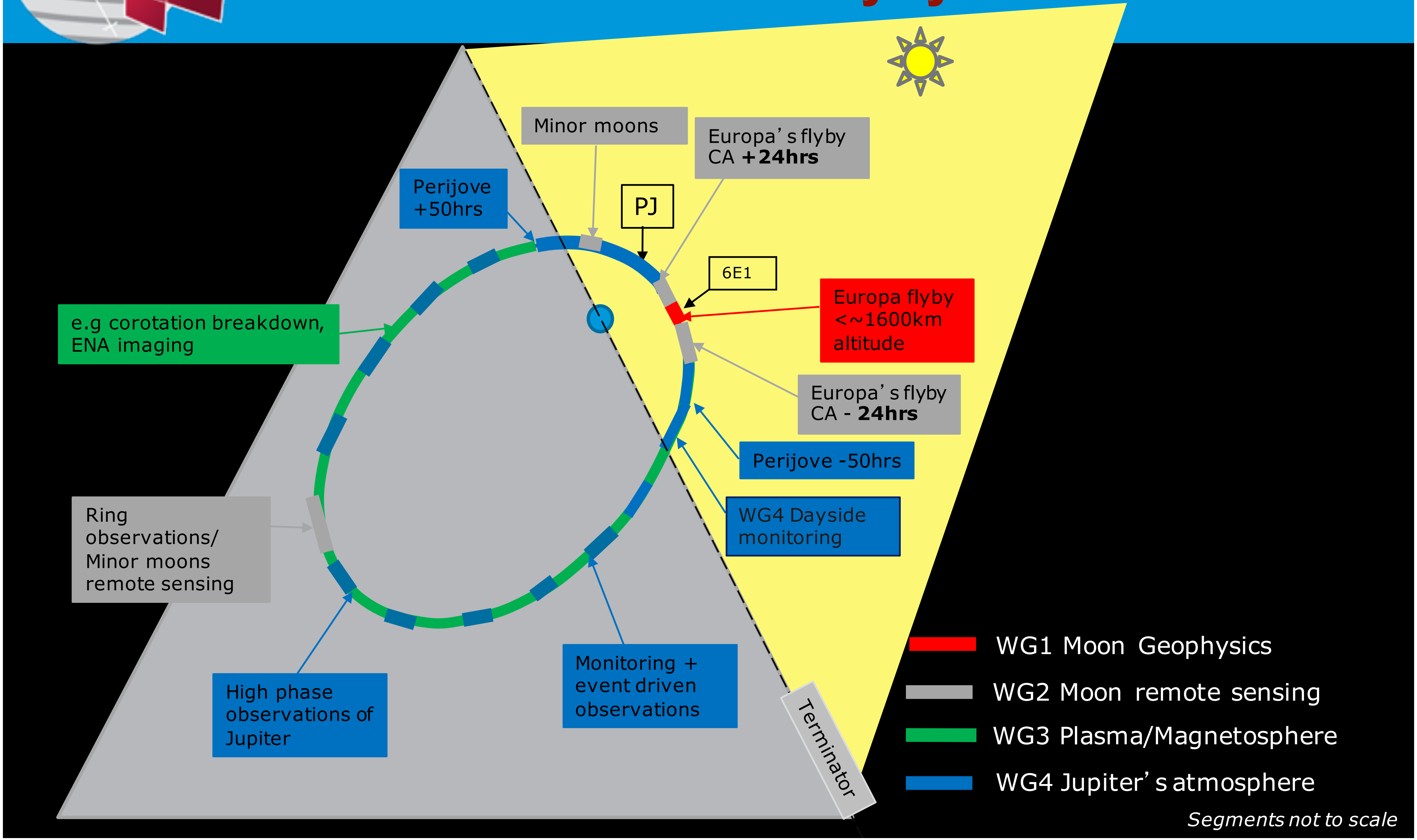
WG2 (moon remote sensing): Expected coverage on Ganymede (JANUS) during 17G5



WG4 (Jupiter atmosphere): Distribution of Earth occultation by Jupiter (radio science)

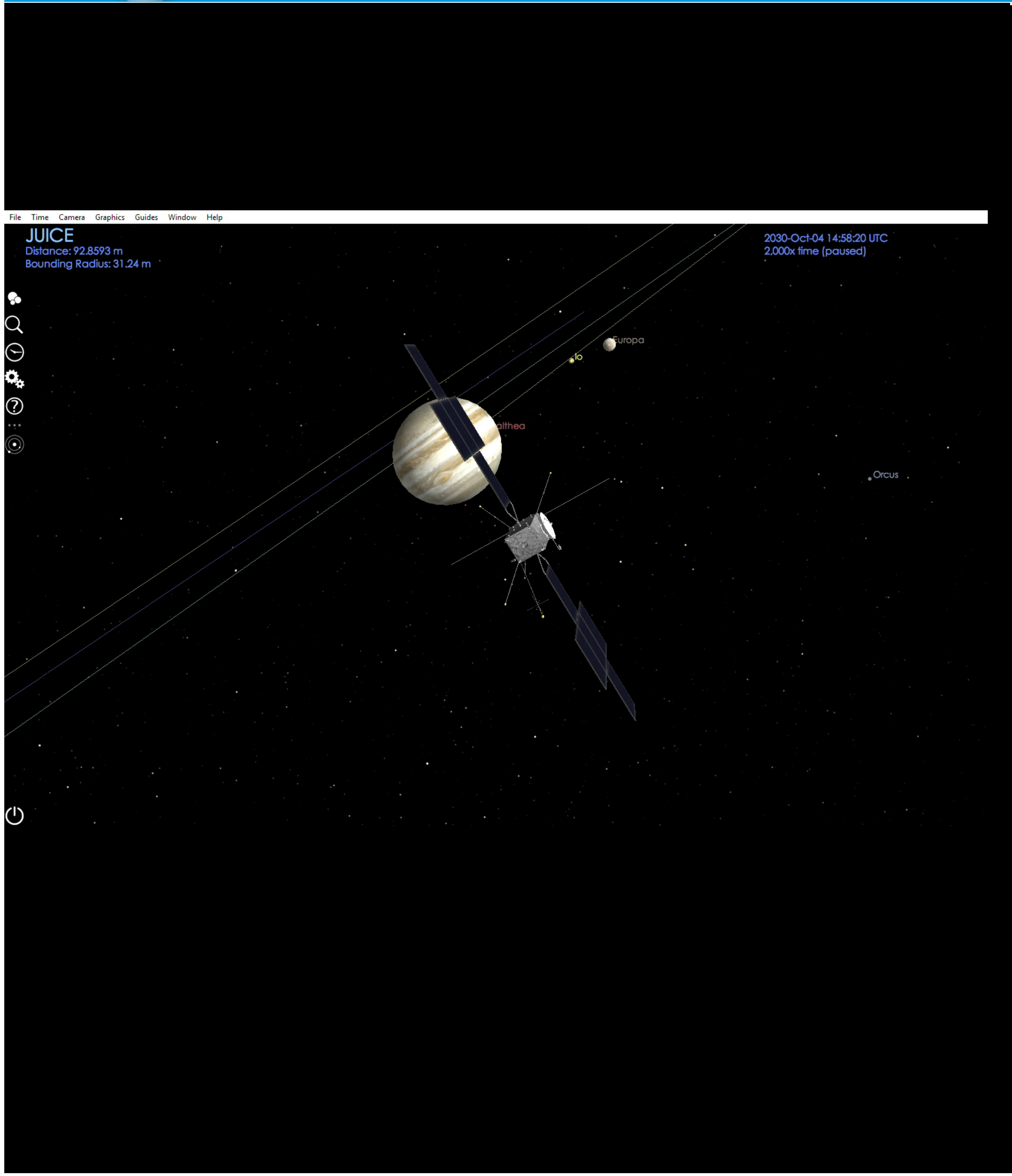


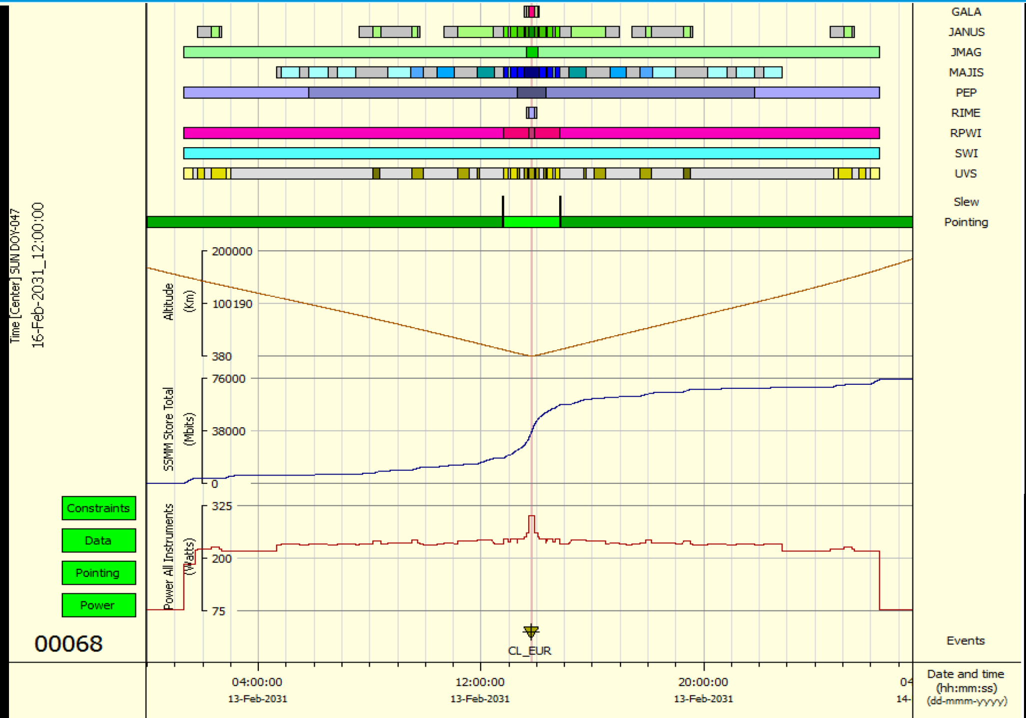
Example of trajectory segmentation: Orbit with flyby

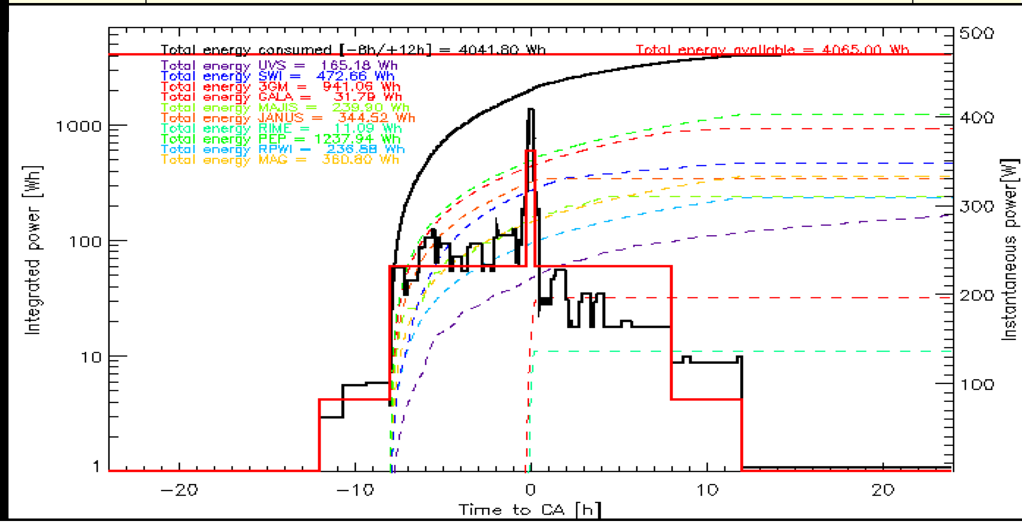


Segments not to scale

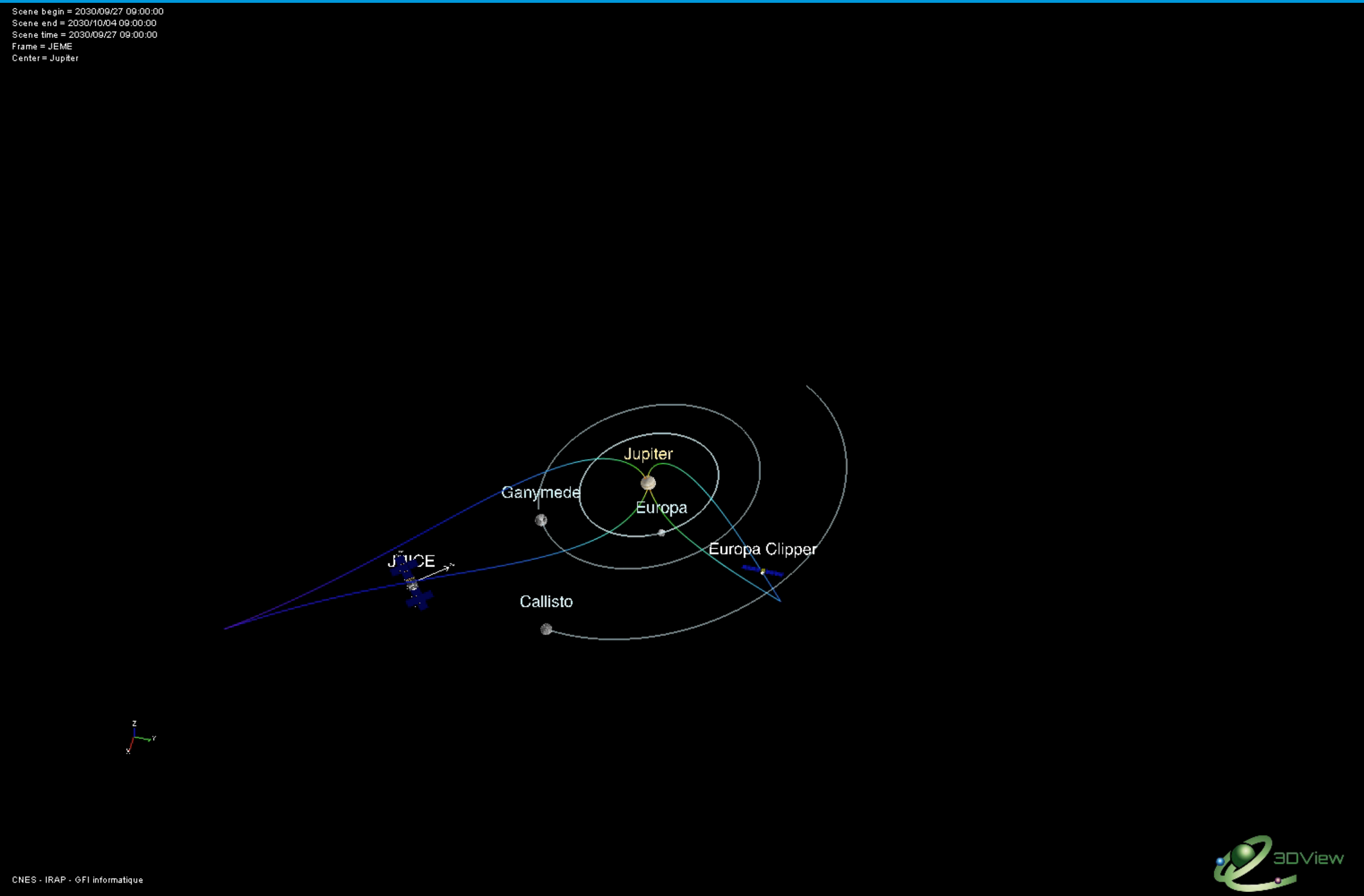
Detailed analysis of operational scenario: Europa







JUICE and Clipper



Courtesy of B. Torn (ESA/ESTEC)

Time Period: 2030/09/27 09:00:00 to 2030/10/04 09:00:00 (JUICE)
Europa-Clipper Timeshift: 4.79 years
------ [Timeshifted so JOI for each spacecraft are the same date] ------

JUICE – Europa Clipper Collaborative Science Workshop

Beckman Institute, California Institute of Technology, Pasadena, California, USA

Sunday, July 22, 2018

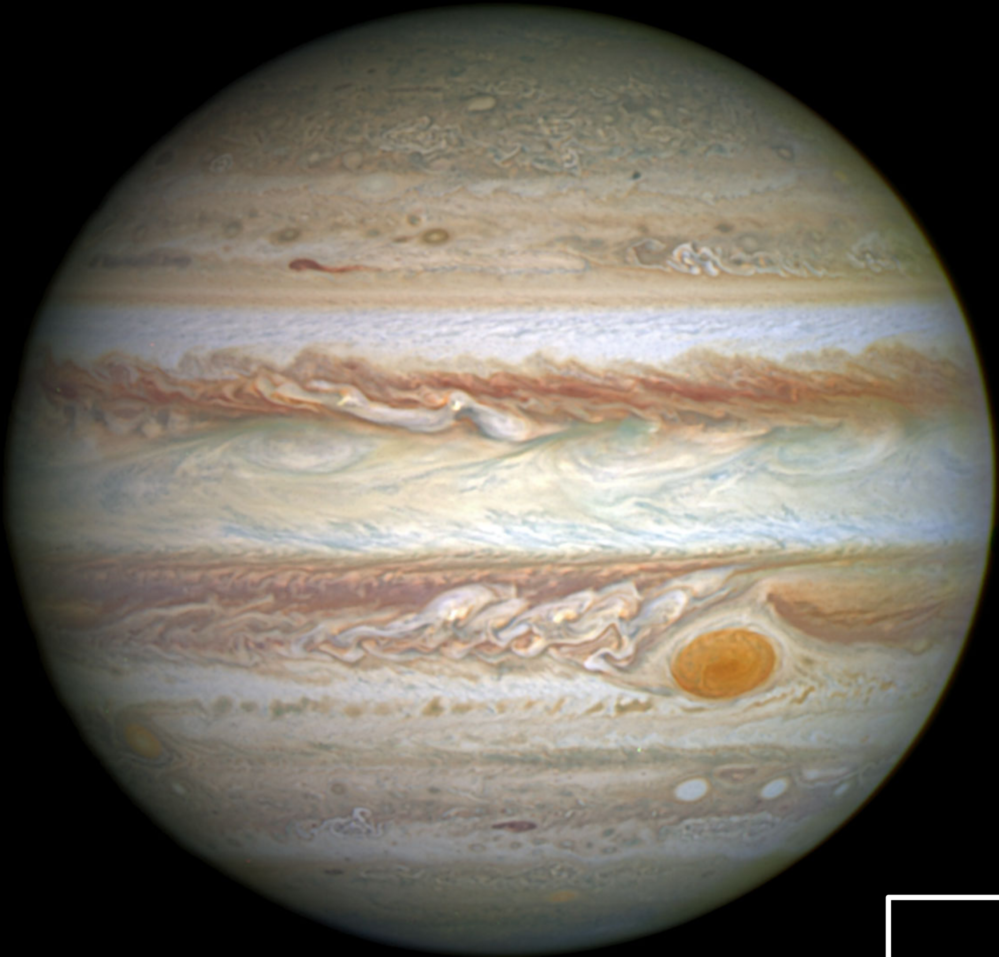
Members of the JUICE and Europa Clipper science teams will discuss potential scientific synergies between the Europa Clipper and JUICE missions

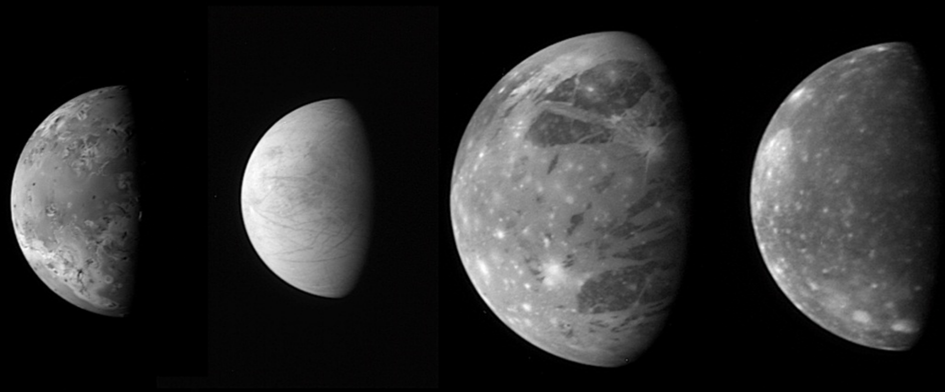
- **Investigations if both missions *are* in the Jupiter system at the same time:**
  - **Multi-point measurements of the characteristics of the Jovian magnetodisc, with each spacecraft providing far-field context for the other**

- **Investigations if both spacecraft *are not* in the Jupiter system at the same time:**
  - **Opportunities for observations that are spatially or otherwise complementary, e.g.**
    - **Complementary coverage in spatial, spectral, energy, and geometric domains**
  - **Observations providing long temporal baselines, e.g.**
    - **Time-variability of the Jovian magnetodisc**
    - **Europa's atmosphere and potential plume activity**

- **Combined data sets will offer a more complete view of the Europa, Ganymede and the Jupiter system, while enabling in-depth comparative studies of the ocean worlds Ganymede and Europa.**

THANK YOU FOR YOUR ATTENTION





Io Europa Ganymede Callisto

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