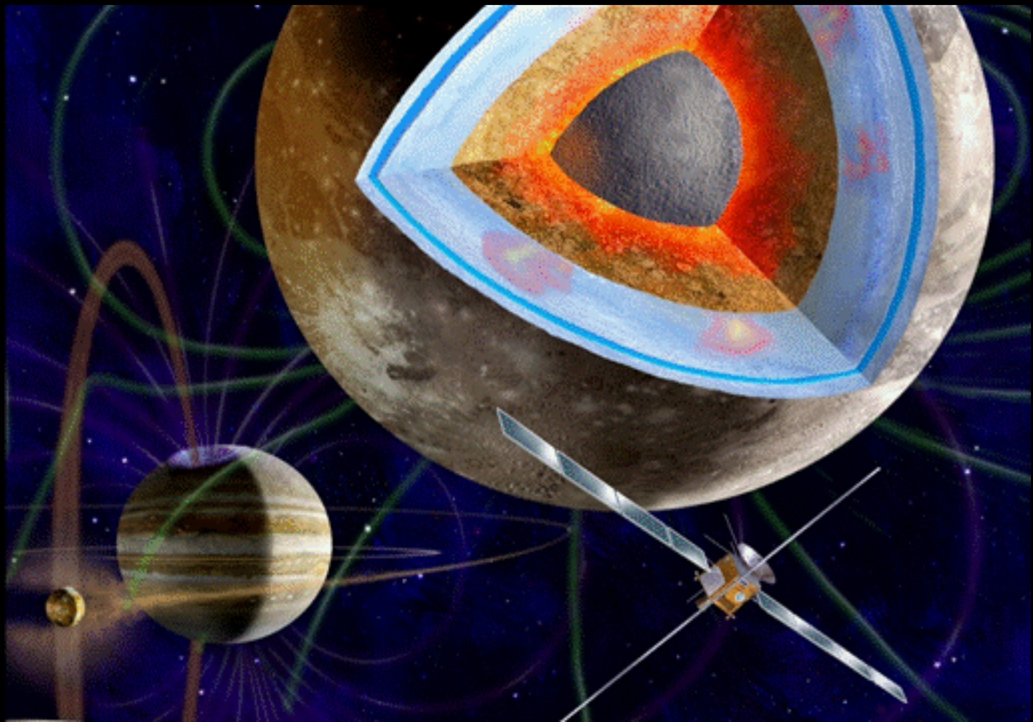
JUICE (JUpiter ICy moons Explorer)



JUICE Science Themes

- *Emergence of habitable worlds around gas giants*
- *Jupiter system as an archetype for gas giants*

Cosmic Vision Themes

- *What are the conditions for planet formation and emergence of life?*
- *How does the Solar System work?*

JUICE concept

- *European-led mission to the Jovian system*
- *JGO/Laplace scenario upgraded with two Europa flybys and high-inclination phase at Jupiter*
- *Model payload is the same as it was on JGO/Laplace*

JUICE versus JGO/EJSM-LAPLACE : what has changed?

JUICE

How does JUICE compare to the previous Jupiter Ganymede Orbiter ?

- Priorities and objectives are similar
- Ganymede remains the top priority and deserves an orbiter
- Two Europa flybys have been added
- The Callisto phase has been modified to allow for the exploration of the unknown high latitudes of the jovian system

How can we keep all former JGO objectives and also add 2 Europa flybys ?

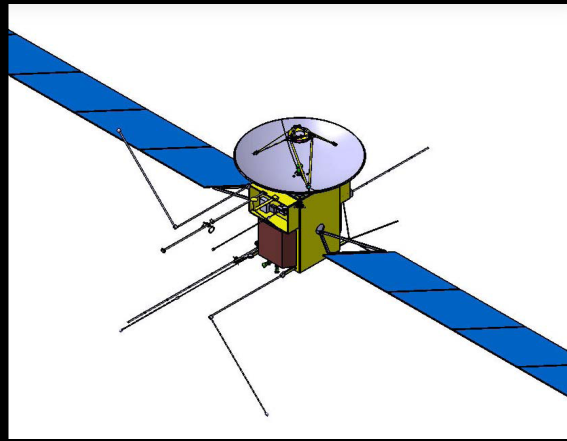
- Increase of radiation exposure balanced by
  - Moderate increase of shielding mass by ~50 kg
  - Higher component tolerance (up to 30 krad)
- Minor additional ΔV required for the additional mission options
  - Higher Jupiter latitude with Callisto gravity assists
  - Europa flybys
- Increased dry mass feasible due to
  - Higher launch capability
  - Longer interplanetary transfer (reduction of ΔV)

Mission design

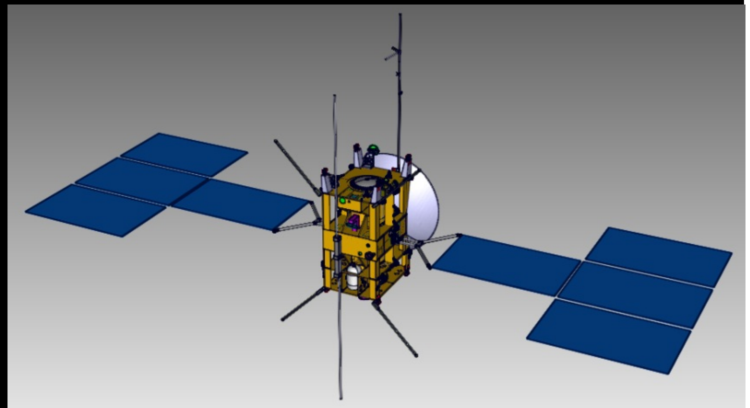
JUICE

Spacecraft Design | Model instruments | Mission phases

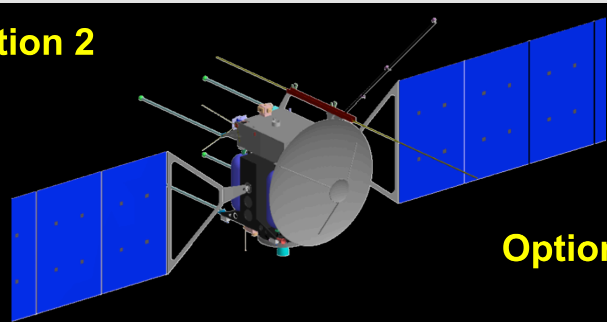
- Dry mass ~1900 kg, propellant mass ~2900 kg
- High Δv required: 2600 m/s
- Model payload 104 kg, ~120 – 150 W
- 3-axis stabilized s/c
- Power: solar array 60 – 70 m^2, 640 – 700 W
- HGA: >3 m, fixed to body, X & Ka-band
- Data return >1.4 Gb per 8 h pass (1 ground station)



Option 1



Option 2



Option 3

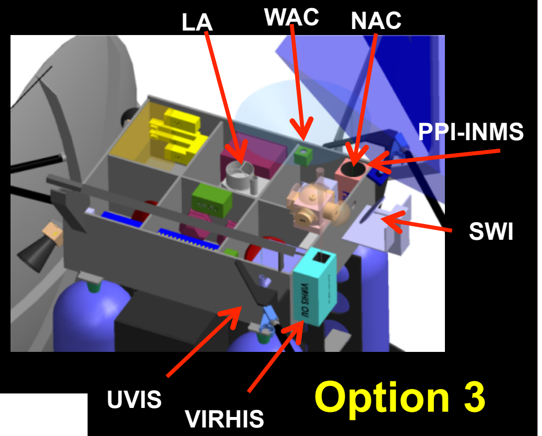
Mission design

JUICE

Spacecraft Design | **Model instruments** | Mission phases

Imaging	
Narrow Angle Camera (NAC)	10 kg
Wide Angle Camera (WAC)	4.5 kg
Spectroscopy	
Visible Infrared Hyperspectral Imaging Spectrometer (VIRHIS)	17 kg
UV Imaging Spectrometer (UVIS)	6.5 kg
Sub-mm Wave Instrument (SWI)	9.7 kg
In situ Fields and Particles	
Magnetometer (MAG)	1.8 kg
Radio and Plasma Wave Instr. (RPWI)	11.2 kg
Particle and Plasma Instr. - Ion Neutral Mass Spectr. (PPI-INMS)	18.2 kg
Sounders & Radio Science	
Laser Altimeter (LA)	11 kg
Ice Penetrating Radar (IPR)	10 kg
Radio Science Instrument (JRST+USO)	4 kg

Total mass: 104 kg



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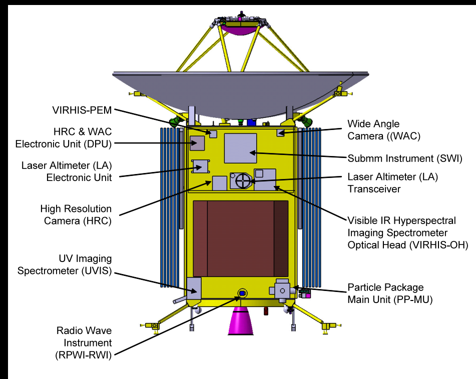
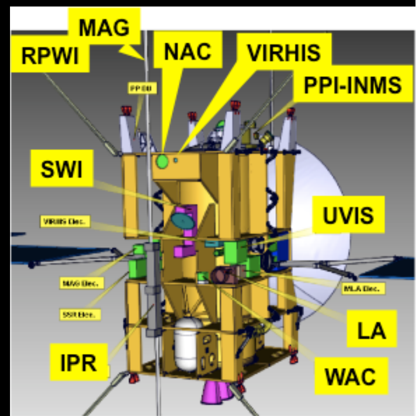


Option 2

Option 1



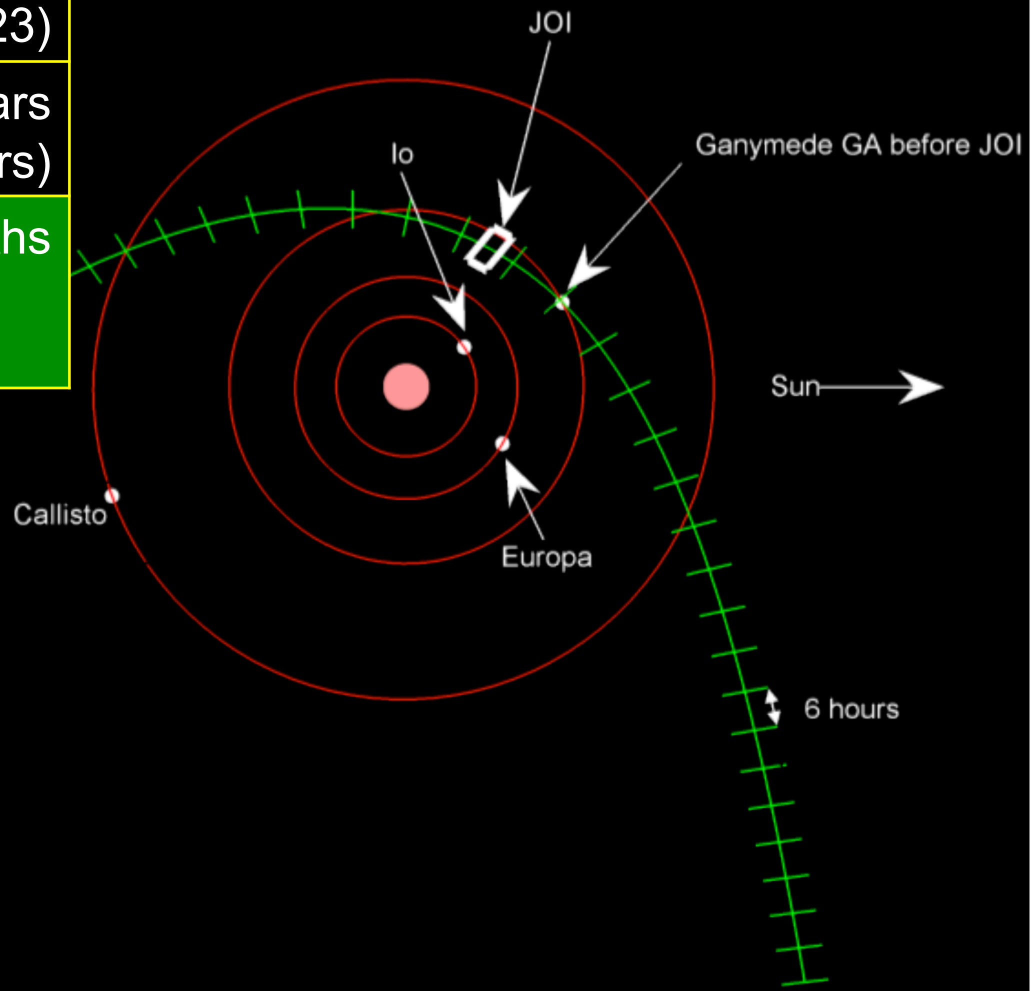
Model payload is based on heritage: *BepiColombo, Juno, Mars Express, Double Star, Venus Express, Rosetta, Dawn, Cassini, etc…*

Mission design

JUICE

Spacecraft Design | Model instruments | Mission phases

Launch	June 2022 (August 2023)
Interplanetary transfer (Earth-Venus-Earth_Earth)	7.6 years (8 years)
Jupiter orbit insertion and apocentre reduction with Ganymede gravity assists	11 months



Mission design

JUICE

Spacecraft Design | Model instruments | **Mission phases**

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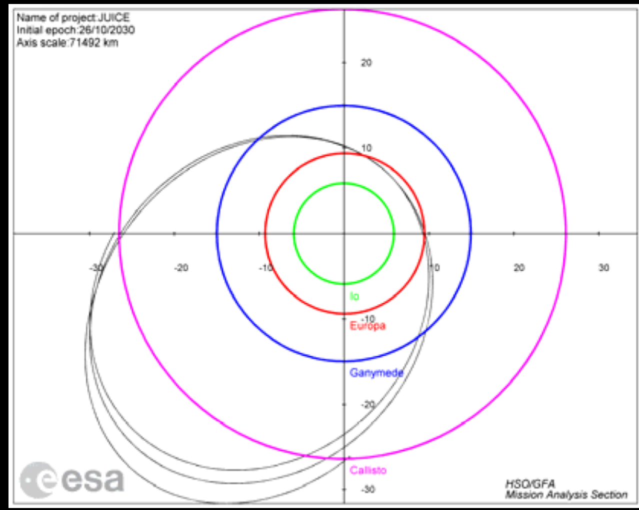

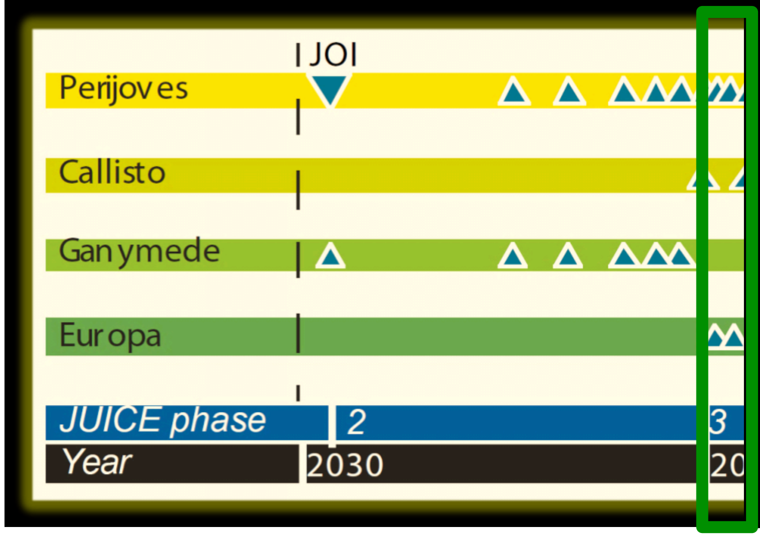

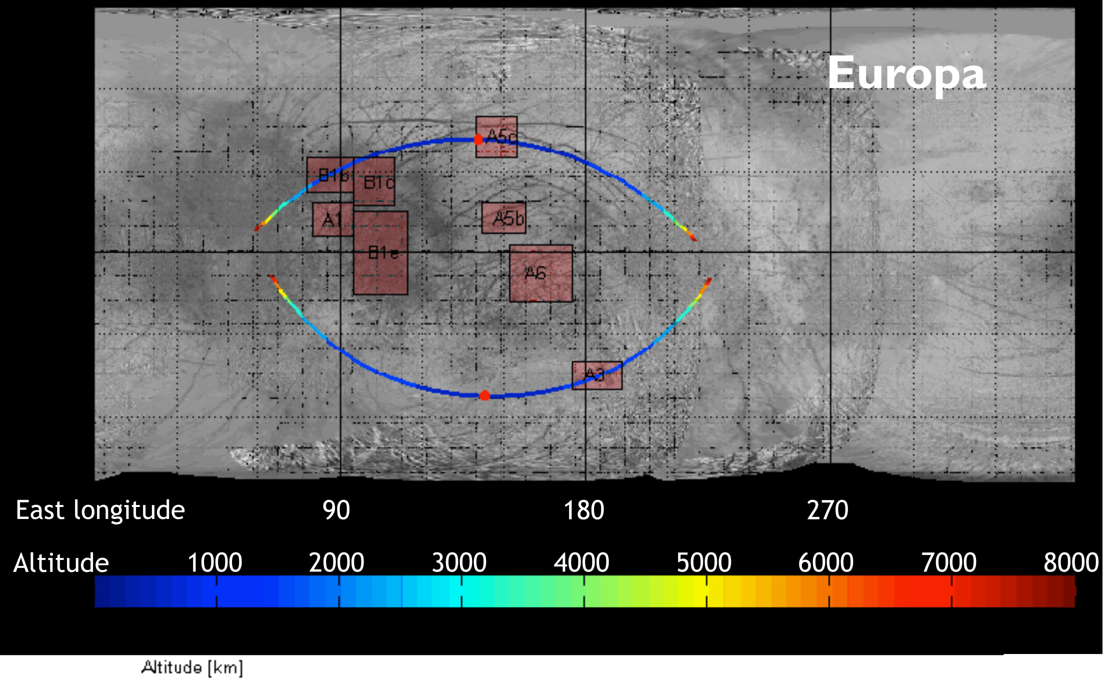

Mission design

JUICE

Spacecraft Design | Model instruments | Mission phases

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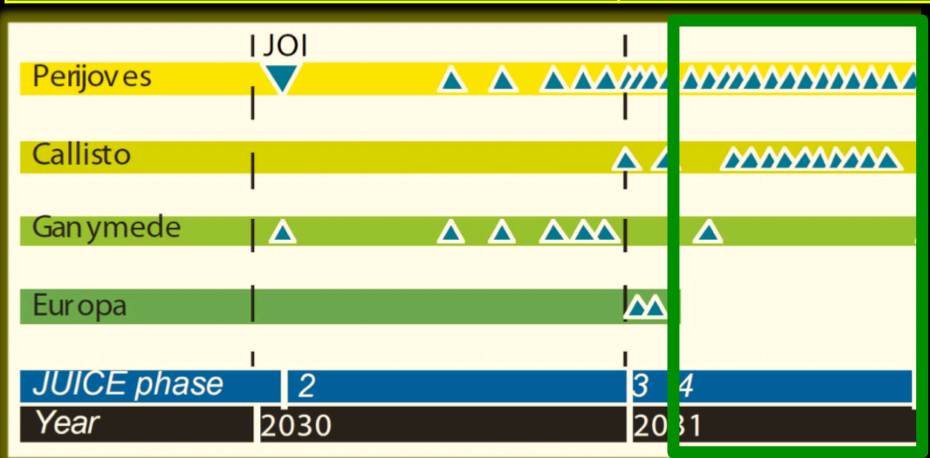
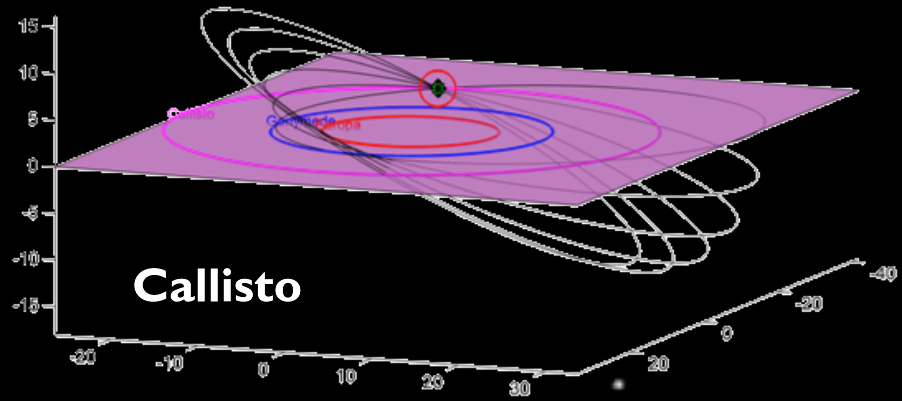
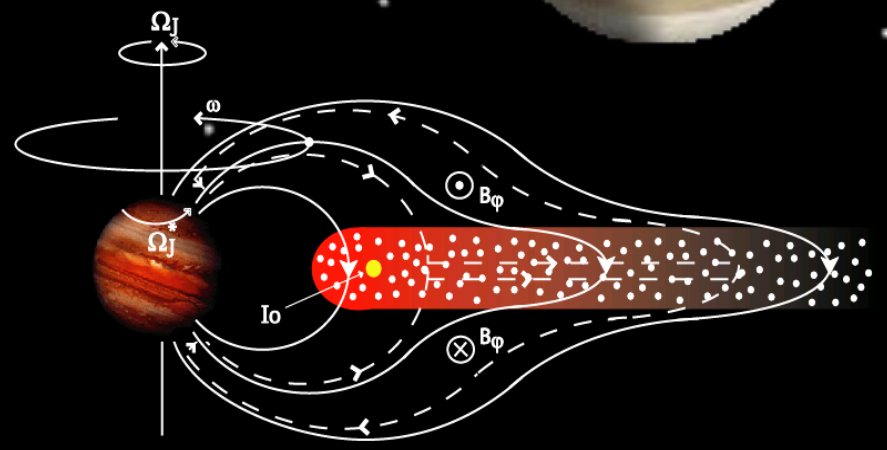
Reduction of v_{inf} (Ganymede, Callisto)	60 days
Increase inclination with 10 Callisto gravity assists	200 days



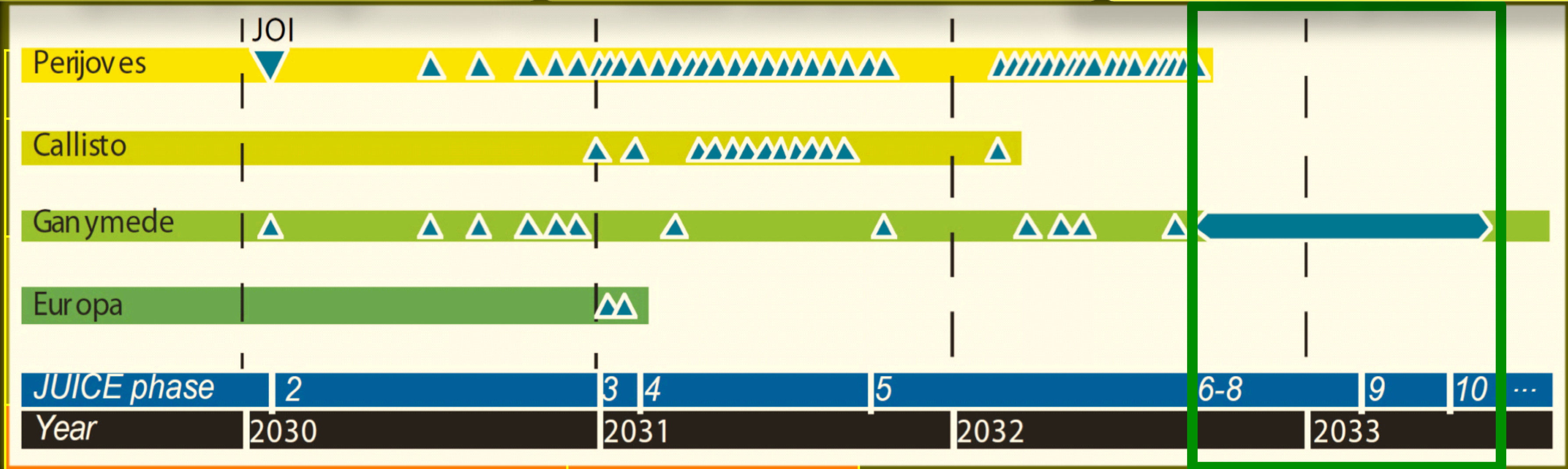




Mission design

JUICE

Spacecraft Design | Model instruments | Mission phases



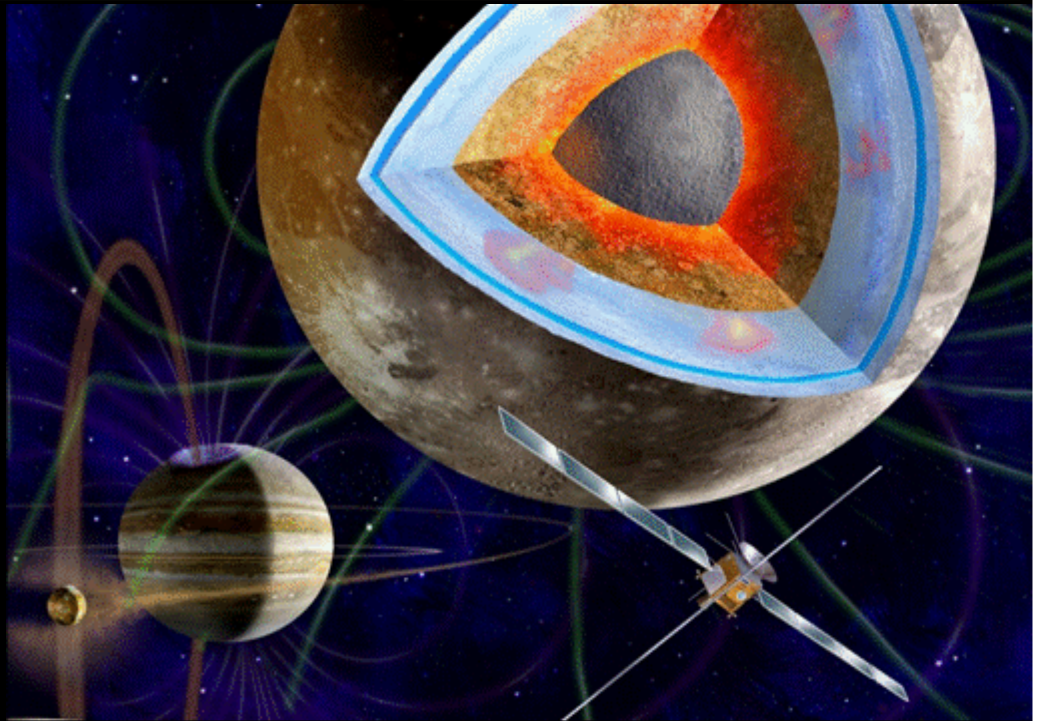
Reduction of v_{inf} (Ganymede, Callisto)	60 days
Increase inclination with 10 Callisto gravity assists	200 days
Callisto to Ganymede	11 months
Ganymede (polar) 10,000x200 km & 5000 km 500 km circular 200 km circular	 150 days 102 days 30 days
Total mission at Jupiter	3 years

Mission design - conclusions

JUICE is technically feasible

JUICE is ready to go: No need for critical technology identified

JUICE is compatible with programme constraints



The overall mission is considered as low risk from technical and programmatic standpoint

Characterise GANYMEDE as a planetary object and possible habitat

JUICE

WHY GANYMEDE ?

- Largest satellite of the solar system (bigger than Mercury)
- A possible habitat
- An intrinsic magnetic field embedded in the Jovian magnetosphere
- Richest crater morphologies in the solar system
- Best example of water-rich exoplanets
- A laboratory to study the Laplace resonance

HIGHLIGHTS

- First orbiter of an icy moon
- First european-led mission to the outer system
- First opportunity to explore the combination of 3 magnetic fields at a planetary scale
- Necessary step forward 30 years after Galileo

JUICE OBJECTIVES

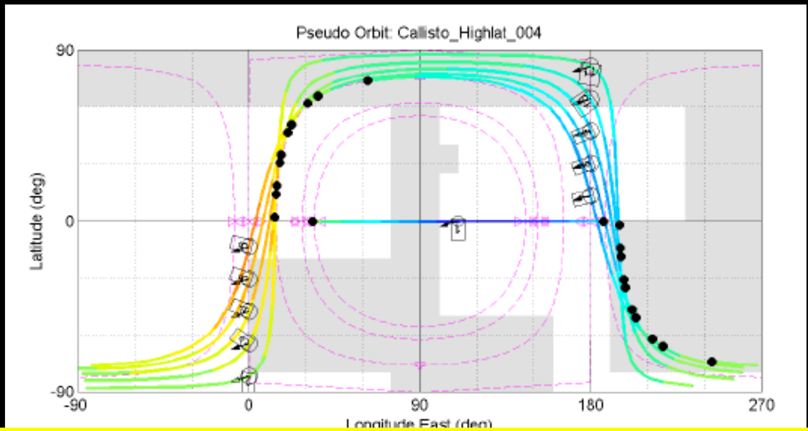
- Characterise the extent of the ocean and its relation to the deeper interior
- Characterize the ice shell
- Determine global composition, distribution and evolution of surface materials
- Understand the formation of surface features and search for past and present activity
- Characterize the local environment and its interaction with the jovian magnetosphere

Study CALLISTO as a remnant of the early Jovian system

JUICE

WHY CALLISTO?

- Best place to study the impactor history through time in the outer system
- Differentiation – still an enigma
- The only known example of a non habitable but ocean-bearing world
- The witness of early ages

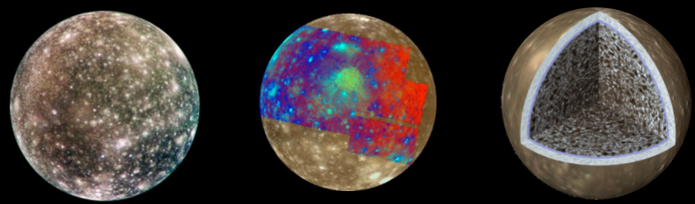


TO BE REMEMBERED

Twelve flybys for science

Two years of remote observations

The Callisto phase is also a requirement for reaching the still unexplored high latitudes of the Jovian system.



JUICE OBJECTIVES

- Characterise the outer shells, including the ocean
- Determine the composition of the non-ice material
- Study the past activity

Explore EUROPA's recently active zones

JUICE

WHY EUROPA ?

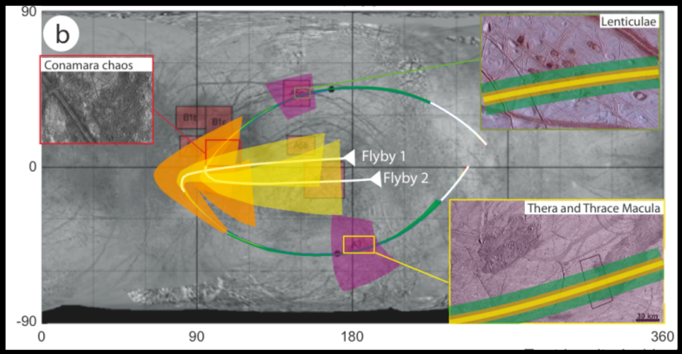
- Attractive moon to study the habitability in the solar system
- Possesses a « salty » ocean in contact with the rocky mantle
- May be an active world

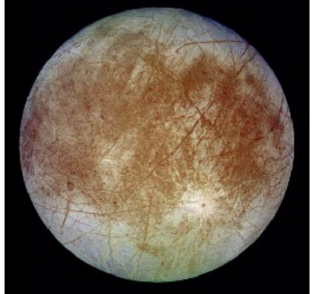
TO BE REMEMBERED

New investigations as compared to Galileo
One flyby is already enough – Two provides a back-up
One year of remote observations in addition to the 2 F/B

JUICE will tell us:

- If the liquid composition is comparable to our oceans
- How thick is the crust in chaos regions
- If liquid reservoirs exist
- If the moon is still active





JUICE OBJECTIVES

- Determine the composition of the non-ice material, especially as related to habitability
- Look for liquid water under the most active sites
- Study the recently active processes

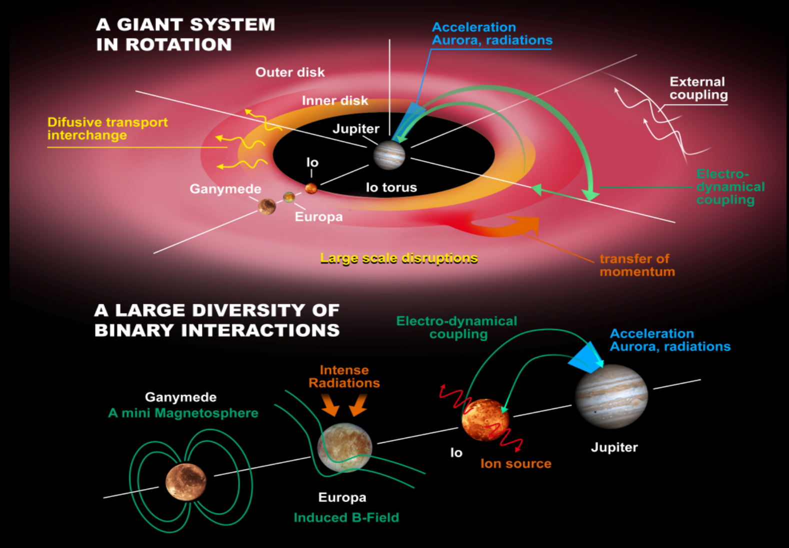
Europa				
Year	2030	2031	2032	2033

Characterise the Jovian magnetosphere

JUICE

Why Jupiter's Magnetosphere?

- Largest object in our Solar System
- Biggest particle accelerator in the Solar System
- Unveil global dynamics of an astrophysical object



HIGHLIGHTS

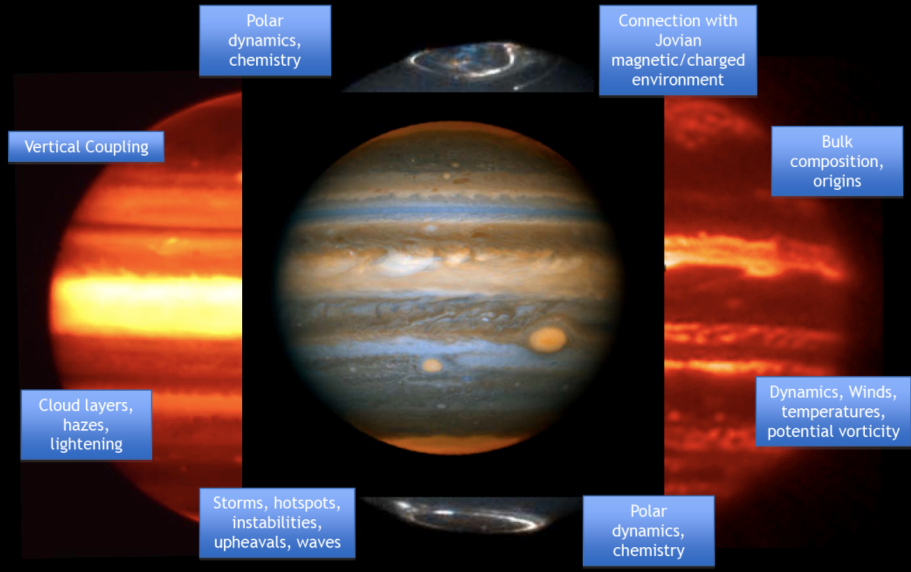
- Study dynamics of magnetosphere in and out of the magnetodisc
- Determine the electrodynamic coupling between the planet and the satellites
- Assess global and continuous acceleration of particles

JUICE OBJECTIVES

- Characterise the magnetosphere as a fast magnetic rotator
- Characterise the magnetosphere as a giant accelerator
- Understand the moons as sources and sinks of magnetospheric plasma

Characterise the Jovian atmosphere

JUICE



WHY JUPITER?

- A paradigm for exoplanetary systems
- The largest window into the evolution of the primordial nebula
- Unresolved questions in the field of atmospheric dynamics and chemistry

HIGHLIGHTS

- First direct measurements of atmospheric circulation in the middle atmosphere
- Complement and extend Juno's (2016+) investigation of deep interior
- Long approach + 2 year baseline of tour-phase observations, includ. access to high latitudes
- Exploration from the dynamic weather layer to the upper thermosphere

JUICE OBJECTIVES

- Characterise the atmospheric dynamics and circulation
- Characterise the atmospheric composition and chemistry
- Characterise the atmospheric vertical structure

Assessment Study Report (Yellow Book) was issued in the end of December 2011

ESA Technical Review Report (mid-December 2011)

- *Mission requirements are complete*
- *Level of system definition is adequate*
- *Design approach is sufficiently robust*

The overall mission is considered as low risk from technical and programmatic standpoint