JUICE: a European mission to Jupiter and its icy moons

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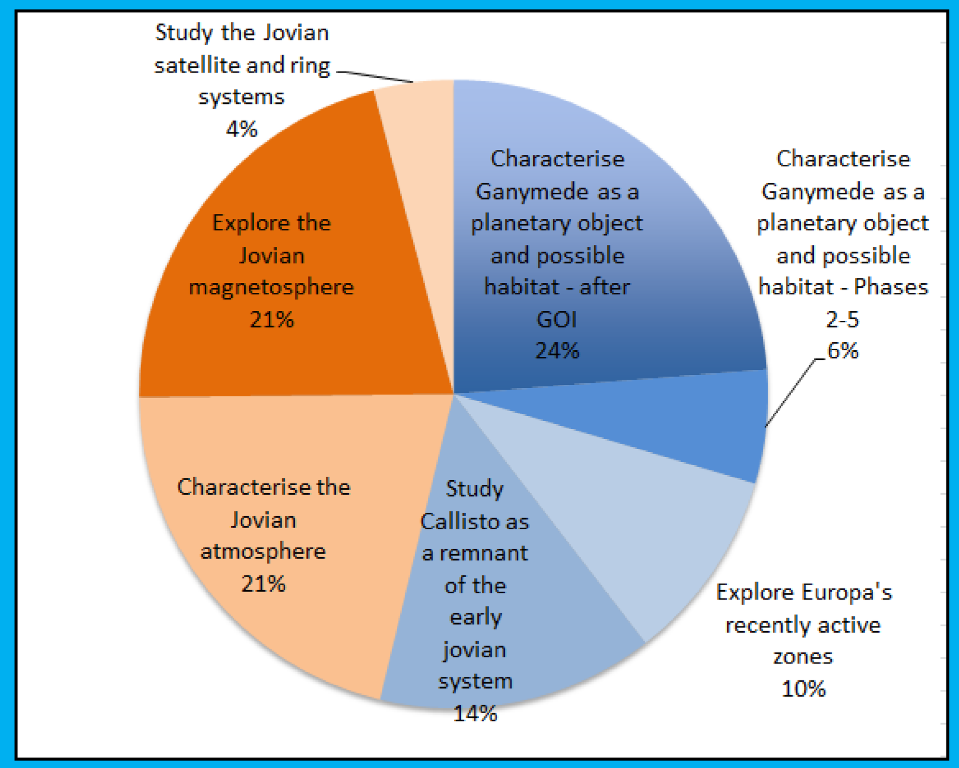
Juice science themes

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



Overall data volume share amongst science objectives

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

10 instruments and 1 investigation

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

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

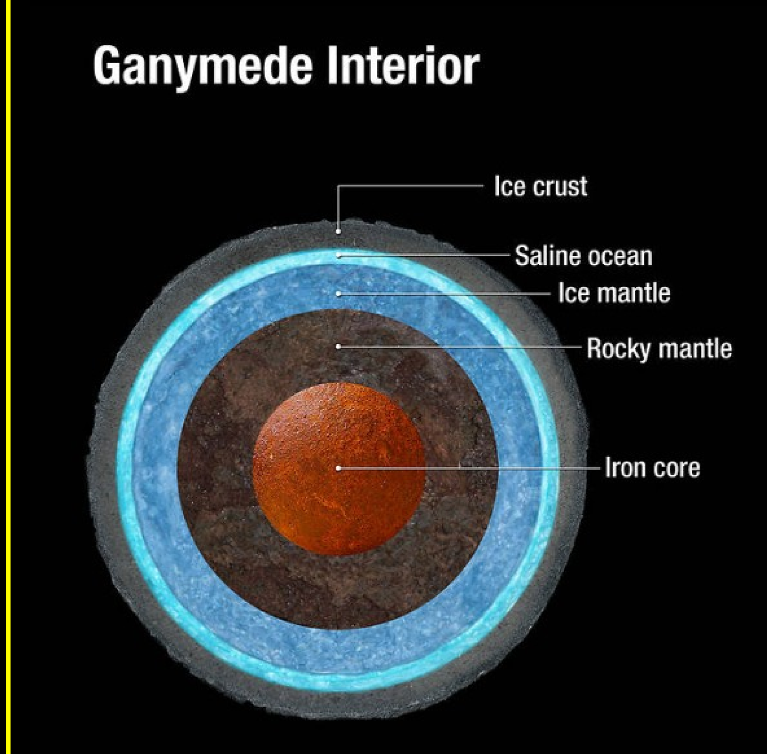
RPWI: Radio and Plasma Wave Investigation
PI: Jan-Erik Wahlund, IRF-U, Sweden
- Langmuir Probes
- Search Coil Magnetometer
- Tri-axial dipole antenna
- E and B-fields
- Ion, electron and charged dust parameters

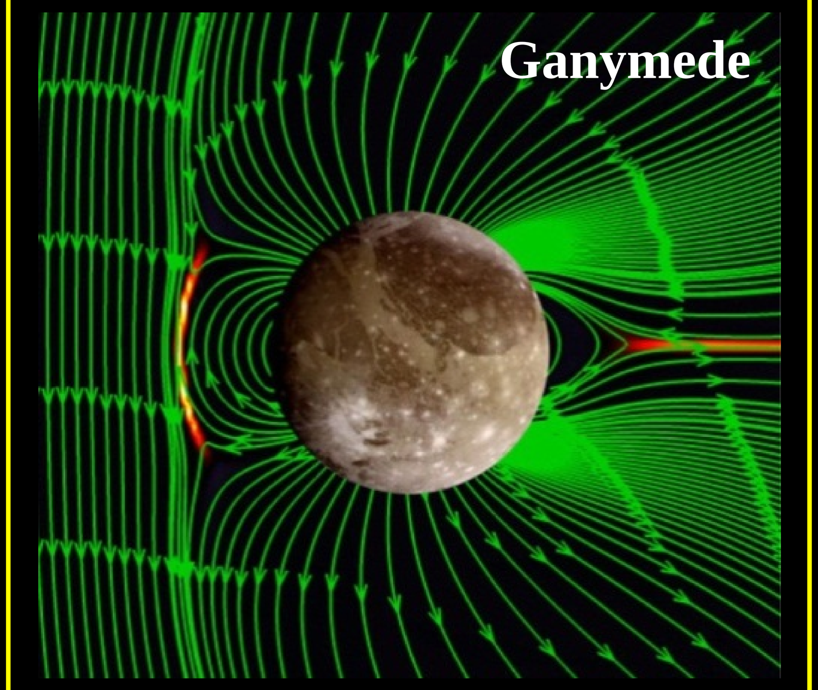
Timeline

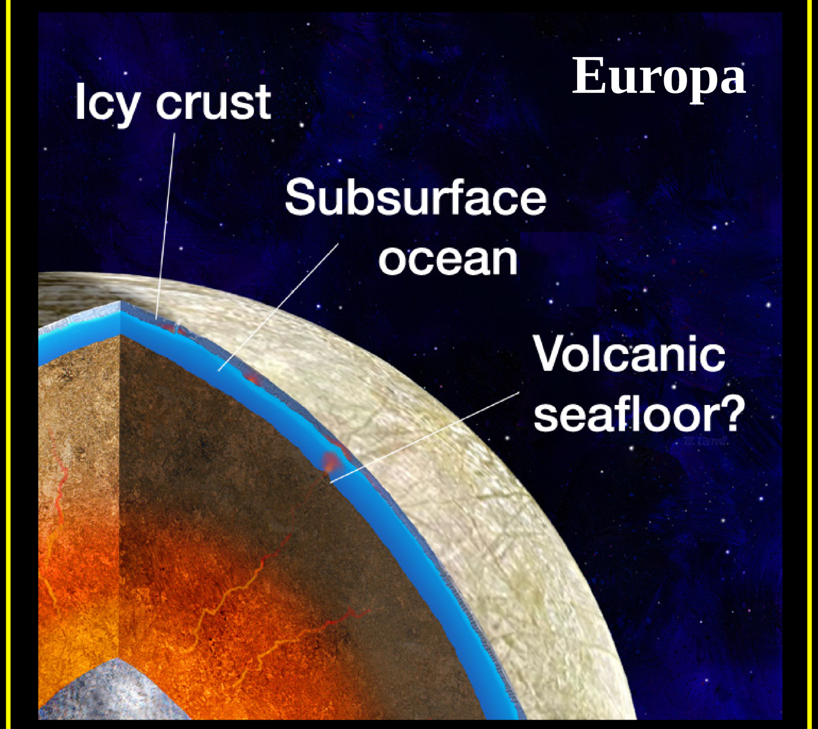
05/2012: Mission selected
02/2013: Payload selected
07/2015: Prime industrial contractor selected
07/2015-03/2017: Phase B2
03/2017 – 03/2019: Phase C
Mid-2019: Instrument flight model deliveries
03/2019-09/2021: Phase D
05/2022: Launch
05/2023: Earth flyby
10/2023: Venus flyby
09/2024: Earth flyby
02/2025: Mars flyby
11/2026: Earth flyby
10/2029: Jupiter orbit insertion
05/2030-09/2030 : 3 Ganymede and 1 Callisto flyby
10/2030: 2 Europa flybys
11/2030-06/2031: Jupiter inclined phase, 9 Callisto flybys
07/2031-08/2032: Transfer to Ganymede, 8 Ganymede and 3 Callisto flybys
08/2032: Ganymede orbit insertion
Elliptical orbit, 5000 km circular orbit, 500 km circular orbit
06/2033: End of mission

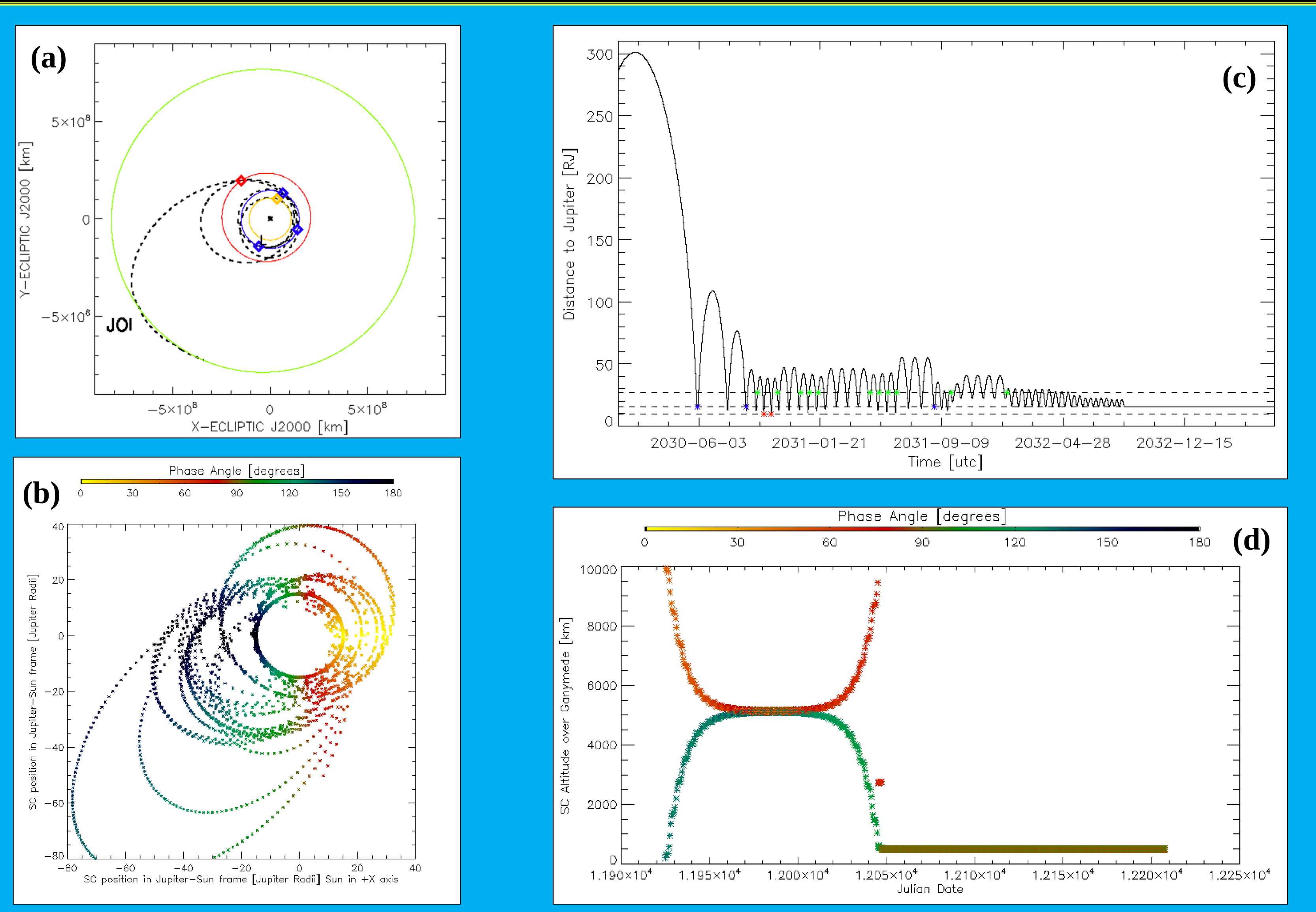
Spacecraft

- 3-axis stabilised
- Mass:
  - Launch mass: 5264 kg
  - Instruments: 219 kg
  - Propellant: 2857 kg
- Radiation monitor
- Solar array 97 m² [Power ~850 W at Jupiter]
- Fixed High Gain Antenna and Steerable Medium Gain Antenna (X, Ka Bands)
- Data Volume ~ 1.4 Gb per day









Trajectory: (a) cruise phase – (b) All orbits view from the North – (c) Distances to Jupiter during the Jupiter tour – (d) Distance to Ganymede during the Ganymede phase (elliptical orbits, 5000/500 km circular orbits).

Study of subsurface water in the Jovian icy moons

The NASA Galileo mission discovered evidence for the existence of subsurface oceans hidden beneath the icy crusts of Europa, Ganymede and Callisto. JUICE will characterise the conditions that may have led to the emergence of habitable environments among these three icy satellites.

- At Ganymede, JUICE will characterise the extent of the ocean, its main physico-chemical properties and its relation to the deeper interior. Exchange processes between surface and subsurface liquid reservoirs will also be studied. Detection of shallow subsurface liquid water will be attempted.
- At Europa, JUICE will search for liquid water in the shallow sub-surface.
- At Callisto, JUICE will characterise the outer shells, including the possible detection of shallow subsurface water and ocean.

A selection of investigations at Ganymede is given below:

- Electrical currents in salty oceans can generate secondary magnetic and electric fields in response to the external rotating Jovian magnetic field. Measurements at multiple frequencies with the J-MAG and RPWI instruments will constrain the electrical conductivity and extent of the ocean.
- The tidal response of the icy shells strongly depends on the presence of ocean. The amplitudes of surface deformation will be measured by GALA. PRIDE will provide complementary information on the shape of the moon.
- Along with the tidal surface displacements, there is a time variability of the gravitational potential of the satellite because of the formation of the tidal bulge, to be measured by 3GM.
- The Galilean moons are locked in a stable 1:1 spin-orbit resonance. However, slight periodic variations in the rotation rate (physical librations) and the amplitudes associated with these librations can provide further evidence for a subsurface ocean. 3GM, GALA and JANUS will measure precisely the rotation rate, pole-position, obliquity, and libration amplitude.

	J-MAG	3GM	GALA	RIME	RPWI	PEP	JANUS	UVS	PRIDE
Ganymede: ocean characterisation									
Europa: search for liquid water in the shallow sub-surface.									
Callisto: possible detection of shallow subsurface water/ocean.									

Instrument contributions to the study of subsurface liquid water in the icy moons. Green: primary instrument. Yellow: supporting instrument.