JUICE: a European mission to Jupiter and its icy moons

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Juice science themes

The focus of JUICE is to characterise the conditions that may have led to the emergence of habitable environments among the Jovian icy satellites, with special emphasis on the three ocean-bearing worlds, Ganymede, Europa, and Callisto. Ganymede is identified for detailed investigation since it provides a natural laboratory for the analysis of the nature, evolution and potential habitability of icy worlds in general, but also because of the role it plays within the system of Galilean satellites, and its unique magnetic and plasma interactions with the surrounding Jovian environment. JUICE will determine the characteristics of liquid-water oceans below the icy surfaces of the moons. This will lead to an understanding of the possible sources and cycling of chemical and thermal energy, allowing an investigation of the evolution and chemical composition of the surfaces and of the subsurface oceans, and enable an evaluation of the processes that have affected the satellites and their environments through time. The study of the diversity of the satellite system will be enhanced with additional information gathered remotely on Io and the smaller moons. The mission will also characterise the diversity of processes in the Jupiter system that may be required in order to provide a stable environment at the icy moons on geologic time scales, including gravitational coupling between the Galilean satellites and their long term tidal influence on the system as a whole. JUICE will carry out extensive new studies of Jupiter’s atmosphere, magnetosphere and their interactions with the satellites to further enhance our understanding of the evolution and dynamics of the Jovian system. Source: red book

10 instruments and 1 experiment

Spacecraft

- 3-axis stabilised
- Mass:
  - Launch mass: ~5300 kg
  - Instruments: ~220 kg
  - Propellant: ~2800 kg
- Radiation monitor
- Solar array 97 m² (power ~850 W at Jupiter)
- Fixed High Gain Antenna and Steerable Medium Gain Antenna (X- and Ka-Bands)
- Data Volume ~ 1.4 Gb per day

Mission trajectory and phases

Cruise phase

- 06/2022: Launch
- 05/2023: Earth flyby
- 10/2023: Venus flyby
- 09/2024: Europa flyby
- 02/2025: Mars flyby
- 11/2026: Earth flyby
- 10/2029: Jupiter orbit insertion

JUICE in the Jupiter system

- Phase 1: Orbit insertion-6 months and 1st orbit
- Phase 2: Orbits 2, 3, 4; three Ganymede and one Callisto flybys
- Phase 3: Two Europa flybys (October 2030)
- Phase 4: Jupiter inclined phase; ten Callisto flybys (~ October 2030 – August 2031)
- Phase 5: Transfer to Ganymede; 8-9 Ganymede and 3 Callisto flybys
- Ganymede orbit insertion (in the timeframe July December 2032); Ganymede phases (in the timeframe July 2032-September 2033): elliptical orbit (GE0) / 500 km circular orbit (GCO500) / 500 km circular orbit (GCO500)
- End of mission: June/September 2033 timeframe

Phase 1 (includes) the approach to Jupiter’s central system plane (out of plane) before the orbit insertion, planned in October 2023. (2) the capture orbit, where the commissioning and the first observations in orbit take place.

Phase 2 last about four months and includes the next three orbits; three Ganymede (300-1400 km) and one Callisto flybys (1200 km flybys)

An activity-driven operations plan for Phase 5: the Jupiter Working Group. Depending upon Jupiter’s activity at EL, the phase plan is adjusted on-the-fly. Phases are defined on 48-hour basis either side of the perijoves, with colour coding for illumination conditions. True north is defined in 8-hour steps; terminator at 90-115 degrees, subsolar at 115-130 degrees.

Spacecraft in the Jupiter system

Ganymede and 3 Callisto flybys at large distances (cross approach about 800 km)

Science operations relevant during an Europa flyby: The horizontal bars in the top indicate the optimal activities as a function of time. The middle panel shows the altitude, and the bottom panel shows the power profile. During each flyby all instruments are operating, generating about 70 Gb of data.

Example of perijoves (yellow stars) and apojoves (black stars) as a function of altitude and latitudes, assumed; blue dots are all perijoves; orange dots are all apojoves. The orange dots are marked by letter A (the apojove closest to the planet).

Simulation of selected observations at Ganymede during GCO500 orbit. The horizontal bar on the top indicates the periodicity as a function of time. The middle panel shows the altitude, and the bottom panel shows the power profile. During each flyby all instruments are operating, generating about 70 Gb of data.

Phase 5 is essentially the two Europa flybys, at a closest approach of 400 km, on the dayside.

Phase 3 lasts about four months and includes the next three orbits; three Ganymede (300-1400 km) and one Callisto flybys (1200 km flybys). The two Europa flybys geometry, from the last JUICE trajectory. The two flybys are separated by 14 days. Flyby velocity ~ 3.8 km/s, closest approach ~ 850 km.

Phase 4 is characterised by a higher inclination – up to 28 degrees - of the orbital plane with respect to the Jupiter equatorial plane. During this phase, higher latitude regions of Jupiter will be studied in detail. The change of inclination is performed with ~8-10 Callisto flybys at 200 km distance.

Phase 2 lasts about four months and includes the next three orbits; three Ganymede (300-1400 km) and one Callisto flybys (1200 km flybys)