ESA’s Juice: Mission Summary and Fact Sheet

JUICE - JUpiter ICy moons Explorer - is the first large-class mission in ESA’s Cosmic Vision 2015-2025 programme. Planned for launch in 2022 and arrival at Jupiter in 2030, it will spend at least three years making detailed observations of the giant gaseous planet Jupiter and three of its largest moons, Ganymede, Callisto and Europa.

Artists impression of the JUICE spacecraft Copyright: ESA/ATG medialab

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<th>JUICE</th>
<th>JUpiter ICy moons Explorer</th>
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<td>Exploring the emergence of habitable worlds around gas giants</td>
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<th>What are the conditions for planet formation and emergence of life?</th>
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<th>Lifetime</th>
<th>7.6 years cruise &amp; 3.5 years in the Jovian system</th>
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Science Objectives
The JUpiter ICy moons Explorer (JUICE) will perform detailed investigations of Jupiter and its system in all their inter-relations and complexity with particular emphasis on Ganymede as a planetary body and potential habitat. Investigations of Europa and Callisto would complete a comparative picture of the Galilean moons.

Jupiter is the archetype for the giant planets of the Solar System and for the numerous giant planets now known to orbit other stars. Moreover, Jupiter's diverse Galilean satellites - three of which are believed to harbour internal oceans - are central to understanding the habitability of icy worlds.

Understanding the Jovian system and unravelling its history, from its origin to the possible emergence of habitable environments, will give us a better insight into how gas giant planets and their satellites form and evolve. In addition, new light should be shed on the potential for the emergence of life in Jupiter-like exoplanetary systems.

The JUICE mission will address two themes of ESA's Cosmic Vision programme: What are the conditions for planet formation and emergence of life? and How does the Solar System work?

**Internal oceans - habitable worlds?**

The focus of JUICE is to characterize 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 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.

The main science objectives for Ganymede, and to a lesser extent for Callisto, are:

- characterization of the ocean layers and detection of putative subsurface water reservoirs;
- topographical, geological and compositional mapping of the surface;
- study of the physical properties of the icy crusts;
- characterization of the internal mass distribution, dynamics and evolution of the interiors;
- investigation of the exosphere;
- study of Ganymede's intrinsic magnetic field and its interactions with the Jovian magnetosphere.

For Europa, the focus is on the chemistry essential to life, including organic molecules, and on understanding the formation of surface features and the composition of the non water-ice material. Furthermore, JUICE will provide the first subsurface sounding of the moon, including the first determination of the minimal thickness of the icy crust over the most recently active regions.
Jupiter system as an archetype for gas giants

The mission will also focus on characterizing the diversity of processes in the Jupiter system which may be required in order to provide a stable environment at Ganymede, Europa and Callisto on geologic time scales.

The studies of the Jovian atmosphere will be focused on investigation of its structure, dynamics and composition. The circulation, meteorology, chemistry and structure of Jupiter will be studied from the cloud tops to the thermosphere. These observations will be attained over a sufficiently long temporal baseline with broad latitudinal coverage to investigate evolving weather systems and the mechanisms of transporting energy, momentum and material between the different layers.

The focus in the Jovian magnetosphere will include an investigation of the three-dimensional properties of the magnetodisc and in-depth study of the coupling processes within the magnetosphere, ionosphere and thermosphere. Aurora and radio emissions and their response to the solar wind will be elucidated.

Within Jupiter's satellite system, JUICE will also study the moons' interactions with the magnetosphere, gravitational coupling and long-term tidal evolution of the Galilean satellites.

Mission Scenario and Operations

The JUICE spacecraft will be launched in June 2022 by Ariane 5 and will use Venus and Earth gravity assists in its 7.6 years cruise to Jupiter. After the orbit insertion in January 2030 the spacecraft will
perform a 2.5 year tour in the Jovian system focusing on continuous observations of Jupiter's atmosphere and magnetosphere.

During the tour, gravity assists with Callisto and Ganymede will shape the trajectory. Two targeted Europa flybys are included focusing on composition of the non water-ice material, and the first subsurface sounding of an icy moon. Additional, Callisto gravity assists will be also used to raise the orbit inclination to almost 30° and to enable observations of the Jupiter polar regions. The frequent Callisto flybys will enable unique remote observations of the moon and in situ measurements in its vicinity. The mission will culminate in a dedicated eight months orbital tour around Ganymede during which the spacecraft will perform detailed investigation of the moon and its environment and will eventually impact on Ganymede.

Illustrative timeline of the JUICE baseline mission. Credit: ESA

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<th>Science phases of the JUICE baseline mission</th>
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<td><strong>Phase</strong></td>
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<tr>
<td>1 Cruise/ Interplanetary transfer</td>
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<td>2 Jupiter equatorial phase #1/Transfer to Callisto</td>
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<td>3 Europa flybys</td>
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Local plasma environment.

Reduction of $V_{\text{inf}}$ / Jupiter high latitude phase with Callisto

4 Jupiter atmosphere at high latitudes.
Plasma and fields out of equatorial plane.
Callisto internal structure, surface and exosphere.
Remote observations of Ganymede, Europa, Io, and small moons.

Jupiter equatorial phase #2 / Transfer to Ganymede

5 Interactions of the Ganymede magnetic field with that of Jupiter.
Jovian atmosphere and magnetosphere as in phase #2

### Ganymede Tour

6 Elliptic #1 30 days
- Global geological mapping.
- Search for past and present activity.
- Global compositional mapping.
- Local plasma environment and its interactions with Jovian magnetosphere.

7 High altitude (5000 km) circular orbit 90 days
8 Elliptic #2 30 days
9 Medium altitude (500 km) circular orbit 102 days
- Extent of the ocean and its relation to the deep interior.
- Ice shell structure including distribution of subsurface water.
- Geology, composition and evolution of selected targets with very high resolution.
- Global topography.
- Local plasma environment.
- Sinks and sources of the ionosphere and exosphere.
- Deep interior.

The total mission duration is close to 11 years, of which about 3.5 years would be spent in the Jupiter system. With the currently envisaged launch opportunities in 2022 and 2023, the nominal mission would end in June 2033 and December 2034, respectively.

### Ground Segment
The JUICE mission would be planned and operated by the ESA ground segment consisting of the Mission Operations Centre (MOC) and the Science Operations Centre (SOC). A single ground station, capable of both X- and K-band operations at the time of the mission, is assumed for the JUICE science operations.