EPSC Abstracts
Vol. 10, EPSC2015-564, 2015
European Planetary Science Congress 2015

JUICE: A European Mission to Jupiter and its Icy Moons

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Abstract

JUICE - JUpiter ICy moons Explorer - is the first large mission in the ESA Cosmic Vision 2015-2025 programme [1]. The mission was selected in May 2012 and adopted in November 2014. The implementation phase starts in July 2015, following the selection of the prime industrial contractor. Planned for launch in June 2022 and arrival at Jupiter in October 2029, it will spend at least three years making detailed observations of Jupiter and three of its largest moons, Ganymede, Callisto and Europa.

Science Objectives

The focus of JUICE is to characterise the conditions that might have led to the emergence of habitable environments among the Jovian icy satellites, with special emphasis on the three worlds, Ganymede, Europa, and Callisto, likely hosting internal oceans [2]. Ganymede, the largest moon in the Solar System, is identified as a high-priority target because it provides a natural laboratory for analysis of the nature, evolution and potential habitability of icy worlds and waterworlds 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 [3]. The mission also focuses on characterising the diversity of coupling processes and exchanges in the Jupiter system that are responsible for the changes in surface, ionospheric and exospheric environments at Ganymede, Europa and Callisto from short-term to geological time scales. Focused studies of Jupiter's atmosphere and magnetosphere, and their interaction with the Galilean satellites will further enhance our understanding of the evolution and dynamics of the Jovian system.

The overarching theme for JUICE is: *The emergence of habitable worlds around gas giants*. At Ganymede, the mission will characterise in detail the ocean layers; provide topographical, geological and compositional mapping of the surface; study the physical properties of the icy crusts; characterise the internal mass distribution, investigate the exosphere; study Ganymede's intrinsic magnetic field and its interactions with the Jovian magnetosphere. For Europa, the focus will be on the non-ice chemistry, understanding the formation of surface features and subsurface sounding of the icy crust over recently active regions. Callisto will be explored as a witness of the early solar system trying to also elucidate the mystery of its internal structure.

JUICE will perform a multidisciplinary investigation of the Jupiter system as an archetype for gas giants. The circulation, meteorology, chemistry and structure of the Jovian atmosphere will be studied from the cloud tops to the thermosphere. The focus in Jupiter's 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 will be elucidated.

JUICE will study the moons' interactions with the magnetosphere, gravitational coupling and long-term tidal evolution of the Galilean satellites.

The Payload

The JUICE payload consists of 10 state-of-the-art instruments plus one experiment that uses the spacecraft telecommunication system with ground-based instruments. This payload is capable of addressing all of the mission's science goals [2], from *in situ* measurements of the plasma environment, to remote observations of the surface and interior of the three icy moons, Ganymede, Europa and Callisto, and of Jupiter's atmosphere. A *remote sensing package* includes imaging (JANUS) and spectral-imaging capabilities from the ultraviolet to the sub-millimetre wavelengths (MAJIS, UVS, SWI). A *geophysical package* consists of a laser altimeter (GALA) and a radar sounder (RIME) for exploring the surface and subsurface of the moons, and a radio science experiment (3GM) to probe the atmospheres of Jupiter and its satellites and to perform measurements of the gravity fields. An *in situ package* comprises a powerful suite to study plasma and neutral gas environments (PEP) with remote sensing capabilities via energetic neutrals, a magnetometer (J-MAG) and a radio and plasma wave instrument (RPWI), including electric fields sensors and a Langmuir probe. An experiment (PRIDE) using ground-based Very Long Baseline Interferometry (VLBI) will support precise determination of the spacecraft state vector with the focus at improving the ephemeris of the Jovian system.

The table below lists the JUICE instruments.

Acronym	Instrument
3GM	Radio-Science experiment
GALA	Laser Altimeter
JANUS	Imaging system
J-MAG	Magnetometer
MAJIS	Visible-Infrared Hyperspectral Imaging Spectrometer
PEP	Particle Environment Package
RIME	Ice Penetrating Radar
RPWI	Radio and Plasma Wave Instrument
SWI	Submillimetre Wave Instrument
UVS	Ultraviolet Imaging Spectrograph

Main Mission Milestones

The table below lists the main milestones of the JUICE mission. The trajectory related events are taken from the current baseline scenario.

Date	Event
May 2012	Mission selection by ESA
February 2013	Payload selection by ESA
November 2014	Mission adoption by ESA
July 2015	Start of the implementation phase
June 2022	Launch
January 2030	Jupiter Orbit Insertion
September 2032	Ganymede Orbit Insertion
July 2033	End of mission

References

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[3] Grasset, O., et al., 2013. Planetary protection requirements at Ganymede, Astrobiology 13, issue 10, 991-1004.