JUPITER ICY MOONS EXPLORER (JUICE): SCIENCE OBJECTIVES, MISSION AND INSTRUMENTS. J. J. Plaut[1], S. Barabash[2], L. Bruzzone[3], M. Dougherty[4], C. Erd[5], L. Fletcher[6], R. Gladstone[7], O. Grasset[8], L. Gurvits[9], P. Hartogh[10], H. Hussmann[11], L. Iess[12], R. Jaumann[11], Y. Langevin[13], P. Palumbo[14], G. Piccioni[15], D. Titov[5] and J.-E. Wahlund[16]. [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, plaut@jpl.nasa.gov, [2]Swedish Institute of Space Physics, Kiruna, Sweden, [3]University of Trento, Italy, [4]Imperial College London, U.K., [5]ESA-ESTEC, Noordwijk, The Netherlands, [6]University of Oxford, UK, [7]Southwest Research Institute, San Antonio, TX, [8]University of Nantes, France, [9]Joint Institute for VLBI in Europe and Delft University of Technology, The Netherlands, [10]Max Planck Institute for Solar System Research, Germany, [11]Institute of Planetary Research, DLR, Germany, [12]University of Rome, La Sapienza, Italy, [13]Institut d'Astrophysique Spatiale, France, [14]Parthenope University, Naples, Italy, [15]IAPS, Rome, Italy, [16]IRF-Uppsala, Sweden.

Introduction: The JUpiter ICy Moons Explorer (JUICE) is a European Space Agency mission that will fly by and observe the Galilean satellites Europa, Ganymede and Callisto, characterize the Jovian system in a lengthy Jupiter-orbit phase, and ultimately orbit Ganymede for in-depth studies of habitability, evolution and the local environment [1].

Science Objectives: The fundamental objective of the JUICE mission is to address two key questions of the ESA's Cosmic Vision program: 1) What are the conditions for planet formation and the emergence of life? and 2) How does the Solar System work? Two major science themes for JUICE have been developed: the emergence of habitable worlds around gas giants, and the Jupiter system as an archetype for gas giants. The JUICE mission will provide a thorough investigation of the Jupiter system in all its complexity with emphasis on the three ocean-bearing Galilean satellites, and their potential habitability. JUICE has been tailored to observe all the main components of the Jupiter system and untangle their complex interactions. The observational strategy to address these objectives has three main components: 1) conduct a comparative study of Ganymede, Callisto and Europa, with an emphasis on the characterization of Ganymede as a planetary object and possible habitat, 2) provide a complete spatio-temporal characterization of the giant, rotating magnetosphere, and of the meteorology, chemistry and structure of Jupiter's gaseous atmosphere, and 3) study coupling processes inside the Jupiter system, with an emphasis on the two key coupling processes within that system: the tidal effects that couple Jupiter with its satellites, and the electrodynamic interactions that couple Jupiter and its satellites with their atmospheres, subsurface oceans, magnetospheres and magnetodisc.

Specific scientific objectives have been developed for each of the three icy moons; broadly they can be described as characterization of the deep interior including subsurface oceans, characterization of the icy shell, search for past and present activity, composition of non-ice material, and the local environment and its interaction with the Jovian magnetosphere. At Europa there will be an emphasis on sites of potential recent activity and the search for shallow liquid water. Callisto, with an apparently quiescent endogenic history, will be studied as a remnant of the early Jovian system. The longer duration of the Ganymede orbital phase will allow a comprehensive interdisciplinary study of the interior (rocky interior, ocean and ice shell), formation and evolution of surface features, global composition of surface materials (ice and non-ice), and the local environment and magnetosphere.

JUICE will perform a multidisciplinary investigation of the Jupiter system as an archetype for gas giants including exoplanets. 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 and their response to the solar wind will be elucidated. Within Jupiter's satellite system, JUICE will study the moons' interactions with the magnetosphere, gravitational coupling and long-term tidal evolution of the Galilean satellites.

Mission: JUICE is currently planned for launch in 2022. After Jupiter orbit insertion in 2030 the spacecraft will perform a 2.5 year tour of the Jovian system focusing on observations of the atmosphere and magnetosphere of Jupiter itself. During the tour, gravity assists at Callisto will shape the trajectory to perform two targeted Europa flybys and raise the orbit inclination up to 30 degrees. The Europa flybys are currently planned to observe regions of likely recent activity and possible shallow liquid water, Thera and Thrace Maculae [2] and Minos Linea. 13 Callisto flybys will enable unique remote observations of the moon and in situ measurements in its vicinity. The mission will culminate in a dedicated 8 month orbital phase around Ganymede in 2032. The Ganymede phase will include high (5000 km), medium (500 km), and low (200 km) circu-

lar orbits that will have different observation conditions optimized for particular science investigations.

Science Instruments: The scientific payload for JUICE was selected in 2013. Instruments and science teams are provided primarily by ESA member states, with NASA contributions to three experiments. Table 1 lists the selected instruments and associated information. The payload suite encompasses much of the electromagnetic spectrum, from the ultraviolet through the infrared and sub-millimeter waves. Fields and particle measurements will include magnetic fields, radio and plasma waves, and charged and neutral particles. Radio science experiments will be used to investigate gravity fields and atmospheric and ionospheric phenomena, and to improve the ephemerides of the Jovian system moons. Active geophysical sounding will be provided by a high-frequency radar and laser altimeter.

Remote sensing instruments include a camera (JANUS), and spectrometers/specto-imagers (MAJIS, UVS, SWI). The geophysical package consists of a laser altimeter (GALA), a radar sounder (RIME), a radio science experiment (3GM) and Very-Long Baseline Interferometry (PRIDE). The *in situ* sensors include particle detectors (PEP), a magnetometer (J-MAG), and the radio and plasma wave instrument (RPWI).

References: [1] Grasset, O. et al., (2013) *Planet. and Sp. Sci. 78*, 1-21. [2] Schmidt, B. E. et al. (2011) *Nature 479*, 502-505.

Instrument	Type	PI - Country	Primary Target(s)
3GM - Gravity & Geophysics of Jupiter and Galilean Moons	Radio science	L. Iess Italy	Moon gravity fields
GALA - Ganymede Laser Altimeter	Laser altimeter	H. Hussmann Germany	Moon surface topography
JANUS - Jovis, Amorum ac Natorum Undique Scrutator	Camera	P. Palumbo Italy	Geology and surface processes
J-MAG - Magnetometer for JUICE	Magnetometer	M. Dougherty U.K.	Magnetic field of Jupiter and its moons
MAJIS - Moons and Jupiter Imaging Spectrometer	Visible-IR spectrometer/spectro-imager	Y. Langevin - France G.Piccioni - Italy	Moon surface composition, Jupiter atmosphere
PEP - Particle Environment Package	Suite of particle sensors	S. Barabash Sweden	Plasma particles
PRIDE - Planetary Radio Interferometer & Doppler Experiment	VLBI	L. Gurvits The Netherlands	Ephemerides of the moons
RIME - Radar for Icy Moon Exploration	Subsurface sounding radar	L. Bruzzone Italy	Subsurface of ice shells, shallow liquid water
RPWI - Radio & Plasma Wave Investigation	Suite of radio and plasma wave detectors	J.-E. Wahlund Sweden	Radio emission and plasma of Jupiter, moons
SWI - Sub-millimeter Wave Instrument	Sub-millimeter wave spectrometer	P. Hartogh Germany	Jupiter atmosphere, moon surfaces and exospheres
UVS - UV imaging Spectrograph	UV spectrograph	R. Gladstone U.S.	Moon exospheres, Jupiter aurora

Table 1. Science instruments of the JUICE payload.