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JUICE

JUPITER ICY MOONS EXPLORER

Science Management Plan

Issue 1
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Key Science Goals	**The emergence of habitable worlds around gas giants** Characterise Ganymede, Europa and Callisto as planetary objects and potential habitats Explore the Jupiter system as an archetype for gas giants
Model payload	***11 instruments*** Narrow Angle Camera Wide Angle Camera Visible and Infrared Hyperspectral Imaging Spectrometer Ultraviolet Imaging Spectrometer Submillimetre Wave Instrument Laser Altimeter Ice penetrating radar Magnetometer Particle Package Radio and Plasma Wave instrument Radio Science Instrument and Ultrastable Oscillator
Mission profile	06/2022 - Launch by Ariane-5 ECA + EVEE-type Cruise 01/2030 - Jupiter orbit insertion Jupiter tour Transfer to Callisto (11 months) Europa phase: 2 Europa and 3 Callisto flybys (1 month) Jupiter High Latitude Phase: 9 Callisto flybys (9 months) Transfer to Ganymede (11 months) 09/2032 – Ganymede orbit insertion Ganymede tour Elliptical and high altitude circular phases (5 months) Medium altitude (500 km) circular orbit (3 months) Low altitude (200 km) circular orbit (1 month) 06/2033 – End of nominal mission
Spacecraft	3-axis stabilised Power: solar panels: 630-700 W (EOM) HGA: 3.2 m, body fixed X- and Ka bands Downlink ≥ 1.4 Gbit/day High delta-V capability (2700 m/s) Radiation level: 240 krad /10 mm Al solid sphere, equipment tolerance <50 krad Dry mass at launch: ~1800 kg
Ground TM stations	ESTRACK network

1 SUMMARY AND SCOPE

JUpiter ICy moons Explorer (JUICE) is an ESA-led L-class mission of the ESA's Cosmic Vision 2015-25 Programme. It aims at a comprehensive exploration of the Jovian system with particular emphasis on Jupiter, its environment, and Galilean moons Ganymede, Europa and Callisto by investigating them as planetary bodies and potential habitats. The mission consists of a spacecraft that will be developed, procured, launched and operated by ESA.

The JUICE baseline configuration consists of a 3-axis stabilized spacecraft powered by solar arrays. It will be launched by Ariane 5 from Centre Spatial Guyanais, Kourou (CSG). The planned launch date is June 2022 with a back-up opportunity in August 2023.

The Science Management Plan (SMP) describes the approach that will be implemented to ensure the fulfilment of the scientific objectives of the JUICE mission and to optimise its scientific return, with special emphasis on payload procurement, science operation and data management.

The SMP first summarises the main features of the mission (Section 2), followed by a description of how the scientific community will be associated with the mission (Sections 3 and 4), focusing in particular on the selection of the instruments that will constitute the JUICE scientific payload. The plan outlines the role of the JUICE science advisory structure, and the ESA science management tasks from instrument selection to data distribution and archiving. The SMP also addresses the duties and rights of the JUICE investigators, as well as their interaction with the JUICE Science Working Team (Sections 5 and 6).

2 MISSION OVERVIEW

2.1 Introduction

In 1995, the *Galileo* spacecraft arrived at Jupiter to conduct a follow-up exploration in the footsteps of the *Pioneer* and *Voyager* missions. *Galileo* made new discoveries in the Jovian system, especially as concerns the four Galilean satellites, which were revealed as new worlds worthy of further in depth exploration. The *Galileo* results included strong evidence of sub-surface oceans hidden underneath icy crusts of Europa, Ganymede and Callisto. This discovery led to emergence of a new habitability paradigm which considers the icy satellites as potential harbours of life. Galileo also found an internal magnetic field at Ganymede, a unique feature for a satellite in the solar system. Ganymede and Europa are believed to be internally active, due to a strong tidal interaction and other energy sources. They are straddled by Io and Callisto, and thus, the study of the diversity of the planetary environment represented by the four satellites should reveal the physical and chemical mechanisms driving the evolution of the Jovian system.

2.2 Scientific Objectives

JUICE is aimed at a thorough investigation of the Jupiter system in all its complexity with emphasis on Galilean satellites, and in particular the potential habitability of the two icy moons, Ganymede and Europa. The overarching theme for JUICE is:

The emergence of habitable worlds around gas giants

The mission would address the following question:

Are there current habitats elsewhere in the Solar System with the necessary conditions (organic matter, water, energy, stability and nutrients) to sustain life?

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 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 a better understanding of the possible sources and cycling of chemical and thermal energy, allow 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 smaller moons. The mission will also focus on characterising 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, including gravitational coupling between the Galilean satellites and their long term tidal influence on the system as a whole. Focused studies of Jupiter's atmosphere (its structure, dynamics and composition), and magnetosphere (three-dimensional properties of the magnetodisc and coupling processes) and their interaction with the Galilean satellites will further enhance our understanding of the evolution and dynamics of the Jovian system that is considered as a mini-Solar System in its own right.

In conclusion, by performing detailed investigations of Jupiter's system in all its complexity, JUICE will address in depth two key questions of ESA's Cosmic Vision programme:

(1) What are the conditions for planet formation and the emergence of life?

(2) How does the Solar System work?

The mission will investigate the Jovian atmosphere and magnetosphere, study Europa during two flybys and Callisto in 12 flybys, and provide a detailed survey of Ganymede, its atmosphere and plasma environment from orbit. Specific science objectives of the JUICE mission are as follows:

I. Exploration of the habitable zone: Ganymede, Europa and Callisto

1. Characterise Ganymede as a planetary object including its potential habitability
    - *a. characterize the ice shell, extent of the ocean and its relation to the deeper interior;*
    - *b. determine global composition, distribution and evolution of surface materials;*
    - *c. understand the formation of surface features and search for past and present activity;*
    - *d. characterize the local environment and its interaction with the Jovian magnetosphere.*
2. Explore Europa's recently active zones
    - *a. determine the composition of the non-ice material, especially as related to habitability;*
    - *b. look for liquid water under the most active sites;*
    - *c. study the recently active processes.*
3. Study Callisto as a remnant of the early Jovian System
    - *a. characterize the outer shells, including the ocean;*
    - *b. determine the composition of the non-ice material;*
    - c. *study the past activity.*

II. Explore the Jupiter System as an archetype for gas giants

1. Characterise the Jovian atmosphere
    - *a. characterize the atmospheric dynamics and circulation;*
    - *b. characterize the atmospheric composition and chemistry;*
    - *c. characterize the atmospheric vertical structure;*
2. Explore the Jovian magnetosphere
    - *a. characterize the magnetosphere as a fast magnetic rotator;*

b. characterize the magnetosphere as a giant accelerator;

c. understand the moons as sources and sinks of magnetospheric plasma.

3. Study the Jovian satellite and ring system

a. study Io's activity and surface composition;

b. study the main characteristics of rings and small satellites.

2.3 Mission Description

The JUICE spacecraft will use chemical propulsion and will carry a significant amount of propellant for the Jupiter orbit insertion and manoeuvres in the Jovian system. It will be powered by solar arrays. The baseline JUICE trajectory will mainly keep the spacecraft outside of the inner radiation belts at Jupiter with exception of two Europa flybys.

As a baseline, JUICE will be launched in June 2022. After 7.5 years of interplanetary transfer and Earth-Venus-Earth-Earth gravity assists JUICE will be inserted into an orbit around Jupiter in January 2030 (Figure 1). The spacecraft will stay for about a year in an evolving elliptic orbit around Jupiter with a pericentre outside the Ganymede orbit (phase 2 in Figure 1). The orbit will allow detailed investigations of the inner magnetosphere of the giant planet, monitoring the Jupiter atmosphere and coupling processes. Six flybys of Ganymede will allow starting of the investigation of the moon.

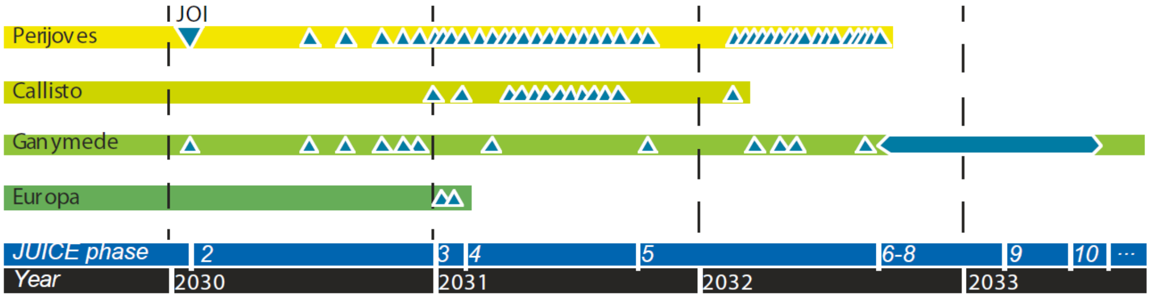

Figure 1*. Illustrative timeline of the JUICE baseline mission.*

In phase 3 JUICE will perform 2 flybys of Europa using gravity assists at Callisto. This will enable investigations of the composition, geology and sub-surface of the moon. In phase 4 the spacecraft will use Callisto flybys to raise the inclination of the orbit around Jupiter to ~30 degrees and come back to the Jovian equatorial plane, which is necessary for the transfer to Ganymede. These orbits will allow observations of the polar regions of Jupiter. During the 12 Callisto flybys (phases 3, 4) the mission will be focused on characterisation of the internal structure, surface and exosphere of the moon. The time between Callisto flybys will be devoted to continuous monitoring of Jupiter’s atmosphere and magnetosphere, rings and environment, and remote observations of the other moons. The following 6 months of transfer to Ganymede (phase 5) will again be favourable for the studies of the interaction of the Jovian magnetosphere with the intrinsic magnetic field of the moon, together with remote observation of the giant planet and the other icy moons.

In September 2032 the spacecraft will be inserted in orbit around Ganymede. The JUICE orbital mission will consists of the following phases: elliptic/high circular orbits (10,000x200 km, ~5000 km circular), 1st low circular orbits at 500 km, and 2nd

low circular orbits at 200 km (phases 6-10, Figure 1). While going closer and closer to the moon the spacecraft will address different scientific goals. In the first part of the Ganymede tour the imaging and spectro-imaging instruments will complete mapping of the surface using optimal illumination conditions. Then, the priority will be given to the geophysical, exospheric and plasma investigations that require to be as close to the moon as possible. At the end of the mission there may be an opportunity to probe lower altitudes during the orbital decay that would allow sounding the Ganymede exosphere at different altitudes. This is considered an option. A mission extension could be achieved by keeping the spacecraft in the 200 km altitude orbit for an additional period of time, using residual capability.

3 PROGRAMME PARTICIPATION

3.1 Payload Consortium Participation

ESA will issue an Announcement of Opportunity (AO) to the Scientific Community for the JUICE payload that will be based on the scientific objectives of the model payload. The AO will call for provision of instruments from nationally funded individual scientists or science consortia willing to participate. In the response to the AO, potential PIs will have the flexibility to identify those elements that could be shared with other instruments for a best use of resources. These eventual elements will be subject to a specific evaluation in order to assess any criticality related to their multi-purpose use. They will be iterated and optimized during the evaluation process, including the common functions and resources which will be provided by the Agency or other instruments if required.

The proposals for the instruments will have to be compatible with the scientific and operational objectives of the JUICE mission and with its design and operational capabilities as defined in the Experiment Interface Document (EID-A). Each proposal for an instrument must identify a single Principal Investigator (PI) heading the instrument consortium. The PI must be fully backed by the national funding agency of her/his country, henceforth called “Lead Funding Agency” (LFA) for the instrument. In some countries, various organisations or institutions may provide resources. In this case the LFA will be the organisation providing representation to the ESA Science Programme Committee or, for non-ESA member states, be represented by a national space agency. The LFA is expected to provide dominant funding for the respective instrument and have prime science and industrial responsibility through the PI and Instrument Manager.

Instrument proposals must be accompanied by a Letter Of Endorsement (LOE) committing to the financial support in the Definition Phase and by a time-line showing milestones leading to full commitment by the time of mission adoption, from the relevant national funding agency, on behalf of all institutions participating in the proposal. Responses will clearly need to spell out the character and level of participation together with the nature of the management structure and financial commitments within each instrument consortium. This LOE will constitute a preliminary agreement between ESA and LFA until formalization of the Multi-lateral Agreement (MLA) between all participating agencies (or Memorandum of Understanding (MOU) in the case of non-ESA member states) at completion of the Definition Phase.

The ESA AO is open to European and non-European scientists, and to other scientific communities with which reciprocity or specific agreements exist (e.g., USA, Russia, Japan).

3.2 Modes of Participation

The possible modes of participation to the JUICE programme are:

(1) Principal Investigator (PI), heading an instrument consortium providing an instrument (section 3.2.1);

(2) Co-Principal Investigator (Co-PI) may be appointed if a major development is carried out in a country/institution different from the one of the PI. A Co-PI will have similar rights as a PI, but the PI will remain the single interface to the ESA Project Office (section 3.2.2);

(3) Co-Investigator (Co-I), a member of a consortium providing an instrument (section 3.2.3);

(4) Interdisciplinary Scientist (IDS), an expert in specific overarching science themes connected to the mission objectives who takes advantage of synergistic use of the data delivered by several experiments (section 3.2.4);

(5) Guest Investigator (GI), scientist participating in the data collection and analysis of one or more instruments and/or performing laboratory studies, theoretical or numerical investigations essential for the mission success (section 3.2.5).

3.2.1 PRINCIPAL INVESTIGATOR

Within the remit of the MLA, the PI or, when applicable, an LFA representative, will have the following responsibilities:

(1) Management

- Establish an efficient managerial scheme, which would be used for all aspects and through all phases of the experiment programme.
- Organise the efforts, assign tasks and guide other members of the instrument consortium.
- Ensure that plans and schedules are properly established, implemented and analysed such that the status reporting complies with the requirements of the ESA Project Office.
- Provide the sole formal managerial and technical interface of the instrument to the industrial prime via the ESA Project Office.
- Support ESA management requirements (e.g. progress reviews, programme reviews, change procedures, product assurance, etc.) outlined in the Experiment Interface Document (EID).
- Where applicable, be responsible for ensuring compliance with all ITAR regulations in a timely manner. Surveillance requirements arising from ITAR regulations shall be reported to ESA and any costs associated with such requirements shall be borne by the PI.

(2) Science

- Monitor the compliance of the instrument design to the scientific requirements outlined in the Sci-RD and report deviations to ESA in a timely manner.
- Attend the meetings of the Science Working Team and its Groups, as appropriate, take full and active part in their work, report on the instrument development, provide summaries of the main scientific results.
- Provide the formal scientific interface of the instrument consortium with ESA.

- Ensure adequate calibration of all parts of the instrument, both on the ground and in space.
- Exploit the scientific results of the mission and assure their diffusion as widely as possible.

(3) Hardware

- Define the functional requirements of the instrument and auxiliary test equipment (e.g. MGSE, EGSE, CGSE, etc.).
- Ensure development, construction, testing and delivery of the instrument. This shall be performed in accordance with the technical and programmatic requirements outlined in the AO including its annexes such as the EID-A, and subsequently reflected in the PI response, EID-B.
- Ensure that the instrument is to a standard that is appropriate to the objectives and lifetime of the mission, and to the environmental and interface constraints under which it must operate.
- Deliver adequate verification models (EQM's, STM's, etc.) of the instrument to ESA, as required to verify system interfaces. The delivery requirements are defined by the EID-A, in accordance with the technical programme needs.
- Deliver the instrument's Flight Model and Flight Spare parts (as appropriate) to ESA in accordance with the technical requirements defined in the EID-A, together with the relevant Ground Support Equipment.
- Support the system level integration and test activities related to and involving the instrument.
- Provide the necessary equipment to process the experiment's data as agreed with ESA and specified in the EID-A.
- Ensure that all procured hardware is compliant with ESA requirements, through participation in technical working groups and control (e.g. cleanliness, planetary protection) boards, as requested, and that the hardware allows system level performance compatibility to be maintained.
- Provide the overall documentation during the project, as defined in the EID-A.

(4) Software

- Ensure development, testing and documenting of all software necessary for the control, monitoring and testing of the instrument, in accordance with the rules and guidelines established in the EID-A.
- Specify and then support the development, testing and documenting of all software necessary for the testing, operation and data reduction/analysis of those parts of the instrument under ESA responsibility, in accordance with the rules and guidelines established in the EID-A.
- Ensure the delivery to ESA of any instrument specific software which is required for testing or operations and its documentation to ESA, or elsewhere, in accordance with approved ESA guidelines, procedures and schedules. This includes the provision of software required in the ESA SOC as agreed in the Science Implementation Requirements Document.

- Maintain and update all PI-provided instrument software and its documentation until the end of the mission. This includes all agreed PI-provided software to be delivered to the SOC as part of the final archive.

(5) Product Assurance

- Provide product assurance functions in compliance with EID-A requirements.

(6) Operations

- Provide support for preparation, implementation and execution of the mission and science operations, up to the end of the mission including delivery of a user manual and data base inputs in accordance to the EID-A requirements.

Specific responsibilities of the PIs with respect to operations are described in Section 6.3.2.

(7) Communications and Public Relations

- Support science communications and public relations activities of ESA (and where applicable, the LFA), and provide suitable information and data in a timely manner, as outlined in the Science Communication Plan (see section 6.5).

The financial status of the PI teams, within the remit of the MLA, will have to be guaranteed by the LFA. Co-I/Co-PI teams are required via their national funding agencies to seek agreement with the LFA on financial matters related to the selected investigations.

Should a PI intend to step down from his role, he will send a formal request to the ESA Director of Science and Robotic Exploration (D/SRE). The PI may provide a non binding proposal for a replacement in the PI role. The D/SRE will assess the proposal and will inform the Steering Committee (see Section 5.5). The D/SRE will appoint a new PI, in consultation with the relevant LFA.

3.2.2 CO-PRINCIPAL INVESTIGATOR

Co-PIs are responsible for their own funding which is guaranteed via their national funding agencies and must be underwritten by formal interagency agreements with the LFA, representing the PI and which holds overall financial responsibility with respect to instrument development and delivery to ESA.

3.2.3 CO-INVESTIGATOR

Members of each PI-led consortium may be proposed as Co-Investigators. Each Co-I should have a well-defined role either with regard to the hardware/software delivery or with regard to the scientific support of the investigations within the instrument consortium. The PI-led consortium may review the status of its members regularly and implement changes if required. The LFA will generally not change during the development of a given instrument.

Co-Is are responsible for their own funding which is guaranteed via their national funding agencies and must be underwritten by formal interagency agreements with the LFA, representing the PI and which holds overall financial responsibility with respect to instrument development and delivery to ESA.

3.2.4 INTERDISCIPLINARY SCIENTIST

To ensure a top-level oversight of mission science, five (TBC) Interdisciplinary Scientists (IDS) will be selected through an open AO process. In general, IDSs should not reflect instrument specific domains, but rather cover specific science themes (e.g, icy moons geology, magnetospheric processes, atmosphere, etc.), take part in the analysis of data from different onboard instruments, and have the same data rights as members of the PI-led experiment consortia. An IDS may also wish to undertake specific and time-limited tasks in areas such as modelling of the planet and its environment, science operation planning, hazard assessment and similar activities that may be required during the course of the mission.

The proposals submitted by IDSs must describe clearly their scientific case, the relevance of their contribution to the mission and the instrument data sets needed to carry out their research programme. Financial endorsement by the national funding agencies or other supporting institutions, should they require funds for their activity, is also required. The IDSs will be selected some years before launch (exact time TBC) according to the process described in Section 4.2 and will be part of the Science Working Team. As a general rule, Co-Is of instrument teams may apply to become IDSs, while PIs and Co-PIs are excluded. The IDSs, like the PIs, are expected to provide adequate support to the communications activities of ESA. The IDSs will be appointed for a first period of three years (TBC), renewable but not exceeding the nominal duration of the mission. The Agency may release additional AOs at a later stage for specific mission phases.

3.2.5 GUEST INVESTIGATOR

Guest Investigators (GIs) are individual scientists who wish to make use of the data collected by one or more instruments, in combination, e.g., with data from other missions and/or ground-based observations, laboratory measurements and model elaborations. Their proposals shall be submitted to ESA following an open AO process. Their tasks shall be agreed directly by the proposers with the PIs, with concurrence of the ESA Project Scientist.

The GIs will be selected after launch, according to the process described in Section 4.3. The GIs are expected to participate to the mission activities and have access to data only via the PIs whom they are associated with; they will be invited to participate to specific activities of the Science Working Team, including science communications.

Should the GIs require funds for their activity, they should secure them with national funding agencies or other supporting institutions. The GIs will be appointed for a first period of three years (TBC), renewable but not exceeding the nominal duration of the mission. The Agency may release additional AOs at a later stage for specific mission phases.

4 SELECTION PROCESS

4.1 Instrument selection

The approach to be adopted for the selection, funding and development of the JUICE payload aims at preserving an efficient procurement of a highly optimised payload to ensure maximised science return from the mission with minimum resources. The payload must be solidly defined technically, financially and programmatically, in order to fit smoothly into the overall mission development schedule, and strictly within the available spacecraft resources, with minimum risk to ESA and the various instrument funding agencies.

For this reason, ESA will appoint a Payload Review Committee (PRC) consisting of independent experts, with competences covering the main scientific areas of the mission, with the main role of guardian of the payload's scientific capability. The terms of reference of the PRC are described in section 4.1.1. In parallel with the work of the PRC, ESA shall undertake an internal technical, financial and management review of each instrument proposal to establish the overall proposal integrity. The instrument evaluation criteria and selection principles are detailed in Section 4.1.2, while the evaluation process is described in Section 4.1.3.

The timetable of events leading to the selection of payload is envisaged as follows:

- June 2012: Issue by ESA of Call for Letters of Intent / Announcement of Opportunity
- October 2012: Receipt of PI-led proposals with LFA's LOE in response to AO
- October – November 2012: Peer review of the instrument proposals and recommendation of instrument consortia
- February 2013: Payload selection by SPC
- Mid 2014: mission adoption and MLA signature.

After the character, structure and funding commitment of the instrument consortia are agreed by the SPC, ESA will propose to commence the implementation phase.

4.1.1 PAYLOAD REVIEW COMMITTEE

An independent international Payload Review Committee (PRC) shall assess instrument proposals in close cooperation with internal ESA technical, financial and management teams. The Executive shall appoint the PRC members after consultation and in agreement with SSEWG and SSAC.

The Payload Review Committee shall review all instrument proposals received in response to the AO according to the following terms of reference:

- Ensure that all science objectives are satisfied within the overall AO response;
- Ensure that each instrument proposal satisfies the science requirements in terms of sensitivity and performance, as specified in the relevant documents, to achieve the specific science objectives;

- Ensure compatibility of each instrument against the objectives of the model payload as defined in the Payload Definition Document;
- Recommend on which proposal should be selected, when competing instrument proposals should be submitted;
- Identify clear alternatives among the proposed instruments in case of too high development risk and/or incompatibility with available spacecraft resources or interfaces;
- Suggest measures to optimise the payload and instrument teams possibly by merging several proposed investigations, identifying potential common hardware etc.

The Payload Review Committee will work in close collaboration with internal ESA review teams consisting of selected personnel of the Agency and its contractors as well as invited specialists. For each instrument proposal, in financial and programmatic areas, ESA will consult extensively with funding agencies and provide, via the appropriate internal review team, the PRC with input on the implementation feasibility and risk assessment.

The "No Conflict of Interest" rule will apply, i.e. no potential PI or Co-PI for any instrument can be a member of the PRC, nor be involved in the selection procedure. This will apply also to potential Co-Is to the maximum possible extent.

4.1.2 EVALUATION CRITERIA AND SELECTION PRINCIPLES

The individual instrument proposals will be evaluated on the basis of the AO and using the following criteria:

(1) Scientific

- Relevance of the scientific objectives and their compatibility with the global objectives of the whole mission;
- Adequacy of the measurements to fulfil the stated objectives and capability of the instrument to perform the required measurements as indicated in the Science Requirement Document;

(2) Technical and Operational

- Feasibility and heritage of the proposed technical solutions;
- Development status of the instrument;
- Availability of relevant technologies and the need for the development of new technologies. The development status of such "new" technologies should also be evaluated based on the AO response. All ITAR-related approval aspects shall be clearly identified and included in the planning.
- Compliance with the interfaces specified through the EID-A.
- Instrument development plan including test and validation programme;
- Compatibility of the instrument with the mission environment, spacecraft resources, accommodation and mission constraints;
- Operational complexity;

- Quality of data analysis plan;

(3) Managerial

- Management plan and its adequacy with the instrument complexity; this specifically includes the complexity of the management interfaces within a consortium;
- Continuity of human and institutional resources to ensure a timely execution of instrument development, calibration and associated tasks, and to support post launch operation and data analysis. The manpower funding profiles, at the science institute level within each consortium, backed by the appropriate funding agency and confirmed through the LFA should be analysed for all mission phases including science exploitation and archive;
- Competence and experience of the team in all relevant areas (science, technology, software, development, management and outreach/science communications);
- Credibility of costing; this will be assessed by ESA staff experienced in instrument cost analysis acting in close cooperation with the relevant funding agencies and coordinated with the LFA's through which the proposal was submitted.
- Compliance with ESA applicable management, engineering, reporting and product assurance requirements and standards;
- Possible financial impact of the proposed instrument upon ESA;
- Commitment of all the national funding agencies to provide the correct level of support to member institutes within the consortium under the overall responsibility of the LFA which represents at a minimum the PI-institutes participation in the consortium;
- Commitment of the PIs funding agency to become the LFA and provision of the LOE.

The composition of the overall payload carried by JUICE will take into account the following criteria:

- Evaluation of individual instrument proposals (see above);
- Potential scientific achievement within the global mission objectives;
- Compatibility with the model payload;
- Compatibility with system resources, mission and programme constraints, and financial envelope imposed by national agencies.

4.1.3 EVALUATION PROCESS

The instrument proposal evaluation and selection for JUICE will be made in the following steps.

(1) Scientific evaluation

The PRC will evaluate the merits of each instrument proposal according to the terms of reference indicated in Section 4.1.1 and in line with the criteria listed in Section 4.1.2 *(1)*.

Candidate PIs with relevant Co-Is may be invited to clarification meetings, individually or collectively, to discuss critical issues and possible areas of overlap or complementarities.

(2) Technical, managerial and financial evaluation

ESA will form a technical review team to evaluate all instrument proposals for their managerial and technical compliance with the mission requirements. The instrument concept, feasibility, management scheme and funding will be assessed. The ESA team will be complemented when required by additional ESA experts and external consultants.

In the frame of the selection process, potential PIs, with the relevant Co-Is and technical support personnel may be invited to attend meetings at the European Space Research and Technology Centre (ESTEC) to clarify details on technical, managerial or financial issues.

The goals of this exercise are:

- To analyse the detailed requirements of the selected instruments to identify potential problem areas.

- To analyse the impact of the proposed instruments on the spacecraft design and payload complement in order to keep the mission cost within the financial envelope, including that for national agency funding of the instruments.

(3) Final Recommendation

Based on the technical and scientific assessments, the PRC will evaluate the configuration of the instrument payload complement which would satisfy the mission science objectives and equates with the objectives of the model payload.

The PRC might consider upgrading, descoping or merging of the instrument proposals, as well as using common parts, during the whole selection process based on the science objectives, technical feasibility, programmatic and financial situation.

The PRC will recommend to the D/SRE a JUICE payload complement matching as closely as possible the objectives of the model payload.

The deliberations of both the PRC and ESA internal review will be submitted to the ESA Advisory Structure (SSEWG, SSAC) for endorsement. The results of this process will be reported to the D/SRE. The ESA Executive will elaborate a proposal to be submitted for evaluation and, eventually, approval by the SPC.

4.2 Selection of Interdisciplinary Scientists

Interdisciplinary Scientists (IDS) will be selected through an open AO process (see section 3.2.4). The proposals will be evaluated through an independent Peer Review. Each IDS will be selected on the basis of the scientific quality and value of the investigation proposed. The proposed research shall not require additional resources or any redesign of the payload. The selection will take place after the completion of the JUICE payload confirmation procedure. The approval will be made by SPC upon proposal of the D/SRE, taking into account the recommendation by SSEWG and SSAC.

4.3 Selection of Guest Investigators

The selection criteria for Guest Investigators (GIs) will be established later in consultation with the SWT (see section 3.2.5) and described in a dedicated AO. The approval will be made by SPC upon proposal of the D/SRE, taking into account the recommendation by SSEWG and SSAC.

5 SCIENCE AND PROJECT MANAGEMENT

5.1 Project Scientist

ESA nominates the JUICE Project Scientist (PS). The PS is the Agency's interface with the Principal Investigators for scientific matters. The PS will chair the Science Working Team (SWT) and coordinate its activities.

During all phases of the mission the PS will be responsible for all scientific issues within the Project. During the development phase, it is PS responsibility to advise the ESA Project Manager on technical matters affecting scientific performance, including the ability of the spacecraft to support achievement of the mission's goals. It is also PS responsibility to monitor the state of implementation and readiness of the instrument operations and data processing systems.

After the in-flight commissioning phase, the PS will continue his/her activity as the main interface with the scientific community and the main scientific interface with the MOC and SOC. The PS will coordinate the creation of the scientific products, and will monitor their archiving and distribution to the scientific community.

5.2 Science Working Team

The SWT will consist of the PS, PIs and IDSs. Co-PIs, Co-Is, GIs and other interested scientists will be invited to participate in SWT meetings, as appropriate. The JUICE PS will chair the SWT.

The SWT will monitor and advise ESA on all aspects of the mission that will affect its scientific performance. It will assist the PS in maximizing the overall scientific return of the mission within the established boundary conditions. It will act as a focus for the interests of the scientific community in JUICE.

The SWT will be asked to review and endorse top-level requirements (in all areas of the project) that impact science return.

In order to account for the multidisciplinary aspects of this mission, the SWT may delegate tasks to scientific subgroups. These subgroups will focus on specific topics of research. One member of the SWT, preferably an IDS, will lead each scientific subgroup. Participation of individual scientists to activities of several subgroups is possible and even recommended. The PS, through SWT meetings, will insure the coordination between these subgroups.

5.3 Project Management

ESA will establish a JUICE Project Office, headed by a Project Manager, which will fulfil its function until the completion of the spacecraft initial commissioning phases. ESA, via the Project Manager and later by the Mission Manager, will retain overall responsibility for the mission through all phases.

The Project Office will be responsible for the mission design and implementation.

With regards to the JUICE Investigator teams, the Project Office will be responsible for:

- The procurement of the JUICE spacecraft (including the payload);
- Launch;
- The commissioning of the system in the early phase of transfer to Jupiter and in orbit around Jupiter;

The ESA Project Manager will periodically call Project Reviews, which will include all aspects of the mission.

After the in-flight commissioning phase, a Mission Manager will take over the responsibility for the mission throughout the exploitation phase: organisation and overall management of teams and staff assigned to the JUICE project, of the science operations team and the mission operations teams. The Mission Manager will have overall responsibility for the delivery of the scientific output of the mission as approved within assigned constraints.

Specifically this will include the overall responsibility for:

- Checkout of JUICE in the cruise phase;
- Insertion of JUICE into its target orbits;
- Mission and science operations;
- Post operations phase, including archiving of the JUICE data products.

The Mission Manager will be supported by the Project Department with respect to spacecraft system engineering issues.

5.4 Monitoring of Instruments Development

The ESA Project Manager, in close coordination with the Project Scientist, will monitor the progress of the design, development and verification of all JUICE instruments. The instrument consortia will be required to demonstrate to ESA in regular reports and during formal reviews, compliance with the scientific mission goals, the spacecraft system constraints, the spacecraft interfaces and the programme schedule as defined in the mutually agreed Experiment Interface Document (EID).

5.5 Steering Committee

A Multi-Lateral Agreement (MLA) will be established between ESA and the LFAs to formalise the commitments and deliverables of all parties. A JUICE Steering Committee with representatives from the LFAs and ESA is then set up to oversee the timely fulfilment of the obligations concerning the payload of all parties to the MLA.

6 OPERATIONS AND DATA

6.1 Mission Operations Concept

ESA will be responsible for the launch and operations/checkout of the spacecraft.

ESA will establish a JUICE Mission Operations Centre (MOC) located at ESOC and a Science Operations Centre (SOC) located at ESAC.

6.2 Mission Operations

The JUICE Project Management will define, in agreement with the MOC, the requirements and responsibilities for the mission operations, on the basis of a Mission Implementation Requirement Document (MIRD) and a Mission Implementation Plan (MIP).

The JUICE MOC will be responsible for the operations of the spacecraft, in particular of the following tasks:

- Monitoring of the spacecraft health & safety. Performing anomaly (out of limit) checks on a set of parameters (including payload) and notifying payload anomalies to the SOC and PI teams;
- Controlling the spacecraft attitude and maintaining its orbit;
- Overall mission planning and upload of the platform and payload telecommands;
- Provision of instruments raw data, spacecraft housekeeping and auxiliary data in a timely manner;
- Maintenance of the platform on-board software and the uplink of payload on-board software executables as generated, validated and delivered by the PI teams.

The ESA Ground Stations network, under the responsibility of ESOC, will support the telemetry and telecommand communications.

6.3 Science Operations

The Science Ground Segment (SGS) consists of the Science Operations Centre (SOC) and contributions from the PI teams.

The overall concept for science operations will be refined by the JUICE PS and SWT, in coordination with the SOC during the early phases of mission implementation.

At top level, ESA will capture requirements and monitor their implementation through the Science Implementation Requirements Document (SIRD) to be answered by the Science (operation) Implementation Plans (SIPs) of the SOC and each PI team, for their respective areas of responsibility.

6.3.1 SOC RESPONSIBILITIES

The SOC is the only interface to the MOC during the routine operations and is responsible to:

- Support the science operations planning by providing a centralized planning system;
- Prepare the long-term and short-term payload operations plan to be submitted to the MOC, based on inputs from the PS and the SWT;
- Provide Quick-Look on the instrument data, in coordination with PI Teams to optimise efficiency and avoid duplications of quick-look data accessibility and use;
- Set-up, maintain and run a pipeline ensuring the processing of raw instrument data (telemetry) until L1b level (un-calibrated science data), based on inputs (routine, calibration files and algorithms) provided by the PI teams, where applicable;
- Distribute instrument raw data, L1b data products and additional auxiliary data to the PI teams;
- Provide Liaison scientists where applicable;
- Define, develop, operate and maintain the JUICE science data archive and populate it with the data and mission products produced by the PI teams for all mission phases (including spacecraft navigation data);
- Support the MOC in the preparation of the payload operations during the commissioning phase.

The SOC is responsible for the development, procurement, integration, validation and maintenance of all the software and hardware systems which it operates.

6.3.2 PI TEAMS RESPONSIBILITIES

The PI Teams are responsible to:

- Support the definition of the science operations;
- Support the preparation of the instrument operation timelines;
- Perform calibration of their instrument on ground and in-flight;
- Monitor the operation of their instrument, perform maintenance operations and optimise instrument performance;
- Deliver the scientific data (raw data, calibrated data, and higher level data), including relevant calibration software and/or products, and associated documentation, to the JUICE archive (in a format that will be agreed with the ESA SOC for application by the general science community) within the end of the proprietary period (see Section 6.4 for data right policy) along with a full instrument technical and science user manual for use by the general science user community;
- Provide to the SOC calibration files and algorithms/routines needed for the raw to L1b data processing;

- Prepare a detailed Instrument Operation Manual;
- Provide unlimited access to all processed and analysed data for public relation purpose, even during their proprietary period; this material shall not be used for scientific publications;
- Provide expert support to the MOC and/or SOC during payload commissioning and critical operations
- Provide inputs for the definition and implementation of scientific data handling and archiving;
- Provide support required by other PIs for science planning purposes, as mutually agreed within the SWT.

6.4 Data Rights

JUICE data will be made available in compliance with the established ESA rules concerning information and data rights and release policy and according to the following procedure. Reduction of science data is under the responsibility of PI teams. Following in-orbit commissioning, the PI teams retain exclusive data rights for a proprietary period of 6 months after the receipt of the original science telemetry and auxiliary orbit, attitude and spacecraft status information. After this proprietary period data will be made available to the scientific community at large through the ESA science data archive. PI teams must clearly indicate in their proposal the level of resources allocated to the task of ensuring delivery of data to the ESA science archive in a timely manner. These resources must be agreed by the funding agencies involved.

During the proprietary period the PI teams will also be required to share data with the SWT proper members so as to enhance the scientific return from the mission, in accordance with the procedures to be agreed and formalised within the SWT.

Release of quick look data in graphic and/or image forms (not digital data) as soon as possible after the data are acquired will be planned upon agreement between the PS and the SWT. The quick look materials will be released only under a strict publication embargo and shall not be used for scientific publications.

The PI teams will provide records of processed data with all relevant information on calibration and instrument properties to ESA periodically, according to a delivery plan developed in agreement with ESA. The ESA science data archive will be the repository of all mission products.

Scientific results from the mission will be published by the instrument teams, in a timely manner, in appropriate scientific and technical journals. A publication policy will be established by the SWT and will be implemented under coordination of the PS. Proper acknowledgement of the services supplied by ESA (and where applicable, the LFA) will be made in all publications.

The PI teams will have to provide ESA (and where applicable, the LFA) with processed and useable data for Science Communication purposes as soon as possible after their receipt, even during their proprietary period.

6.5 Communication and Public Outreach

The JUICE mission is expected to attract much public interest. Hence, the mission will be given a proper importance and exposure within the framework of the communication activities of the ESA Science Programme. Each JUICE Investigator must provide material and information for Public Relations to ESA (and where applicable, to the LFAs).

During the development phase of the mission, ESA will set up web pages on the JUICE mission as an information tool for the general public and the media. With the progress of the mission the web pages will be enriched with more material and features related to the mission.

The active cooperation of all scientists involved in the JUICE mission in providing relevant information and results to ESA (and where applicable, to the LFAs) is expected for the success of the related communication activities.

For the purpose of public relation activities PIs will provide to ESA unlimited access to all processed and analysed data, even during their proprietary period; this material shall not be used for scientific publication purposes.

The JUICE mission will be included in the overall ESA Communications Plan and a detailed JUICE Communication Plan will be drafted in due time with inputs from the Project Scientists.

The Project Scientist will initiate and publish project related progress reports and reviews of scientific results from the mission. Scientific articles suitable for public release will be provided by the members of the SWT, upon their own initiative or upon request from the Project Scientist, at any time during the development, operational and post-operational phases of the mission.

Acronyms

3-D	3-Dimensional
AO	Announcement of Opportunity
CGSE	Calibration Ground Support Equipment
Co-I	Co-Investigator
Co-PI	Co-Principal Investigator
CSG	Centre Spatial Guyanais
EDDS	ESOC Ground System Data Dissemination System
EGSE	Electrical Ground Support Equipment
EID	Experiment Interface Document
EID-A	EID-Part A (spacecraft interface)
EID-B	EID-Part B (instrument specific interface)
EQM	Engineering and Qualification Model
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
FM	Flight Model
FOP	Flight Operations Plan
GI	Guest Investigator
GSE	Ground Support Equipment
IDS	Interdisciplinary Scientist
ITAR	International Traffic in Arms Regulations
LFA	Lead Funding Agency
MGSE	Mechanical Ground Support Equipment
MIP	Mission Implementation Plan
MIRD	Mission Implementation Requirements Document
MLA	Multi-lateral Agreement
MOC	Mission Operations Centre
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
OGS	Operations Ground Segment
PI	Principal Investigator
PRC	Payload Review Committee
PS	Project Scientist
Sci-RD	Science Requirements Document
SGS	Science Ground Segment
SIP	Science Implementation Plan
SIRD	Science Implementation Requirements Document
SMP	Science Management Plan
SOC	Science Operations Centre
SOWG	Science Operations Working Group
SPC	Science Programme Committee
SSAC	Space Science Advisory Committee
SSEWG	Solar System and Exploration Working Group
STM	Structural Thermal Model
SWT	Science Working Team
TBC	To Be Confirmed
TBD	To Be Defined