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Science Operations Support Activities for the Definition Phase of the Jupiter Icy Moons Explorer (JUICE)

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Abstract

JUICE is a mission chosen in the framework of ESA's Cosmic Vision 2015-2025 program. JUICE will survey the Jovian system with a special focus on the three Galilean Moons. Currently the mission is under study activities during its Definition Phase. For this period the future mission scenarios are being studied by the Science Working Team (SWT). The Mission Analysis and Payload Support (MAPPS) and the Solar System Science Operations Laboratory (SOLab) tools are being used to provide active support to the SWT in synergy with other operational tools used in the Science Operations Department at the European Space and Astronomy Centre (ESAC) in order to evaluate the feasibility of those scenarios. This contribution will outline the capabilities, synergies as well as use cases of the mentioned tools focusing on the support provided to JUICE's study phase on the study of its critical operational scenarios and the early developments of its Science Ground Segment demonstrating the added value provided to planetary science missions.

1. JUICE Mission

JUICE is the first Large-class mission chosen as part of ESA's Cosmic Vision 2015-2025 programme. It will be launched in 2022 from Europe's spaceport in Kourou, French Guiana, on an Ariane 5, arriving at Jupiter in 2030 to spend at least three years making detailed observations. With Europa, Ganymede and Callisto all thought to host internal oceans; the mission will study the moons as potential habitats for life. JUICE will continuously observe Jupiter's atmosphere and magnetosphere, and the interaction of the Galilean moons with the gas will twice fly by Europa. JUICE will make the first measurements of the thickness of Europa's icy crust and will identify candidate sites for future in situ exploration. The spacecraft will finally enter orbit around Ganymede in 2032, where it will study the icy surface and internal structure of the moon, including its subsurface ocean.

2. Science Operations Support Tools

A number of software planning tools are being used by the Science Operations Centres at ESAC in development and operations of planetary missions. The two main tools object of this article are MAPPS/EPS and SOLab.

2.1 MAPPS/EPS

The Mission Analysis and Payload Planning Support (MAPPS) tool has been used by most of ESA's planetary missions and it allows real-time simulation of the spacecraft behaviour and its environment. MAPPS is used by SGS and the PI teams to simulate the mission and to generate and validate timelines used in all planning cycles (Long, Medium and Short). MAPPS has the capability to compute and display all the necessary geometrical information such as the distances, illumination angles and projected field-of-view of an imaging instrument on the surface of the given body. Moreover MAPPS can simulate all the pointing and commanding of the spacecraft against spacecraft constraints and operational databases.

The Experiment Planning System (EPS) is embedded within MAPPS and models the experiment operations for computation and validation of many operational details such as state modes, commanding activities, data rates, power usage etc. EPS is also used for the final generation of command level sequences that will be delivered to the MOC for uplink to the spacecraft.

2.2 SOLab

The Solar System Science Operations Laboratory (SOLab) is a research and development project carried out at ESAC by the authors of the present article. The motivation for the development of Solar System Science Operations Laboratory (SOLab) comes from the attempt to tackle different science operations' needs and can be outlined in the following: 1) Quickly analyse and visualize the geometry of a given observation scenario. 2) Support for the medium and long term science operations of a planetary mission. 3) Science opportunity analysis of geometrical and operational conditions.

After being used as a prototype in Venus Express and Mars Express operations, SOLab capabilities were improved to support the Long Term Planning for the identification of mission phases, high level geometry analysis and trade off studies.

3. Science Operations Support to JUICE

3.1 JUICE sizing mission scenarios

The JUICE sizing scenarios have been prepared by the Science Working Team as a guide to analyse the spacecraft resource requirements as driven by the payload based on the Ganymede 500 km circular orbit and Europa fly-by. The results of this sizing cases have been used to compare the results provided to the industry to size the spacecraft and most important to ensure that the science objectives are covered within the proposed sizing of the spacecraft. The results have been achieved after several iterations within the authors and a designed Working team from the JUICE Science Working Team.

3.2 A simulated SOC for JUICE

In order to analyse the sizing scenarios a limited operative environment had to be setup and the authors developed a skeleton Science Operations Centre (SOC) organisation for JUICE. MAPPS and SOLab were the tools used for the study of the sizing cases in a virtual environment that contained three fundamental points: MAPPS and SOLab configuration, payload and spacecraft modelling, and preliminary operations timelines based on SWT inputs.

The MAPPS JUICE setup was performed based on the expertise gained from other operational missions (Mars Express, Venus Express). The instrument modelling was done according to the EID-B documentation of the instruments and with very specific iterations with the PI teams. For the generation of the operational timelines, the authors acted as science operations engineers to discuss the scientific and operational inputs provided by the Science Operations Working Group, and played the role of instrument liaison scientists to iterate with the instrument teams for the detailed modelling and scientific objectives of the observation timelines.

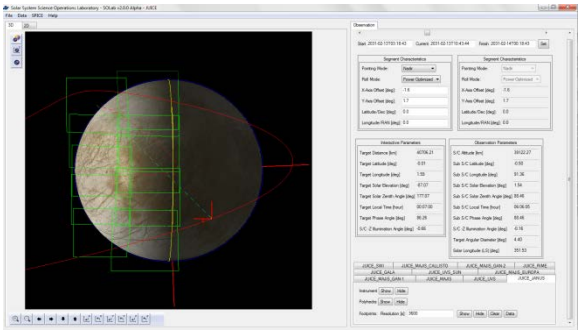

Figure 1. SOLab simulation of the Europa fly-by, including a mosaic observation planned for the JANUS imaging camera on the illuminated side.

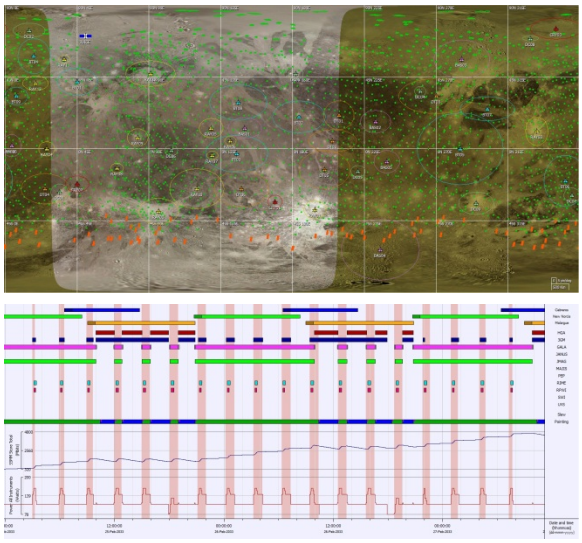

Figure 2. MAPPS coverage map and timeline simulation of Ganymede phase at 500km altitude, including an analysis of the data and power resources based on a preliminary payload observation plan.