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The JUICE Science Operations

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Abstract

The JUICE ESA Science Operation Centre (SOC) is in charge of implementing the planning of the science operations of the JUICE mission. At this stage, the SOC main activities are twofold:

- The support and implementation of a high level science planning (also known as Strategic Planning).

- The development and analysis of detailed science scenarios to check the operation feasibility for specific mission phases.

1. Introduction

1.1 The JUICE mission

JUICE - JUpiter ICy moons Explorer - is the first large mission in the ESA Cosmic Vision 2015-2025 programme that will provide a thorough investigation of the Jupiter system in all its complexity: it will characterize the three ocean-bearing icy worlds, Ganymede, Europa and Callisto, as planetary objects and potential habitats; it will also explore the Jupiter system as an archetype of gas giants, focusing in the study of Jupiter's atmosphere (structure, dynamics and composition) and magnetosphere, and their interactions with the Galilean satellites. Finally, it will be the first mission to orbit a Moon (Ganymede) of a Giant Planet [1].
The JUICE payload consists of 10 state-of-the-art instruments plus one experiment that uses the spacecraft telecommunication system with ground-based instrumentation. This payload will address all the mission's science goals of the mission.

Starting in 2029, a Jupiter tour of almost three years will include close flybys of Europa, Ganymede, and Callisto, together with an inclined orbit phase of six months, followed by an additional 10 months in orbit around Ganymede.

The JUICE mission is a multi-body, multi-targets, multi-community mission. Its trajectory design includes unique opportunities for science observations. One of the main tasks of the Science Operation Centre is to ensure that the high-priority objectives of the mission are met and to provide an evaluation of the expected scientific return of the mission. During the development phase, this is done through strategic planning on one hand, and through the study of detailed scenario examples on the other hand.

2. The Strategic Planning

The JUICE Science Working Team has mandated 4 working groups, constituted by members of the science community and covering the main disciplines of the mission, to advise on scientific matters. Using the expertise of the working group members, the SOC is in charge of translating the mission science goals into a scientifically valid plan, compatible with the mission constraints.

2.1 Science opportunity identification and segmentation

The first step of the strategic planning is to identify the science opportunities along the trajectory. For each discipline, a set of parameters are computed (in the form of time series or events) that can help to identify measurement opportunities. The distribution of opportunities vs time for each discipline can be computed, helping to identify conflicts (Fig 1).

Based on the opportunities identified along the tour, a segmentation of the trajectory can be derived. The trajectory segmentation is the identification of the highest priority science objective for each period: only one science objective at a time has priority for resources (mainly pointing and power), and additional observations are then identified, resources allowing.

2.2 High level data volume analysis

Once the science priorities for a given trajectory have been established for a given trajectory and endorsed by the Science Working Team, an analysis of the data volume at high level is performed to estimate the evolution of the Solid State Mass Memory usage strategy as well as to ensure a share of the science return per JUICE target compatible with the Science Working Team baseline. The SOC has been working on this aspect, using the segmentation activity as starting point (Fig. 2).

3. Detailed scenarios analysis

Examples of detailed scenarios are complementary to the strategic planning approach. Typically, a limited period of time (a few days) is analysed and optimized in details to assess the scientific return in the constraints of realistic spacecraft resources. Detailed analysis provides an assessment of the feasibility of observations within spacecraft's resources during critical phases of the mission: power, data volume and pointing/slews capabilities are considered, taking into account realistic science inputs from the teams and assessing them in increasingly more realistic details.

As an example, the Europa flybys of the JUICE mission represent the densest observational timelines of the entire tour, involving simultaneous operations of all payload instruments, with only two opportunities to observe Europa up close during the whole mission. This part of the trajectory thus requires high power and high data rate demands as well as complex pointing. Through the detailed analysis of such flyby scenarios (Fig 3), the SOC then monitors that with the evolving details JUICE is able to deliver the science it has been selected for.

4. Figures

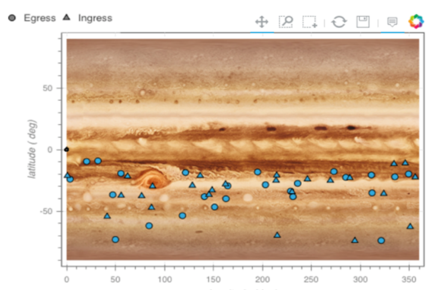

Figure 1: Identification of opportunities of radio occultation by Jupiter during the Jupiter tour

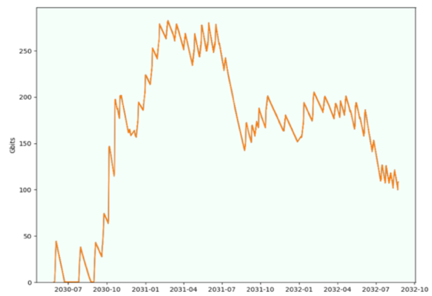

Figure 2: SSMM filling state as a function of time

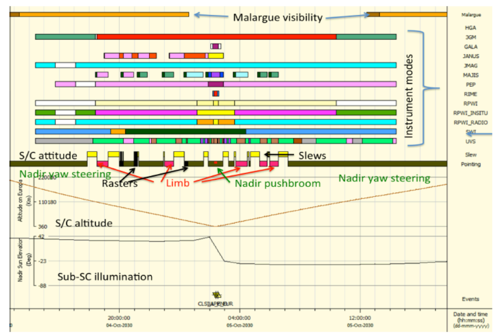

Figure 3: Simulation of instrument operations as function of time covering 24h of science operations centred around the closest approach of Europa. Each colour corresponds to a different instrument mode (instrument line), or pointing type (pointing line).

5. Summary and Conclusions

High level strategic science planning and examples of detailed scenarios analysis are two complementary activities being carried out by the Science Operations Center to prove the expected science return of the mission.

References

[1] O. Grasset et al., JUpiter ICy moons Explorer (JUICE): An ESA mission to orbit Ganymede and to characterise the Jupiter system, Planetary and Space Science, 2013, Vol. 78