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Science Opportunity Analysis for the Jupiter Icy Moons Explorer (JUICE) mission

A. Cardesín Moinelo (1), **M. Costa i Sitjà** (1), N. Altobelli (1), C. Vallat (1), D. Frew (1), M. Almeida (1), O. Witasse (2), C. Acton (3), P. Hebrero Casasayas (4)

(1) ESA-ESAC, European Space Agency, Madrid, Spain
(2) ESA-ESTEC, European Space Agency, Noordwijk, The Netherlands
(3) NAIF-JPL, Navigation and Ancillary Information Facility, Pasadena, US
(4) UPM, Universidad Politécnica de Madrid, Madrid, Spain

Abstract

JUICE is the first large 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. The mission has recently been adopted and big efforts are being made to analyze the future mission scenarios by the Science Ground Segment (SGS). The Science Operations Centre (SOC) at the European Space and Astronomy Centre (ESAC) is providing active support to the Science Working Team (SWT) to build the preliminary science observations timeline and therefore evaluate the feasibility of the mission with respect to the science goals. This contribution will outline some of the science opportunity activities carried out by the SOC, in close collaboration with the Navigation and Ancillary Information Facility (NAIF), with a summary of the main tools and the support provided to JUICE development on the study of its critical operational scenarios and the early developments of its Science Ground Segment demonstrating the added value for planetary missions.

1. Science Opportunity Analysis

One of the main tasks of the Science Operations Center in the support to the Science Working Team is the science opportunity analysis, meant to identify and analyze all the science opportunity windows to build the observations timeline and therefore evaluate the feasibility of the science goals of the mission.

1.1 Opportunity Analysis Input Data

Observation Geometrical Conditions: JUICE science working groups provide the geometrical conditions necessary to cover the main scientific objectives via the definition of detailed observation geometry. (e.g. occultation events, surface landmark coordinates with particular illumination angles, etc).

Operational Constraints and Events: operational information based on the mission events, either in the form of geometrical conditions (e.g. ground station visibilities), technical constraints (e.g. spacecraft illumination limits) or in the form of pre-computed events (e.g. orbit control maneuvers, etc)

Spacecraft Geometry Information: knowledge of the spacecraft ephemeris, reference frames, planetary constants, instrument models, etc, usually available in the form of SPICE kernels or other file formats coming from Mission Analysis.

1.2 Opportunity Analysis Core Elements

Event Finder: responsible for finding the list of time windows for any defined geometrical or operational parameter (distances, angles, visibilities, etc), based on any mathematical condition (equal, less, greater, minimum, etc) and flexible enough to cover multiple observers, target bodies and reference frames.

Context Finder: used to compute, for any given list of opportunity windows (basically a list of times), the contextual information on other geometrical and operational parameters (e.g. altitude, illumination angle, ground station visibility,...) that may be of interest for the scientific and operational analysis.

Event Handler: this module is used to load the list of opportunity windows and contextual information and combine them following basic logical rules (e.g. illuminated AND north pole OR south pole) and filter them based on any of the contextual parameters

(e.g. occultation in the northern hemisphere). This is the core module for the analysis of the scientific or operational quality of the opportunity windows through visualization of the contextual parameters and advanced display capabilities (latitude and longitude coverage maps, illumination plots, etc).

1.3 Opportunity Analysis Output Data

Science Opportunity Database: all science opportunity windows, including the contextual parameters and all the results of the combination/filtering process are stored in an internal Science Opportunity Database (in the form of ascii event time tables or more advanced SQL data bases)

Observation Opportunity Windows: The final output of the Opportunity Analysis are the list of observation opportunity windows (event times) which serve as input for the science operations scheduling and planning processes.

2. SOC 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 following tools are currently being used to cover some of the functionalities required for Science Opportunity Analysis.

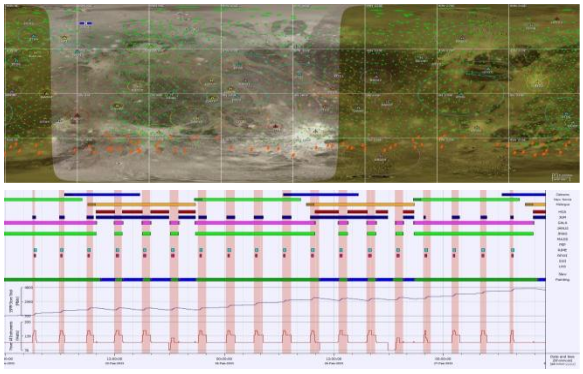

Figure 1. MAPPS coverage map and timeline simulation of Ganymede phase at 500km altitude.

2.1 MAPPS/EPS

The Mission Analysis and Payload Planning Support (MAPPS) and the Experiment Planning System (EPS) [1] tools have been used by most of ESA's planetary missions to generate and validate science observation timelines for the simulation of payload and spacecraft operations. MAPPS and EPS have 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.

2.2 SPICE based tools: WebGeoCalc, Cosmographia, SOLab eFinder

The Navigation and Ancillary Information Facility (NAIF) at JPL provides valuable SPICE support to the JUICE mission and several tools are available to compute and visualize science opportunities. In particular the WebGeoCalc [2] and Cosmographia [3] systems are provided by NAIF to compute time windows and create animations of the observation geometry available via traditional SPICE data files, such as planet orbits, spacecraft trajectory, spacecraft orientation, instrument field-of-view "cones" and instrument footprints. Other software tools developed by ESA are being used to support the science opportunity analysis for all missions, like the eFinder within the SOLab project [4].

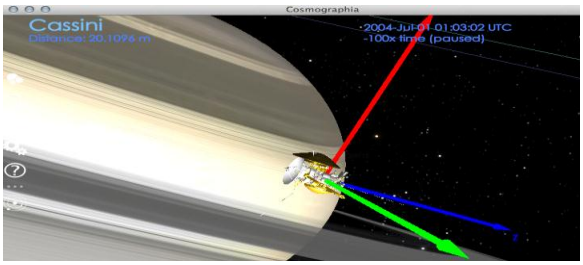

Figure 2. SPICE Cosmographia example visualization of Cassini geometry over Saturn rings.

References

[1] ESA Planetary Science Operations Tools: http://www.esa.int/TEC/Modelling_and_simulation/SEMQ0I8LURE_0.html

[2] WebGeocalc - A GUI Interface to SPICE: http://wgc.jpl.nasa.gov:8080/webgeocalc/

[3] SPICE Cosmographia Mission Visualization Software: http://naif.jpl.nasa.gov/naif/cosmographia.html

[4]: Solar System Operations Lab for Constructing Optimized Science Observations: SpaceOps 2012