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An update on SPICE for ESA Planetary Missions

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Abstract

SPICE is an information system that provides the geometry needed to plan scientific observations and to analyze the obtained. The ESA SPICE Service generates the SPICE Kernel datasets for missions in all the active ESA Planetary Missions. This contribution describes the current status of the datasets, the extended services and the SPICE support provided to the ESA Planetary Missions (Mars Express, ExoMars2016, ExoMars2020, Solar Orbiter, BepiColombo, JUICE, Rosetta, Venus Express and SMART-1) for the benefit of the science community.

1. Introduction

SPICE is an information system the purpose of which is to provide scientists the observation geometry needed to plan scientific observations and to analyze the data returned from those observations. SPICE is comprised of a suite of data files, usually called kernels, and software -mostly subroutines [1]. A customer incorporates a few of the subroutines into his/her own program that is built to read SPICE data and compute needed geometry parameters for whatever task is at hand. Examples of the geometry parameters typically computed are range or altitude, latitude and longitude, phase, incidence and emission angles, instrument pointing calculations, and reference frame and coordinate system conversions. SPICE is also very adept at time conversions.

2. The ESA SPICE Service

The ESA SPICE Service (ESS) leads the SPICE operations for ESA missions. The group generates the SPICE Kernel Datasets (SKDs) for missions in operations (ExoMars 2016, Mars Express and BepiColombo) missions in development (Hera, ExoMars 2020 and JUICE) and legacy missions (Rosetta, Venus Express). ESS is also responsible for the generation of SPICE Kernels for Solar Orbiter. The generation of SKDs includes the operation software to convert ESA orbit, attitude, payload telemetry and spacecraft clock correlation data into the corresponding SPICE format. ESS also provides consultancy and support to the Science Ground Segments of the planetary missions, the Instrument Teams and the science community. ESS works in partnership with NAIF.

3. Providing the best possible data

The quality of the data contained on a SKD is paramount. Bad SPICE data can lead to the computation of wrong geometry and wrong geometry can jeopardize science results. ESS, in collaboration with NAIF is focused on providing the best SKDs possible. Kernels can be classified as Setup Kernels (Frame Kernels that describe Reference Frames of a given S/C, Instrument Kernels that describe a given sensor FoV and other characteristics, etc.) and Time-varying Kernels (SPK and CK kernels that provide Trajectory and Orientation data, SCLK that provide Time Correlation Data, etc.). Setup Kernels are iterated with the different agents involved in the determination of the data contained in those kernels (Instrument Teams the Science Ground Segment, etc.) and Time-varying kernels are automatically generated by the ESS SPICE Operational pipeline to feed the Operational kernels that are used in the day-to-day work of the missions in operations (planning and data analysis). These Time-varying kernels are peer-reviewed a posteriori for the consolidation of SKDs that are archived in the PSA and PDS. This contribution will outline the status of the SKDs maintained by ESS.

3.1 SPICE Kernels archived in the PSA

ESS is also responsible for the generation of PDS3 and PDS4 formatted SPICE Archives that are published by the PSA. ESS in close collaboration with NAIF peer-reviews the operational kernels for the PSA [2] to publish being compliant with the Planetary Data System (PDS) standards and uses them in the processes that require geometry computations. After a long break the publication of PDS3 Datasets has been re-started by ESS and the first PDS4 Bundle has been published.

4. Extended Services

ESS offers other services beyond the generation and maintenance of SPICE Kernels datasets, such as configuration and instances for WebGeocalc and Cosmographia for the ESA Missions

4.1 SPICE-Enhanced Cosmographia

NAIF offers for public use a SPICE-enhanced version of the open source visualization tool named Cosmographia. This is an interactive tool used to produce 3D visualizations of planet ephemerides, sizes and shapes; spacecraft trajectories and orientations; and instrument field-of-views and footprints. ESS Service provides the framework and configuration in order to load the ESA Planetary Missions in Cosmographia, this contribution will present the latest version available and will demonstrate its usage within the ESA Planetary missions [3].

4.2 WebGeocalc

The WebGeocalc tool (WGC) provides a web-based graphical user interface and a programmatical (RESTful API) to many of the observation geometry computations available from the "SPICE" system. A WGC user can perform SPICE computations without the need to write a program; the user need have only a computer with a standard web browser or from the command line. WGC is provided to the ESS by NAIF. This contribution will outline the WGC instances for ESA Planetary missions [3].

References

[1] Acton C. (1996) *Planet. And Space Sci., 44,* 65-70.

[2] Besse, S. et al., (2017) *Planet. And Space Sci.*

[3] Acton, C. et al., (2017) *Planet. And Space Sci.*