

SPICE for ESA Missions

Marc Costa Sitjà

**SPICE and Auxiliary Data Engineer
Cross Mission Office, Science Department, ESA
EPSC, Riga, Republic of Latvia 21/09/2017**

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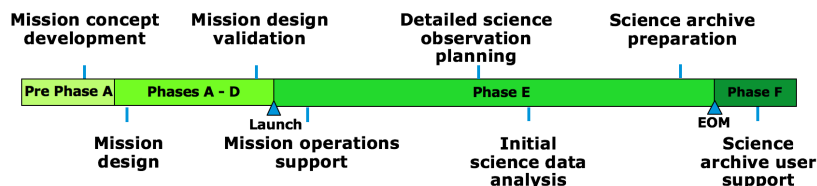
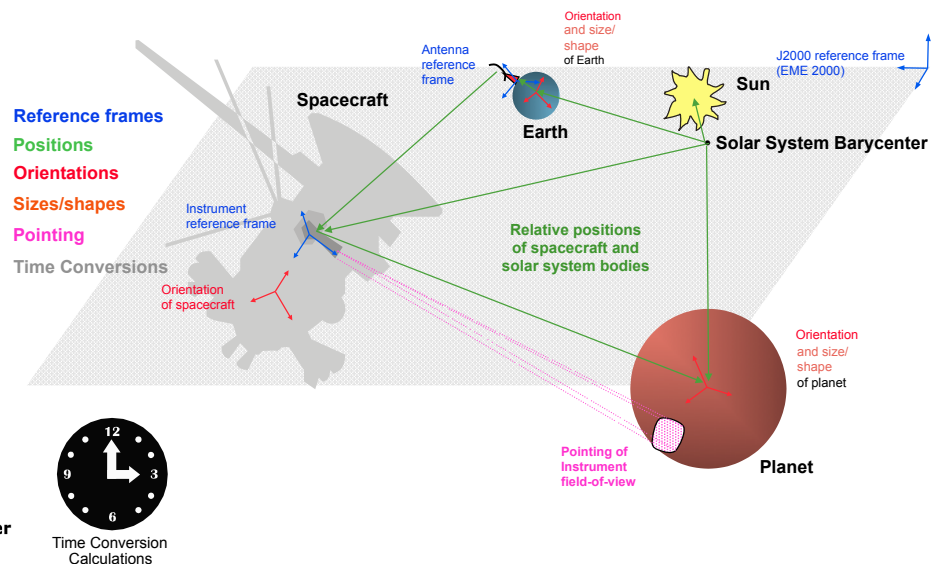
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SPICE in a nutshell

- SPICE is an information system that uses *ancillary data* to provide Solar System geometry information to scientists and engineers for planetary missions in order to plan and analyze scientific observations from space-born instruments. SPICE was originally developed and maintained by the Navigation and Ancillary Information Facility (NAIF) team of the Jet Propulsion Laboratory (NASA).
- “Ancillary data” are those that help scientists and engineers determine:
 - where the spacecraft was located
 - how the spacecraft and its instruments were oriented (pointed)
 - what was the location, size, shape and orientation of the target being observed
 - what events were occurring on the spacecraft or ground that might affect interpretation of science observations
- **SPICE** provides users a large suite of SW used to read SPICE ancillary data files to compute observation geometry.
- The ancillary data (kernels) comes from: The S/C, MOC/SGS, S/C manufacturer and Instrument teams, Science Organizations.



The ESA SPICE Service



- The ESA SPICE Service (ESS) leads the SPICE operations for ESA missions. Its main activities:
 1. The group is responsible for the generation, development, maintenance and archive of the **SPICE Kernel Datasets for the ESA Planetary Missions** (and Solar Orbiter)
 2. It develops and operates software to convert orbit, attitude, telemetry and spacecraft clock correlation data into the corresponding SPICE formats.
 3. Provides consultancy and support to the Science Ground Segments and the Science Community of the planetary missions for SPICE and ancillary data management.
- ESS also provides an instance of **WebGeocalc** and **Cosmographia**
- WebGeocalc is a web-based interface to some SPICE Functions, extremely powerful for quick-look data
- Cosmographia is a Visualization Tool for a full SPICE Scenario.
- Everything is accessible from: **spice.esac.esa.int**
- Contact the service via e-mail
 - esa_spice@sciops.esa.int
 - marc.costa@esa.int
- Join the **OpenPlanetary** Slack Community

The screenshot shows the ESA SPICE Home page. The header includes navigation links for SCIENCE MISSIONS, EUROPEAN SPACE AGENCY, SCIENCE & TECHNOLOGY, and a SIGN IN button. The main content area is titled 'WELCOME TO THE ESA HOME FOR SPICE' and features a navigation menu on the left. The menu items are: Home, Data, Missions, WebGeoCalc, Cosmographia, Training, and Planetary Science Archive. The main content area is divided into several sections: 'ABOUT SPICE', 'QUICKLINKS', 'DATA', 'OPERATIONAL KERNELS', 'PDS ARCHIVED KERNELS', 'SERVICES', and 'WEBGEOCALC'. The 'ABOUT SPICE' section provides a detailed description of the SPICE system, its purpose, and its history. The 'QUICKLINKS' section lists various links to related resources. The 'DATA' section provides information about the data available in the SPICE system. The 'OPERATIONAL KERNELS' section lists the operational kernels for ESA's missions. The 'PDS ARCHIVED KERNELS' section lists the archived kernels for ESA's missions. The 'SERVICES' section lists the services available to users. The 'WEBGEOCALC' section provides information about the web-based graphical user interface. At the bottom of the page, there is a diagram illustrating the SPICE system architecture, showing the flow of data between various components like Reference frames, Positions, Orientations, Time Conversions, and the Solar System Barycenter.

SPICE for ESA Missions



Available, SPICE Kernels Datasets:

Releases and support
to the community is
provided



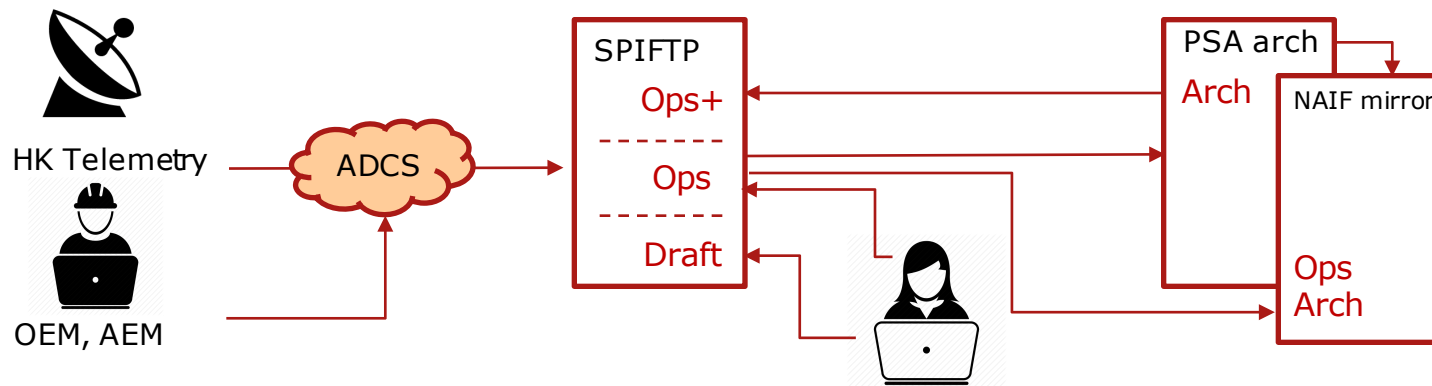
- Having good, reviewed and validated SPICE data a.k.a. as kernels is fundamental. The data for ESA Planetary Missions can be classified as follows:
- Function of the **mission phase**:
 1. **Study** Kernels (Solar Orbiter, JUICE, BepiColombo)
 2. **Operations** (Mars Express, Rosetta)
 3. **Legacy** (Venus Express, SMART-1)
- Function of the **kernel "processing" level**:
 1. **Draft** Kernels (Payload related Kernels not reviewed by IT, S/C on paper or non-launched)
 2. **Operational** Kernels (Kernels generated by pipelines and changing)
 3. **Archived** Kernels (peer reviewed kernels by ESS, NAIF and IT)

IMPORTANT: If you are a SPICE Kernel producer (Reconstructed Trajectory, S/C Orientation, Natural Body Ephemeris) please contact us and share your data with the community.

SPICE for ESA Missions

➤ Operational kernels contain the following information:

1. Set of Reference Frames of interest for geometry computations
2. FoV and boresight modeling for remote and in situ sensors (at least)
3. Predicted trajectory and as-planned or default orientation for S/C
4. Reconstructed trajectory and orientation and on-board measured orientation for S/C
5. OBT to UTC/CAL time conversion
6. Orientation of Solar Arrays and HGA (if applicable)
7. Position of scans or turn-tables or articulations of payload



➤ Is this information available for all ESA Planetary Missions? Not yet, but we are working on it:

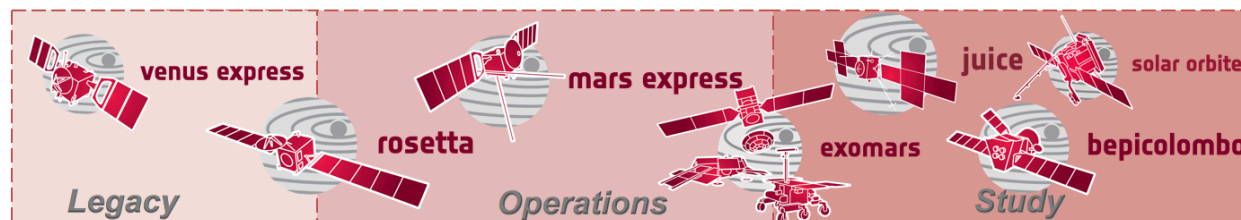
SPICE for ESA Missions



Mission	Ref Frames FOV LOS	Predicted Orbit Attitude	Measured Attitude	Reconstructed Attitude	OBT conversion	S/C Element Orientation	Payload Orientation	Archived?
Mars Express	Green	Green	Yellow	Red	Green	Yellow	Green	Yellow
ExoMars TGO	Green	Green	Yellow	Red	Green	Red	Yellow	White
Rosetta	Green	Green	Yellow	Yellow	Green	Green	Green	Yellow
Venus Express	Green	Green	Red	Red	Green	Yellow	Yellow	Yellow
BepiColombo	Green	Green	White	White	White	White	White	White
Solar Orbiter	Green	Green	White	White	White	White	White	White
JUICE	Green	Green	White	White	White	White	White	White
SMART-1	Green	Green	Red	Red	Green	Green	White	Red
Chandrayaan-1	Yellow	Yellow	Red	Red	Yellow	Yellow	White	Red
(Cassini-)Huygens	Red	Red	Red	Red	Red	White	White	Red
Giotto	Red	Yellow	Red	Red	Red	White	White	Red

Available, SPICE Kernels Datasets:

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provided



Introducing **spiops** a collaborative Python package

- **spiops** is a **Python package** that uses **SpicePy** to use SPICE Toolkit APIS to provide higher-level functions than the ones available with SPICE. This functions have been identified in my day-to-day work from having to implement multiple times a series of SPICE APIs to obtain a given derived functionality. **spiops** is aimed to assists the users to extend the usage of SPICE.
- **Functionalities** vary from the computation of the illumination of a given Field-of-View to obtaining the coverage of a given S/C for a particular meta-kernel, plotting Euler Angles or comparing different kernels.
- The underlying idea of **spiops** is to be used as a **multi-user and multi-disciplinary pool of re-usable SPICE based functions** and to provide an easier interface to certain SPICE functionalities with objects to provide cross mission and discipline support of SPICE for ESA Planetary and Heliophysics missions.

➤ Available for Python in PyPI `pip install spiops`

➤ ReadTheDocs documentation:

<ftp://spiftp.esac.esa.int/spiops/html/index.html>

```
start_time = '2014-11-12T15:00:03'
stop_time = '2014-11-12T17:34:03'

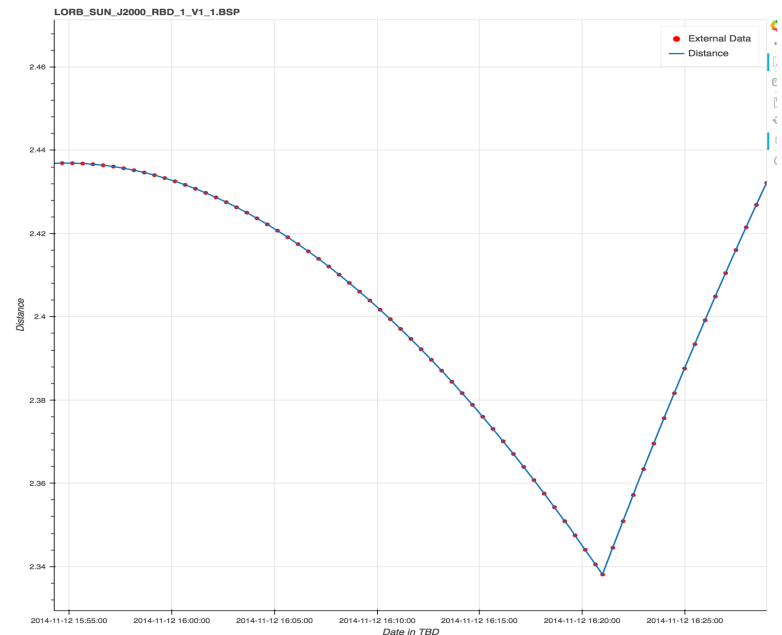
resolution = 1

interval = TimeWindow(start_time, stop_time, resolution=1)

comet = Target('67P/C-G', time=interval, frame='67P/C-G_CK')
lander = Observer('ROS_LANDER', time=interval, target=comet)

external_data = utils.convert_ES0Corbit2data('LORB_EME2000_RBD_1_V1_0.ROS')

lander.Plot('distance', external_data=external_data)
```



REMARKS

- We are moving towards providing the best SPICE Kernels for ESA Planetary Missions possible.
- In the coming months the Rosetta, MEX and VEX Archived Dataset will be consolidated and ExoMars 2106 kernels will start being routinely produced.
- Using Cosmographia and WebGeocalc might be an asset that you had not considered.
- Kernels Dataset releases are announced in the mailing lists and release notes are available.

COMMUNICATE

- Stay tuned. You can join one of the mailing list. There's one for each planetary mission:
spice_mex@sciops.esa.int, spice_vex@sciops.esa.int, spice_ros@sciops.esa.int, spice_em16@sciops.esa.int,
spice_bc@sciops.esa.int, spice_juice@sciops.esa.int
- You can also join the OpenPlanetary **slack** channel.
- I am open to suggestions to other communication channels (twitter?)

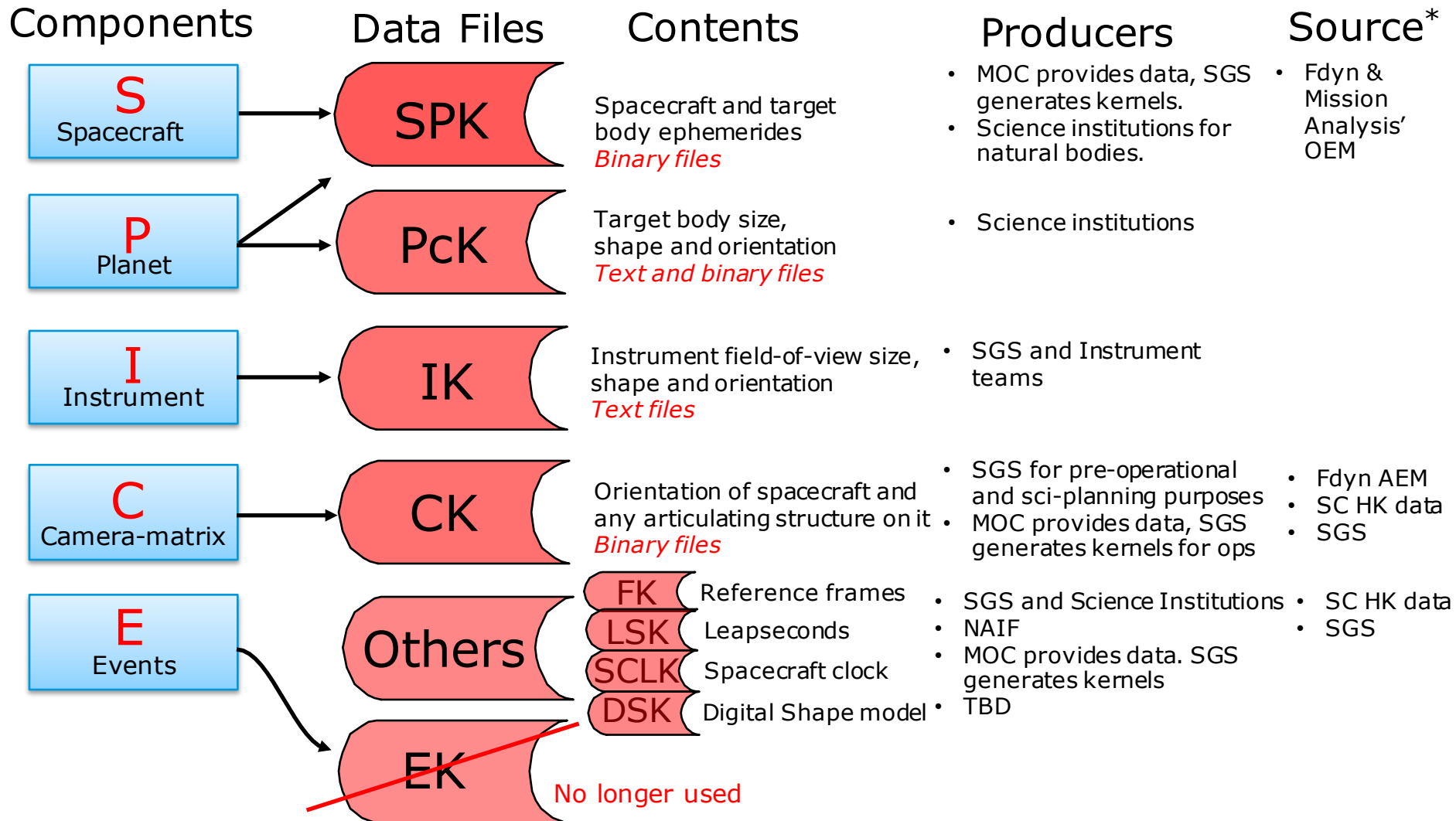
COLLABORATE

- Are you producing SPICE kernels that can enhance or complement our dataset? Provide it to us!
- Do you have a certain SPICE-derived function or have the need for one? consider **spiops!**

LEARN

- We provide **SPICE Training Classes** in Europe (typically Madrid) in a biannual basis. Last training was in September 2016 in Madrid.
- **Next training by NAIF in Monrovia (California) 7-9th November 2017.**

Backup - SPICE kernels



Backup - SPICE kernels

