

SPICE for ExoMarsRSP

SPICE implementation for ROCC



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ESA SPICE Service
by RHEA Group



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The **ESA SPICE Service (ESS)** is based at ESAC and it is provided by RHEA System. ESS leads the SPICE operations for ESA's planetary missions. Its main activities

- Generate, develop, maintain and archive the SPICE Kernel Datasets (SKD) for the ESA Planetary Missions (and Solar Orbiter);
- Develop and operates software to convert orbit, attitude, telemetry and spacecraft clock correlation data into the corresponding SPICE formats;
- Provide consultancy and support to the Science Ground Segments and the Science Community of the planetary missions for SPICE and ancillary data management.

ESA SPICE Service are: Marc Costa Sitja (lead) and Alfredo Escalante and (sometimes) a trainee (Former member: Bjoern Grieger member until Dec 2019).



ESS also provides an instance of **WebGeocalc** and the **Cosmographia** configuration for ESA missions:

- **WebGeocalc** is a web-based interface to some SPICE Functions, extremely powerful for quick-look data analysis
- **Cosmographia** is a 3D-Visualization Tool for a full SPICE Scenario.
 - Not really adept for Rover Operations ideal for ExoMars TGO.

We provide **SPICE Training Classes** in Europe in a biannual basis. Next 3 day training with NAIF: 16th-19th June 202.

- Recording of last SPICE Training at ESAC is available in YouTube

- **A SKD** consists on a complete set of SPICE Kernels that cover the whole mission lifespan including long term predicted trajectory and orientation. Kernels in a SKD can be classified in two main types:
 - **Setup kernels (STK)** [FK, IK, PCK, LSK] are developed by the ESA SPICE Service (ESS) and are reviewed and iterated with the SGS and with the Instrument Teams when need be during the whole duration of the mission.
 - **Time-varying kernels (TVK)** [SPK, CK, SCLK, MK] are generated by ESS with an operational pipeline and the source data is provided by the Flight Dynamics or the given SGS Downlink group in terms of OEMs, AEMs and Housekeeping TM data.
- ESS has focused efforts on systematically providing meta-kernels (**MK**) to users.

It Is also important to distinguish in between SKDs published in the ESA FTP (Study and Operational) and BitBucket and the peer-reviewed **and PSA-PDS compliant Archived SKDs** (following the PDS3 and PDS4 standards from the PDS and IPDA).

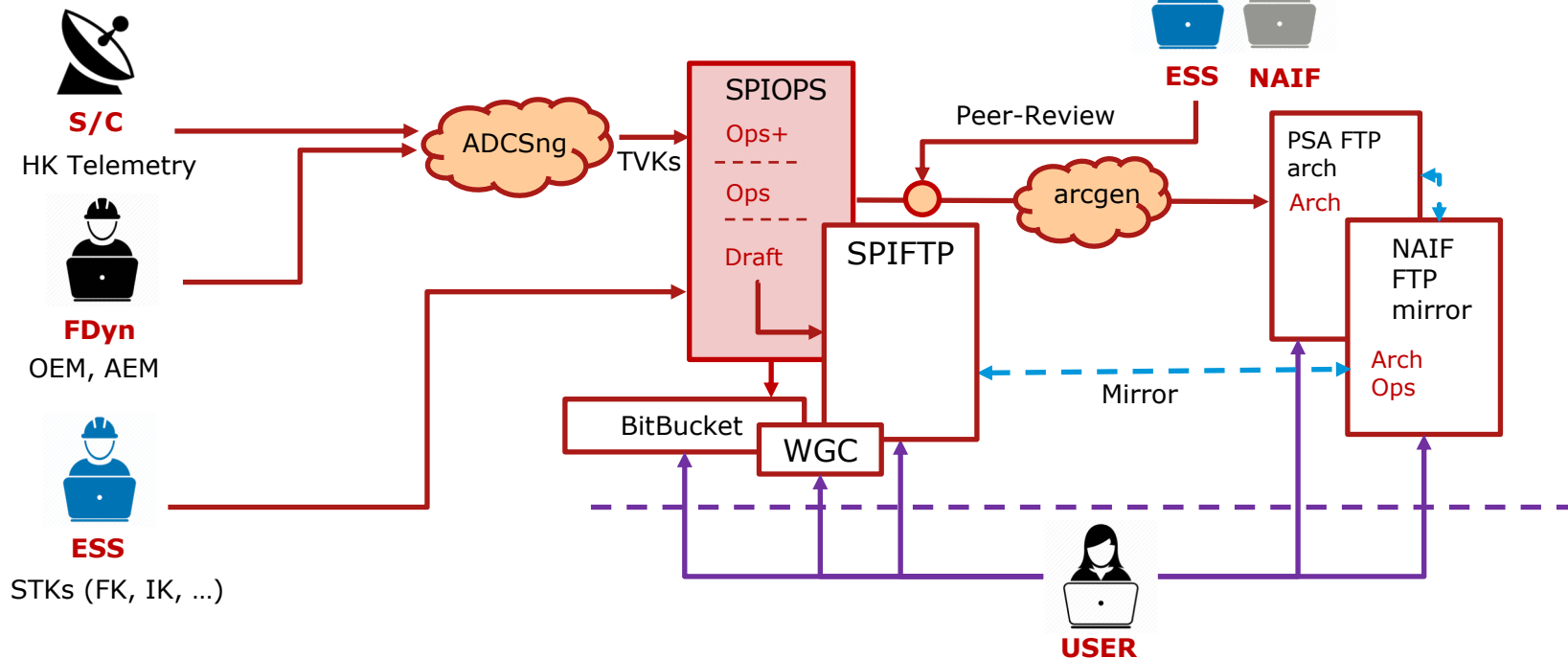
Version and Configuration Control

- All SKDs are under configuration control and new release happen constantly.
- SKDs are released on a regular basis when **STKs are updated** and when in operations are time tagged in a daily/weekly basis when **TVKs are updated**.

The distribution of SKDs is done via:



SPICE Kernel Dataset Workflow



- The Auxiliary Data Conversion System next-generation (ADCSng) generates the time-varying kernels when the mission is in operations and provides up-to-date time correlation, trajectory and orientation information to users.

ESA SKD Status



Mission	Status	BitBucket	Archive	WGC	Cosmo	Frames and sensors	Predicted Orbit & Attitude	Reconstructed Orbit & Attitude	OBT conversion	S/C Element and Payload Orientation
ExoMars2016	OPERATIONAL		PDS4							
Mars Express	OPERATIONAL		PDS3							
BepiColombo	OPERATIONAL		PDS4							
Solar Orbiter	STUDIES									
JUICE	STUDIES		PDS4							
ExoMarsRSP	STUDIES		PDS4							
Hera	STUDIES		PDS4							
EnVision	STUDIES		PDS4							
Rosetta	LEGACY		PDS3							
Venus Express	LEGACY		PDS3							
SMART-1	LEGACY		PDS3							
Chandrayaan-1	LEGACY		PDS3							
(Cassini-) Huygens	LEGACY		PDS3							
Giotto	LEGACY		PDS3							

PDS3 SPICE datasets and PDS4 SPICE bundles for the archive produced by the ESS are/will be available from the PSA UI, the PSA FTP server and the NAIF FTP server. They are to be published every 4-6 months.

PDS4 Archives

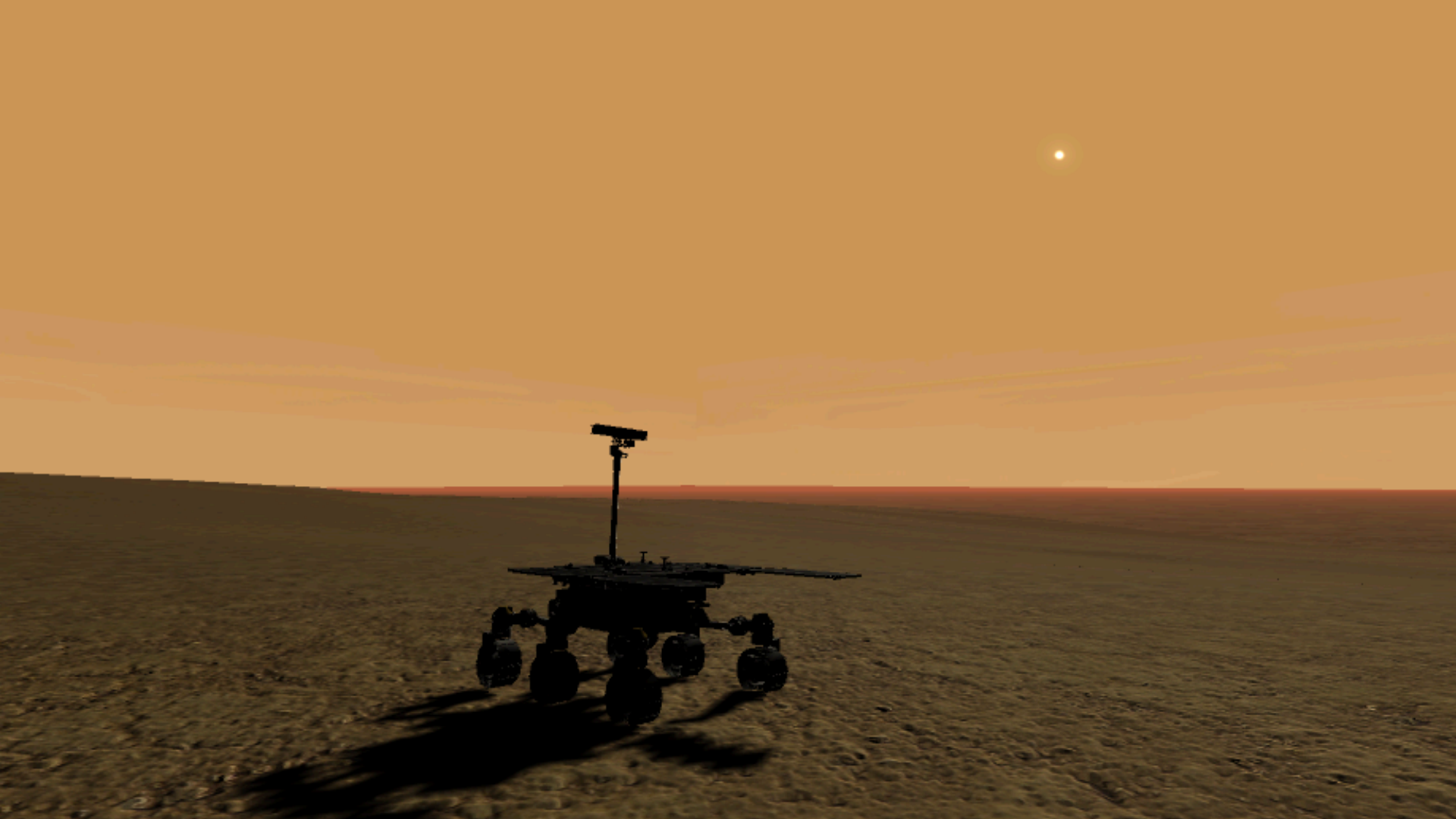
- First PDS4 SPICE Bundle **ExoMars2016 was released this summer.**
- BepiColombo will follow spring 2020.

DOIs

- We are the first service to fully implement DOIs for ESA Science, all DOIs available here: <https://www.cosmos.esa.int/web/spice/data>
- We encourage (ask) you to cite the ESS DOIs in all the work that you publish in which you have used ESA SPICE data.
- DOIs are available for both Operational and Archived SKDs.

RM SPICE Kernels, what to expect?





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➤ Setup Kernels:

- Rover FK (Including RM_MLG definition)
- Rover IKs (Adron, Clupi, ISEM, LocCam, NavCam, PanCam, WISDOM)
- Local Mars Solar Time SCLK, RM SCLK
- Generic Kernels: LSK, PCKs, SSO SPKs

➤ Time Varying Kernels

- Landing Site and "Travel Sites" positions
- Rover Position and Orientation
- Rover Fix mechanism (Mast, PTR, NavCam-L, NavCam-R, etc)
- Rover mechanisms positions (Drill Box, Drill Tip, ALD CSTM)
- Rover mechanisms orientation (PTR, Drill Box, ALD PSDDS, SA)

RM SPICE Kernels, what to expect?



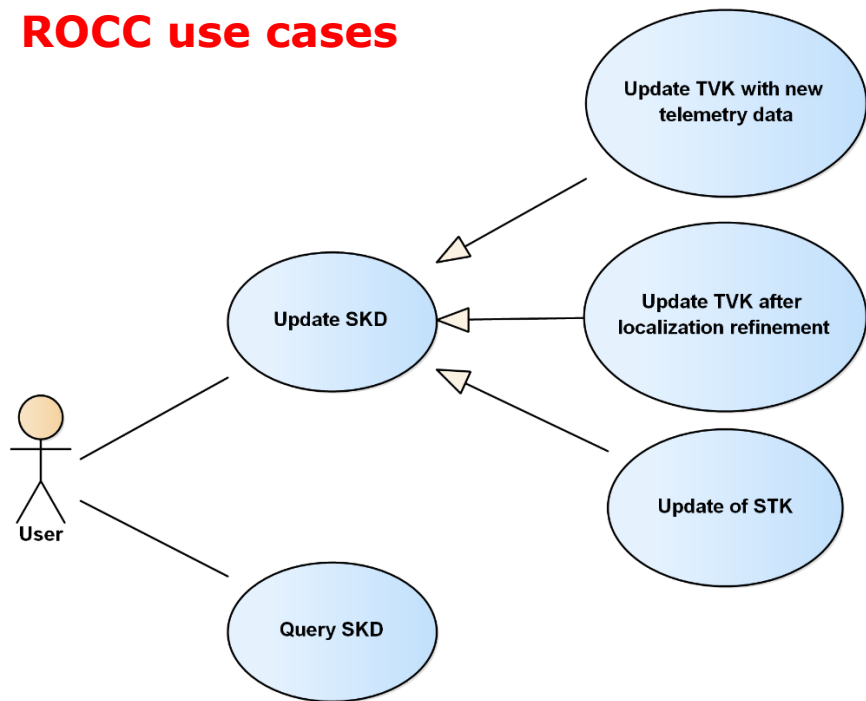
RM GNS and MEC positions and orientations:

- **Telemetry:** will be generated after every pass and will include position and orientation from RM TM. This data will have limited interpolation periods.
- **Interpolated:** based on 'Telemetry' the data will be interpolated (linear) and extended for 7 Sols for coverage purposes (for Downlink window negotiation)
- **Reconstructed:** ground-processed data (re-localised) will be the 'best' available interpolated data for position and orientation.

- Two Meta-kernels will be made available:
 - Telemetry (TLM + INTER)
 - Reconstructed (INTER + REC)

RM SPICE Kernels, what to expect?

ROCC use cases



There are three different scenarios when the TVK is updated during mission:

- **Update TVK with new telemetry data**
- **Update TVK after localization refinement**
- **Update STK:**
 - After new Site definition
 - Bug-Fix
 - Generic Kernel update

RM SPICE Kernels, what to expect?

Mission phase	SPK and CK update frequency	SCLK update frequency
Pre-launch	As needed for SKD development	As needed for SKD development
Launch and early operations		
Cruise	No update.	Once per checkout
Entry descent and landing		No update.
Post-landing to Egress	Once per sol (each downlink).	Once.
Surface	Once per sol (each downlink).	When necessary: Onboard clock drift, hibernation ...

RM SPICE Kernels, what to expect?



Availability SKD querying may be performed in three different ways:

- Querying the Time and Geometry Server (TGS) at ROCC.
- Obtaining the SKD from ROCC and using SPICE kernels toolkit APIs in your own program.
- Using WebGeocalc installation fom ROCC (or ESS)

or ...

- Downloading the **EMRSP Bundle** from the PSA and using SPICE kernels toolkit APIs in your own program.

- The EMRSP Bundle consists of **RM** (ROCC) + **SP** (NNK) + **CM** (ESS)
- SP Kernels are developed by IKI/NNK:
 - They are delivered to ESAC
 - ESAC integrates them to the EMRSP RM Bundle provided by ROCC
 - A Schedule has been put in place with IKI (culminates early 2020) and an ICD is work on progress
- CM Kernels are developed by ESAC
 - Generated with products from FDy (Trajectory and measured attitude)
 - Integrated to the EMRSP Bundle before/at start of operations
- EMRSP Kernels are integrated by ESAC: Joint Bundle is consolidated and published (PSA, FTP)

