SPICE-BASED PYTHON PACKAGES FOR ESA SOLAR SYSTEM EXPLORATION MISSION'S GEOMETRY EXPLOITATION.

M. Costa[1], M. Grass[2,]
[1]ESA/ESAC Camino Bajo del Castillo s/n, Ur. Villafranca del Castillo, 28692 Villanueva de la Canada, Madrid, Spain, marc.costa@esa.int, [2]IRS, Univesity of Stuttgart, Pfaffenwaldring 29, 70569 Stuttgart, Germany.

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.

The ESA SPICE Service: The ESA SPICE Service (ESS) leads the SPICE operations for ESA missions. ESS generates the SPICE Kernel Datasets (SKDs) for missions in operations (ExoMars 2016, Mars Express) missions in development (BepiColombo, 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 [2]. In addition to the services described in the previous section, ESS is developing several services in the shape of Python packages to enhance the exploitation of SPICE data.

spiops a Python package for SPICE: spiops is a Python package that uses SpiceyPy to use SPICE Toolkit APIS to provide higher-level functions than the ones available with SPICE. spiops is aimed to assists the users to extend the usage of SPICE.

These functions have been identified on the author's and ESA colleagues that use SPICE day-to-day work from having to implement multiple times a series of SPICE APIs to obtain a given derived functionality. Functionalities vary from the computation of the illumination of a given Field-of-View to obtaining the coverage of a given spacecraft (S/C) for a particular meta-kernel, plotting Euler Angles or comparing different kernels. There are three different levels of functions used:

1. SPICE based derived functions
2. non-SPICE based derived functions
3. an object-oriented SPICE interface

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.

spiops is available as a PyPi package and in Bitbucket and is fully documented with ReadTheDocs. This contribution will further describe spiops and will go through several usecases for it.

adcsng a SPICE processing pipeline Python package: SKDs of missions in operations (Mars-Express and ExoMars2016) are regularly updated in missions with new predicted and reconstructed trajectory and attitude information -usually provided by the mission's flight dynamics team- and with Housekeepig Telemertry that provides information of moveable parts of the S/C or the science payload. With these data time-varying kernels are generated (SPKs, CKs and SCLKs) with an automatic processing pipeline: the Auxiliary Data Conversion System next generation (adcsng). adcsng is made available to the ESA missions as a Python Package.

spispy, yet another Python package for SPICE: Although this package is not open to contributions, ESS is also developing a Python package which in combination with adcsng and spiops will provide to the ESA SPICE users a web-based quick-look of a complete SKD. With spispy functionalities, the user will be available to quickly evaluate the state of a given SKD and at the same time to obtain a glimpse of the status of the S/C and the basic geometry of the mission scenario (Measured Attitude, Trajectory, Phase function on a given mission target, Events timeline, etc.) with the kernels generated by adcsng.

References: [1] Acton C. (1996) *Planet. And Space Sci., 44,* 65-70. [2] Costa, M., (2018) this conference.