# Virtual SPICE Training Class
## BepiColombo

**Marc Costa Sitja**

ESA SPICE Service
by RHEA Group

**21st July 2020, Webex**

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# Agenda

**Tuesday (21st July)**

- 09:30 – 10:00 Introduction to SPICE (00)
- 10:00 – 11:00 SPICE fundamentals (01-02)
- 11:15 – 13:00 SPICE fundamentals (03-08)
- 13:00 - 14:00 Lunch Break
- 14:00 - 16:15 SPICE fundamentals (09-12)
- 16:30 – 17:00 Setting up SPICE
- 17:00 - 17:30 Hands-on SPICE (I): Remote Sensing Observation Tutorial

**Wednesday (22nd July)**

- 09:00 - 10:30 SPICE fundamentals (12-17)
- 10:30 - 11:00 Hands-on SPICE (II): Remote Sensing Observation Tutorial
- 11:15 - 12:00 WebGeocalc and SPICE-enhanced Cosmographia
- 12:00 - 13:00 SPICE for BepiColombo
- 13:00 - 14:00 Lunch Break
- 14:00 – 16:15 Hands-on SPICE (II): Venus first swingby
- 16:30 – 17:30 Wrap-up: Open Discussion, Q/A, AOBs

# Welcome & Logistics

- **WebEx sessions** for the training:
  - **Tuesday 21st:** https://esait.webex.com/esait/j.php?MTID=m405a5988f63451aadfef5dd860a12fe3
  - **Wednesday 22nd:** https://esait.webex.com/esait/j.php?MTID=m849920b7f6d75a90780a319cb05b5659
- **MATERIAL:** All the required information can be obtained from the dedicated GitHub Repository: https://github.com/esaSPICEservice/ess_workshop_4pdw
- **SET UP SPICE:** It is recommended to install the SPICE Toolkit in advance (we recommend you to use some time during the lunch break if you have not done so yet). 30 minutes will be dedicated to set up SPICE but it would be better to use that slot to answers questions. We also recommend to download the BepiColombo SPICE Kernel dataset and to install SPICE-enhanced Cosmographia.
- **LANGUAGES**: The hands-on lessons will be provided in Python using SpiceyPy. Users of other programming languages are supposed to have enough knowledge of the language such that she or he can conduct the hands-on lessons.
- The hands-on lessons will be done synchronously; we will give you some time to answer each of the sections of the hands on lessons and then the solution of that section will be provided.
- Feel free to interrupt me anytime during the lessons and to ask questions during the hands-on lessons.
- This training will be recorded and distributed to the BepiColombo community (if everyone agrees).

# An Introduction to SPICE & the ESA SPICE Service

**Marc Costa Sitja**

RHEA GROUP

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# Ancillary Data

are those that help scientists and engineers determine:

- where the S/C was located, how the S/C and its instruments were oriented
- what was the location, size, shape and orientation of the target body
- what events were occurring on the S/C

The ancillary data comes from: The S/C, MOC/SGS, S/C manufacturer and Instrument teams, Science Organizations.

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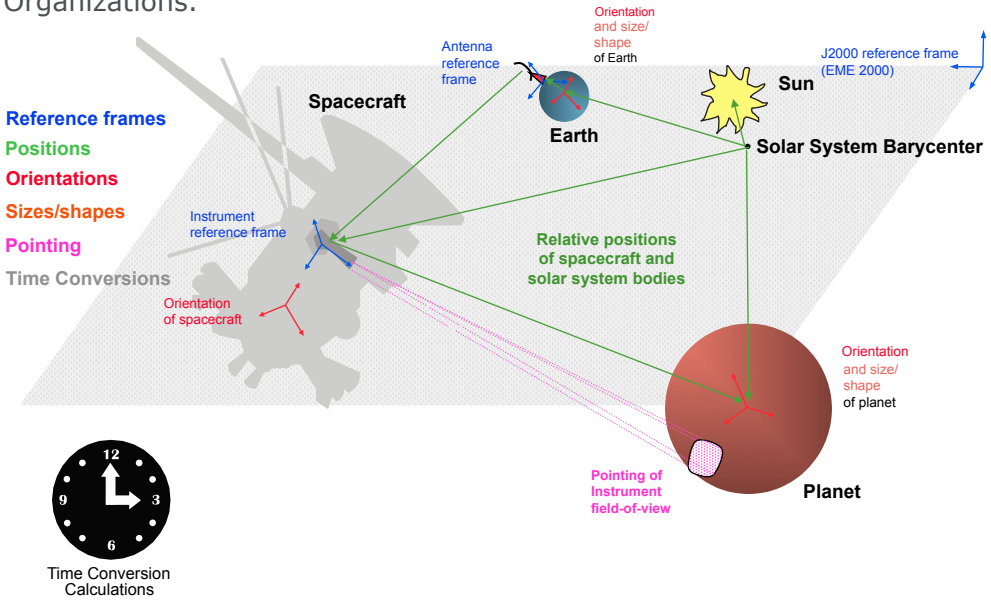


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# Ancillary Data are those that help scientists and engineers determine:

ments were oriented

he target body

nufacturer and

ORMM_FDRMMA_DA_070901000000_00419.MEX

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DERIVATIVES_FLAG     = 1
META_STOP

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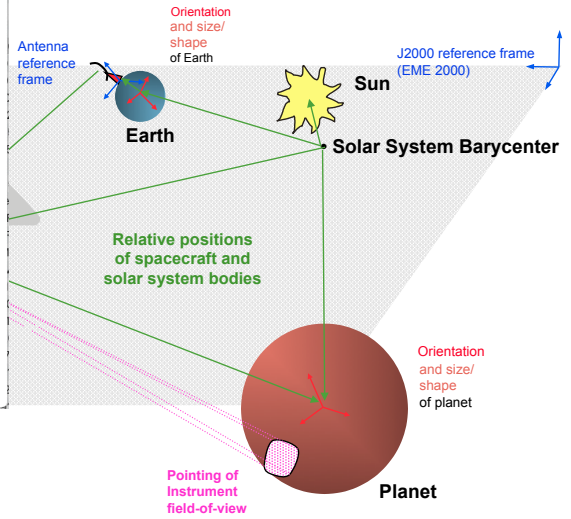

Time Conversion Calculations

# Ancillary Data are those that help scientists and engineers determine:

ments were oriented

he target body

nufacturer and

ORMM_FDRMMA_DA_070901000000_00419.MEX

```
ESOC_TOS_GFI_ORBIT_FILE_VERSION = 1.0


META_START
OBJECT_NAME          = MARS EXPRESS
OBJECT_ID            = 41
CENTER_NAME          = MARS
REF_FRAME            = EME2000
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ATNM_FDLMMA_DAP030602191822_00021.MEX

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ESOC_TOS_GFI_ATTITUDE_FILE_VERSION = 1.0


META_START
OBJECT_NAME     = MARS EXPRESS
OBJECT_ID       = 41
TIME_SYSTEM     = TDB
REF_FRAME       = EME2000
START_TIME      = 2003-06-02T19:18:21.79999999
STOP_TIME       = 2003-06-02T19:18:21.80000160
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FILE_TYPE       = ATTITUDE FILE
VARIABLES_NUMBER = 4
DERIVATIVES_FLAG = 0
META_STOP

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2003-06-02T19:18:21.80000160 -0.5547164052939074D+00  0.1880967866597057 2D+00  0.4639426567451245 8D+00  0.6645799572246480 8D+00


META_START
OBJECT_NAME     = MARS EXPRESS
OBJECT_ID       = 41
TIME_SYSTEM     = TDB
REF_FRAME       = EME2000
START_TIME      = 2003-06-02T19:18:21.80000160
STOP_TIME       = 2003-06-03T00:56:31.79999999
CREATION_DATE   = 2003-07-11T07:30:36
FILE_TYPE       = ATTITUDE FILE
VARIABLES_NUMBER = 4
DERIVATIVES_FLAG = 0
META_STOP

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2003-06-02T19:22:21.79999999 -0.6347782508702981 6D+00  0.3568465047226562 1D-01  0.6063927037253985 5D+00  0.4775678661837698 1D+00
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```

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2007-08-31T23:37:35.35325258  0.6943214306708067 9D+04 -0.1735862746549652 0D+04  0.9766283563894934 3D+03 -0.9147553792291464 0D+00  0.1212415574404035 7D+01 -0.2137437803401211 6D+01
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2007-08-31T23:38:08.77534489  0.6912198317059978 8D+04 -0.1695231117957110 9D+04  0.9051295300437462 9D+03 -0.9413323663450902 1D+00  0.1219004240288356 3D+01 -0.2141065635901846 1D+01
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2007-08-31T23:38:41.85878831  0.6880614830527455 0D+04 -0.1654794685190933 3D+04  0.8342390768805154 3D+03 -0.9680609298080881 1D+00  0.1225503474634626 1D+01 -0.2144454796910546 1D+01
```

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9508864856302D+06 -0.5592566329682420 4D+02  0.1723113067182274 7D+02 -0.1450881840231034 5D+02
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2007206964529D+04 -0.7585705477128401 6D+00  0.1171101544570464 4D+01 -0.2110820120493412 9D+01
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1923426912665D+04 -0.6328704440674448 0D+00  0.1134522760269000 0D+01 -0.2082600754269871 2D+01
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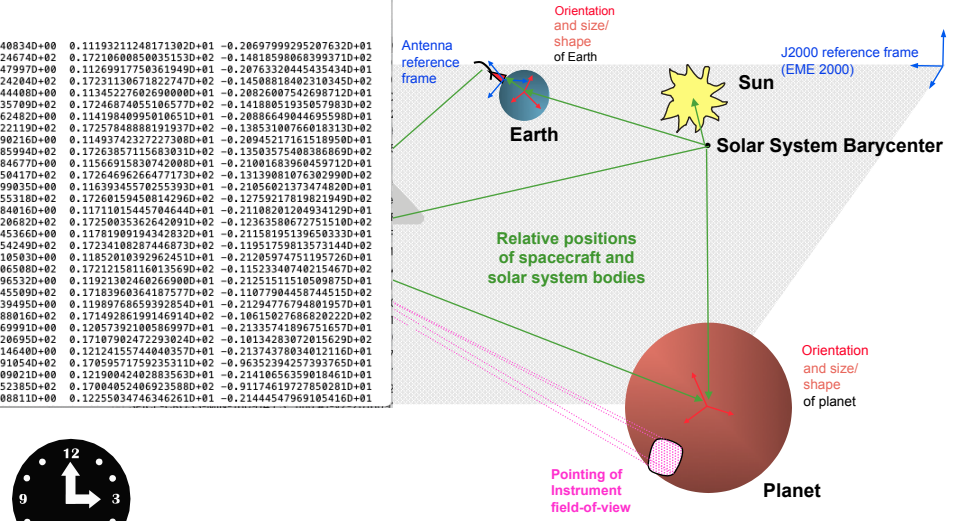
2609620973228D+04 -0.6576777851046248 2D+00  0.1141984099501065 1D+01 -0.2080664904469559 8D+01
6064774616840D+06 -0.5784679267802211 9D+02  0.1725784888881919 3D+02 -0.1385310076601833 0D+02
8908738097571D+04 -0.6826526505069021 6D+00  0.1149374232722730 8D+01 -0.2094521716151895 0D+01
6667627552524D+06 -0.5882351578838599 4D+02  0.1726385711568303 1D+02 -0.1350357540836866 9D+02
0874248114328D+04 -0.7077938836438467 7D+00  0.1156691583074208 6D+01 -0.2100168396045971 2D+01
5454941837190D+06 -0.5981584267495041 7D+02  0.1726469626647717 3D+02 -0.1313908107630299 0D+02
8557390770700D+04 -0.7331002723129903 5D+00  0.1163934557025539 3D+01 -0.2105602137347482 0D+01
2402466682449D+06 -0.6081820398535531 8D+02  0.1726015945081429 6D+02 -0.1275921781982194 9D+02
2007206964529D+04 -0.7585705477128401 6D+00  0.1171101544570464 4D+01 -0.2110820120493412 9D+01
7485841062694D+06 -0.6183236352382068 2D+02  0.1725003536264209 1D+02 -0.1236358067275151 0D+02
1270570456008D+04 -0.7842033834174536 6D+00  0.1178190919434283 2D+01 -0.2115819511396503 3D+01
0680600658129D+06 -0.6285823785865424 9D+02  0.1723410828744687 3D+02 -0.1195175981357314 4D+02
6392220022915D+04 -0.8099973943531050 3D+00  0.1185201039296245 1D+01 -0.2120597474511957 26D+01
1962185033809D+06 -0.6389573192500650 8D+02  0.1721215811601356 9D+02 -0.1152334074021546 7D+02
7414792023355D+04 -0.8359511357796532 0D+00  0.1192130246026690 0D+01 -0.2125151151050985 0D+01
1305945080495D+06 -0.6494473862304550 9D+02  0.1718396036418577 5D+02 -0.1107790445874451 5D+02
4378853331341D+04 -0.8620631022653949 5D+00  0.1198976865939285 4D+01 -0.2129477679480195 7D+01
```



Time Conversion Calculations

# Ancillary Data are those that help scientists and engineers determine:

ments were oriented

ORMM_FDRMMA_DA_070901000000_00419.MEX

```
ESOC_TOS_GFI_ORBIT_FILE_VERSION = 1.0


META_START
OBJECT_NAME          = MARS EXPRESS
OBJECT_ID            = 41
CENTER_NAME          = MARS
REF_FRAME            = EME2000
```

ATNM_FDLMMA_DAP030602191822_00021.MEX

```
ESOC_TOS_GFI_ATTITUDE_FILE_VERSION = 1.0

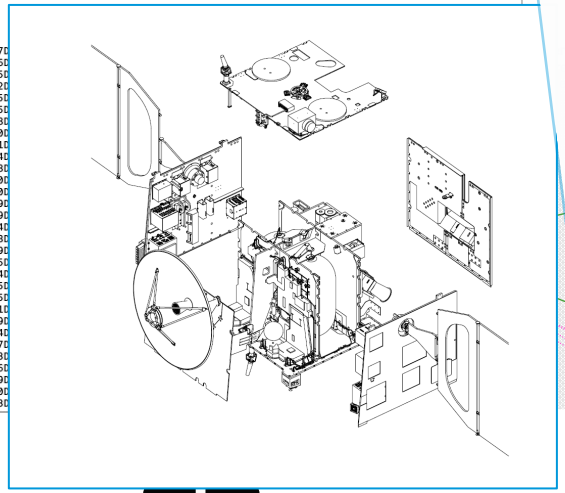

META_START
OBJECT_NAME    = MARS EXPRESS
OBJECT_ID      = 41
TIME_SYSTEM    = TDB
REF_FRAME      = EME2000
START_TIME     = 2003-06-02T19:18:21.79999999
STOP_TIME      = 2003-06-02T19:18:21.80000160
CREATION_DATE    = 2003-07-11T07:30:36
FILE_TYPE        = ATTITUDE FILE
VARIABLES_NUMBER = 4
DERIVATIVES_FLAG = 0
META_STOP

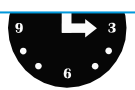
2003-06-02T19:18:21.79999999 -0.5547164049244698 3D+00  0.1880967872963082 7D+00  0.4639426556709658D+00  0.6645799583032275 8D+00
2003-06-02T19:18:21.80000160 -0.5547164052930974 0D+00  0.1880967866597057 2D+00  0.4639426567451245 8D+00  0.6645799572246408 0D+00


META_START
OBJECT_NAME    = MARS EXPRESS
OBJECT_ID      = 41
TIME_SYSTEM    = TDB
REF_FRAME      = EME2000
START_TIME     = 2003-06-02T19:18:21.80000160
STOP_TIME      = 2003-06-03T00:56:31.79999999
CREATION_DATE    = 2003-07-11T07:30:36
FILE_TYPE        = ATTITUDE FILE
VARIABLES_NUMBER = 4
DERIVATIVES_FLAG = 0
META_STOP

2003-06-02T19:18:21.80000160 -0.5547164052930913 0D+00  0.1880967866597061 7D+00  0.4639426567451251 4D+00  0.6645799572246415 8D+00
2003-06-02T19:20:21.79999999 -0.5863302031495473 1D+00  0.1366424017509324 8D+00  0.5427412089622871 7D+00  0.5856430030423844 8D+00
2003-06-02T19:22:21.79999999 -0.6347782508702981 6D+00  0.3568465047226562 1D-01  0.6063927037253985 5D+00  0.4775678661837690 1D+00
2003-06-02T19:24:21.79999999 -0.6809210255375135 5D+00 -0.1139311043186668 0D+00  0.6380994857857639 1D+00  0.3480743249335742 2D+00
2003-06-02T19:26:21.79999998 -0.6958443908660239 0D+00 -0.2668719395320877 2D+00  0.6325507898986346 0D+00  0.2108540959925568 0D+00
2003-06-02T19:28:21.79999998 -0.6818551076779865 2D+00 -0.3827141704801418 4D+00  0.6116677031865553 8D+00  0.1202750881250528 6D+00
2003-06-02T19:30:21.80000000 -0.6565307861851913 0D+00 -0.4621481444207535 9D+00  0.5931683640355154 0D+00  0.6114367656338781 0D+01
```

```
2007-08-31T23:37:01.58917582  0.6973652901866532 4D+04 -0.1776686181551965 3D+04  0.1048732293461083 4D+04
                             -0.7675186118619993 8D+05  0.1041758677490811 0D+06 -0.1843408099879398 7D+06
2007-08-31T23:37:35.35325258  0.6943214306708067 9D+04 -0.1735862746549695 2D+04  0.9766283563894934 3D+04
                             -0.7903486476541086 4D+05  0.1047527056285118 5D+06 -0.1846746262138664 6D+06
2007-08-31T23:38:08.77534489  0.6912198317059978 8D+04 -0.1695231117957110 9D+04  0.9051295304374629 0D+04
                             -0.8133111645221362 4D+05  0.1053219663609134 4D+06 -0.1849880709419192 0D+06
2007-08-31T23:38:41.85878831  0.6880614830527435 5D+04 -0.1654794685190933 3D+04  0.8342390768805154 3D+04
```





Time Conversion Calculations

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OBJECT_ID      = 41
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START_TIME     = 2003-06-02T19:18:21.79999999
STOP_TIME      = 2003-06-02T19:18:21.80000160
CREATION_DATE    = 2003-07-11T07:30:36
FILE_TYPE        = ATTITUDE FILE
VARIABLES_NUMBER = 4
DERIVATIVES_FLAG = 0
META_STOP

2003-06-02T19:18:21.79999999 -0.554716404924469830+00  0.188096787296308270+00  0.463942655657096580+00  0.66
2003-06-02T19:18:21.80000160 -0.554716405293090740+00  0.188096786659705720+00  0.463942656745124580+00  0.66
```

vmc_model.edf — Edited

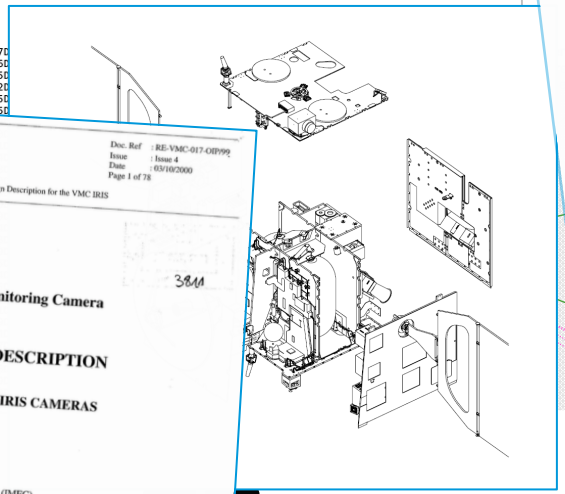
```
# This file contains the VMC modelling
#
# $Log: vmc_model.edf,v $
# Revision 1.1  2016/02/29 13:48:30  acardesin
# Test VMC model
#

# Experiment FOV definitions

# Rectangular FOV: 40deg along+Y, 30deg along+X
FOV: VMC
FOV_lookat: 0.0 -0.32557 0.94552
FOV_upvector: 0.0 1.0 0.0
FOV_type: RECTANGULAR
FOV_geometric_angles: 30.00 40.00 [degrees]
FOV_active: \
            MODE ON     \
            MODE DUMMY

# Rectangular FOV: 0.4deg along+Y, 0.3deg along+X
FOV: VMC_centre
FOV_lookat: 0.0 -0.32557 0.94552
FOV_upvector: 0.0 1.0 0.0
FOV_type: RECTANGULAR
FOV_geometric_angles: 0.3 0.4 [degrees]
FOV_active: \
            MODE ON     \
            MODE DUMMY

# Rectangular FOV Corners X-Shape
```



OIP
Opronic Instruments & Products
Wenteringe 21
B - 9700 Oudenaarde

Doc. Ref : RE-VMC-017-OIP/99
Issue : Issue 4
Date : 03/10/2000
Page 1 of 78

VMC: Design Description for the VMC IRIS

3811

**Visual Monitoring Camera**

**DESIGN DESCRIPTION**

**for the VMC IRIS CAMERAS**

| | |
|---|---|
| PREPARED BY : | L. DE VOS<br>W. OGIERS (IMEC) |
| APPROVED BY : | L. DE VOS |
| RELEASED BY : | G. BRANDT |
| UPDATED FOR MEX: | ESTEC-TOS-ETD |

**European Space Agency**

**Directorate of Operations and Infrastructure**

**Ground Systems Engineering Department**

**ROSETTA / MARS EXPRESS / VENUS EXPRESS**

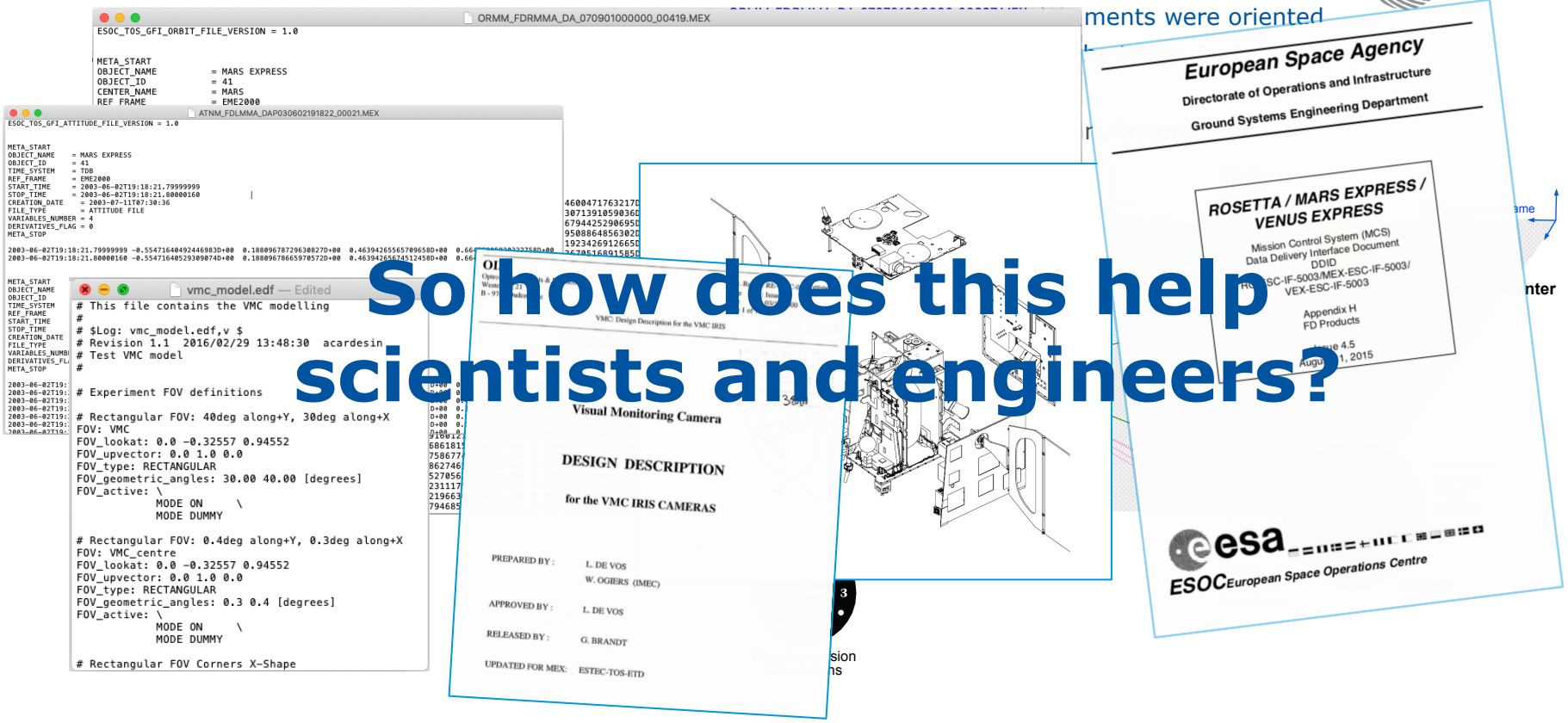
Mission Control System (MCS)
Data Delivery Interface Document
DDID
RO-ESC-IF-5003/MEX-ESC-IF-5003/
VEX-ESC-IF-5003

Appendix H
FD Products

Issue 4.5
August 11, 2015

esa
ESOC European Space Operations Centre

# Ancillary Data are those that **help scientists and engineers** determine:




# So how does this help scientists and engineers?

# 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).

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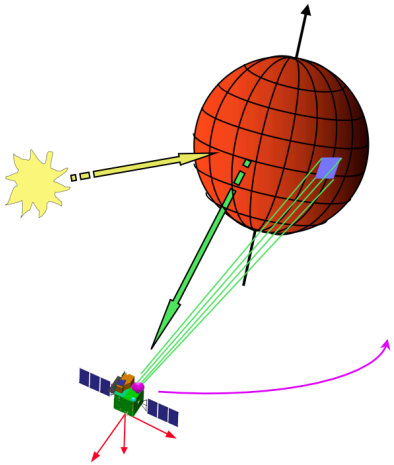
## Compute many kinds of observation geometry parameters at selected times

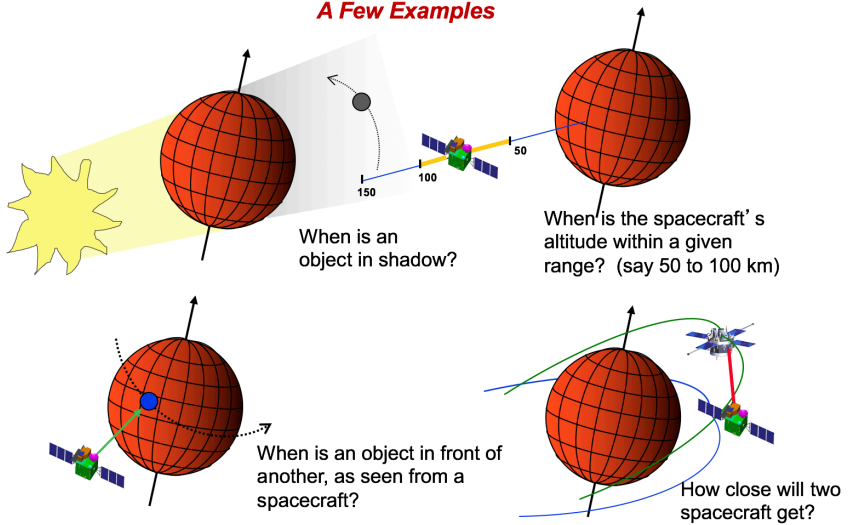


***A Few Examples***

- Positions and velocities of planets, satellites, comets, asteroids and spacecraft
- Size, shape and orientation of planets, satellites, comets and asteroids
- Orientation of a spacecraft and its various moving structures
- Instrument field-of-view location on a planet's surface or atmosphere

## Find times when a specified "geometric event" occurs, or when a specified "geometric condition" exists

***A Few Examples***



# SPICE components

- Ancillary data files (”kernels”)
- Software Library (SPICE Toolkit)
- Documentation
- Tutorials
- Programming lessons
- Training Classes
- User Consultation

**Library of subroutines**

Typically just a few are used within a customer’s program to compute quantities derived from SPICE data files

**Programs**

SPICE data production

SPICE data management

**Documentation**

Highly annotated source code

Technical Reference Manuals (23)

User Guides for programs

Highlights of the most useful subroutines

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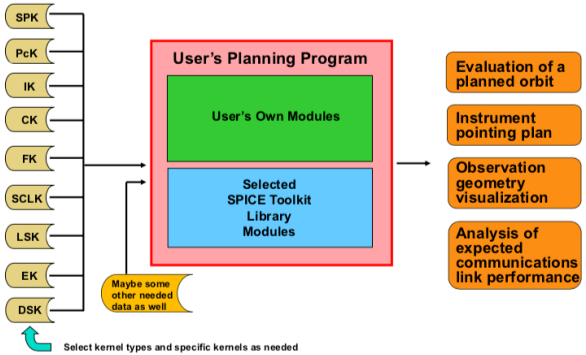


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SPICE data management

**Documentation**

Highly annotated source code

Technical Reference Manuals (23)

User Guides for programs

Highlights of the most useful subroutines

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# Using the SPICE Library ( julia )

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# Using the SPICE Library (

)

**spice.funrsh(meta-kernel)**
loop per pixel
**spice.getfov**
**spice.sincpt**
**spice.illumf**

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# Using the SPICE Library ( Fortran julia ) esa

**spice.funrsh(meta-kernel)**
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**spice.illumf**

# Using the SPICE Library ( C++ Fortran MATLAB IDL Java Python Ruby Swift julia ) esa

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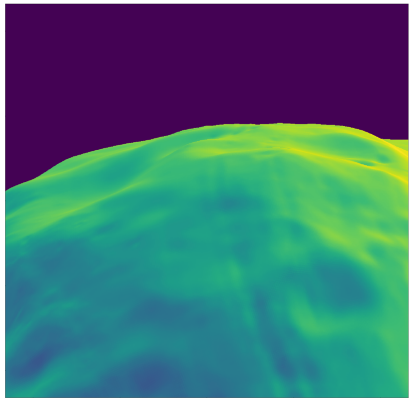

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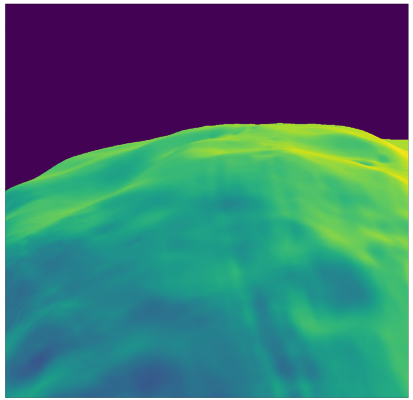
**spice.funrsh(meta-kernel)**
**spice.funrsh(dsk)**
loop per pixel
**spice.getfov**
**spice.sincpt**
**spice.illumf**
adjust matrix



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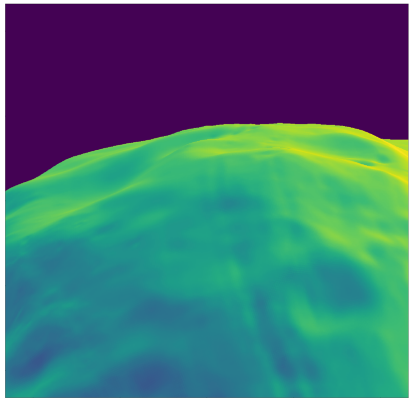

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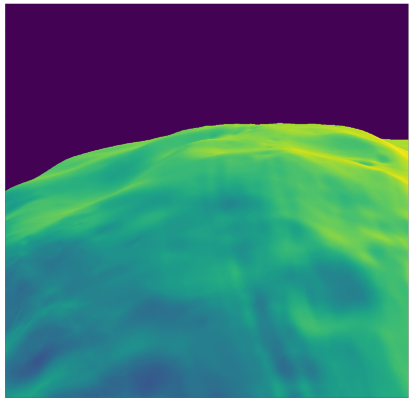

**spice.funrsh(meta-kernel)**
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loop per pixel
**spice.getfov**
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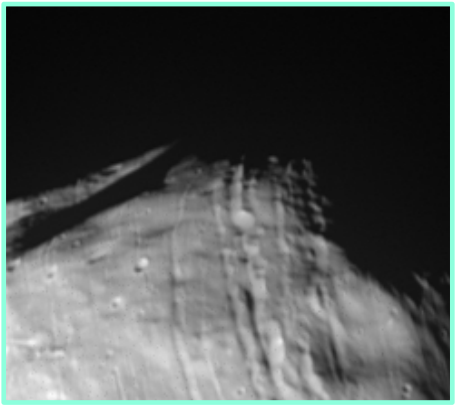
adjust matrix

**Current Data**



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# Using the SPICE Library ( Fortran julia ) esa

**spice.funrsh(meta-kernel)**
loop per pixel
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Lines of code 37

**spice.funrsh(meta-kernel)**
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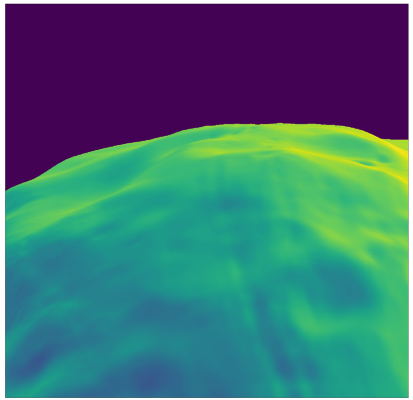

Lines of code 38

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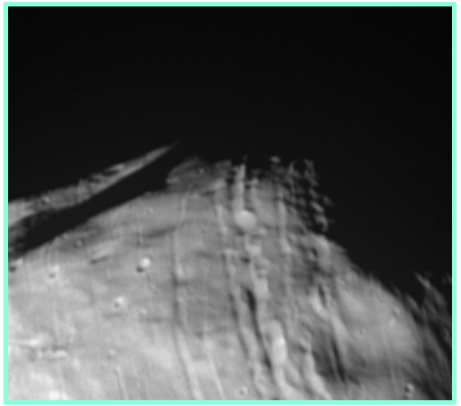
Lines of code 75

**Current Data**



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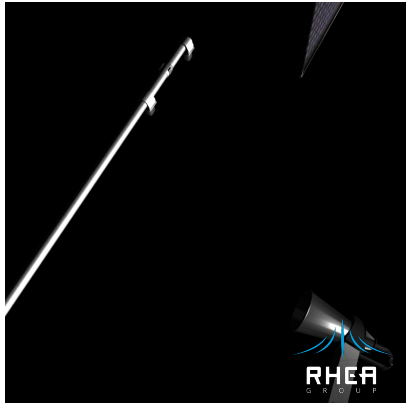
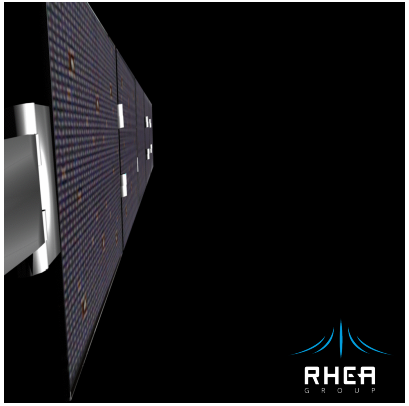
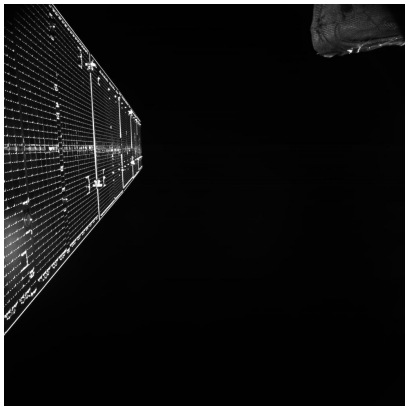
# These are the things we do with SPICE





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# These are the things we do with SPICE

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# ESA SPICE Service

**The ESA SPICE Service (ESS)** based at ESAC leads the SPICE operations for ESA's planetary missions. Its main activities are:

- Generate, develop, maintain and archive the SPICE Kernel Datasets (SKD) for the ESA Solar System Explorers
- 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 is provided by Rhea System for ESA:

- Marc Costa Sitja
- Alfredo Escalante Lopez
- and a Trainee (Marina de Brito)

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.

We provide **SPICE Training Classes** in Europe in a biannual basis.

Small Workshops on SPICE held regularly in conferences or for instrument teams

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# SPICE Kernel Dataset

- 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.

- The distribution of the SKDs is done via:

An operational FTP with all the kernels that were ever produced: **ftp://spiftp.esac.esa.int/data/**SPICE

Peer-reviewed kernels are published as PDS3/4 Bundles in the PSA FTP

A permanent link to a ZIP file that contains the the latest operational subset of the SPICE Kernels

A BitBucket Git repository with a given subset of the SPICE Kernels (operational, planning, archived etc.). **Https://repos.cosmos.esa.int/socci/projects/SPICE_KERNELS**

# 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 | OPERATIONAL | | | | | | | | | |
| 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 | | | | | | | |

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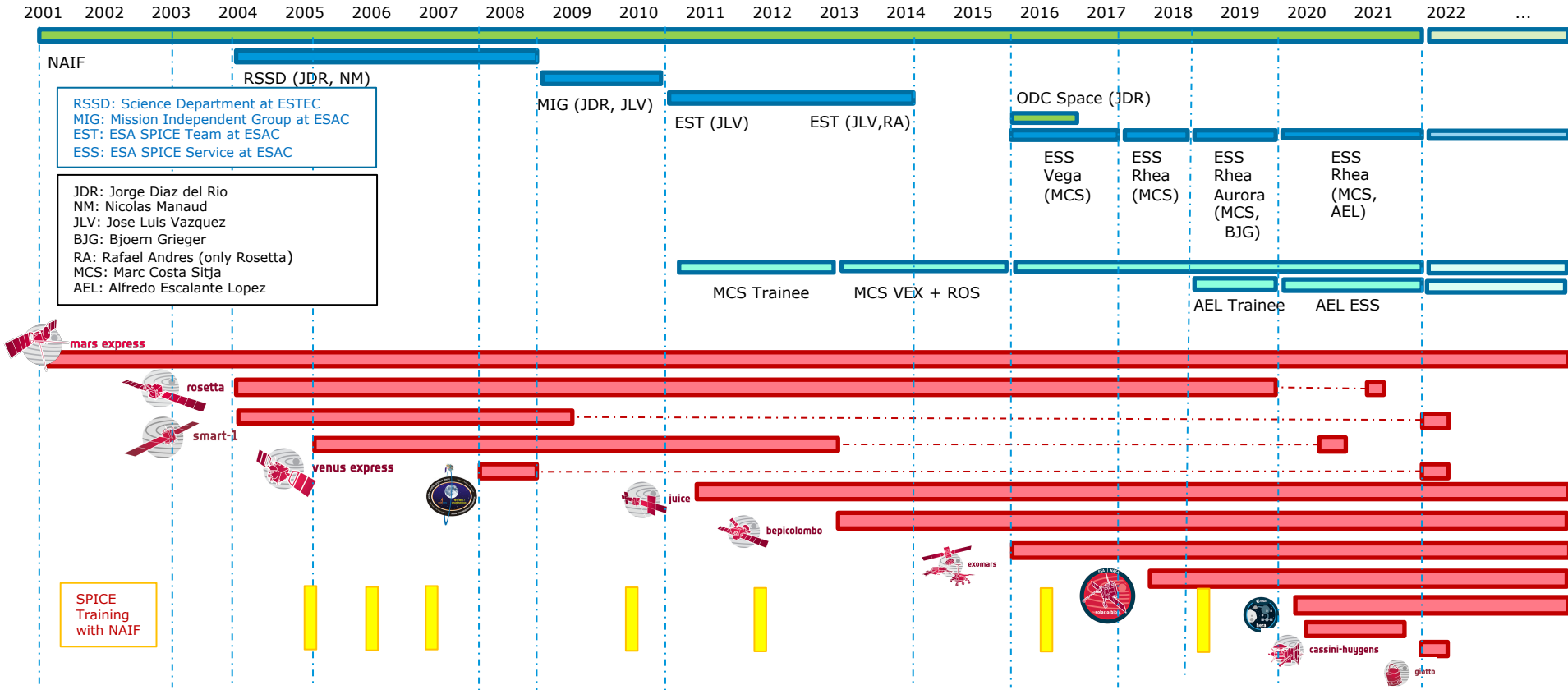
# Example of SPICE Users

| Data Restorations | Selected Past Users | Current/Pending Users | Examples of Possible Future Users |
|---|---|---|---|
| Apollo 15, 16 [L] | Magellan [L] | Cassini Orbiter | NASA Discovery Program |
| Mariner 2 [L] | Clementine (NRL) | Mars Odyssey | NASA New Frontiers Program |
| Mariner 9 [L] | Mars 96 (RSA) | Mars Exploration Rover | Lunar IceCube (Moorehead State) |
| Mariner 10 [L] | Mars Pathfinder | Mars Reconnaissance Orbiter | LunaH-Map (Arizona State) |
| Viking Orbiters [L] | NEAR | Mars Science Laboratory | Luna-Glob (RSA) |
| Viking Landers [L] | Deep Space 1 | Juno | Aditya-L1 (ISRO) |
| Pioneer 10/11/12 [L] | Galileo | MAVEN | **Examples of Users not Requesting NAIF Help** |
| Haley armada [L] | Genesis | SMAP (Earth Science) | GOLD (LASP, UCF) (Earth Science) [L] |
| Phobos 2 [L] (RSA) | Deep Impact | OSIRIS REx | Hera (ESA) |
| Ulysses [L] | Huygens Probe (ESA) | InSight | ExoMars RSP (ESA, RSA) |
| Voyagers [L] | Stardust/NExT | Mars 2020 | Emmirates Mars Mission (UAE via LASP) |
| Lunar Orbiter [L] | Mars Global Surveyor | Europa Clipper | Hayabusa-2 (JAXA) |
| Helios 1,2 [L] | Phoenix | NISAR (NASA and ISRO) | Proba-3 (ESA) |
| Giotto [L] | EPOXI | Psyche | Parker Solar Probe |
| | GRAIL | Lucy | EUMETSAT GEO satellites [L] |
| | DAWN | Lunar Reconnaissance Orbiter | MOM (ISRO) |
| | Messenger | Mars Express (ESA) | Chandrayan-2 (ISRO) |
| | Phobos Sample Return (RSA) | ExoMars 2016 (ESA, RSA) | Solar Orbiter (ESA) |
| | Venus Express (ESA) | Akatsuki (JAXA) | STEREO [L] |
| | Rosetta (ESA) | Korean Pathfinder Lunar Orbiter (KARI) | Spitzer Space Telescope [L] |
| [L] = limited use | Chandrayaan-1 (ESA/ISRO) | New Horizons | Kepler [L] |
| [S] = special services | Hayabusa (JAXA) | JUICE (ESA) | Hubble Space Telescope [S][L] |
| | Kaguya (JAXA) | Bepicolombo (ESA, JAXA) | James Webb Space Telescope [S][L] |
| | LADEE | Gaia (ESA) [S] | Altius (Belgian earth science satellite) |
| | ISO [S] (ESA) | Lisa Pathfinder (ESA) [S] | Armadillo (CubeSat, by UT at Austin) |
| | Smart-1 (ESA) | Deep Space Network | Spectrum-RG (RSA) |

# SPICE at ESA Timeline

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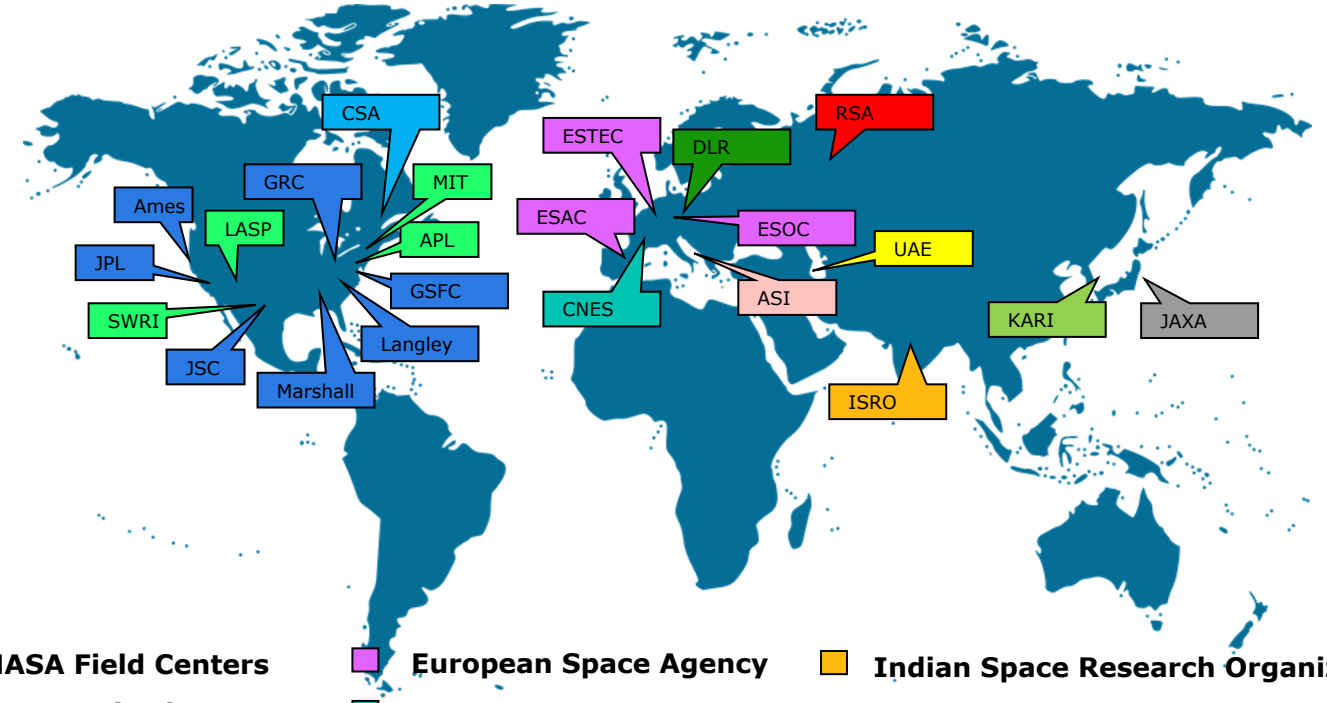
# Space Agencies Using SPICE




- NASA Field Centers
- U.S. Institutions
- Canadian Space Agency
- United Arab Emirates Space Agency
- European Space Agency
- French Space Agency
- German Space Agency
- Italian Space Agency
- Indian Space Research Organization
- Japan Aerospace Exploration Agency
- Russian Federal Space Agency
- Korean Aerospace Research Institute

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# Take Home (but not yet!)

- SPICE has been in use since the Magellan mission to Venus in 1990, without any failures. Pretty much all worldwide planetary missions since Magellan have used SPICE, with the likely exception of Chinese missions (China have shown interest).
- SPICE has been adopted by many space agencies and is adopted as a standard by the International Planetary Data Alliance.
- SPICE is free of export and licensing restrictions, and SPICE is free of cost.
- It takes a small effort for an expert to setup a basic SPICE configuration
- While conceived for planetary missions, today it is also used for heliophysics, earth science, astronomy and tech demonstrations (and NASA DSN!).
- NAIF has consistently had, and has now, solid funding from NASA, ESA supports NAIF them through the MOUs.

**SPICE is the de-facto standard system for ancillary data and solar system exploration geometry for the Planetary Science Community. We don’t see why this could not be expanded to missions of other nature.**

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