



Navigation and Ancillary Information Facility

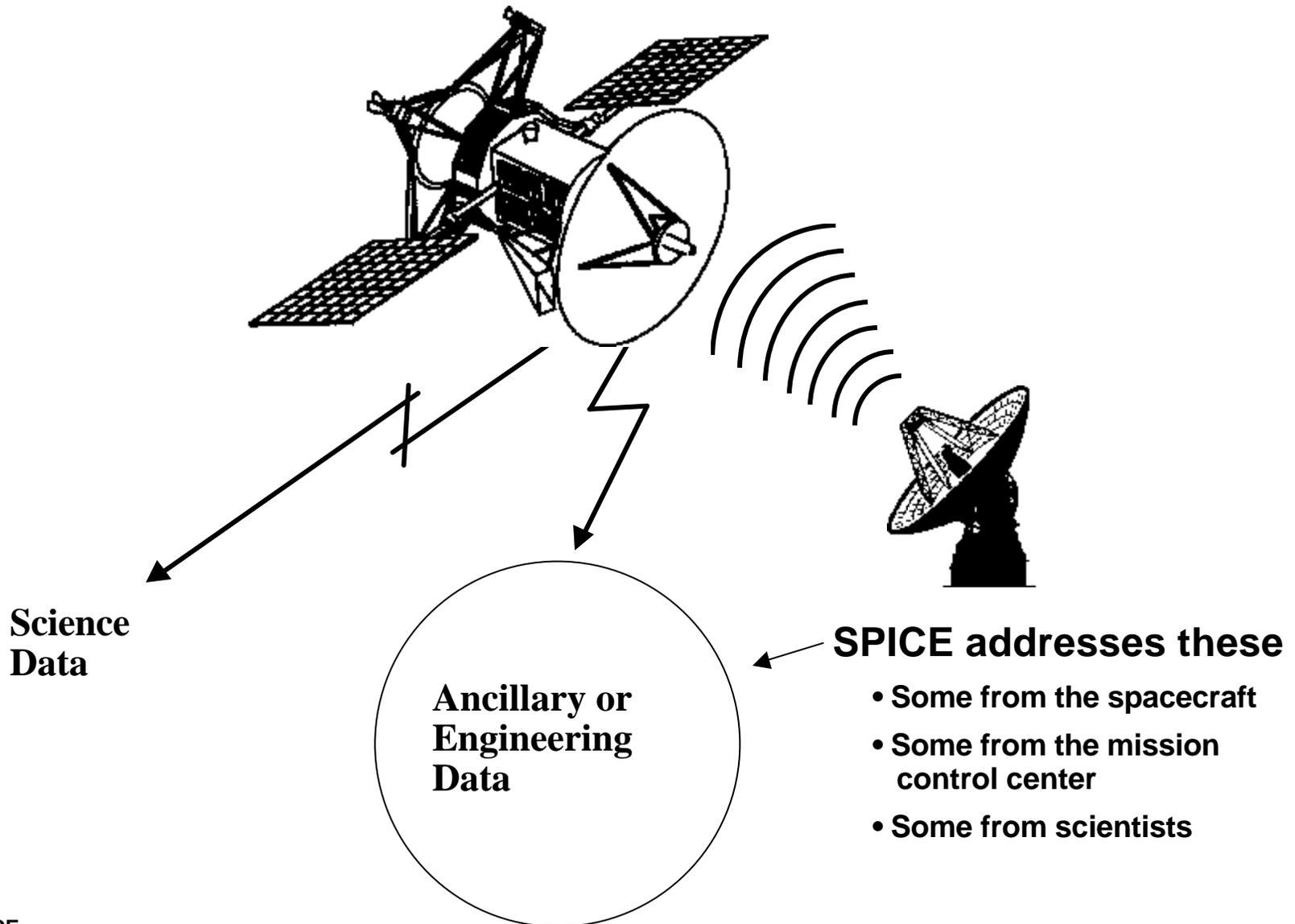
An Overview of SPICE

November 8, 1999



Space Data: Two Categories

Navigation and Ancillary Information Facility





What are “Ancillary Data”?

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- **“Ancillary data” are those that help you determine:**
 - when an instrument was taking data
 - how an instrument was acquiring data (operating mode)
 - 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 other relevant events were occurring on the spacecraft or within the ground data system



Why Is NAIF Building SPICE?

Navigation and Ancillary Information Facility

- **The space science community says it would like to:**
 - **minimize the number of information systems that must be learned to access data returned from the many spacecraft of all space science disciplines**
 - **understand the calculations and transformations used to produce reduced science data products**
 - **have ready access to, and the ability to revise the fundamental data and software tools used to produce reduced science data products**



SPICE System Components

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The principal SPICE system components are:

- Data files (often called “kernels” or “kernel files”)
- Software (the SPICE Toolkit)

Also part of SPICE are:

- Standards
- Documentation
- Customer support
- SPICE system maintenance



Genesis of the SPICE Acronym*

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S

Spacecraft

P

Planet

I

Instrument

C

C-matrix (spacecraft attitude)

E

Events

* Coined by Dr. Hugh Kieffer, USGS Astrogeology Branch, Flagstaff AZ



Logical vs. Physical View

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Logical View

S
Spacecraft

P
Planet

I
Instrument

C
C-matrix

E
Events

S
Software

Physical View (real files)

SPK

PcK

IK

CK

EK

Others

SPICE Toolkit

FK
LSK
SCLK
DBK



SPICE System Contents - 1

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SPK

- Space vehicle ephemeris (trajectory)
- Planet, satellite, comet and asteroid ephemerides
- More generally, position of something relative to something else

PcK

- Planet, satellite, comet and asteroid orientations, sizes, shapes
- Possibly other similar “constants” such as gravitational parameters

IK

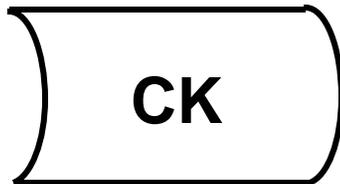
- Instrument information such as:
 - Field-Of-View specifications
 - Internal timing

(Separate IK file for each instrument)



SPICE System Contents - 2

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- Instrument platform attitude
- More generally, orientation of something relative to some reference frame



- Three components:
 - Science observation plans (ESP)
 - Spacecraft & instrument commands (ESQ)
 - Spacecraft “notebooks” and ground data system logs (ENB)



SPICE System Contents - 3

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FK

- **Frame Definitions**
 - Definitions of and specification of relationships between coordinate systems

LSK

- **Leapseconds**
 - Used for UTC* <--> ET* time conversions

SCLK

- **Spacecraft Clock Coefficients**
 - Used for SCLK* <--> ET* time conversions

**Other
Kernels**

- **Mission kernel**
- **Star catalog kernel**
- **Shape model kernel for small, irregular bodies**
- **Control net kernel**

UTC = Universal Time Coordinated ET = Ephemeris Time SCLK = Spacecraft Clock Time



SPICE System Contents - 4

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Generic SPICE Toolkit

- **SPICELIB or CSPICE routines library, used to**
 - write (binary) SPICE kernel files
 - read all SPICE kernel files
 - compute quantities derived from SPICE kernel data
- **Example (“cookbook”) programs**
- **Utility programs**
 - Kernel summarization or characterization
 - Kernel management
- **Application programs (few)**
 - E.g. “chronos” time conversion application
- **Kernel production programs (few)**
 - E.g. “mkspk” trajectory generator



SPICE System Contents - 5

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Mission-specific Toolkit Augmentation

- Instrument or mission-specific additions to the Toolkit that are not appropriate for inclusion in the generic Toolkit
 - Exists only if needed for a particular mission



What's SPICE Good For ?

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**Mission
maturity**



- **Mission planning, modeling and visualization**
- **Mission evaluation from a science perspective**
- **Detailed science observation planning**
- **Mission operations (engineering)**
- **Science data analysis**
- **Correlation of results between instruments, and with data obtained from other missions**
- **PDS archive standard**



Acquiring SPICE Kernel Files

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Where can you acquire a mission's SPICE files?

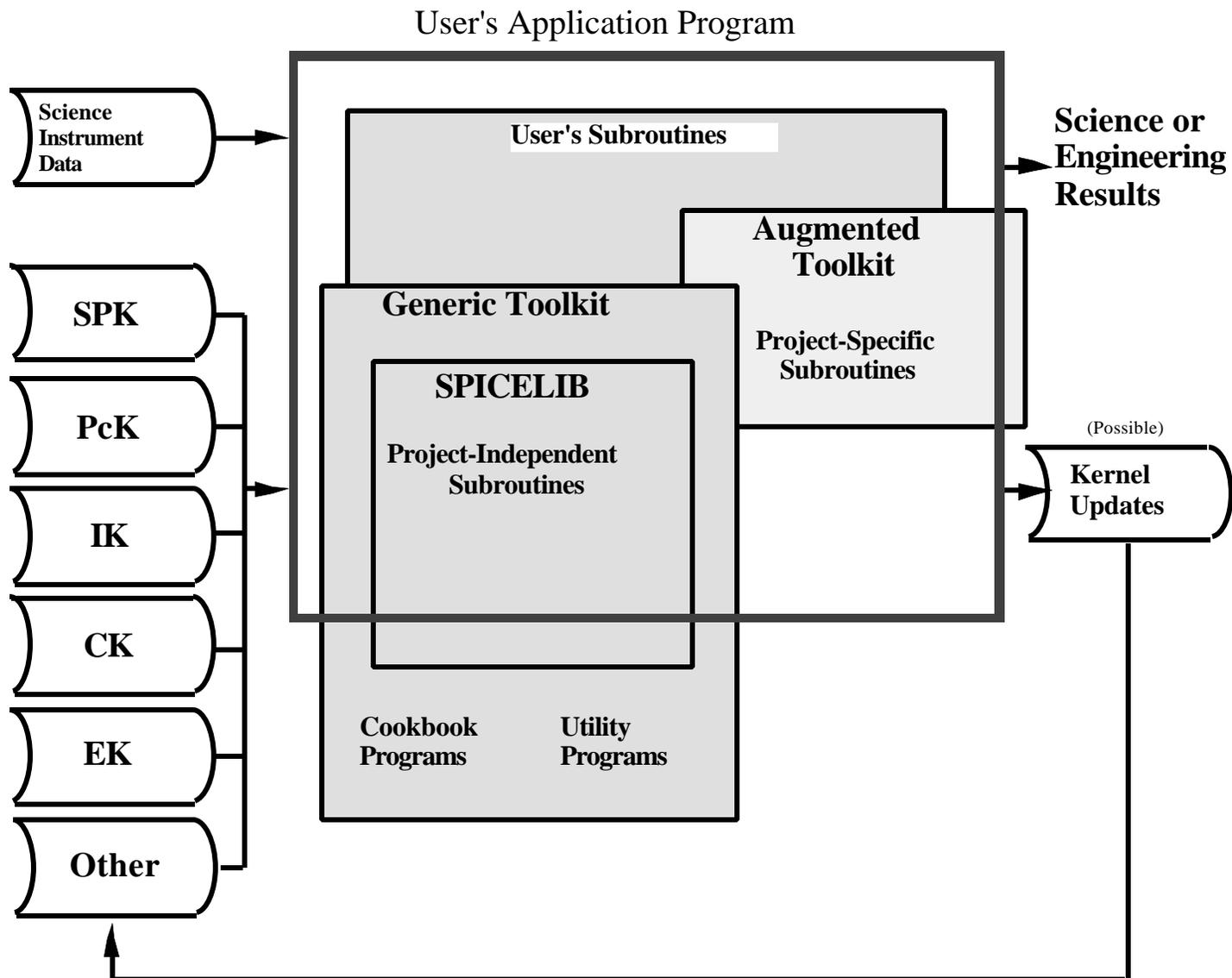
- **During the mission:**
 - **From the project's database or website**
 - » **Generally not from the discipline archive (e.g. NAIF), unless the mission has provided incremental archival deliveries**

(Note: In some cases NAIF has been contracted to provide a SPICE database service for instrument and engineering teams associated with an active mission.)
 - **From the discipline archive**
 - » **For example, the NAIF node of the Planetary Data System**



Using SPICE Products

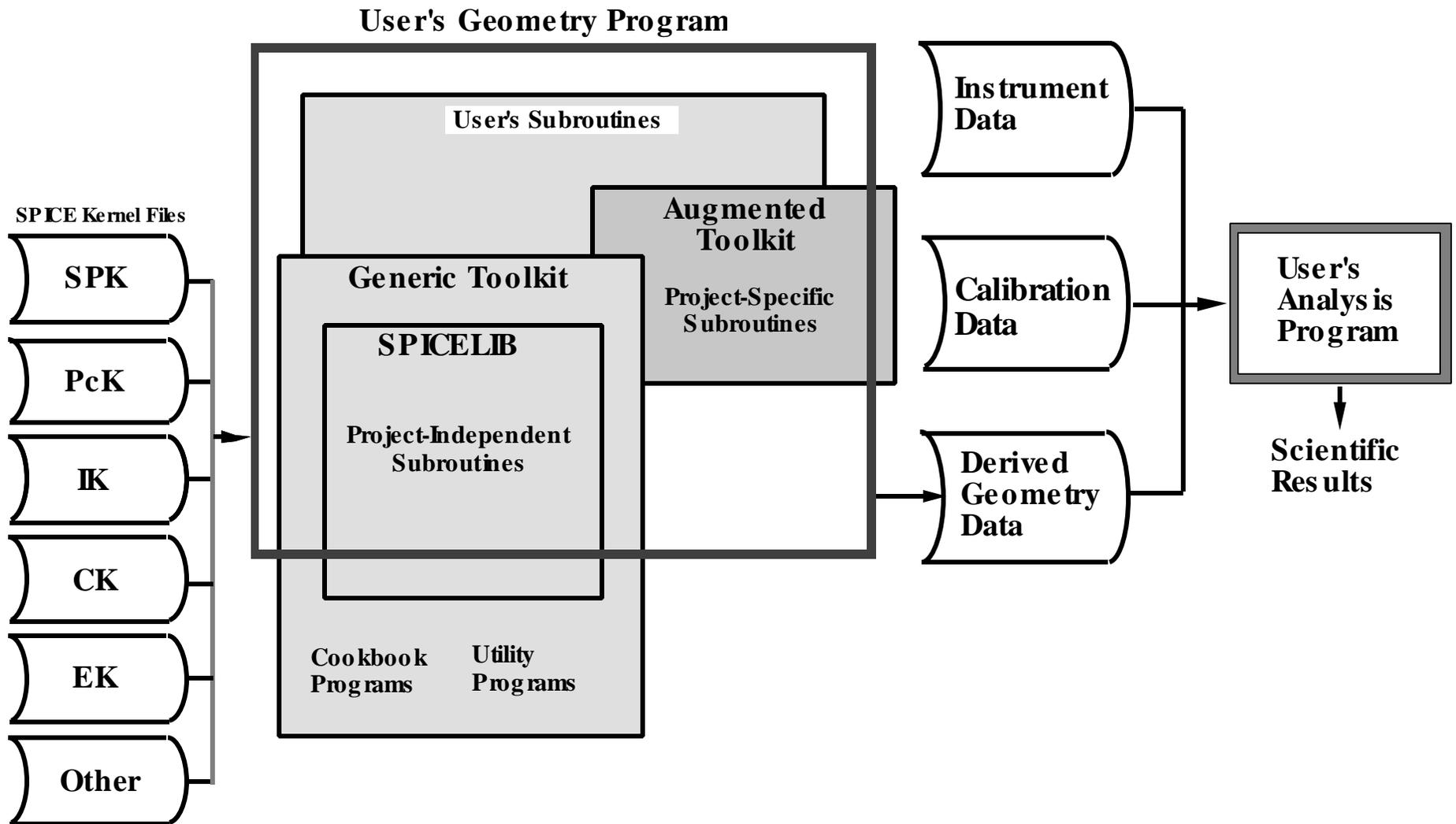
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Another Possible User Scenario

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SPICE System Characteristics - 1

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- **Portable SPICE kernel files**
 - **Use of text format and SPICE “transfer format” files makes porting easy**
 - » **Note: New software under development will soon make the need for “transfer format” obsolete**
- **Portable SPICE Toolkit software**
 - **Already ported to and tested on most popular platforms**
- **Focus is on the customer**
 - **Code is well crafted and well tested**
 - **Extensive, clear documentation is provided**
 - » **Includes well documented source code**
 - **SPICE Toolkit contains some example (“cookbook”) programs**



SPICE System Characteristics - 2

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- **Kernel files are separable**
 - Use only those you need for a particular application
- **Kernel files are extensible**
 - New types can be added within a family
 - New kinds of kernels can be defined
- **Broad applicability and good value**
 - Multimission and multidiscipline
 - SPICE development and maintenance costs are shared across many customers
- **Continuing core SPICE system development is funded by NASA's Office of Space Science**



Major Flight Project Customers

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<u>Restorations</u>	<u>Past</u>	<u>Current</u>	<u>Future Possibilities</u>
Apollo 15 [P]	Voyagers [P]	Galileo	Muses-CN (ISAS)
Mariner 9 [P]	Magellan [P]	NEAR	Mars Express (ESA)
Mariner 10 [P]	Clementine (NRL)	Mars Global Surveyor	Space Technology 3, ..
Viking Orbiters [P]	Mars Observer	Space VLBI [P]	Nozomi (Japan)
Pioneer 10/11 [P]	Mars 96 (Russia)	Stardust	Contour
Haley armada [P]	Hubble Telescope [S]	Cassini	Messenger
Phobos 2 [P] (Russia)	ISO [S]	Deep Space 1	EOS - TES
Ulysses [P]	MSTI-3 (by ACT)	DSN Metric Predicts	Deep Impact
	OTD (by MSFC)	Mars 01	Rosetta (ESA)
	Mars Pathfinder	SIRTF [S]	Selene (Japan)
	Mars Climate Orbiter	Genesis	
	Mars Polar Lander	Mars 03	
		Mars 05	
		SIM [P]	

[P] = partial use of SPICE

[S] = special tools or services provided by NAIF