NAIF

Navigation and Ancillary Information Facility

An Overview of SPICE

February 28, 2001

NAIF   # Space Science Data: Two Kinds

Navigation and Ancillary Information Facility

Science Instrument Data

Ancillary or Engineering Data

SPICE deals with <u>these</u> data
- Some from the spacecraft
- Some from the mission control center
- Some from spacecraft and instrument builders
- Some from scientists

What are "Ancillary Data"?

Navigation and Ancillary Information Facility

- **"Ancillary data" are those that help scientists and engineers determine:**
  - when and how an instrument was acquiring data
  - 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 (selected) other relevant events were occurring on the spacecraft that might affect interpretation of:
    - » science observations
    - » spacecraft systems performance

SPICE System Components

Navigation and Ancillary Information Facility

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*

S	Spacecraft
P	Planet
I	Instrument
C	C-matrix (spacecraft attitude)
E	Events

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

Logical versus Physical View
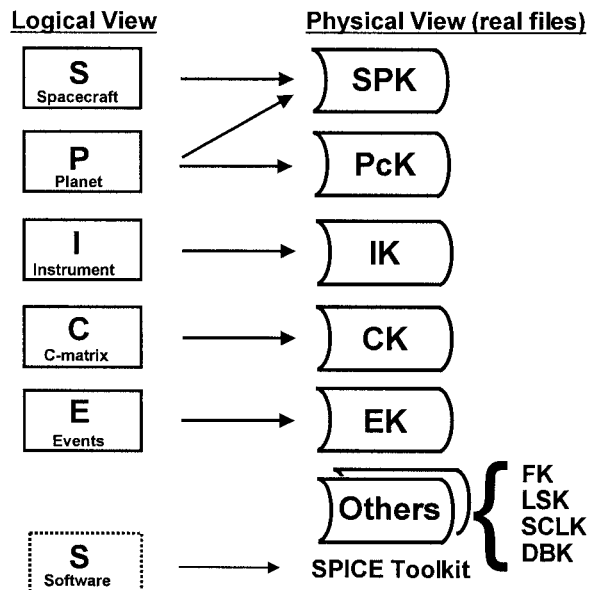
Logical View → **Physical View (real files)**

Logical View		Physical View (real files)
S Spacecraft	→	SPK
P Planet	→	PcK
I Instrument	→	IK
C C-matrix	→	CK
E Events	→	EK
		Others { FK, LSK, SCLK, DBK
S Software	→	SPICE Toolkit

SPICE System Contents - 1

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

CK

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

EK
3 components

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

SPICE System Contents - 3

FK
- **Frames 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**
- **Star (sky) catalog***
- **Shape model for small, irregular bodies***
- **Terrain***
- **Control net***

* = under development

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

---

SPICE System Contents - 4

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

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 mission
  - NAIF tries to avoid having to create these

What's SPICE Good For ?

Mission maturity

- Mission planning, modeling and visualization

- Pre-flight mission evaluation from a science perspective

- Detailed science observation planning

- Mission operations engineering functions

- Science data analysis, including correlation of results between instruments, and with data obtained from other missions

  The original focus of SPICE

- Archiving in the NASA Planetary Data System

Acquiring SPICE Kernel Files

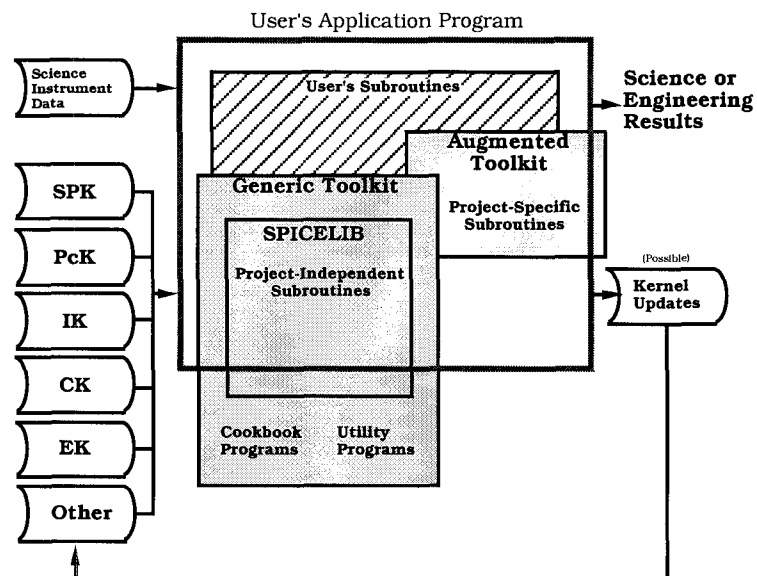Navigation and Ancillary Information Facility

Where can you acquire a mission's SPICE files?

- During the mission:
  - From the project's database or website
  - Generally <u>not</u> 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.)
- After the mission:
  - From the discipline archive
    - » **For example, the NAIF node of the Planetary Data System**
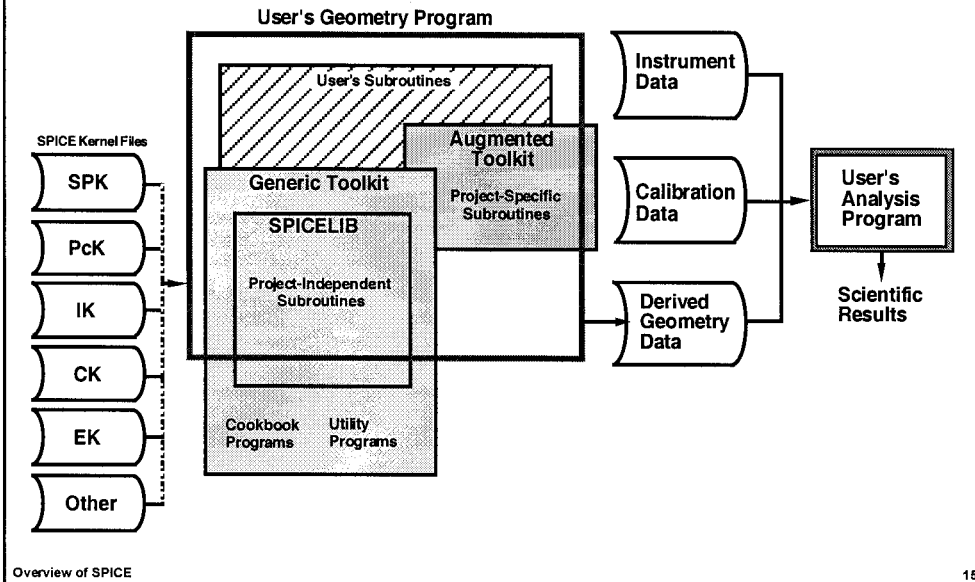
Using SPICE Products

Navigation and Ancillary Information Facility

User's Application Program

Another Possible User Scenario

Navigation and Ancillary Information Facility

User's Geometry Program

User's Subroutines

Augmented Toolkit

Generic Toolkit

Project-Specific Subroutines

SPICELIB

Project-Independent Subroutines

Cookbook Programs   Utility Programs

SPICE Kernel Files

SPK

PcK

IK

CK

EK

Other

Instrument Data

Calibration Data

Derived Geometry Data

User's Analysis Program

Scientific Results

SPICE System Characteristics - 1

Navigation and Ancillary Information Facility

- 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

Navigation and Ancillary Information Facility

- 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

Navigation and Ancillary Information Facility

Restorations	Past Customers	Current Customers	Future Possibilities
Apollo 15, 16 [P]	Magellan [P]	Galileo	Mars 05, 07, ...
Mariner 9 [P]	Clementine (NRL)	NEAR	Nozomi (Japan)
Mariner 10 [P]	Mars Observer	Mars Global Surveyor	Messenger
Viking Orbiters [P]	Mars 96 (Russia)	Space VLBI [P]	EOS - TES Instrument
Pioner 10/11 [P]	Hubble Telescope [S]	Stardust	Space Technology 3
Haley armada [P]	ISO [S]	Cassini/Huygens	Rosetta (ESA)
Phobos 2 [P] (Russia)	MSTI-3 (by ACT Corp.)	Deep Space 1	Muses-CN (ISAS)
Ulysses [P]	OTD (by MSFC)	Mars Odyssey	Selene (Japan)
Voyagers [P]	Mars Pathfinder	Mars Exploration Rover	BepiColombo (ESA)
	Mars Climate Orbiter	SIRTF [S]	
	Mars Polar Lander	Genesis	
		Mars Express (ESA)	
		DSN Metric Predicts [S]	
		Deep Impact	
		CONTOUR	
		SIM [P]	

[P] = partial use of SPICE   [S] = special tools or services provided by NAIF