An Overview of SPICE

February 28, 2001

Space Science Data: Two Kinds

Science Instrument Data

Ancillary or Engineering Data

SPICE deals with these data:
- Some from the spacecraft
- Some from the mission control center
- Some from spacecraft and instrument builders
- Some from scientists
What are "Ancillary Data"?

- "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

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)

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

Overview of SPICE
SPICE System Contents - 1

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

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

- Instrument information such as:
  - Field-Of-View specifications
  - Internal timing
  (Separate IK file for each instrument)

SPICE System Contents - 2

- 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

Navigation and Ancillary Information Facility

**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

Overview of SPICE

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SPICE System Contents - 4

Navigation and Ancillary Information Facility

**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

Overview of SPICE
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

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.)
- After the mission:
  - From the discipline archive
    - For example, the NAIF node of the Planetary Data System

Using SPICE Products

Overview of SPICE

User's Application Program

Science or Engineering Results

Kernel Updates

Overview of SPICE
Another Possible User Scenario

Overview of SPICE

SPICE System Characteristics - 1

- 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

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<td>Mars Polar Lander</td>
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[P] = partial use of SPICE  [S] = special tools or services provided by NAIF