An Overview of SPICE

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Space Science Data: Two Categories

Navigation and Ancillary Information Facility

SPICE addresses these:

- Some from the spacecraft
- Some from the mission control center
- Some from scientists

Ancillary or Engineering Data

Science Instrument Data
What are “Ancillary Data”?  

- “Ancillary data” are those that tell:
  - 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?

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
The principal SPICE system components are:

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

Also part of SPICE are:

- Standards
- Documentation
- User support
- System maintenance
Genesis of the SPICE Acronym*

Spacecraft

Planet

Instrument

C-matrix  (spacecraft attitude)

Events

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

Navigation and Ancillary Information Facility

The Acronym
- **S**: Spacecraft
- **P**: Planet
- **I**: Instrument
- **C**: C-matrix
- **E**: Events

Real SPICE Files
- **SPK**: S
- **PcK**: P
- **IK**: I
- **CK**: C
- **EK**: E
- **Others**: Software NAIF Toolkit

Others
- **FDK**
- **LSK**
- **SCLK**
- **DBK**
SPICE System Contents

Navigation and Ancillary Information Facility

- SPK
  - Spacecraft 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 $G_m$

- IK
  - Instrument information such as:
    - Mounting alignment
    - Field-Of-View specifications
    - Internal timing
  (Separate IK file for each instrument)
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SPICE System Contents, cont'd

**CK**
- Instrument platform attitude
- More generally, orientation of something relative to some reference frame
  (Separate file for each platform)

**EK**
- Science Observation plan (ESP)
- Spacecraft & instrument commands (ESQ)
- Scientists' “notebooks” and ground data system logs (ENB)

**Others**
- Frame definitions (FDK)
- Leapseconds (LSK)
- Spacecraft clock coefficients (SCLK)
- Still more: (using “database kernel”- DBK)
  - Star catalog
  - Shape model, for small irregular bodies
SPICE System Contents Cont'd

Navigation and Ancillary Information Facility

NAIF Toolkit

- SPICELIB subroutine library, used to
  - write (binary) SPICE kernel files
  - read all SPICE kernel files
  - compute quantities derived from SPICE kernel data

- Utility programs
- Example (“cookbook”) programs

Also...

- Some kernel production programs
- A generic “Database Kernel” (DBK) system
  - Relational model, SQL query language, API interfaces, report generator, portable, free
• Available in ANSI FORTRAN 77 and ANSI C*
  – The C version (often called “CSPICE”) is produced by:
    » Translating the FORTRAN version to C using f2c
    » Writing new, native C-language “wrappers” for the most used subroutines
    » Writing native C-language versions of some low-level routines that deserve such new implementation
  – The first step above is repaeated each time a new FORTRAN version of the NAIF Toolkit is released

• Numerous platforms and operating systems are supported, including*:
  – Sun/Solaris, Sun/SunOS, SGI/IRIX, HP/HPUX, Mac/MacOS, PC/W3.11, PC/Win95, PC/NT, PC/Linux, NeXT/NeXTSTEP, DEC Alpha/VMS, DEC Alpha/Digital Unix

* Note: The C version may not be available on all platforms
What's SPICE Good For?

Mission planning/modeling/visualization

Mission evaluation from a science perspective

Detailed science observation planning

Mission operations (engineering)

Science data analysis

Correlation of results with other missions

Original focus
Who Makes SPICE Kernel Files?

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- **“PREDICT”** versions
  - Mission modelers/designers
    » mission design and mission evaluation
  - Mission Operations teams
    » observation planning
    » spacecraft operations
    » quick-look science data analysis
    » PR and public outreach
- **“Definitive”** or **“Reconstruction”**
  - Mission Operations teams
    » science data analysis
    » spacecraft performance analysis
- **“Updates”** (post mission)
  - Science and engineering teams
    » Result of and/or for continuing data analysis
Management of SPICE Kernel Files

Navigation and Ancillary Information Facility

Flight Project Center

Science and Engineering Teams

- SPK
- PcK
- IK
- CK
- EK
- Other

Project Database

- During the active mission
- Peer review and subsequent delivery to permanent archive
- After the mission
Where can you acquire a mission’s SPICE files?

• During the mission:
  – from the mission database (if you are authorized access by the mission)
    » not from the discipline archive (e.g. NAIF), unless the mission has provided incremental archival deliveries

• After the mission:
  – from the discipline archive, such as NAIF for NASA missions
Using SPICE Products
Navigation and Ancillary Information Facility

User's Application Program

Science or Engineering Results

Kernel Updates

Science Instrument Data

SPK
PcK
IK
CK
EK
Other

SPICELIB
Project-Independent Subroutines

Cookbook Programs
Utility Programs

Augmented Toolkit
Project-Specific Subroutines

Generic Toolkit
User's Subroutines
Another Possible User Scenario

Navigation and Ancillary Information Facility

User's Geometry Program

SPICE Kernel Files
- SPK
- PcK
- IK
- CK
- EK
- Other

Generic Toolkit
- Project-Independent Subroutines
  - SPICELIB
  - Cookbook Programs
  - Utility Programs

Augmented Toolkit
- Project-Specific Subroutines

Instrument Data
- Calibration Data
- Derived Geometry Data

User's Subroutines

User's Analysis Program

Scientific Results
**SPICE System Characteristics**

Navigation and Ancillary Information Facility

- **Portable SPICE kernel files**
  - Use of text format and SPICE “transfer format” files makes porting easy

- **Portable NAIF Toolkit software**
  - Already ported to many popular platforms
  - Users get source code
  - Environment-specific aspects are few, isolated and clearly marked

- **Focus is on the customer**
  - Code is well crafted and well tested
  - Extensive, clear documentation is provided
  - NAIF Toolkit includes some example programs
• Components are separable and extensible
  – Use only those elements you need
  – SPICE kernel file designs are very flexible
    » New types within a family are easily added

• Broad applicability and good value
  – Multimission and multidiscipline
  – Costs are shared across many customers

• Continuing core SPICE system development is funded by NASA's Office of Space Science
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[P] = partial use of SPICE  
[S] = special tools or services provided by NAIF