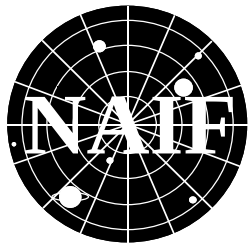


Navigation and Ancillary Information Facility

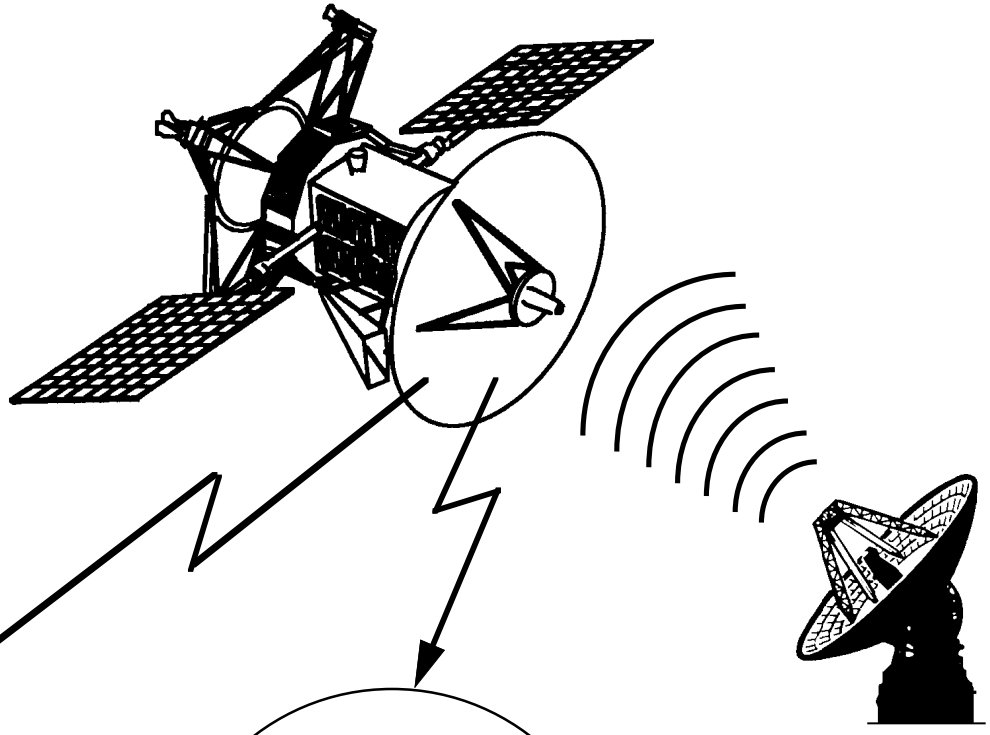
An Overview of SPICE

November 1998

Charles Acton
Jet Propulsion Laboratory

Space Science Data: Two Categories

Navigation and Ancillary Information Facility

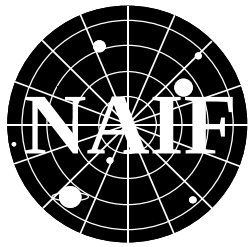


Science Instrument Data

Ancillary or Engineering Data

SPICE addresses these

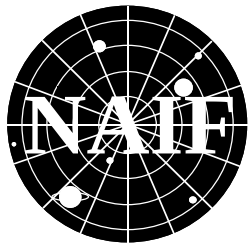
- **Some from the spacecraft**
- **Some from the mission control center**
- **Some from scientists**



What are “Ancillary Data”?

Navigation and Ancillary Information Facility

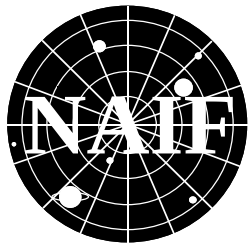
- **“Ancillary data” are those that tell:**
  - **when an instrument was taking data**
  - **how an instrument was acquiring data (operating mode)**
  - **where the spacecraft was located**
  - **how the spacecraft and its instruments were oriented (pointed)**
  - **what was the location, size, shape and orientation of the target being observed**
  - **what other relevant events were occuring 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

Navigation and Ancillary Information Facility

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*

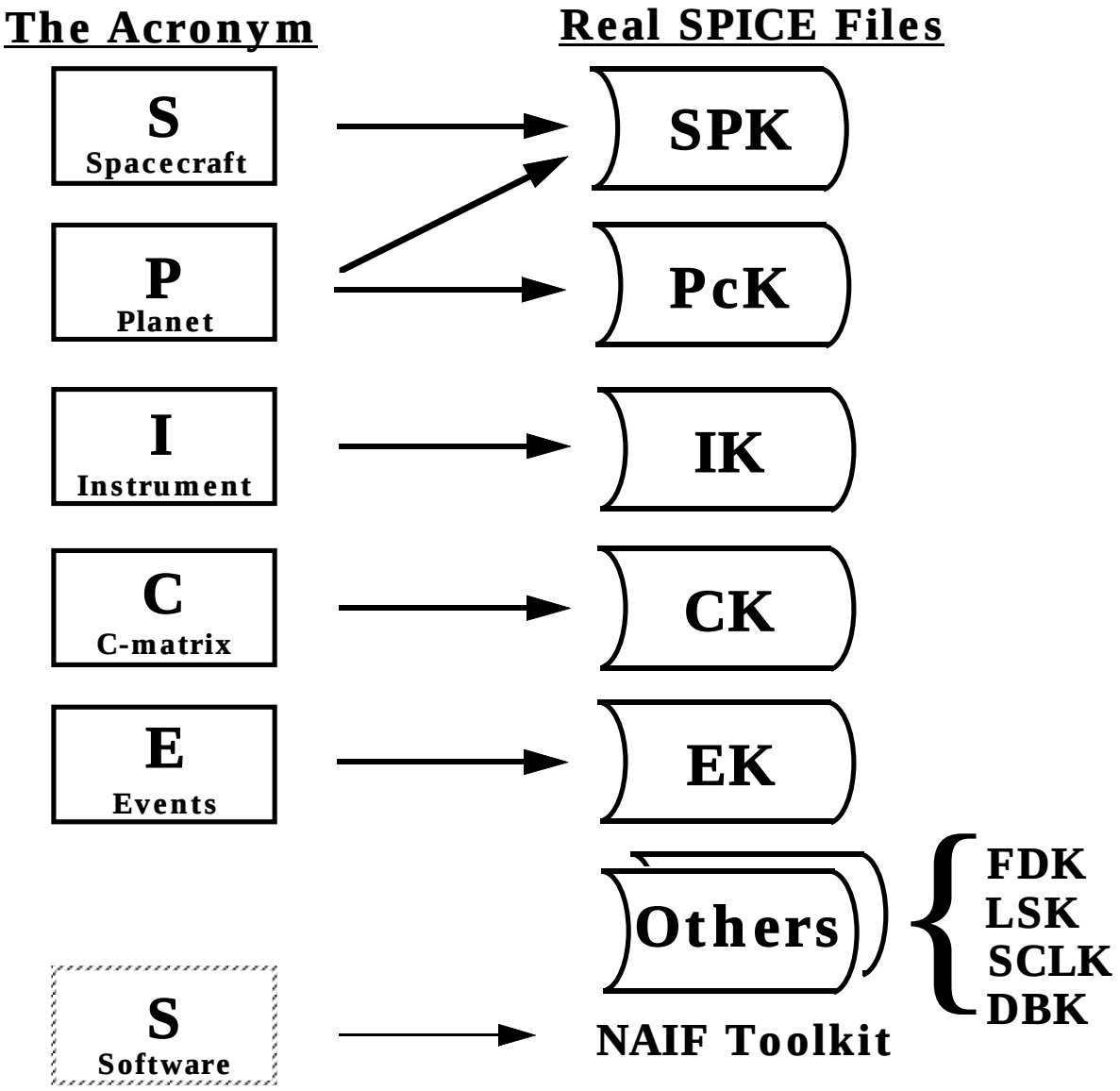
Navigation and Ancillary Information Facility

S	**S**pacecraft
P	**P**lanet
I	**I**nstrument
C	**C**-matrix (spacecraft attitude)
E	**E**vents

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

Translating the Acronym

Navigation and Ancillary Information Facility



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**

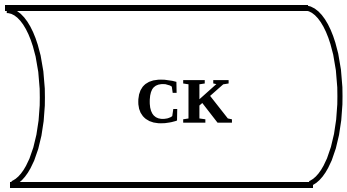
IK

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

(Separate IK file for each instrument)

SPICE System Contents, cont'd

Navigation and Ancillary Information Facility

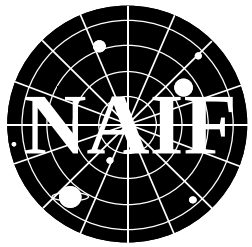


- **Instrument platform attitude**
- **More generally, orientation of something relative to some reference frame**

  (Separate file for each platform)

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

- **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...

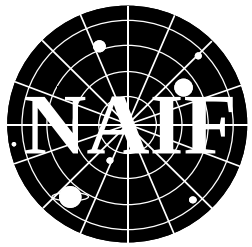
- **Some kernel production programs**
- **A generic “Database Kernel” (DBK) system**
  - **Relational model, SQL query language, API interfaces, report generator, portable, free**

NAIF Toolkit Environment

Navigation and Ancillary Information Facility

- **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 ?

Navigation and Ancillary Information Facility

Mission maturity

- **Mission planning/modeling/visualization**
- **Mission evaluation from a science perspective**
- **Detailed science observation planning**
- **Mission operations (engineering)**
- **Science data analysis** — **Original focus**
- **Correlation of results with other missions**

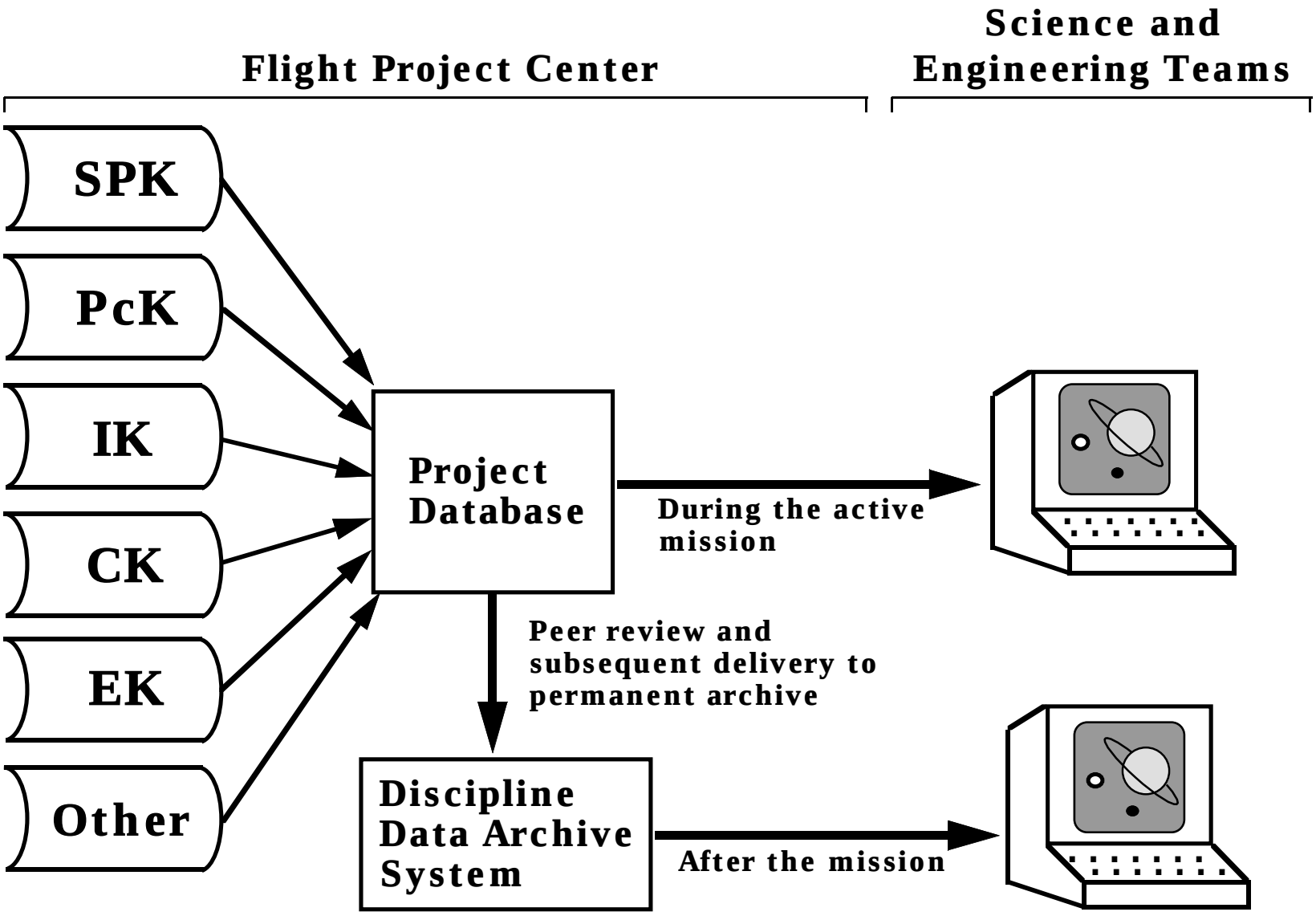
Who Makes SPICE Kernel Files?

Navigation and Ancillary Information Facility

- **"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



Acquiring SPICE Kernel Files

Navigation and Ancillary Information Facility

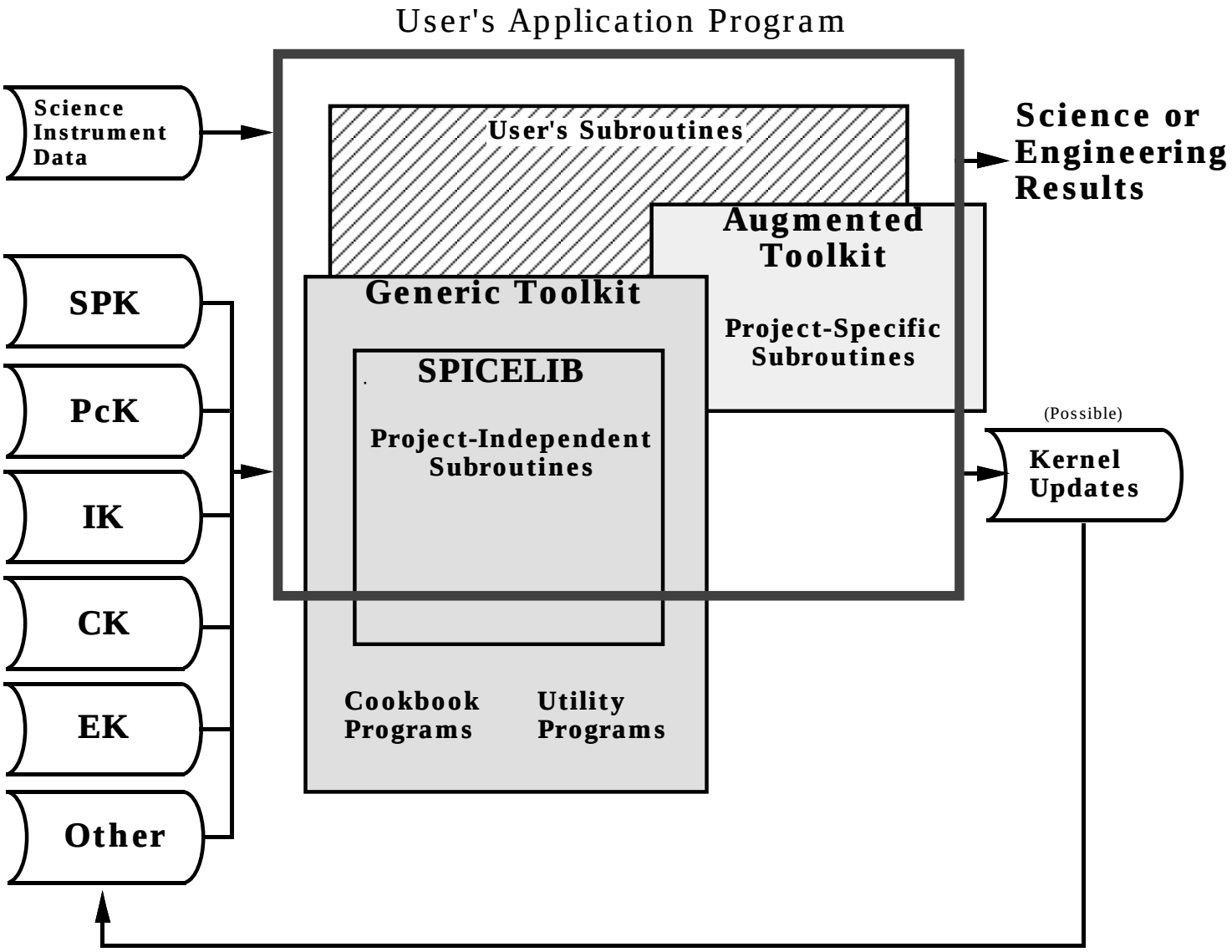
Where can you acquire a mission's SPICE files?

- **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**

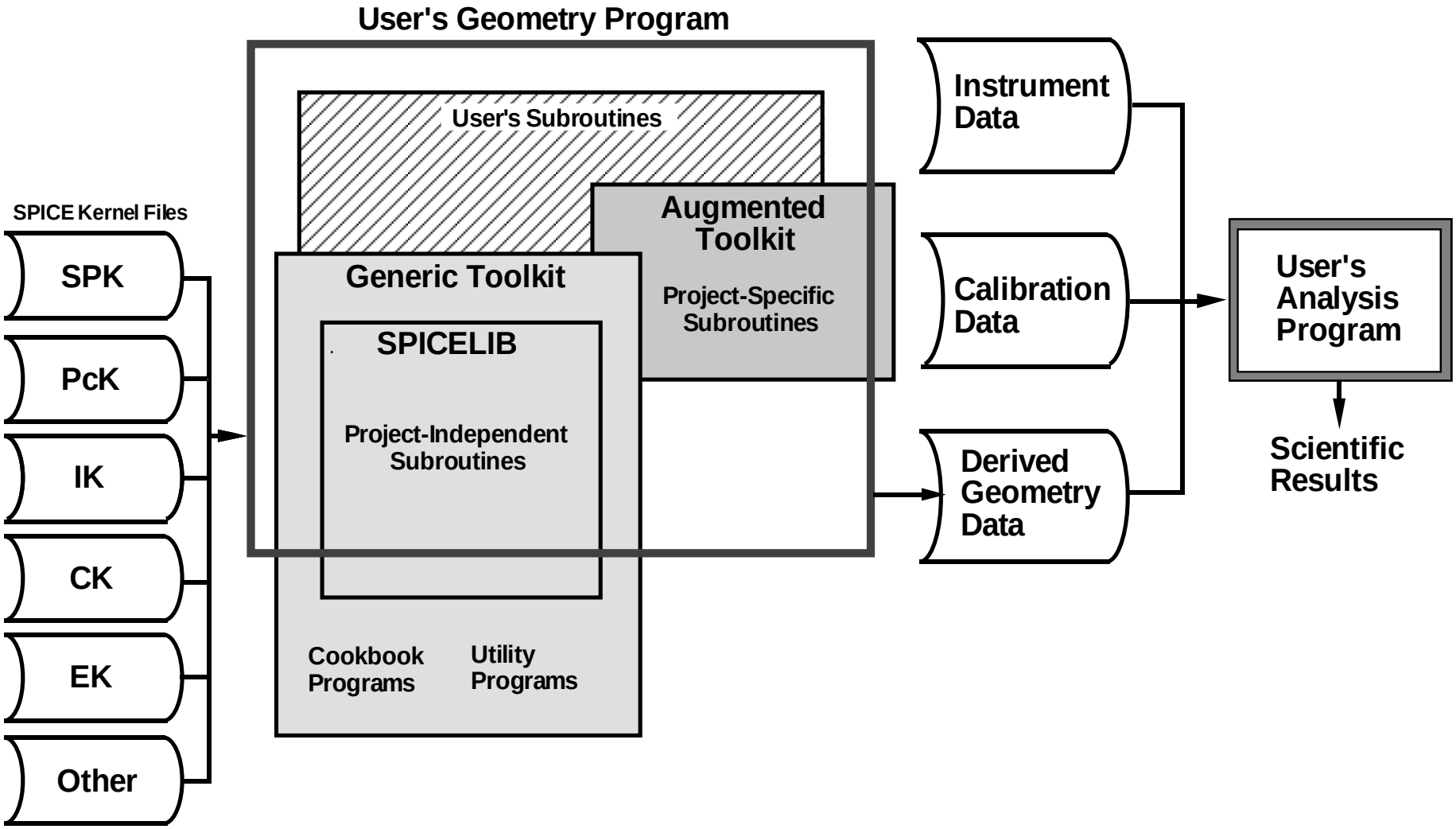
Using SPICE Products

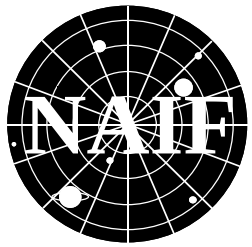
Navigation and Ancillary Information Facility



Another Possible User Scenario

Navigation and Ancillary Information Facility

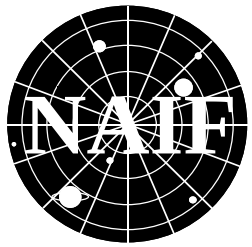




SPICE System Characteristics

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**



SPICE System Characteristics, cont'd

Navigation and Ancillary Information Facility

- **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**

Major Flight Project Customers

Navigation and Ancillary Information Facility

Restorations

Apollo 15 [P]
Mariner 9 [P]
Mariner 10 [P]
Viking Orbiters [P]
Pioneer 10/11 [P]
Haley armada [P]
Phobos 2 [P] (Russia)
Ulysses [P]

Past

Voyagers [P]
Magellan [P]
Clementine (NRL)
Mars Observer
Mars 96 (Russia)
Hubble Telescope [S]
ISO [S]
MSTI-3 (by ACT)
OTD (by MSFC)

Current

Galileo
NEAR
Mars Pathfinder
Mars Global Surveyor
Mars 98
Stardust
Cassini
Mars 01
DSN Metric Predicts
SIRTF [S]
Space VLBI [P]
SIM [P]
Deep Space -1
Genesis

Pending

Muses-CN
Mars 03, 05

Future Possibilities

Deep Space - n
Planet-B (Japan)
Mars Express (ESA)
Contour
Discovery - n
Rosetta (ESA)
EOS - MISR [P]
EOS - TES
Selene (Japan)

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