Science Mission Directorate
Solar System Division

Archiving Data with the Planetary Data System

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Topics

- Science Data Management Policies
- Overview of Planetary Data System
- Planetary Data System Organization
- Planetary Data System Services
- Considerations for Proposers

- **Key Objectives**
  - Preserve and utilize space science data as a National resource
  - "Open" Data: data ultimately belongs to science community and public
  - Appropriate and balanced allocation of resources for data issues through mission life cycle

- **Requirements**
  - Projects develop a Project Data Management Plan in coordination with the PDS Science Discipline Node(s)
  - ***Timely*** delivery of science data products to archives for open availability
  - Data Analysis Programs (DAPs) must utilize data residing in the PDS

Overview of the Planetary Data System

- PDS is the official planetary science data archive for the NASA Science Mission Directorate's Planetary Science Division
- PDS is chartered to ensure that planetary data are archived and available to the scientific community
- PDS is a distributed system designed to optimize scientific oversight in the archiving process
- The PDS has been in existence in its present form for ~16 years
  - evolved from an offline media archive to a distributed online system, and still evolving…

Planetary Data System Organization

PDS is a close federation of Nodes with both Science and Support functions

- Science functions are organized by discipline and include:
  - data ingestion
  - data distribution
  - interfacing with data suppliers and users to ensure that:
    - maximum science value is captured within the archive
    - the archive is of greatest utility to both immediate and long-term science users
      - *Immediate users*, by their use of the system, help PDS understand if the services and data sets are of optimal use to the community. These users have the benefit of an active instrument team to whom comments and replies can be passed, if needed, allowing the archive to be modified.
      - *Long-term users* need final, stand-alone archives because the instrument experts may no longer be available.

Planetary Data System Organization

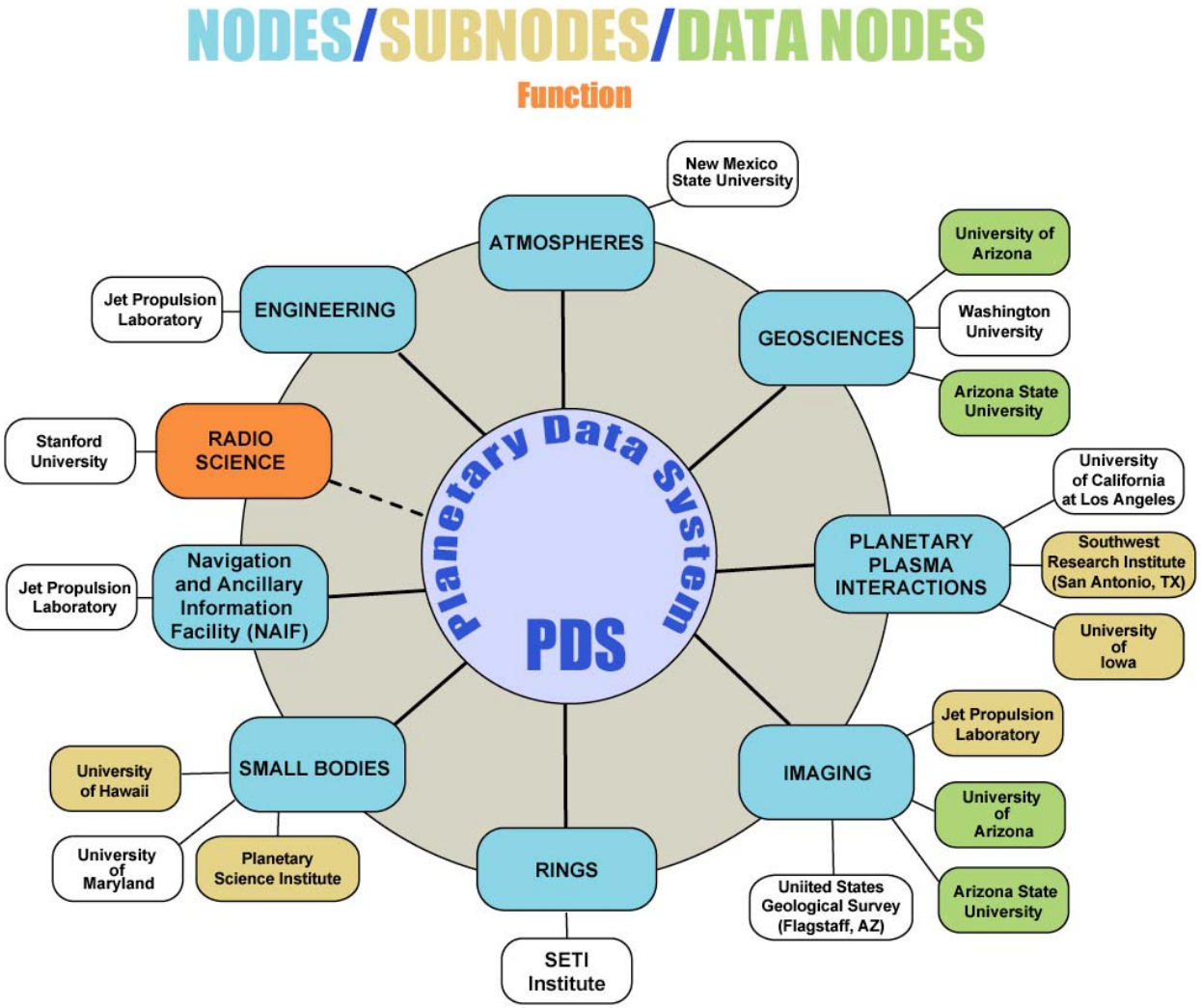
PDS is a close federation of Nodes with both Science and Support functions

- Support functions include basic development and cross-discipline support such as
  - common tools, libraries, procedures, and standards for data preparation, submission, and management
  - common tools for data manipulation
  - an infrastructure that facilitates
    - easy navigation within and access to holdings throughout the federation
    - simple system-wide maintenance and upgrades
- The Engineering Node focuses primarily on Support; the other Nodes focus primarily on Science, but all have at least test bed and review tasks

Planetary Data System Organization

- **Management Node (GSFC) -** Provides Program Management, budget support – *Ed Grayzeck*
- **Science Discipline Nodes -** Discipline Scientists provide expertise to interface with Flight Program Scientists. Science Discipline Nodes are:
  - Atmospheres (NMSU) – *Reta Beebe*
  - Geosciences (Washington U) – *Ray Arvidson*
  - Imaging (USGS Flagstaff/JPL) – *Lisa Gaddis*
  - Planetary Plasma Interactions (UCLA) – *Ray Walker*
  - Rings (NASA Ames) – *Mark Showalter*
  - Small Bodies (U of Maryland) – *Mike A'Hearn*
- **Support Nodes –** Provide support services to Science Discipline Nodes and/or the Science Community
  - Engineering Node (JPL) – *Dan Crichton*
  - Navigation Ancillary Information Facility (JPL) – *Chuck Acton*

New Frontiers-3 AO Workshop
Archiving Data with the Planetary Data System
Planetary Data System Organization



Planetary Data System Services

- PDS establishes and maintains standards for high quality data archives
- PDS works with missions to create complete data sets (calibrations, documentation, metadata)
  - PDS develops and maintains a suite of tools to help data producers create and validate archive-quality data products
  - PDS personnel can be funded by the mission to perform mission archiving tasks
- PDS provides expert assistance to the scientists who use the archives
- PDS ensures the viability of planetary data that might otherwise be lost

Considerations for Proposers

- *Early* involvement/interface with PDS is *necessary and critical* to satisfy the required product delivery/pipeline
- Lead PDS Discipline Node scientists guide/establish use of PDS standards and formats by Projects for each data set
- Data providers should strive for delivery of higher order, usable data products to the PDS
- Delivery of data to PDS must occur within six months of collection, allowing for an exclusive use period by Project PI's
  - Future goal is to make Project Ground Data System/Science Data System completely PDS compliant
- Archiving with PDS is a requirement, not an option…
  - Past performance with the PDS is a criteria in Phase B down-selections

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Archiving Data with the Planetary Data System
Considerations for Proposers (continued)

- PDS continues to evolve. Check back for updates → *http://pds.nasa.gov*
- Proposers Archive Guide (PAG) provided to assist in archive costing and interfacing with the PDS → *http://pds.nasa.gov/documents/pag/pag.pdf*
- Cost Model available for estimates (under Documents)
- Latest standards, formats and sample archive plans also available
- Please contact PDS representatives if you have any questions

SPICE Summary for New Frontiers-3 AO Workshop

12/05/08

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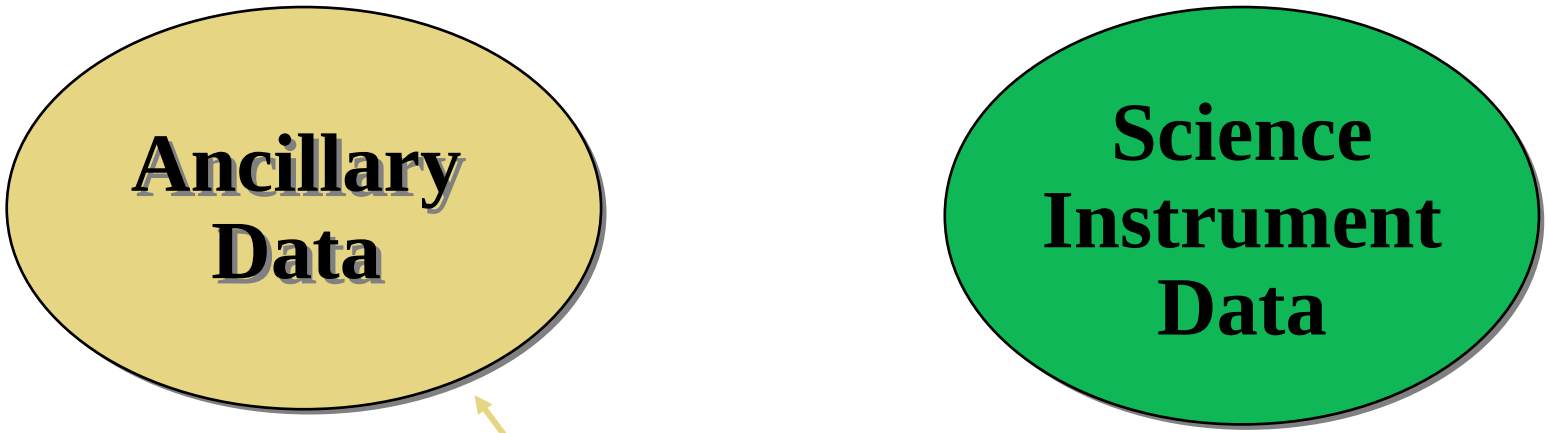
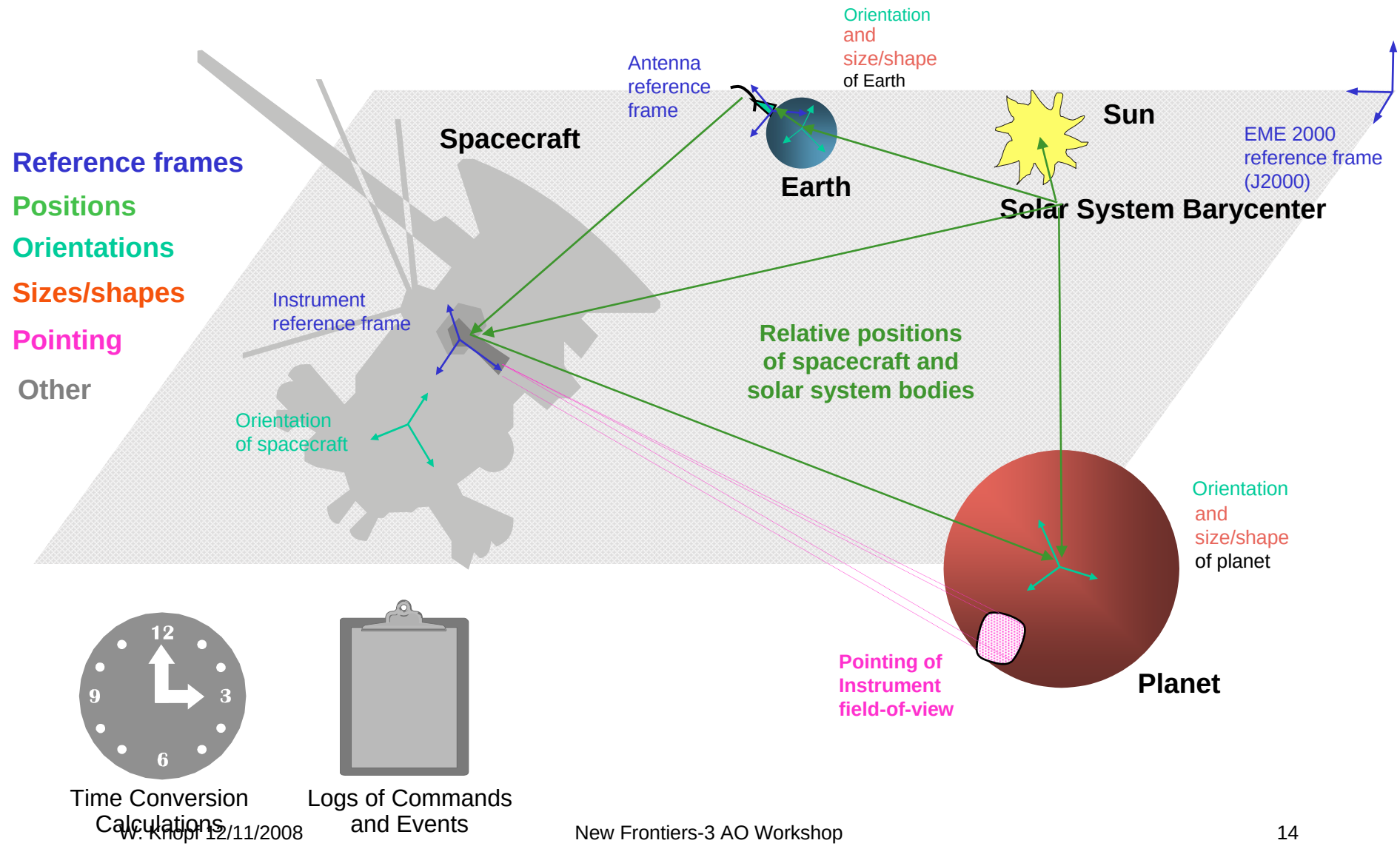
A Simplistic View of Space Science Data



SPICE deals with these data to support the planning for and analysis of these data.

SPICE also supports many mission planning and mission operations engineering functions.

What are "Ancillary Data?"



From Where do Ancillary Data Come?

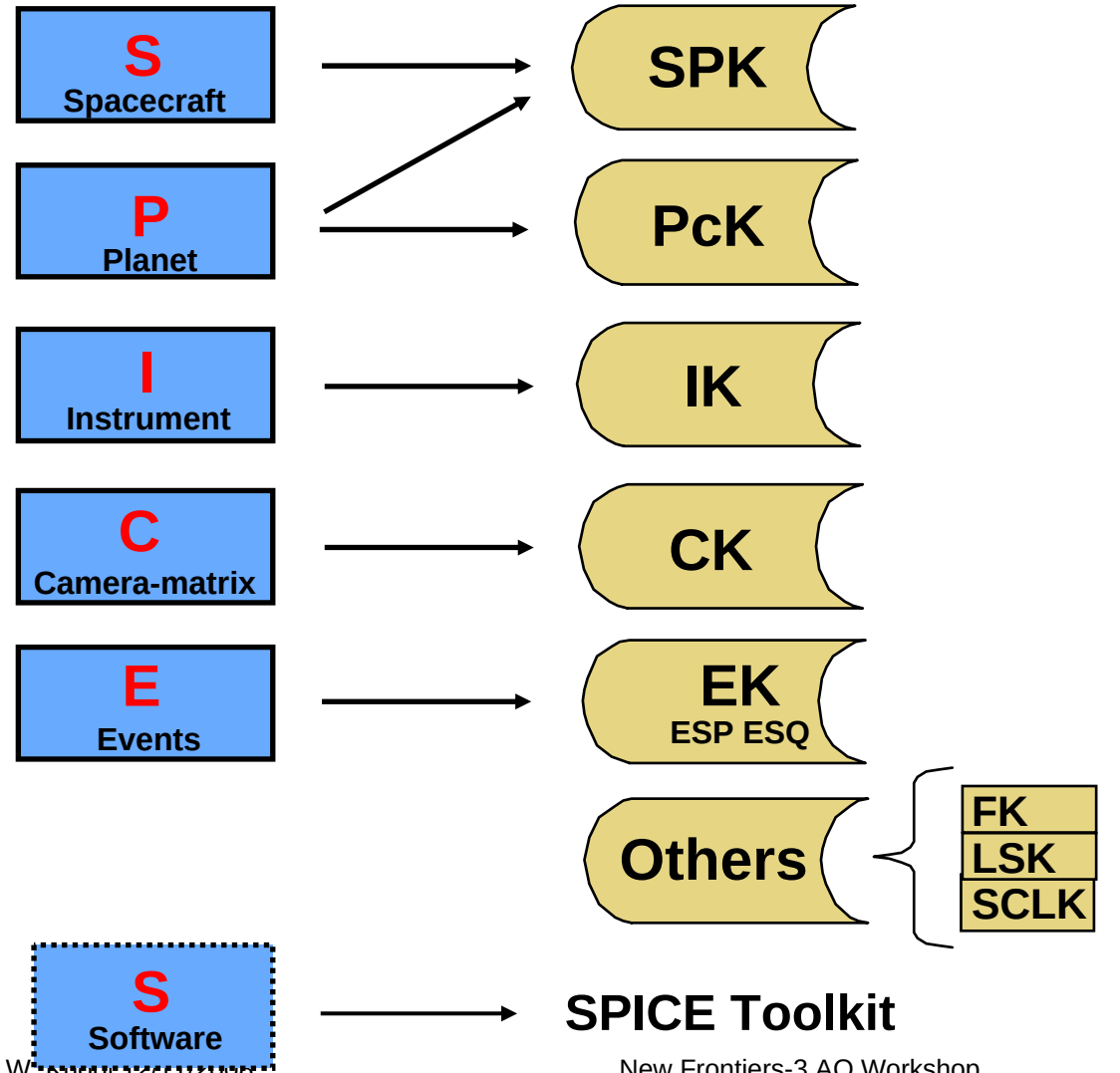
- Some come from the spacecraft
  - Spacecraft attitude
- Some come from the mission control center
  - Spacecraft trajectory and target body ephemerides
- Some come from the spacecraft and instrument builders
  - Spacecraft and instrument reference frames
  - Instrument mounting alignment and field of view
- Some come from scientists
  - Target body size, shape, orientation

Using SPICE

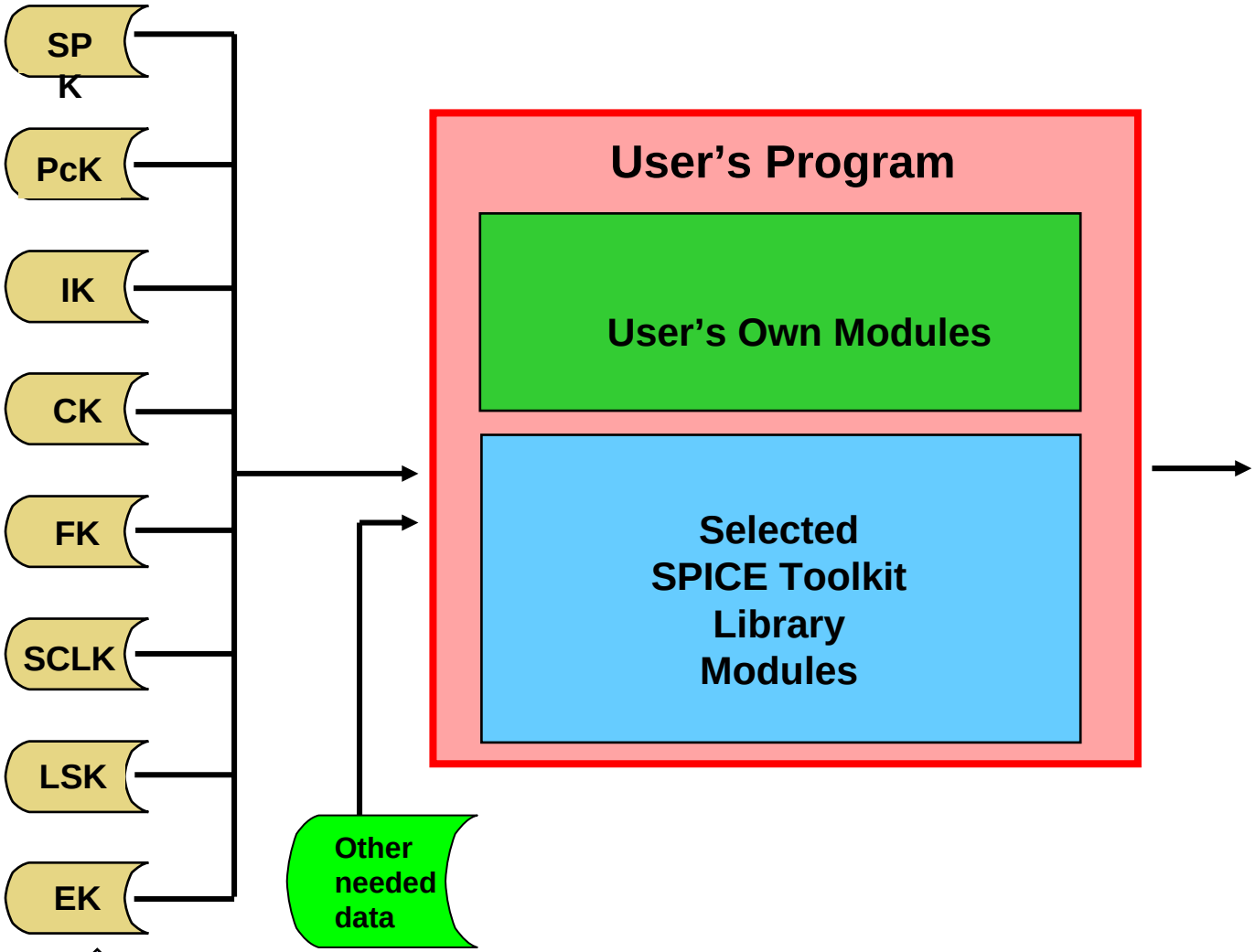
- SPICE is used to organize and package ancillary data in a collection of useful, stable file types–called "kernels."

- The kernels are made available, along with SPICE Toolkit software:
  - to help scientists in the planning for and analysis of science observations, and
  - to help engineers in planning for and analysis of spacecraft and ground system operations.

Logical versus Physical View



Using SPICE: A Picture



- Evaluation of a planned orbit
- Instrument pointing plan
- Analysis of expected communications link performance
- Science data archiving
- Science data analysis
- Multi-instrument data correlation

For What Jobs is SPICE Used ?

Increasing mission maturity (time)

- 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
- Data archiving, for future use by all planetary scientists
- Education and public outreach

SPICE System Components

- The principal SPICE system components are:
  - Data files, often called “kernels” or “kernel files”
  - Software, known as the SPICE Toolkit, consisting of:
    - a subroutine/function library
    - a number of programs (executables)
      - Some are “meaty” applications, used to make kernels
      - Some are “simple” utilities focused on kernel management
  - Documentation
    - Substantial source code documentation for all subroutines
    - Technical reference documents for major families of subroutines
    - User Guides for programs
  - Tutorials (PowerPoint presentations)
  - Programming lessons, which focus on using SPICE subroutines

Key SPICE Characteristics

- The SPICE Toolkit is available in four languages (FORTRAN, C, IDL, MATLAB), and for “all” popular computing environments.
  - NAIF provides already built, well tested packages for 29 computing “environments,” with more being added all the time.
  - “Environment” = CPU + OS + Language + Compiler
- SPICE software is exceedingly stable and truly multi-mission
  - No capability is ever removed
  - No functionality is ever changed
- Well documented source code is provided.
- SPICE distribution is not restricted under ITAR.
- No copyright or licensing restrictions apply.
- Everything about SPICE is freely available from the NAIF server: http://naif.jpl.nasa.gov/naif/

Why SPICE?

- Knowing observation geometry is an important element:
  - in the design of space missions,
  - in the specification of observations,
  - and in archiving and analysis of the science data returned from the instruments.
- Having proven and reusable means for producing and using ancillary data reduces cost and risk, and can help scientists and engineers achieve more substantive, accurate and timely results.
- SPICE is the “de facto” standard for producing and using ancillary data on planetary missions, both in the U.S. and abroad.
  - Has been used on every NASA planetary mission since Magellan, except for Lunar Prospector.
  - (However, using SPICE is not a requirement of NASA for mission ops nor for archiving in the PDS.)

Major SPICE Users

Restorations	Past Users	Current Users	Anticipated
Apollo 15, 16 [L]	Magellan [L]	Cassini Orbiter	NASA Mars Program
Mariner 9 [L]	Clementine (NRL)	Mars Odyssey	NASA Discovery Program
Mariner 10 [L]	Mars Observer	Mars Exploration Rover	NASA Scout Program
Viking Orbiters [L]	Mars 96 [F] (RSA)	Mars Express (ESA)	NASA New Frontiers Program
Viking Landers [L]	Hubble Space Telescope [S]	Mars Reconnaissance Orbiter	Next outer planet mission
Pioner 10/11 [L]	ISO [S] (ESA)	DAWN	
Haley armada [L]	MSTI-3 (NRL/ACT Corp.)	Phoenix	***Future ?***
Phobos 2 [L] (RSA)	Optical Transient Detector	New Horizons	Constellation
Ulysses [L]	Mars Pathfinder	Messenger	ExoMars (ESA)
Voyagers [L]	Mars Climate Orbiter [F]	Mars Science Lab	Grunt (RSA)
Lunar Orbiter [L]	Mars Polar Lander [F]	Rosetta (ESA)	Beppi Colombo (ESA)
	NEAR	Venus Express (ESA)	Lunar mission (DLR)
	Deep Space 1	Hayabusa (JAXA)	Chandrayaan-2 and more (ISRO)
	CONTOUR [F]	Kaygua (JAXA)	
	Space VLBI [L] (multinational)	NExT, EPOXI	***Some of the Numerous Unaffiliated Users***
[L] = limited use	Galileo	LCROSS	
[S] = special services	Genesis	Lunar Reconnaissance Orbiter	Kepler [L]
[F] = mission failed	Deep Impact	Juno	Planck [L] (ESA)
	Huygens Probe (ESA)	Chandrayaan (ISRO)	WISE [L]
	Stardust		
	Mars Global Surveyor	Planetary Data System	NASA Deep Space Network
	Smart-1 (ESA)	Planetary Science Archive (ESA)	
	Spitzer Space Telescope [L]		

- NAIF has/had project-supplied funding to support mission operations, consultation for flight team members, and data archive preparation.
- NAIF has token funding to consult with kernel producers at APL.
- NAIF has modest PDS-supplied funding to consult only on assembly of a SPICE archive.
- NAIF has NASA funding to support ESA in SPICE operations and review of SPICE archive, and to consult with flight team users.
- NAIF has PDS funding to help any professional scientist with using SPICE data that have been archived at the NAIF Node of the PDS: http://naif.jpl.nasa.gov/naif/data_pds_archived.html

How Can New Frontiers 3 Use SPICE?

- The project must produce SPICE files for use by scientists and others who need mission geometry
  - Have well trained SPICE producers at your mission control center

    or
  - Contract with the NAIF group at JPL to do the SPICE production, or to train your own SPICE producers, and to do follow-on consultation
- Instrument teams (and other presumptive SPICE users) need to learn to use SPICE
  - Your mission ops center people can provide that training, if already well versed in SPICE kernel production

    or
  - Contract with the NAIF group at JPL to provide a SPICE training class and follow-on consultation
- For SPICE archiving, the NAIF Node of the PDS is already funded through the PDS to provide a SPICE Archive User's Guide to your mission ops archive entity, and to ingest and peer review your SPICE archival data set.