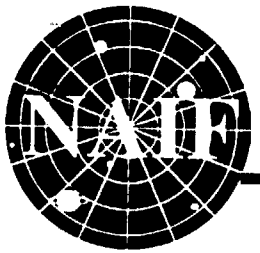

Navigation and Ancillary Information Facility

Standards Supporting Cooperation on Mission Planning, Data Analysis and Correlation of Results Within a Broad-based Mars Exploration Program

Poster Presentation By

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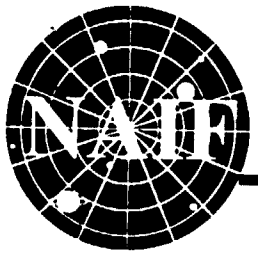
Caltech/Jet Propulsion Laboratory

February 2-3, 1999

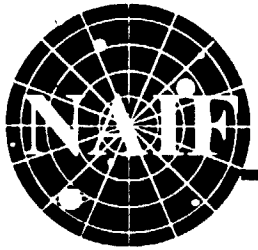
This work was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration



Purpose

Navigation and Ancillary Information Facility

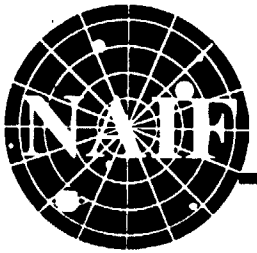
This poster is an invitation for participation in the specification and implementation of engineering and ancillary data standards, and allied software tools needed to conceptualize, design, operate and analyze the data returned from Mars and other solar system exploration missions



Why Have International Standards

Navigation and Ancillary Information Facility

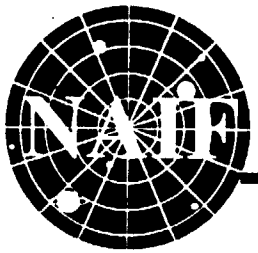
- Promote the exchange of ideas for mission design
- Help international team members participate in constructing or understanding detailed observation plans
- Improve national space agency cooperation in supporting mission operations, particularly as regards tracking and data acquisition
- Maximize the full and precise interpretation of data returned from the international Mars armada
- Reduce local development costs for information systems
- Make data readily accessible and easily/correctly useable by all interested parties



What Applications Can Be Addressed

Navigation and Ancillary Information Facility

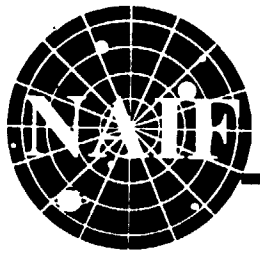
- **Planetary cruise**
  - In-situ measurement
  - Instrument calibration
- **Orbiters**
  - Remote sensing
  - In-situ measurement
  - Communications relay
- **Landers**
  - Remote sensing
  - In-situ measurements
  - Surface analysis
  - Rover relay
- **Rovers**
  - In-situ sensing
  - Surface Analysis
- **Balloons**
  - Remote sensing
  - In-situ measurements



What Information System Components Should Be Addressed

Navigation and Ancillary Information Facility

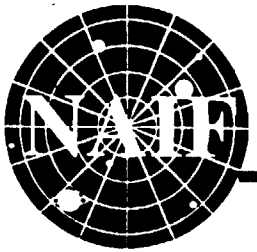
- **Ancillary Data**
  - Target and spacecraft positions and velocities
  - Target size, shape and orientation
  - Spacecraft orientation (pointing)
  - Instrument geometry (field-of-view size, shape, orientation)
  - Logs of commands and events
- **Reference systems**
  - Coordinate systems
  - Target shape models
  - Time
- **Related software for producing, using and comparing ancillary data**
- **Archive issues**
  - Standards
  - Servers, data searches and data access



What Kinds of Software Should Be Addressed - 1

Navigation and Ancillary Information Facility

- **Application Programs focused on ancillary data**
  - Mission (trajectory) visualization
  - Search for occurrences of interesting mission geometry
  - Detailed instrument observation planning
  - Instrument observation coverage/comparison
  - Timeline/events display
  - Comparisons of ancillary data between two missions
  - Mechanisms for recording important notes for future use



What Kinds of Software Should Be Addressed - 2

Navigation and Ancillary Information Facility

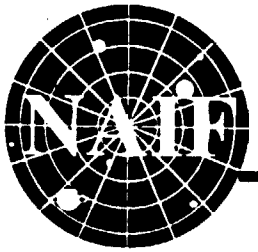
- **Utility Programs for ancillary data**
  - Archive browsing and data access
  - Data conversions between popular formats
  - File Management
  - Data validation
  - Data characterization and summarization
  - Archive products generation

- **Subprograms (subroutines)**
  - All conceivable functions potentially useful to the production, access, computation and management of ancillary data
  - All conceivable functions potentially useful to scientists for mission design, observation planning and science data analysis

What Should be Basic Requirements on Ancillary Data and Software

Navigation and Ancillary Information Facility

- Portable: files and software must be useable on, and easily moved between, all popular computing platforms
- Convenient: software must be available in popular languages
- Extensible: it must be easy to add/extend functionality
- Correct: all components must be thoroughly validated
- Precise: strictly limit and control the use of approximations; document such where used
- Documented: all components must be clearly documented to ensure easy and correct use
- Open: it seems best to make source code readily available
- Free: all components must be freely available and easily obtained by all interested parties
- Supported: real human help must be available



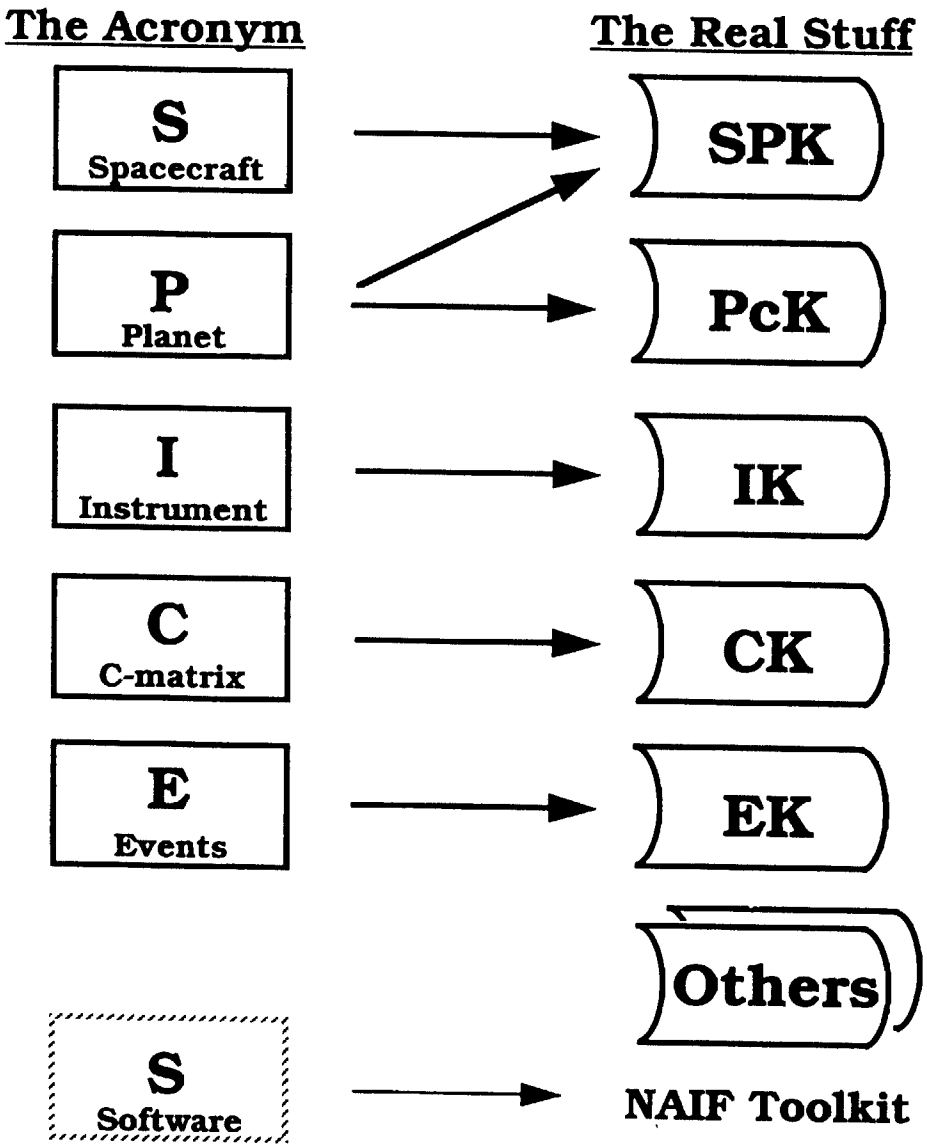
A Starting Point

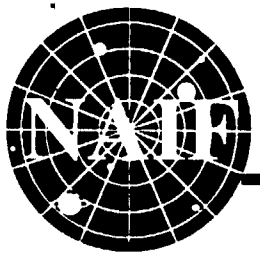
Navigation and Ancillary Information Facility

NASA offers its "SPICE" ancillary information system as a model and core set of blocks for building the tools needed to help design and execute a multimission, international exploration program.

Translating the Acronym

Navigation and Ancillary Information Facility





SPICE System Components

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"

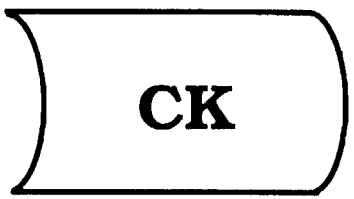
IK

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

(Separate IK file for each instrument)

SPICE System Components - 2

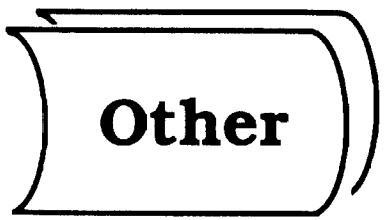
Navigation and Ancillary Information Facility



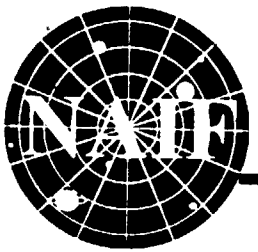
- Instrument platform attitude
- More generally, orientation of something relative to some reference frame

  (Separate file for each platform)

- Observation plan
- Spacecraft & instrument commands
- Scientists' "notebooks" and ground data system logs



- Spacecraft clock coefficients file
- Leapseconds file
- Other possibilities:
  - Star catalog, shape model, catalog, ...



SPICE System Components - 3

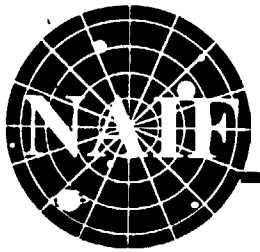
Navigation and Ancillary Information Facility

NAIF Toolkit

- SPICELIB subroutine library, used to
  - write SPICE kernel files
  - read SPICE kernel files
  - compute quantities derived from SPICE kernel data
- Example and utility programs

Also...

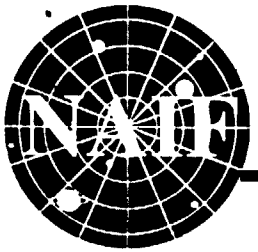
- Some kernel production programs
- A generic "Database Kernel" (DBK)
  - Relational model; SQL query language
- Broadly applicable SPICE-based tools are being developed, such as a "Solar System Calculator"



Examples of What Can You Do With SPICE - 1

Navigation and Ancillary Information Facility

- **Mission Designer**
  - Compute all interesting orbit properties; compare these with those of another design, or with another mission
  - Evaluate possibilities for relay link times and durations
- **Mission Operations**
  - Predict or evaluate telecommunications link performance
  - Analyze spacecraft orientation history
  - Determine elevation and rise/set times of sun and tracking stations
  - Determine location of a long range rover or a balloon

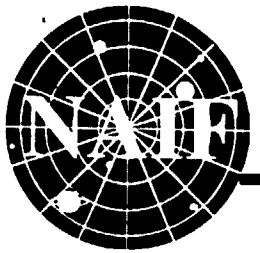


Examples of What Can You Do With SPICE - 2

Navigation and Ancillary Information Facility

- **Science**
  - Compute footprint coverage over time; compare against those from another instrument on your spacecraft or on a different spacecraft
  - Target specific observations to be acquired by your instrument
  - Compute observation geometry needed to analyze your data
    - » Lighting angles (phase, incidence, emission)
    - » Location (LAT/LON) of instrument footprint
    - » Smear magnitude

- **Visualization and Public Outreach**
  - Drive WWW pages giving interesting parameters such as ranges, velocities, time of day on Mars
  - Drive animations showing spacecraft location in orbit, spacecraft orientation, instrument footprint projected on Mars surface, relative locations of all probes



Room For Work by Partners

Navigation and Ancillary Information Facility

- **Extending core functionality (new building blocks)**
  - Target models
  - Landmark/features databases
  - Instrument models
  - Routines to search for specified geometric conditions
  - SPICELIB migration to C++ or Java
- **Building application programs**
  - Orbit characterization
  - Tools to facilitate cooperative planning in a distributed environment
  - Visualization
- **Data management**
  - Data files aggregation in a kernel library
  - SPICE kernels database
  - Mirror sites