Extending NASA's SPICE Ancillary Information System to Meet Future Mission Needs

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The SPICE system has been developed by the California Institute of Technology, under contract with the National Aeronautics and Space Administration

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Space Science Data: A Simplistic View

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Science Instrument Data including calibration data

For example:
- Images
- Spectra
- Counts
- etc.

Ancillary or Engineering Data

For example:
- Spacecraft Trajectory
- Target body location/shape
- Spacecraft orientation
- etc.

SPICE deals with these kinds of data

- **Some from the spacecraft**
- **Some from the mission control center**
- **Some from the spacecraft and instrument builders**
- **Some from scientists**

What are "Ancillary Data"?

- In the sense of this paper, "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 body being observed
  - what events were occurring on the spacecraft or ground that might affect interpretation of:
    - science observations
    - spacecraft systems performance

Pictorial of Ancillary Data

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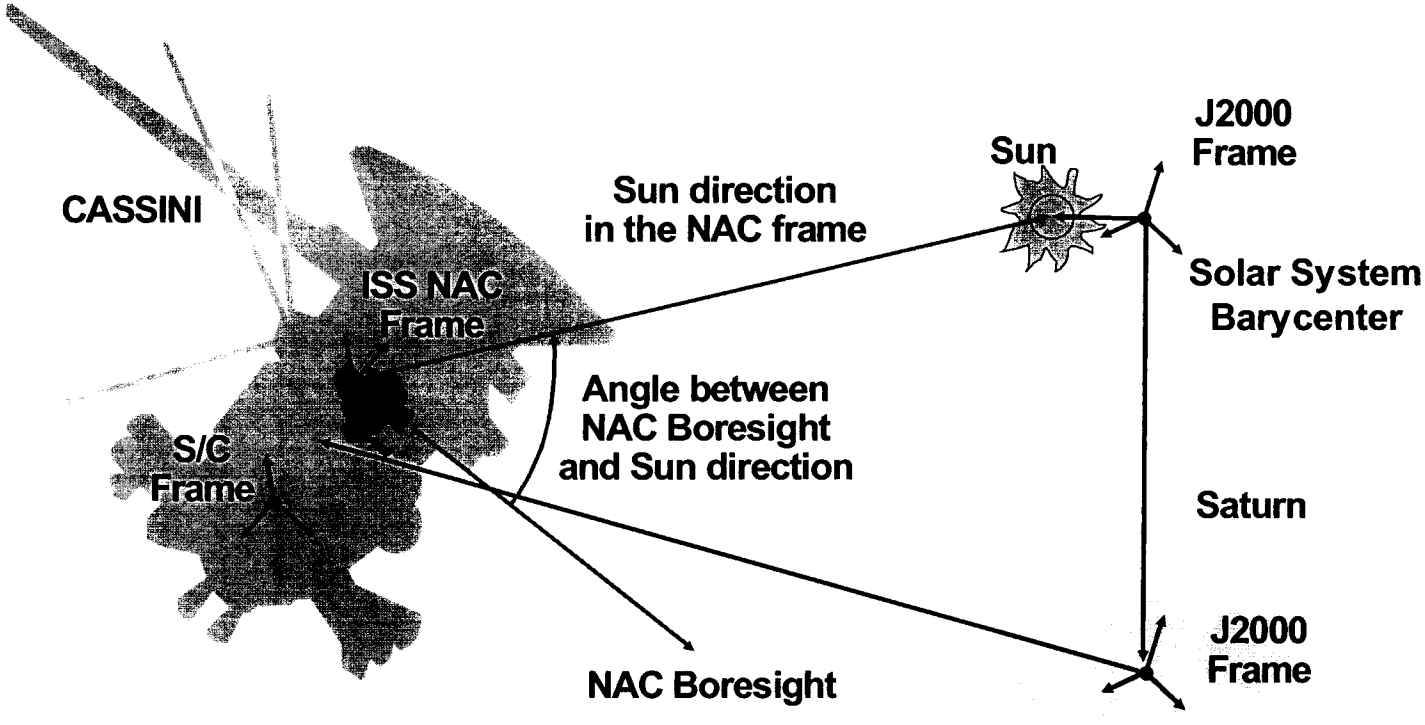
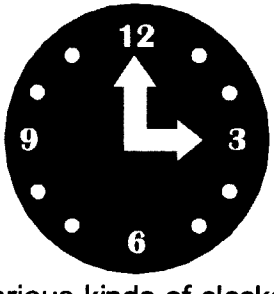
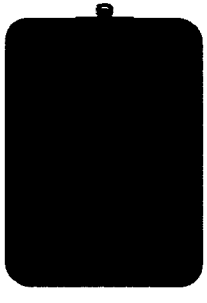
Observation Geometry,Time and Events

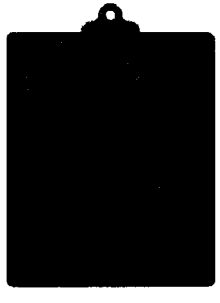




Various kinds of clocks (time systems)



Today's Plan of Observations



Yesterday's Log of Events

ISS = Imaging Science System:
NAC = Narrow Angle Camera
WAC = Wide Angle Camera

SPICE System Components

- The principal SPICE system components are two:
  - data files, often called “kernels” or “kernel files”
  - the SPICE Toolkit, consisting of:
    - an extensive subroutine library
    - utility programs
    - examples of how to use SPICE Toolkit subroutines
    - software documentation
- Also part of SPICE are:
  - customer support
  - system maintenance and evolution
  - deployment on flight projects
  - archiving of all SPICE data and software

Logical versus Physical View

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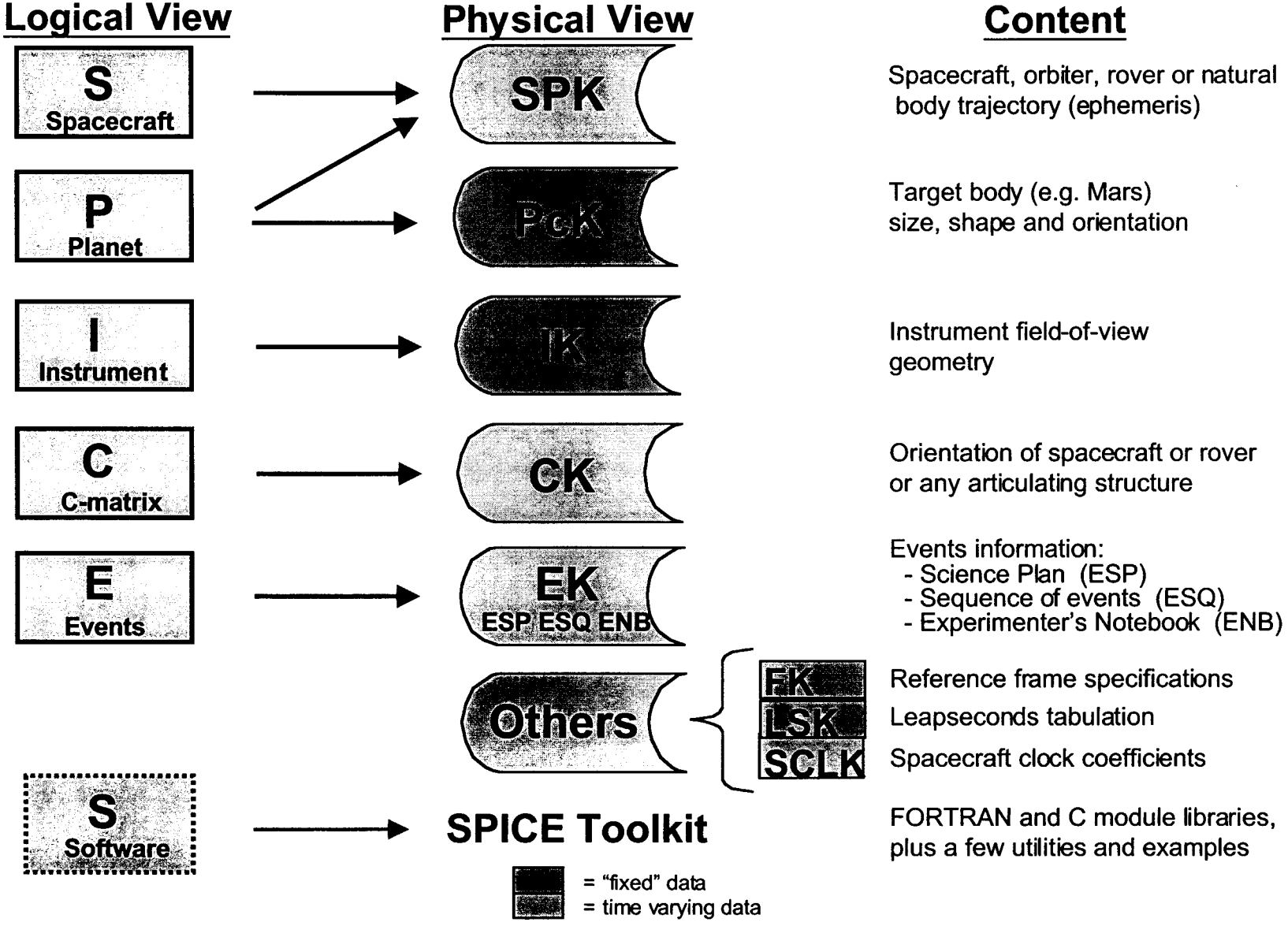

Using SPICE Library Modules

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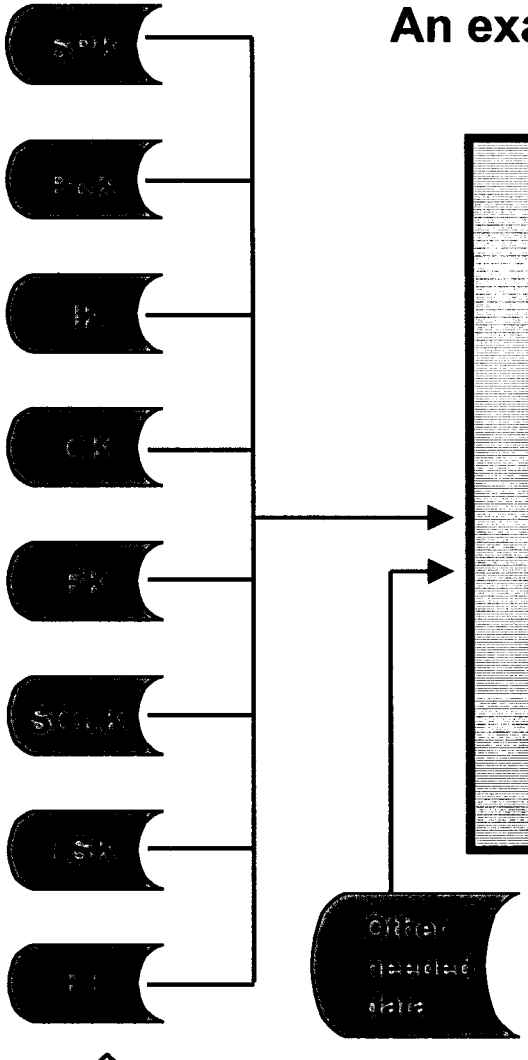
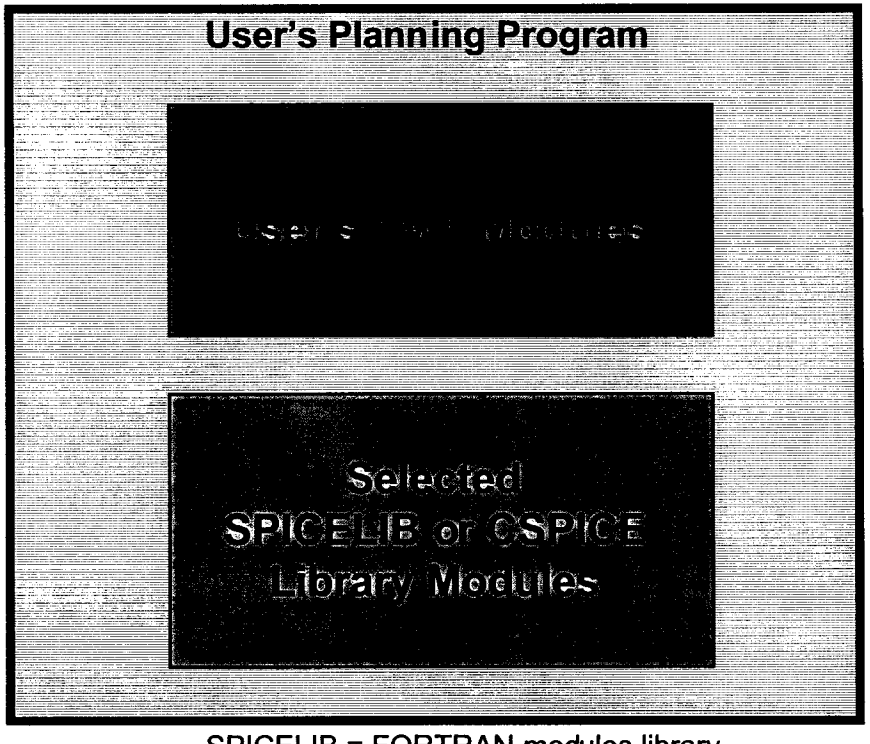
An example of using SPICE in a planning activity





SPICELIB = FORTRAN modules library
CSPICE = C modules library

- Instrument pointing plan

or

- Observation geometry visualization

or

- Analysis of expected communications link performance

Select kernel types as needed

Using SPICE Library Modules

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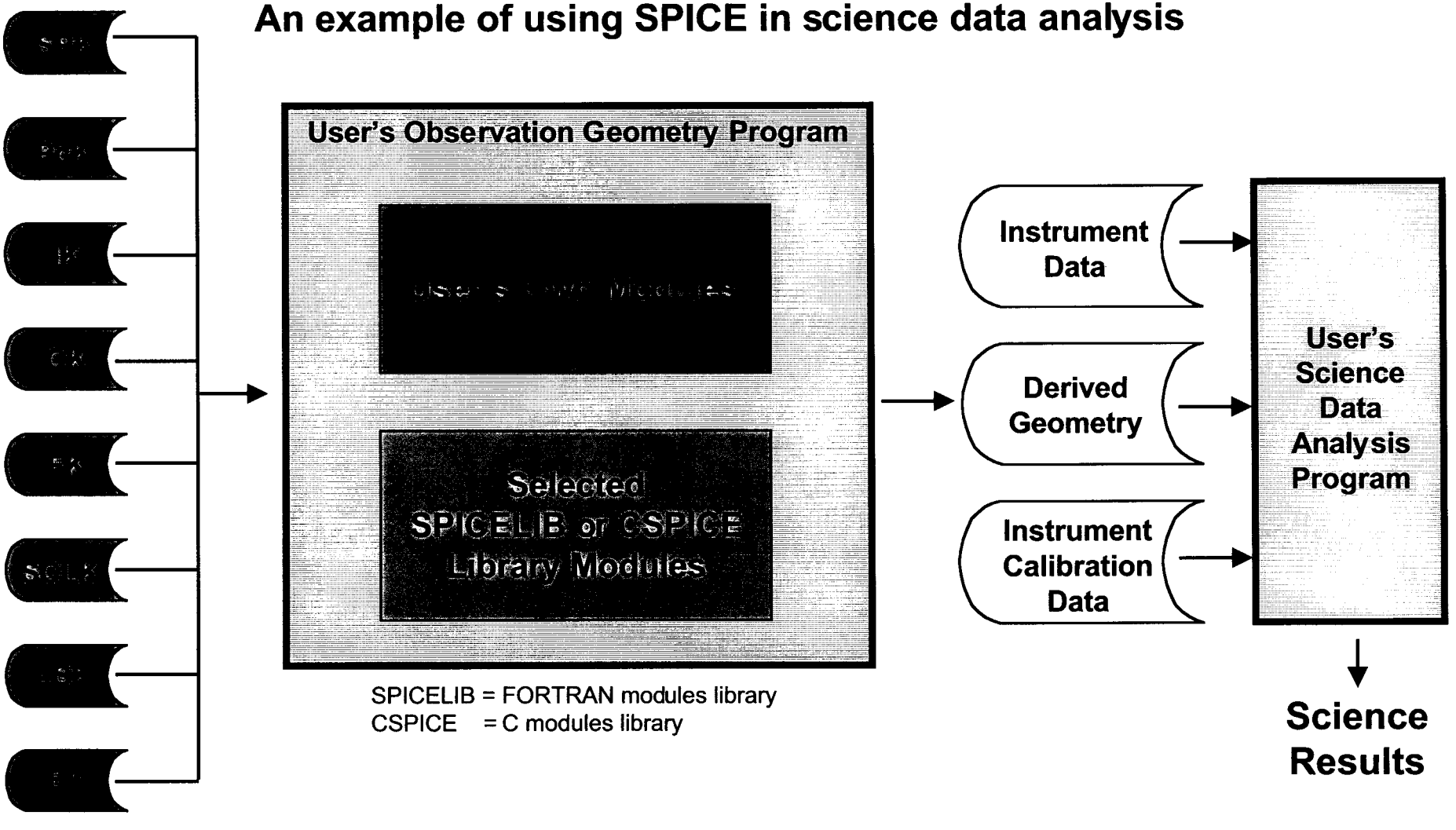
An example of using SPICE in science data analysis



SPICELIB = FORTRAN modules library
CSPICE = C modules library

Select just those SPICE files needed for your particular task

Key SPICE System Characteristics

- SPICE kernel files and Toolkit software are portable to all popular computing platforms
- All computations are double precision
- Kernel files are separable and extensible
- Multimission and multidiscipline applicability
- The SPICE Toolkit is free to individual users
- Very few restrictions on distribution and use of SPICE software and SPICE files

For What Jobs is SPICE Used ?

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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
- Helping to point and tune Deep Space Network antennas
- Science data analysis, including correlation of results between instruments, and with data obtained from other missions
- Data archiving, for future use by others

The original focus of SPICE

- Education and public outreach

Planned New Capabilities - 1

- New interfaces to SPICELIB for user's local applications
  - IDL© (partial implementation in Beta-test now)
  - Matlab© (implementation has been started)
  - Java
  - Excel©
- Simple web-based ancillary information tools
  - See "GEOCALC" chart attached
- SPICE interpreter
  - Will provide most SPICE functionality without customer having to write a program
- SPICE kernels database
  - Means for logically aggregating related SPICE kernel files for some purpose
- Broader scoped and more easily used SPICE kernel production tools
- More validation tools for SPICE kernel producers

Planned New Capabilities - 2

- New kernel types
  - Terrain data
  - Sky catalog data
  - Tessellated plate model for small, irregularly shaped bodies
  - Control net data
- Better integration with popular orbit visualization tools
  - See attached chart
- Provide SPICE programming lesson book

Possibilities for Further Evolution - 1

- Add mechanism(s) for providing and using accuracy information in orbit (SPK) and attitude (CK) files
- Add more high-level computations such as coverage analysis
- Add additional target models: rings, gravity, atmosphere, magnetosphere
- Provide tools for easier specification and visualization of reference frames
- Add hyperlinks to all SPICE documentation

Possibilities for Further Evolution - 2

- Provide direct interface with JPL's extensive high-precision comet & asteroid database
- Provide a thread-safe version of CSPICE
- Develop an object-oriented version of SPICE
- Develop a more flexible and extensible instrument modeling mechanism
- Provide interface(s) with popular CAD modeling tools

GEOCALC
A Simple, Web-based Geometry Calculator

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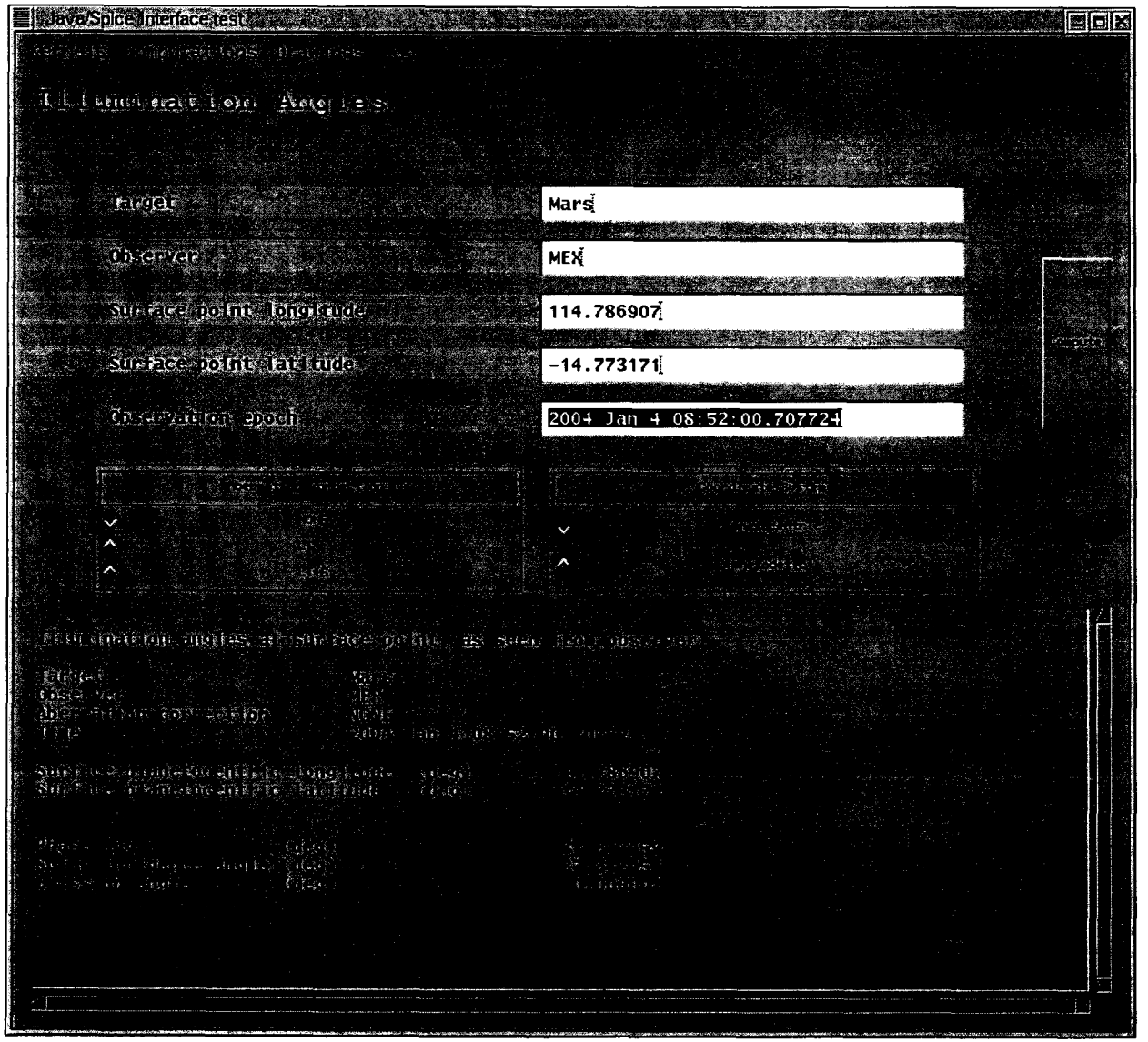

Compute the phase, solar incidence and emission angles at some surface point on a target as seen from an observer at some epoch.

In this example, compute the illumination angles on Mars at LON 114.7 and LAT -14.7 as seen from Mars Express on 2004 JAN 4 08:52:00. Can pick either planetocentric or planetodetic frame.

Visualization Tools Using SPICE

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Graphic courtesy of Analytical Graphics Inc.

Several popular COTS and GOTS tools such as Satellite Toolkit© and Satellite Orbit Analysis Program© already have some capabilities to use portions of SPICE, but further integration is possible.

Building Blocks for Your Applications

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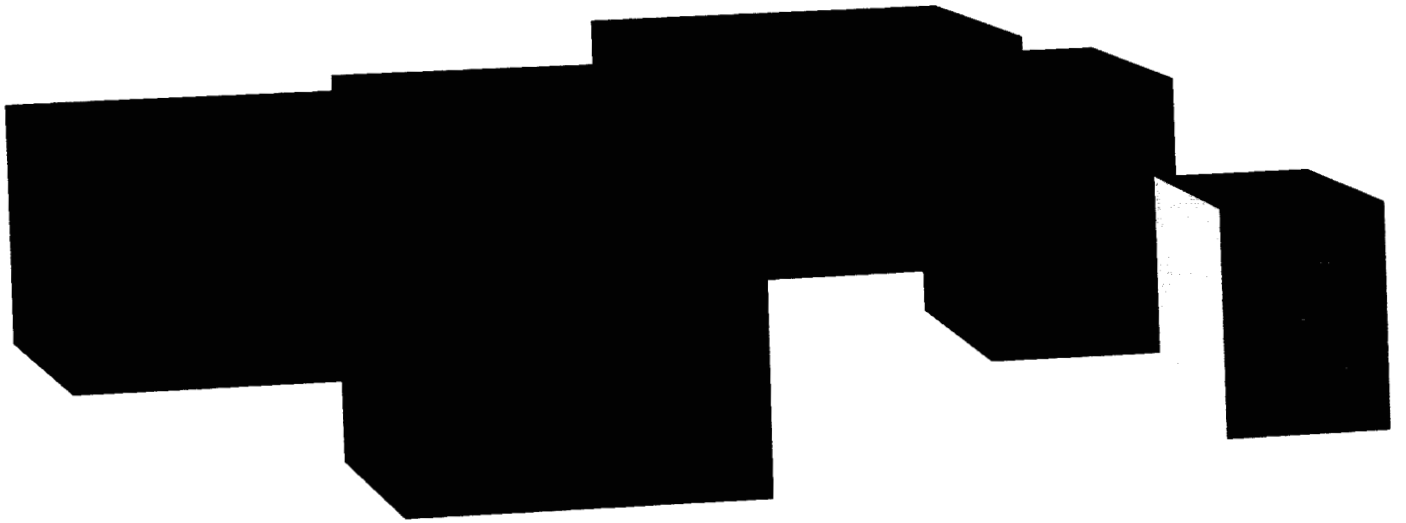
NAIF offers its "SPICE" ancillary information system as a model and core set of blocks for building tools that can help execute a multimission, international space exploration program



Interfaces with CCSDS Standard Products

- The Consultative Committee on Space Data Systems, Panel 1J, has recently developed a draft standard–called "Orbit Data Message"–for interagency exchange of orbit data
  - This provides two distinct standards for easily exchanging orbit information
    - "OPM": State vector or conic element set
    - "EPM": Set of state vectors, providing a complete ephemeris
      - SPICE system engineers have already developed software to convert the "EPM" style Orbit Data Message into a SPICE SPK file
- A somewhat similar standard for interagency exchange of spacecraft attitude data is also being developed
  - A utility to convert this attitude product into a SPICE CK file will be implemented once the standard is approved by the CCSDS

How Can SPICE Help You?

Contact the author if you have questions about how SPICE capabilities might help your endeavor

or

if you have suggestions for how to improve or extend SPICE functionality.