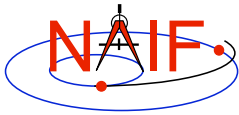


Navigation and Ancillary Information Facility

Introduction to the SPICE Toolkit

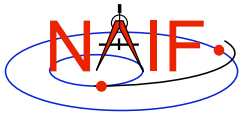
March 2006



Topics

Navigation and Ancillary Information Facility

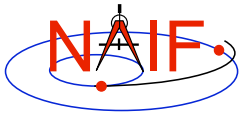
- **SPICE Toolkit Components**
- **SPICE Toolkits for Fortran, C, and IDL**
- **Supported Platforms**
- **Kernels**
- **Applications**
- **Library Functionality**
- **Documentation**
- **Installed Directory Structure**



SPICE Toolkit Components - 1

Navigation and Ancillary Information Facility

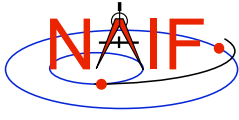
- **The SPICE Toolkit is available in Fortran, C and IDL***
 - The Fortran and C Toolkits provide virtually identical functionality
 - » Differences will be elaborated upon later
 - Icy, the IDL Toolkit, will eventually duplicate almost all functionality from the C Toolkit API-level routines.
- **Toolkits contain:**
 - **Software**
 - » **Subroutine libraries, with source code included**
 - SPICELIB (Fortran)
 - CSPICE (C)
 - Icy (C)
 - » **Executable programs**
 - application and utility programs
 - cookbook examples
 - » **Installation scripts**
 - **Documentation**
 - » **readme**
 - » **dscripnt.txt**
(continued on next page)



SPICE Toolkit Components - 2

Navigation and Ancillary Information Facility

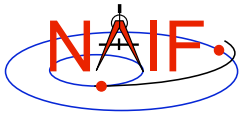
- » **intrdctn.txt**
- » **whats.new**
- » **“Required Reading” reference documents for major families (ASCII and HTML)**
- » **User’s Guides for executables (ASCII and HTML)**
- » **permuted index**
 - Fortran Toolkit: spicelib.idx
 - CSPICE, Icy: cspice.idx
- » **mostused.ps (Fortran Toolkit only)**
- » **module headers (ASCII and HTML, HTML for CSPICE & Icy API)**
- **Data**
 - » **Sample kernel files**
 - Supplied **ONLY** for use with cookbook programs, not valid for general use
- **The components listed above are included in the generic Toolkit**
 - **Toolkits delivered to missions or other special customers may be augmented with mission- or customer-specific products**



Fortran SPICE Toolkit

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- **The Fortran SPICE Toolkit:**
 - Developed first: in use for about 15 years
 - Contains code written only in ANSI Standard Fortran 77
 - » A few widely supported non-ANSI extensions are used, for example DO WHILE, DO...END DO
 - Compiles under a wide variety of Fortran compilers

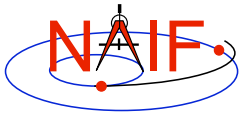


CSPICE - 1

Navigation and Ancillary Information Facility

- **CSPICE is a newer product—first officially delivered in 1999—designed to duplicate the functionality of the Fortran Toolkit**
 - All CSPICE source code is in ANSI C
 - » Fortran SPICE Toolkit code has been converted to ANSI C using the automatic translation program f2c
 - » High-level functions have been hand-coded in C and documented in C style in order to provide a natural C-style API. These functions are called “wrappers”
 - » Most wrappers encapsulate calls to C functions generated by f2c
 - The simpler wrappers do their work in-line, to boost performance
 - CSPICE documentation has been “converted to C”
 - » Code examples are in C
 - CSPICE runs under a wide variety of ANSI C compilers
 - CSPICE functions may be called from within C++ source code
 - » CSPICE prototypes are protected from name mangling

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CSPICE - 2

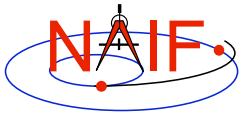
Navigation and Ancillary Information Facility

- f2c'd functions may be called directly, but this is not recommended since f2c'd functions emulate Fortran functionality:
 - » Call by reference
 - » Fortran-style array indexing
 - » Fortran-style strings

- **Current CSPICE Limitations**

- Not all “Required Reading” reference documents have been converted to C style, with C examples
 - » Eventually all will be converted
- CSPICE wrappers exist for only a subset of the functionality provided by SPICELIB
 - » Includes all the most commonly used modules
 - » More will be added as time permits

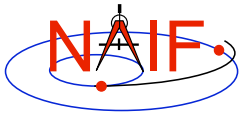
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CSPICE - 3

Navigation and Ancillary Information Facility

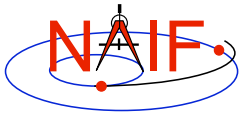
- In some very limited cases, code generated by f2c fails to emulate Fortran accurately
 - » List-directed I/O has some problems (not consequential for CSPICE)
 - » Treatment of white space in text output is slightly different in CSPICE
 - » Logical unit-to-file name translation does not handle file name "synonyms" properly under Linux: once opened with a specified name, a file must be referred to using the same name throughout a program run.



Icy - 1

Navigation and Ancillary Information Facility

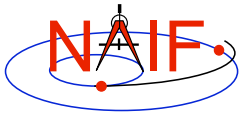
- **Icy is a SPICE Toolkit for IDL users.**
 - First delivered as part of the N0057 Toolkit in March, 2004.
 - Has existed as a distributed prototype system for several years.
- **Icy provides an IDL-callable “wrapper” interface for most CSPICE wrapper routines**
 - Example:
 - » CSPICE: `spkezt_c (targ, et, ref, abcorr, obs, state, &itime);`
 - » Icy: `cspice_spkezt, targ, et, ref, abcorr, obs, state, itime`
 - Currently 290 CSPICE wrappers are callable from IDL via the Icy interface.
 - Eventually most CSPICE wrappers will be callable from IDL via Icy
- **By necessity all Icy Toolkit packages include the complete CSPICE Toolkit.**



Icy - 2

Navigation and Ancillary Information Facility

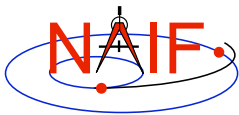
- **Icy API software components**
 - IDL interface wrappers (implemented in ANSI C)
 - Icy cookbook programs (implemented in IDL)
- **Icy Documentation**
 - Icy Reference Guide
 - » Each Icy wrapper has an HTML page serving as SPICE “module header”
 - » Principal documentation showing how to call Icy wrappers
 - » HTML pages contain code examples
 - Icy Required Reading
 - » Provides background information essential for programming with Icy
- **Icy Testing**
 - A regression test suite (`ticy`) exercises the complete Icy API on all supported platforms.



Compatibility

Navigation and Ancillary Information Facility

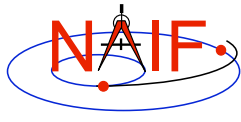
- **The Fortran, CSPICE and IDL Toolkits use identical kernel files on all platforms.**



Supported Platforms - 1

Navigation and Ancillary Information Facility

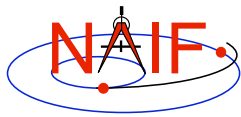
- **The SPICE Toolkit has been ported to a wide variety of popular platforms**
 - Each platform is characterized by
 - » Hardware type
 - » Operating System
 - » Compiler
 - » Selected compilation options
- **NAIF provides separate SPICE Toolkit packages for each supported platform**
 - If you cannot find a pre-built package for the platform of interest to you, contact NAIF
 - » **Don't try to port the Toolkit from another platform**



Supported Platforms - FORTRAN

Navigation and Ancillary Information Facility

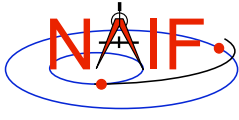
Product Name	Operating System	Compiler
HP	HP-UX	HP FORTRAN
Mac_OSX_Abssoft	OS 10.x	Abssoft f77
Mac_OSX_g77	OS 10.x	g77
PC_Cygwin	Windows/Cygwin	g77
PC_Lahey	Windows 95/98/NT/2K	Lahey 95
PC_Linux	Red Hat Linux 6.1+	g77
PC_Win95/NT_Digital FORTRAN	Windows 95/98/NT/2K	Visual Fortran (Digital/Compaq)
Sun_Solaris	Solaris 7+	Sun Fortran



Supported Platforms - C

Navigation and Ancillary Information Facility

Product Name	Operating System	Compiler
HP_C	HP-UX	HP C
Mac_OSX_Apple_C	OS 10.x	Apple/gcc
PC_Cygwin_C	Windows/Cygwin	gcc
PC_Linux_C	Red Hat Linux 6.1+	gcc
PC_Win95NT_C	Win 95/98/NT/2K	MS Visual C/C++
Sun_Solaris_C	Solaris 7+	Sun C
Sun_Solaris_GCC	Solaris 7+	gcc
Sun_Solaris_GCC_64bit	Solaris 7+	gcc 64 bit

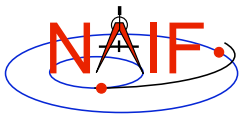


Supported Platforms - IDL

Navigation and Ancillary Information Facility

Product Name	Operating System	Compiler
Mac_OSX_Apple_C	OS 10.x	Apple/gcc
PC_Linux_C	Red Hat Linux 6.1+	gcc
PC_Win95NT_C	Win 95/98/NT/2K	MS Visual C/C++
Sun_Solaris_C	Solaris 7+	Sun C
Sun_Solaris_GCC	Solaris 7+	gcc

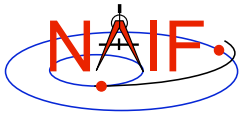
IDL version is 6.2 for all of the above platforms



Toolkit Utility Programs

Navigation and Ancillary Information Facility

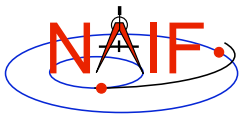
- **SPICE Toolkit utility programs are available to:**
 - port binary SPICE kernels between incompatible systems
 - » tobin, toxfr, spacit
 - add comments to binary kernels
 - » commnt
 - read comments from binary kernels
 - » commnt, spacit
 - » inspekt (only for EK/ESQ files)
 - summarize coverage of binary kernels
 - » brief, ckbrief, spacit
 - merge or subset SPK files
 - » spkmerge
 - Indicate current Toolkit version
 - » version



Toolkit Application Programs

Navigation and Ancillary Information Facility

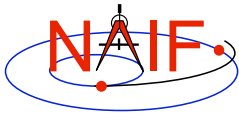
- **SPICE Toolkit application programs perform various tasks:**
 - create a new SPK file from a text file holding one of various kinds of state vectors
 - » `mkspk`
 - carry out a wide assortment of time conversions
 - » `chronos`
 - query binary Event Kernels (EKs)
 - » `inspekt`



Toolkit Library Functionality - 1

Navigation and Ancillary Information Facility

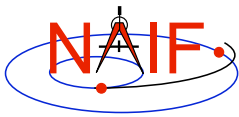
- **Kernel read access**
 - “Load” kernels
 - Get state or position vectors (SPK)
 - Get orientation of planets, natural satellites, etc. (PCK)
 - Get body shape parameters or physical constants (PCK)
 - Get orientation of spacecraft or spacecraft instruments or structures (CK, FK)
 - Get instrument parameters (e.g., FOV) (IK)
 - Query binary EK files (EK-ESQ)
- **Kernel write access**
 - SPK writers
 - CK writers
 - EK writers (sequence component, ESQ)
 - PCK writers (only for binary PCK files)



Toolkit Library Functionality - 2

Navigation and Ancillary Information Facility

- **Additional ephemeris functions**
 - Classical osculating elements
 - Two-body Keplerian propagation
 - Two line elements sets (TLE) propagation
 - Light time and Stellar aberration computation
- **Frame transformation**
 - Obtain 3x3 matrices for frame transformations of positions
 - Obtain 6x6 matrices for frame transformations of states
- **Time conversion**
 - Conversion between standard systems: TDB, TT (TDT), UTC
 - Conversion between SCLK and other systems
 - Parsing and formatting

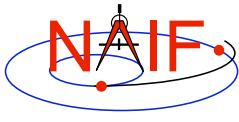


Toolkit Library Functionality - 3

Navigation and Ancillary Information Facility

- **Math**
 - Vector/Matrix operations
 - Rotations, Euler angles, quaternions
 - Coordinate conversion (systems: latitudinal, cylindrical, rectangular, RA and DEC, spherical, geodetic, planetographic)
 - Geometry: ellipsoids, ellipses, planes
 - High-level functions: illumination angles, sub-observer point, sub-solar point, surface intercept point.
- **Constants**
 - Julian date of epoch J2000, SPD(seconds per day), PI, etc.
- **Strings**
 - Parsing: find tokens, words
 - Numeric conversion

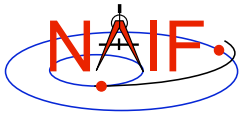
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Toolkit Library Functionality - 4

Navigation and Ancillary Information Facility

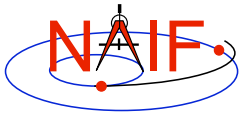
- Pattern matching
- Replace marker, substring
- Suffix, prefix
- Case conversion
- Find first/last non-blank character, first/last printing character
- **Arrays**
 - Sorting, finding order vector, reordering
 - Searching: linear, binary
 - Insertion and deletion
- **Name/code conversion**
 - Bodies
 - Frames



Toolkit Library Functionality - 5

Navigation and Ancillary Information Facility

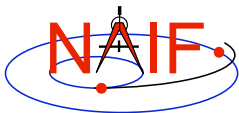
- **I/O support**
 - Logical unit management
 - Open, read, write text files
 - Kernel pool API
- **Exception handling**
 - Control exception handling behavior: mode, message set, output device
 - Construct error messages
- **Advanced data types**
 - Cells, Sets
 - Schedules
 - Symbol Tables
 - Planes, Ellipses



Toolkit Documentation - 1

Navigation and Ancillary Information Facility

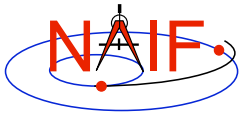
- **Module headers**
 - Act as functional specification: I/O, exceptions, particulars defining behavior of module
 - Contain code examples
 - Standard format, used for each routine or entry point
- **intrdctn.txt**
 - Introduction to the SPICE Toolkit : organization and contents
- **Required Reading**
 - References for principal subsystems
 - Provides many low-level details
 - Provides code examples
- **User's guides for applications**
 - [brief.ug](#), [commnt.ug](#), [chronos.ug](#), etc.



Toolkit Documentation - 2

Navigation and Ancillary Information Facility

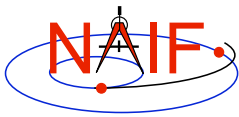
- **Permuted Index**
 - Maps phrases describing functionality to corresponding module names and file names
 - Shows locations of entry points in Fortran toolkits
- **dscriptn.txt**
 - Describes the directory structure and contents of an installed Toolkit
 - Customized based on set of delivered products and platform
- **README**
 - Contains Toolkit installation instructions
- **whats.new**
 - Describes new features and bug fixes
- **version.txt**
 - Indicates Toolkit version
- **HTML pages**
 - For User's Guides, Required Reading, and Module Headers



Installed Directory Structure - 1

Navigation and Ancillary Information Facility

- **Fortran, C and IDL Toolkits are delivered as distinct, standalone products**
 - The IDL product includes the CSPICE Toolkit
- **Directory structures for the Toolkits are almost identical. However...**
 - Unlike SPICE, CSPICE and Icy have a directory for include files
 - The names for application source code directories in CSPICE differ, slightly, from those in SPICE
 - Icy has additional directories for
 - » Icy source code
 - » Icy cookbook programs
 - » Icy HTML pages comprising the Icy Reference Guide



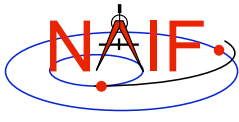
Installed Directory Structure - 2

Navigation and Ancillary Information Facility

Directory structure

- **The top level is**
 - “toolkit” for Fortran Toolkits
 - “cspice” for C Toolkits
 - “icy” for IDL Toolkits
- **The next level is comprised of:**
 - data
 - » cookbook example kernels (use ONLY for training with cookbook programs)
 - doc
 - » *.req, *.ug, spicelib.idx/cspice.idx, whats.new, dscriptn.txt, intrdctn.txt, version.txt
 - » Now contains HTML documentation as well in “html” subdirectory
 - » For Icy, the “html” subdirectory contains an “icy” subdirectory for the HTML pages comprising the Icy Reference Guide.
 - etc
 - » Miscellaneous items. Example: nav libraries for the conversion program niospk (not part of the generic Toolkit). This directory is empty by default.

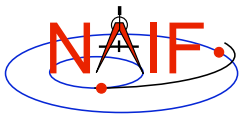
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Installed Directory Structure - 3

Navigation and Ancillary Information Facility

- **exe**
 - » **Toolkit executables:** brief, chronos, ckbrief, commnt, inspekt, spacit, spkmerge, tobin, toxfr
- **include** (Applies to CSPICE and Icy)
 - » **API header files.**
 - File to include in callers of CSPICE is SpiceUsr.h
- **lib**
 - » **Toolkit libraries:**
 - spicelib.a / cspice.a (public modules; use these)
 - support.a / csupport.a (private modules; don't use these)
 - For icy:
 - icy.so (shared object library)
 - icy.dlm (dynamically loadable module)
- **src**
 - » **Source code directories for products:** executables, libraries. Files have type *.f, *.for, *.inc, *.pgm, *.c, *.h, *.x, .pro
 - » **.h files appearing here are not part of user API**



Toolkit Versions

Navigation and Ancillary Information Facility

- **Generic SPICE Toolkits have an associated Version number**
 - Example: "N0060" (also written as "N60")
- **The version number applies to the FORTRAN, C and IDL implementations for all supported platforms.**
- **Toolkit deliveries to flight projects normally consist of the current generic Toolkit, possibly augmented with a few mission-specific extras**
- **When does NAIF release new SPICE Toolkit versions?**
 - Not according to a fixed schedule
 - Primarily driven by addition of significant, new capabilities to Toolkit
 - » Icy, for example
 - Occasionally minor Toolkit updates are released to fix bugs, improve documentation, or satisfy an urgent request from a flight project