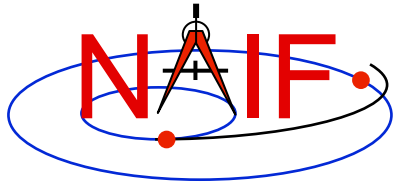


Navigation and Ancillary Information Facility

Introduction to the Family of SPICE Toolkits

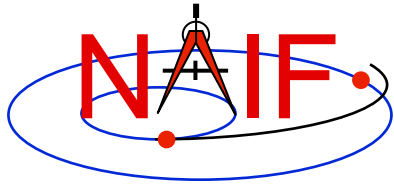
April 2016



Topics

Navigation and Ancillary Information Facility

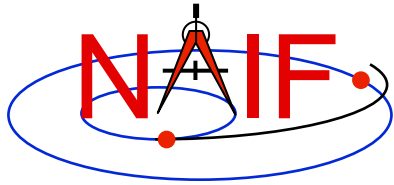
- **Architecture**
- **Contents**
- **Characteristics**
- **Versions**
- **Capabilities**
- **Directory Structure**
- **Application Programs**
- **Utility Programs**
- **Documentation**
- **Backup: Currently Supported Environments**



Toolkit Architecture

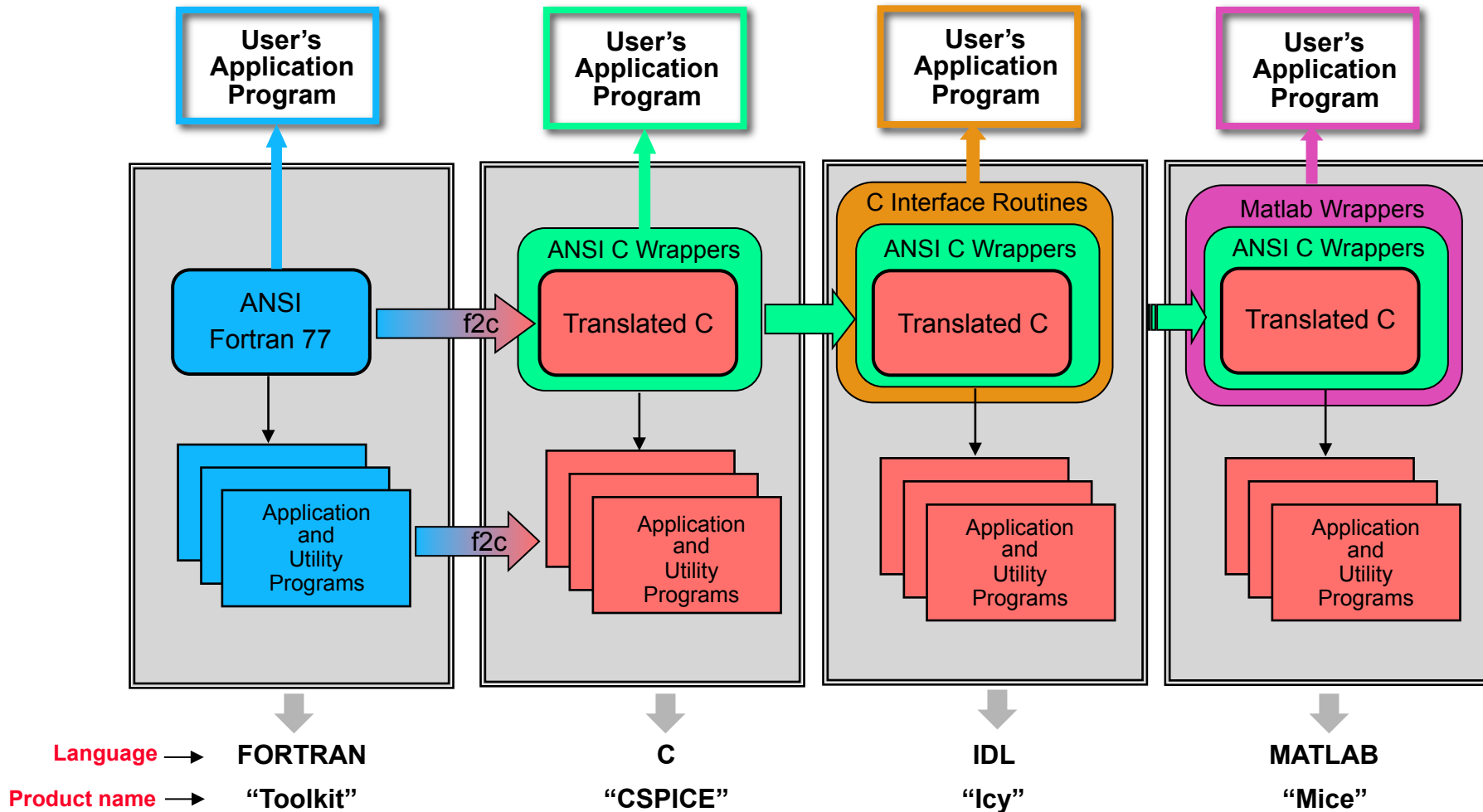
Navigation and Ancillary Information Facility

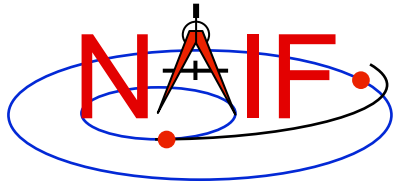
- **The SPICE Toolkit is available in Fortran, C, IDL (Interactive Data Language), and Matlab.**
- **The Fortran, C, IDL, and Matlab Toolkits are packaged and delivered as standalone products.**
 - **The IDL and Matlab Toolkits, by necessity, also include the complete C Toolkit.**



Toolkit Architecture Pictorial

Navigation and Ancillary Information Facility

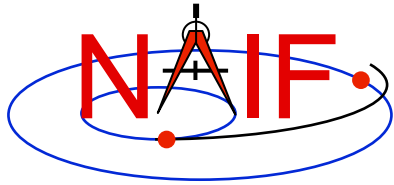




Toolkit Contents

Navigation and Ancillary Information Facility

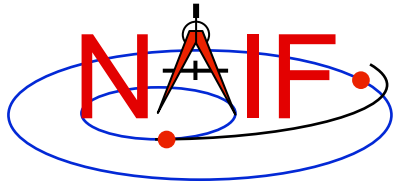
- **Software**
 - Subroutine libraries, with source code
 - » SPICELIB (Fortran)
 - » CSPICE (C)
 - » Icy (C)
 - » Mice (C and Matlab scripts)
 - Executable programs
 - » Application and utility programs
 - » A few example programs (called “cookbook”)
 - Installation/build scripts
- **Documentation**
 - Available in plain text and HTML
- **Data**
 - Sample kernel files (supplied only for use with cookbook example programs, not valid for general use).



Toolkit Characteristics

Navigation and Ancillary Information Facility

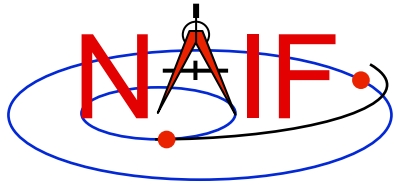
- **Computations are identical in all languages.**
- **For a given computer and operating system, all Toolkits use identical kernel files.**
 - Refer to the “Porting Kernels” tutorial for information about using kernels received from a machine different from what you are using.
- **Code is well tested before being released to users.**
- **New Toolkits are always backwards compatible.**
 - An application that worked when linked against an older Toolkit will link and work, without need for changes, using a new Toolkit.
 - Past functionality is never changed or removed, except that:
 - » enhancements of existing routines are allowed.
 - » NAIF reserves the right to fix bugs.
- **Extensive user-oriented documentation is provided.**
 - Includes highly documented source code.



Toolkit Versions

Navigation and Ancillary Information Facility

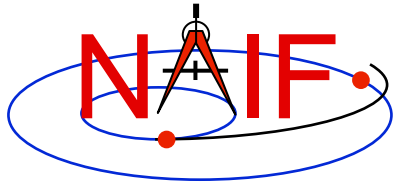
- **Toolkit Version**
 - **SPICE Toolkits have an associated Version number**
 - » Example: “N0065” (also written as “N65”)
 - **The version number applies to the Fortran, C, IDL and Matlab implementations for all supported platforms.**
- **When does NAIF release a new SPICE Toolkit version?**
 - » **Not according to a fixed schedule**
 - » **Primarily driven by availability of significant new capabilities**
 - For example, the digital shape kernel subsystem (DSK)
 - » **On rare occasion a Toolkit update is released to fix bugs, improve documentation, or satisfy an urgent request from a flight project.**



Toolkit Library Overview

Navigation and Ancillary Information Facility

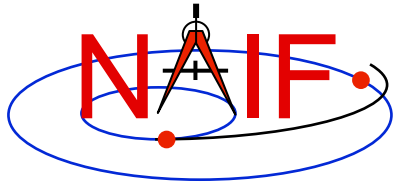
- **Toolkit libraries contain a broad set of capabilities related to the computations needed for determining “observation geometry” and time conversions.**
- **Not all functionality is present in all four language versions of the Toolkit library.**
 - **The Fortran (Toolkit) and C (CSPICE) Toolkits provide almost identical functionality.**
 - **The IDL (Icy) Toolkit duplicates most functionality available in the C Toolkits.**
 - **The Matlab (Mice) Toolkit provides interfaces to those routines NAIF considers the most often needed by users.**
 - » **We add additional interfaces as time permits.**



Toolkit Library Capabilities - 1

Navigation and Ancillary Information Facility

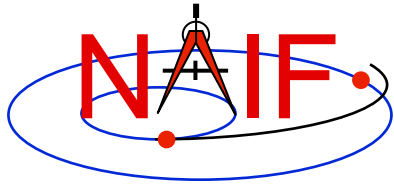
- **Kernel read access**
 - “Load” kernels
 - Get state or position vectors (SPK)
 - Get orientation of planets, natural satellites, etc. (PCK)
 - Get body shape parameters or physical constants (PCK)
 - Get orientation of spacecraft or spacecraft instruments or structures (CK, FK)
 - Get instrument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



Toolkit Library Capabilities - 2

Navigation and Ancillary Information Facility

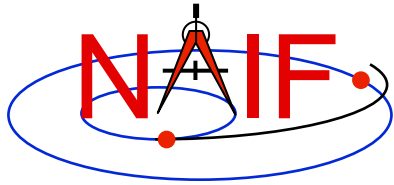
- **Additional ephemeris functions**
 - Classical osculating elements
 - Two-body Keplerian propagation
 - NORAD two line elements sets (TLE) propagation
 - Light time and Stellar aberration computation
- **Frame transformations**
 - Obtain 3x3 matrices for frame transformations of positions
 - Obtain 6x6 matrices for frame transformations of states
- **Time conversions**
 - Conversion between standard systems: TDB, TT (TDT), UTC
 - Conversion between SCLK and other systems
 - Parsing and formatting
- **Geometry finder calculations**
 - Find times or time spans when a specified geometric situation is true
 - Find times or time spans when a specified geometric parameter is within a given range, or is at a maximum or minimum



Toolkit Library Capabilities - 3

Navigation and Ancillary Information Facility

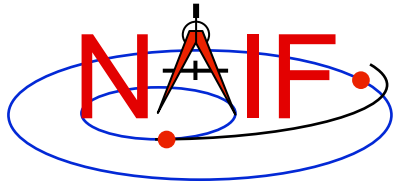
- **Math**
 - Vector/Matrix operations
 - Rotations, Euler angles, quaternions
 - Coordinate conversion (systems: latitudinal, cylindrical, rectangular, RA and DEC, spherical, geodetic, planetographic)
 - Geometry: ellipsoids, ellipses, planes
 - High-level functions: illumination angles, sub-observer 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
 - Pattern matching
 - Replace marker, substring
 - Suffix, prefix
 - Case conversion
 - Find first/last non-blank character, first/last printing character



Toolkit Library Capabilities - 4

Navigation and Ancillary Information Facility

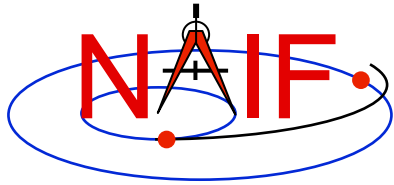
- **Arrays**
 - Sorting, finding order vector, reordering
 - Searching: linear, binary
 - Insertion and deletion
- **Name/ID code conversion**
 - Bodies
 - Frames
- **I/O support**
 - Logical unit management (Fortran toolkits)
 - Open, read, write text files
 - Kernel pool API
- **Exception handling**
 - Control exception handling behavior: mode, set message, assign output device.



Toolkit Library Capabilities - 5

Navigation and Ancillary Information Facility

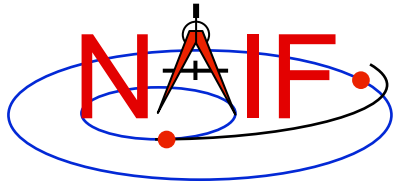
- **Advanced data types**
 - Cells, Sets
 - Windows (sometimes called schedules)
 - Symbol Tables
 - Planes, Ellipses



Toolkit Directory Structure

Navigation and Ancillary Information Facility

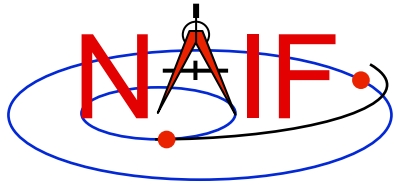
- **The top level directory name for each Toolkit is:**
 - “**toolkit**” for Fortran Toolkits.
 - “**cspice**” for C Toolkits.
 - “**icy**” for IDL Toolkits.
 - “**mice**” for Matlab Toolkits.
- **The directory structures for the four kinds of Toolkits are almost identical. However...**
 - The **CSPICE**, **Icy** and **Mice** Toolkits also have a directory for include files.
 - The names for application source code directories in **CSPICE**, **Icy** and **Mice** differ slightly from those in the Fortran toolkit.
 - **Icy** and **Mice** include additional directories for :
 - » **Icy/Mice** source code
 - » **Icy/Mice** cookbook programs



Toolkit Directory Structure

Navigation and Ancillary Information Facility

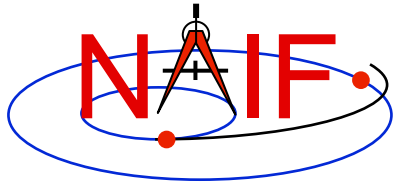
- **The next level is comprised of:**
 - **data**
 - » Cookbook example kernels (use **ONLY** for training with cookbook programs).
 - **doc**
 - » Text documents — *.req, *.ug, spicelib.idx/cspice.idx, whats.new, dscripnt.txt, version.txt.
 - » Subdirectory containing HTML documentation, called “html”.
 - The “html” subdirectory contains a single file — the top level HTML documentation index called “index.html” — and a number of subdirectories, one for each of the various groups of documents in HTML format (API Reference Guide pages, User’s Guide pages, etc.).
 - **etc**
 - » In most Toolkits this directory is empty.
 - **exe**
 - » Executables for some SPICE application and utility programs:
 - brief, chronos, ckbrief, commnt, frmdiff, inspekt, mkspk, msopck, spacit, spkdiff, spkmerge, tobin, toxfr, version.
 - » Executables for the several cookbook example programs:
 - simple, states, subpt, tictoc



Toolkit Directory Structure

Navigation and Ancillary Information Facility

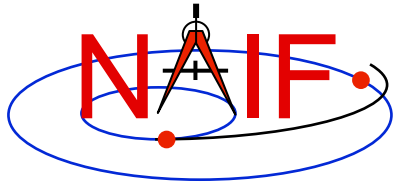
- **include** (applies only to CSPICE, Icy, and Mice)
 - » **API header files.**
 - File to include in callers of CSPICE is SpiceUsr.h
- **lib**
 - » **Toolkit libraries:**
 - **For Fortran Toolkits**
 - spicelib.a or spicelib.lib (public modules; use these)
 - support.a or support.lib (private modules; don't use these)
 - **For C Toolkits**
 - cspice.a or cspice.lib (public modules; use these)
 - csupport.a or csupport.lib (private modules; don't use these)
 - **For Icy Toolkits:**
 - icy.so or icy.dll (shared object library)
 - icy.dlm (dynamically loadable module)
 - cspice.a or cspice.lib
 - csupport.a or csupport.lib
 - **For Mice Toolkits:**
 - mice.mex* (shared object library)
 - cspice.a or cspice.lib
 - csupport.a or csupport.lib
- **src**
 - » **Source code directories for executables and libraries**
 - Files have type *.f, *.for, *.inc, *.pgm, *.c, *.h, *.x, *.pro, *.m
 - *.h files appearing here are not part of the user API



Toolkit Application Programs

Navigation and Ancillary Information Facility

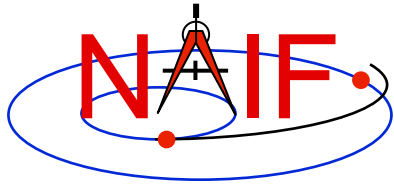
- **SPICE Toolkit application programs are available to:**
 - create a new SPK file from a text file of state vectors or elements
 - » `mkspk`
 - compare (diff) two SPKs
 - » `spkdiff`
 - analyze or dump the contents of an spk file
 - » `spy`
 - compare (diff) two reference frames
 - » `frmdiff`
 - create a new CK from a text file of attitude data
 - » `msopck`
 - carry out a wide assortment of time conversions
 - » `chronos`
 - query an Event Kernel (EK)
 - » `inspekt`
- **Some additional application programs are available only from the NAIF website**
 - <http://naif.jpl.nasa.gov/naif/utilities.html>



Toolkit Utility Programs

Navigation and Ancillary Information Facility

- **SPICE Toolkit utility programs are available to:**
 - **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`
 - **port binary SPICE kernels between incompatible systems (infrequently needed)**
 - » `tobin`, `toxfr`, `spacit`
 - » `bingo` (available only from the NAIF webpage)
 - **port text SPICE kernels between incompatible systems**
 - » `bingo` (available only from the NAIF webpage)

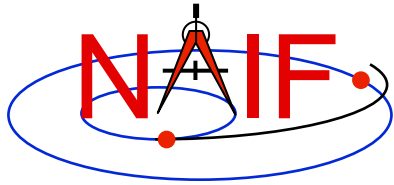


Toolkit Documentation

Navigation and Ancillary Information Facility

- **All Toolkits include documentation in plain text and HTML formats.**
 - Plain text documents are located under the “doc” directory
 - HTML documents are located under the “<toolkit_name>/doc/html” (Unix) or “<toolkit name>\doc\html” (Windows) directory
 - » “index.html” is the top level index... your starting point
- **All Toolkits include the following kinds of documents**
 - **Module headers**
 - » They act as primary functional specification: I/O, exceptions, particulars defining behavior of module
 - » They contain code examples
 - » A standard format is used for each routine or entry point
 - » **Location of HTML Module Headers:**
 - Use the “API Reference Guide” link from the top level index
 - » **Location of plain text Module Headers:**
 - Fortran: the top comment block in the source code files under “src/spicelib”
 - C: the top comment block in the source code files under “src/cspice”
 - IDL: Icy Module Headers are not available in plain text format
 - Matlab: accessible via “`help function_name`” command

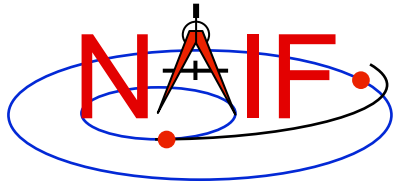
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Toolkit Documentation

Navigation and Ancillary Information Facility

- **“Required Reading” documents**
 - » **Extensive technical references for principal subsystems**
 - Provide many low-level details
 - Provide code examples
 - » **HTML versions are accessible using the “Required Reading Documents” link from the top level index.**
 - » **Plain text versions are located under “doc” and have extension “.req”**
 - » **Not all Required Readings were adapted for all languages**
 - Some of the Required Reading documents provided with CSPICE are based upon Fortran SPICE
 - Some of the Required Readings for Icy or Mice toolkits are based upon CSPICE
- **User’s Guides**
 - » **Tell how to use the utility and application programs.**
 - » **HTML versions are accessible using the “User’s Guide Documents” link from the top level index.**
 - » **Plain text versions are located under “doc” and have extension “.ug.”**

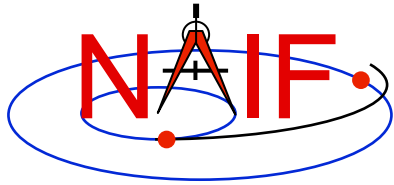


Toolkit Documentation

Navigation and Ancillary Information Facility

- **Other documents**
 - **Permuted Index**
 - » **Maps phrases describing functionality to corresponding module names and file names**
 - » **Shows names of all entry points in Fortran toolkit APIs**
 - » **HTML version is accessible using the “Permuted Index” link from the top level index.**
 - » **Plain text version is located under “doc” and has extension “.idx”:**
 - **Fortran: spicelib.idx**
 - **C: cspice.idx**
 - **IDL: icy.idx and cspice .idx**
 - **Matlab: mice.idx and cspice.idx**
 - **Toolkit Description**
 - » **Describes the directory structure and contents of an installed Toolkit**
 - » **Customized based on set of delivered products and platform**
 - » **HTML version is accessible using the “Toolkit Contents” link from the top level index.**
 - » **Plain text version is “doc/dscriptn.txt”**

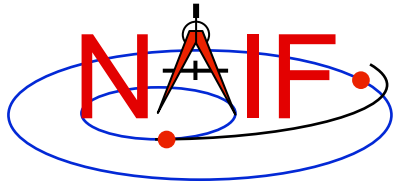
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Toolkit Documentation

Navigation and Ancillary Information Facility

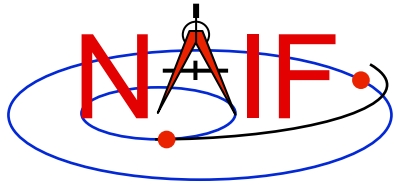
- Introduction to SPICE
 - » HTML document containing a brief introduction to the Toolkit and SPICE system; accessible using the “Introduction to the SPICE System” link from the top level index.
- What’s New in SPICE
 - » Describes new features and bug fixes in each Toolkit release, covering the last 20 years.
 - » Plain text version is “doc/whats.new”.
 - » HTML version is accessible using the “What’s New in SPICE” link from the top level index.
- Toolkit Version Description
 - » Indicates Toolkit version
 - » Plain text version is “doc/version.txt”
 - » Not available in HTML



Navigation and Ancillary Information Facility

Backup

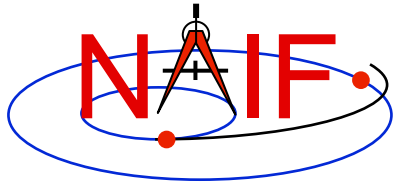
Supported Environments



Supported Environments

Navigation and Ancillary Information Facility

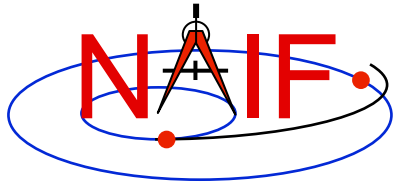
- **NAIF ports the SPICE Toolkit to many popular environments.**
 - Each environment is characterized by
 - » Language
 - » Hardware type (platform)
 - » Operating System
 - » Compiler
 - » Selected compilation options
- **NAIF provides SPICE Toolkit packages for each supported environment.**
 - If you cannot find a package built for the environment of interest to you, contact NAIF.
 - » **Please don't try to use or port a Toolkit built for another environment.**



Supported Environments - Fortran

Navigation and Ancillary Information Facility

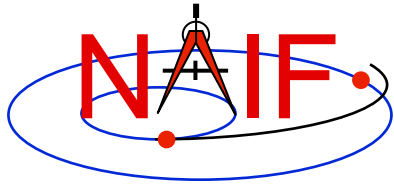
Product Name	Operating System	Compiler
Mac/Intel, OS-X, Intel FORTRAN, 32bit	OS X 10.6.8	Intel Fortran 10.1
Mac/Intel, OS-X, Intel FORTRAN, 64bit	OS X 10.6.8	Intel Fortran 10.1
Mac/Intel, OS-X, gfortran, 32bit	OS X 10.6.8	gfortran, GNU Fortran 4.3
Mac/Intel, OS-X, gfortran, 64bit	OS X 10.6.8	gfortran, GNU Fortran 4.3
PC, CYGWIN, gfortran, 32bit	Windows/Cygwin	gfortran, GNU Fortran 4.8.2
PC, CYGWIN, gfortran, 64bit	Windows/Cygwin	gfortran, GNU Fortran 4.8.2
PC, Linux, Intel FORTRAN, 32bit	Red Hat Linux (RHE5)	Intel Fortran 10.0
PC, Linux, Intel FORTRAN, 64bit	Red Hat Linux (RHE5)	Intel Fortran 10.0
PC, Linux, g77, 32bit	Red Hat Linux (RHE5)	g77, GNU Fortran 3.4
PC, Linux, gfortran, 32bit	Red Hat Linux (RHE5)	gfortran, GNU Fortran 4.3
PC, Linux, gfortran, 64bit	Red Hat Linux (RHE5)	gfortran, GNU Fortran 4.3
PC, Windows, Intel FORTRAN, 32bit	Windows XP and above	Intel Fortran 9.1
PC, Windows, Intel FORTRAN, 64bit	Windows XP and above	Intel Fortran 9.1
Sun/Intel, Solaris, SUN FORTRAN, 32bit	Solaris 9	Sun FORTRAN 95 8.2
Sun/Intel, Solaris, SUN FORTRAN, 64bit	Solaris 9	Sun FORTRAN 95 8.2
Sun/SPARC, Solaris, SUN FORTRAN, 32bit	Solaris 9	Sun FORTRAN 95 8.2



Supported Environments - C

Navigation and Ancillary Information Facility

Product Name	Operating System	Compiler
Mac/Intel, OS-X, Apple C, 32bit	OS X 10.4.x	gcc, GNU C 4.2.1
Mac/Intel, OS-X, Apple C, 64bit	OS X 10.4.x	gcc, GNU C 4.2.1
PC, CYGWIN, gCC, 32bit	Windows/Cygwin	gcc, GNU C 4.8.2
PC, CYGWIN, gCC, 64bit	Windows/Cygwin	gcc, GNU C 4.8.2
PC, Linux, gCC, 32bit	Red Hat Linux (RHE5)	gcc, GNU C 3.4.6
PC, Linux, gCC, 64bit	Red Hat Linux (RHE5)	gcc, GNU C 3.4.6
PC, Windows, Microsoft Visual C, 32bit	Windows XP and above	Microsoft Visual Studio 2008 C
PC, Windows, Microsoft Visual C, 64bit	Windows XP and above	Microsoft Visual Studio 2008 C
Sun/Intel, Solaris, SunC, 32bit	Solaris 10	Sun C 12.1
Sun/Intel, Solaris, SunC, 64bit	Solaris 10	Sun C 12.1
Sun/SPARC, Solaris, gCC, 32bit	Solaris 9	gcc, GNU C 3.3.2
Sun/SPARC, Solaris, gCC, 64bit	Solaris 9	gcc, GNU C 3.3.2
Sun/SPARC, Solaris, SUN C, 32bit	Solaris 9	Sun C 5.8
Sun/SPARC, Solaris, SUN C, 64bit	Solaris 9	Sun C 5.8

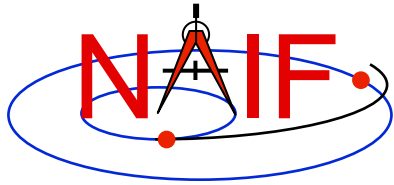


Supported Environments - IDL*

Navigation and Ancillary Information Facility

Product Name	Operating System	Compiler
Mac/Intel, OS-X, Apple C/IDL, 32bit	OS X 10.6.8	gcc, GNU C 4.2.1
Mac/Intel, OS-X, Apple C/IDL, 64bit	OS X 10.6.8	gcc, GNU C 4.2.1
PC, Linux, gcc/IDL, 32bit	Red Hat Linux (RHE5)	gcc, GNU C 3.4.6
PC, Linux, gcc/IDL, 64bit	Red Hat Linux (RHE5)	gcc, GNU C 3.4.6
PC, Windows, Microsoft Visual C/IDL, 32bit	Windows XP and above	Microsoft Visual Studio 2008 C
PC, Windows, Microsoft Visual C/IDL, 64bit	Windows XP and above	Microsoft Visual Studio 2008 C
Sun/Intel, Solaris, SUN C/IDL, 64bit	Solaris 10	Sun C 12.1
Sun/SPARC, Solaris, gcc/IDL, 32bit	Solaris 9	gcc, GNU C 3.3.2
Sun/SPARC, Solaris, gcc/IDL, 64bit	Solaris 9	gcc, GNU C 3.3.2
Sun/SPARC, Solaris, SUN C/IDL, 32bit	Solaris 9	Sun C 5.8

***NAIF built and tested lcy using IDL version 8.1.**

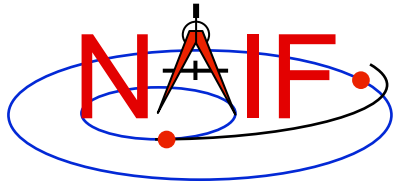


Supported Environments - Matlab*

Navigation and Ancillary Information Facility

Product Name	Operating System	Compiler
Mac/Intel, OS-X, Apple C, 32bit	OS X 10.6.8	gcc, GNU C 4.2.1
Mac/Intel, OS-X, Apple C, 64bit	OS X 10.6.8	gcc, GNU C 4.2.1
PC, Linux, gCC, 32bit	Red Hat Linux (RHE5)	gcc, GNU C 3.4.6
PC, Linux, gCC, 64bit	Red Hat Linux (RHE5)	gcc, GNU C 3.4.6
PC, Windows, Microsoft Visual C/ Matlab, 32bit	Windows XP and above	Microsoft Visual Studio .NET 7.0 C
PC, Windows, Microsoft Visual C/ Matlab, 64bit	Windows XP and above	Microsoft Visual Studio 2008 C
Sun/SPARC, Solaris, SUN C/Matlab, 32bit	Solaris 9	Sun C 5.8

***Mice requires use of Matlab version 7.2 (R2006a) or higher**



Status for Other Environments

Navigation and Ancillary Information Facility

- **NAIF is unable to support environments other than those listed on the previous set of charts.**
- **The SPICE and CSPICE packages should function as expected on platforms running any Linux OS (Ubuntu, Fedora, etc.), BSD OS (OpenBSD, FreeBSD, etc.), or a Linux based OS environment (minGW) using a standard GCC tool-chain (gfortran or gcc compiler).**
 - Version 4.2 or later for gfortran; 4.0 or later for gcc
- **The Mice package has been successfully built against the octave environment (version > 3.4) on Linux and OS X. Contact NAIF if you have questions concerning use with Octave.**
- **Apple OS9 and earlier computers are no longer supported.**