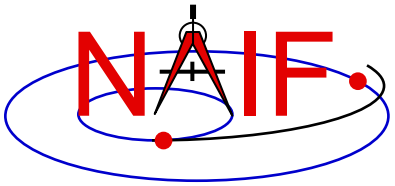


SPICE Conventions

A summary of standards, lingo and common usage within SPICE

January 2018

SPICE Lexicon - 1

Navigation and Ancillary Information Facility

SPICE

- The name of this ancillary information system

NAIF

- The name of the team of people at JPL who lead development of the SPICE system.
- Also the name of the ancillary data node of NASA's Planetary Data System (PDS).

SPICE Lexicon - 2

Navigation and Ancillary Information Facility

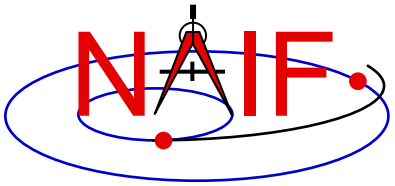
SPICE Toolkit The Toolkit	• Names that refer to the principal collection of software produced by JPL's NAIF Team as part of the SPICE information system.
Toolkit	• The Fortran 77 version of the Toolkit.
SPICELIB	• The principal user library found within Fortran versions of the Toolkit.
CSPICE	• Used to refer to the entire C Toolkit, and also to the principal user library found within C versions of the Toolkit.
Icy	• An IDL interface to CSPICE
Mice	• A MATLAB interface to CSPICE
Kernel	• A SPICE data file

Sorry for this rather confusing terminology!

SPICE Lexicon - 3

Navigation and Ancillary Information Facility

- **Text kernel**
  - Any kernel type consisting entirely of ASCII information, with each line terminated using the local operating system convention (CR, LF, or CR+LF)
  - Text kernel types are FK, IK, text PcK, LSK, SCLK, MK ("Furnsh")
  - Any set of text kernels, excepting MKs, could be combined in a single file.
    - » But this is certainly not recommended!
- **Binary kernel**
  - Any kernel type using a binary file format
  - Binary types are SPK, binary PcK, CK, DBK and DSK
  - Different binary kernel types cannot be combined together
- **Transfer format kernel**
  - A hexadecimal (ASCII) version of a binary kernel, used ONLY for porting a binary kernel between incompatible computers.
  - Not as important as it was prior to the addition of the "run-time translation" capability added in Toolkit version N0052 (January 2002).
    - » But still has a role in making native binary kernels required for some operations.



SPICE Lexicon - 4

- **"Command file"**
  - Many SPICE application and utility programs either require, or optionally accept, an input file containing program directives, and sometimes input data.
  - Unfortunately NAIF has not used a consistent approach for referring to such files. The following names have been used:
    - » setup file
    - » preferences file
    - » command file
    - » specifications file
    - » definitions file
- **"Found flag"**
  - A Boolean output ("True" or "False") from a SPICE API that informs your program whether or not data were found that match your request
- **Database Kernel (DBK)**
  - A SPICE kernel that, in conjunction with Toolkit DBK software, provides a self-contained SQL-like database capability.

SPICE Lexicon - 5

- **Coverage**
  - The period(s) of time for which a time-based kernel contains data
- **Deprecated software**
  - Code that, while still useable, has been superseded with a newer and presumably better version
  - We encourage you to not use deprecated SPICE software
  - Deprecated modules are so marked in their headers
- **Toolkit version naming**
  - "Nxxxx" e.g. N0066 is Version 66
    - » Often shortened to just Nxx (e.g. N66)
  - Used for all instances of a given toolkit release
    - » Fortran ("Toolkit"), C ("CSPICE"), IDL ("Icy"), MATLAB ("Mice")
- **"Satellite" is used to refer only to a natural satellite, never to a spacecraft.**
- **"Run-time" occurs when you execute a program**

SPICE Lexicon - 6

Navigation and Ancillary Information Facility

Names used synonymously

- Kernel, SPICE file, SPICE kernel, SPICE kernel file
- Meta-kernel, Furnsh Kernel
- Module, routine, subroutine, procedure, function, application program interface (API)
- Application, program, utility, executable
- Metadata, comments
- Time, Epoch
- Encoded SCLK, ticks*
- Frame, Reference Frame** (≠ Coordinate System)
- Ephemeris, trajectory
- Rectangular coordinates, Cartesian coordinates**
- Geodetic, Planetodetic (coordinate system)
- Ephemeris time (ET), Barycentric Dynamical Time (TDB)
- Attitude, orientation
- International Celestial Reference Frame (ICRF) and Earth Mean Equator and Equinox of 2000 reference frame (J2000)
- "Body", "solar system object," "ephemeris object"

* Encoded SCLK always refers to absolute time; "ticks" is used to refer to both durations and absolute times.

** Outside of SPICE the term "coordinate system" is often used synonymously with "frame" or "reference frame." We prefer to use "coordinate system" in the sense of describing how coordinates are measured (e.g. cylindrical coordinate system, rectangular coordinate system, polar coordinate system, etc) within a frame, and to use "frame" in the sense of a set of three orthogonal vectors that define an orientation.

Kernel File Names

Navigation and Ancillary Information Facility

- SPICE imposes some restrictions on kernel file names
  - No white space allowed within a name
  - Maximum length of a name (including any path specifications) is 255 characters
    - » See the tutorial "Intro_to_kernels" for limitations on file name specifications contained within meta-kernels ("furnsh kernels")

- NAIF suggests names conform to the PDS standard: "36.3"
  - <1 to 36 alphanumeric characters>.<1 to 3 chars>

- Common usage within NAIF for SPICE kernel file name extensions is listed on the next page, with the following general style used:

  t* text format (e.g. pck00010.tpc)
  b* binary format (e.g. de430.bsp)
  x* transfer format (e.g. de430.xsp)

Common SPICE Kernel File Name Extensions

Navigation and Ancillary Information Facility

SPK:

.bsp	binary SPK file
.xsp	transfer format SPK file

PcK:

.tpc	text PcK file (The most common type PcK)
.bpc	binary PcK file (Very few instances of this)
.xpc	transfer format PcK file

IK:

.ti	text IK file

FK:

.tf	text FK file

LSK:

.tls	text LSK file

CK:

.bc	binary CK file
.xc	transfer format CK file

SCLK:

.tsc	text SCLK file

MK:

.tm	text meta-kernel file (“FURNSH kernel”)

DSK:

.bds	binary DSK file

DBK:

.bdb	binary database kernel
.xdb	transfer format database kernel

EK Family (ESP, ESQ, ENB)

ESP:

.bep	binary Science Plan EK file
.xep	transfer format Science Plan EK file

ESQ:

.bes	binary Sequence Component EK file
.xes	transfer format Sequence Component EK file

ENB:

.ten	text Experimenter’s Notebook EK file

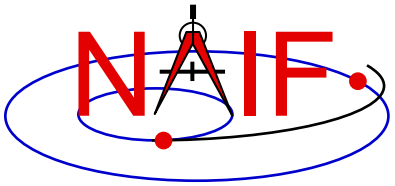
These are strong suggestions but not requirements

Common Document Name Extensions

- **These extensions are used for plain ASCII documents included with each Toolkit delivery**

.ug	User's Guide
.req	"Required Reading" technical reference document
.txt	Used for a few miscellaneous documents
.idx	Used only for the permuted index document

- **All HTML documents included in the Toolkit have extension .html**

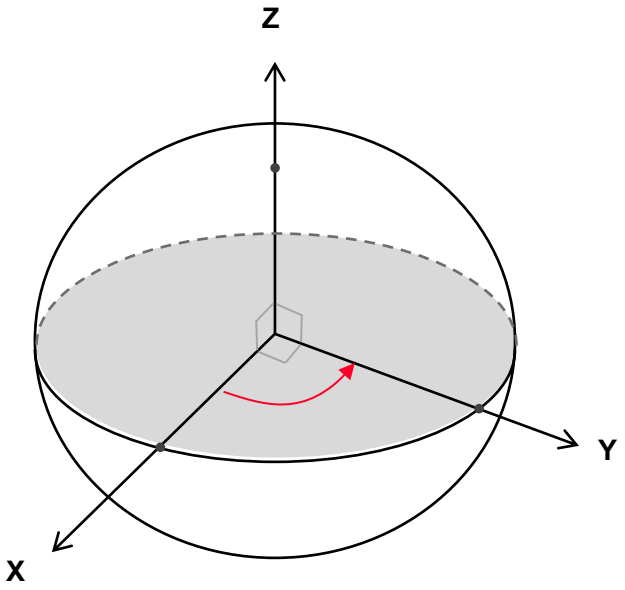


Public and Private Modules

- All Toolkits include public and private modules
- Public modules are available for your use
  - Names of public APIs are different in the four SPICE library implementations. For example, the top level SPK reader SPKEZR has the following names
    - » In SPICELIB (FORTRAN) SPKEZR
    - » In CSPICE (C) spkezr_c
    - » In ICY (IDL) cspice_spkezr
    - » In MICE (MATLAB) cspice_spkezr and mice_spkezr
  - The API Reference Guide included in the Toolkit HTML documentation provides the complete list of all public SPICE APIs available in a specific implementation of the Toolkit
- Private modules are for NAIF staff use only
  - Names of private modules start with “ZZ”
  - They are present in the Toolkit only to support operations of “public” modules
  - Private APIs are not listed in the API Reference Guide but can be seen in the source code directories for SPICELIB, CSPICE, ICY and MICE
  - Do not use “private” modules in your code – they may be changed by NAIF without notice

Reference Frame Conventions

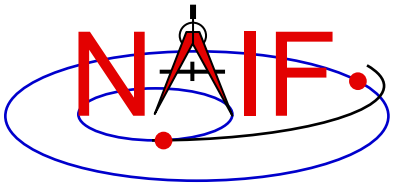
- **All reference frames used within SPICE are right handed systems: this means X cross Y = Z**



Quaternions

Navigation and Ancillary Information Facility

- The SPICE system uses quaternions to provide orientation in C-kernels
- There are different "styles" of quaternions used in science and engineering applications. Styles are characterized by
  - The order of the quaternion elements
  - The quaternion multiplication formula
  - The convention for associating quaternions with rotation matrices
- Two of the commonly used styles are
  - "SPICE"
    - » Used by Sir William Rowan Hamilton (discoverer of quaternions)
    - » Used in math and physics textbooks
  - "Engineering" or "MSOP"
    - » Widely used in attitude control and other aerospace applications
- The relationship between SPICE and MSOP quaternions is:
  - Let M be a rotation matrix such that for any vector v, M*v is the result of rotating v by Θ radians in the counterclockwise direction about unit vector A. Then the quaternions representing M are:
    - » SPICE: (+/-) (cos(Θ/2), sin(Θ/2)A(1), sin(Θ/2)A(2), sin(Θ/2)A(3))
    - » MSOP: (+/-) (-sin(Θ/2)A(1), -sin(Θ/2)A(2), -sin(Θ/2)A(3), cos(Θ/2))
- Details about SPICE quaternions are found in:
  - Rotations Required Reading document
  - NAIF white paper on quaternions: ftp://naif.jpl.nasa.gov/pub/naif/misc/Quaternion_White_Paper/
  - SPICE quaternion conversion routines: M2Q, Q2M



Names and IDs

- **Many items within SPICE have assigned names (text strings) and IDs (integer numbers)**

- **The rules, standards, practices and exceptions regarding these names and IDs are discussed in a separate tutorial ("NAIF IDs and Names")**

Pluto is a Special Case in SPICE

- For practical and historical reasons, Pluto is treated as a planet when speaking about ephemerides (SPK).

- But Pluto is treated as a “dwarf planet” when speaking about orientation and rotational state (PCK).