Multimission Software Interface Specification (SIS)

SPICE
Leapseconds Kernel

LSK

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PURPOSE: This SIS describes the format and content of SPICE Leapseconds Kernel (LSK) files. The LSK file is used for converting between Universal Time Coordinated (UTC, also frequently called Spacecraft Event Time, or SCET) and Barycentric Dynamical Time (TDB),

formerly called Ephemeris Time (ET) prior to 1984. It also describes and gives examples of how to use NAIF Toolkit ANSI FORTRAN 77 subroutines to access and use the data in a SPICE LSK file.

CHANGE LOG

Version	Date	Page Nos.	Reason
1.0	25 May 2000	All	New multimission version.

List of Acronyms

ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee on Space Data Standards
CK	SPICE C-kernel
ET	Ephemeris Time
JPL	Caltech/Jet Propulsion Laboratory
FTP	File Transfer Protocol
FTS	SFOC File Transfer Service
LSK	SPICE Leapseconds Kernel
MGSO	Multimission Ground Systems Office
NAIF	Navigation and Ancillary Information Facility
PDB	Project Data Base
PDS	Planetary Data System
SFDU	Standard Formatted Data Unit
SIS	Software Interface Specification
SPICE	S-, P-, I-, C- and E-kernels; the principal logical data components of a particular NASA ancillary information system
TDB	Barycentric Dynamical Time
TMOD	Telecommunications and Mission Operations Directorate
VMS	Digital Equipment Corporation's Virtual Memory Operating System

Section 1
General Description

1.1 Purpose of Document

This Software Interface Specification (SIS) module specifies the structure and content of SPICE leapseconds kernel files (LSK). It also provides an overview of software provided in the SPICE Toolkit for using the data in LSK files.

1.2 Scope

This is a multimission SIS, applicable to all projects and processes that use the SPICE ancillary information system.

1.3 Applicable Documents

The following reference documents are all available within each copy of the SPICE Toolkit.

No.	Name	NAIF Doc. No.
1	Time Required Reading	335
2	Kernel Required Reading	318

1.4 Functional Description

SPICE LSK files contain data needed to convert a specific epoch of time measured in the Universal Time Coordinated (UTC) system to the equivalent epoch measured in the Barycentric Dynamical Time (TDB) system, and vice-versa. TDB time is the independent variable used in several SPICE files, including ephemerides of planets and their satellites, comets and asteroids (SPK). (In the remainder of this SIS—and throughout the SPICE system documentation—the acronym ET is used in place of TDB.)

For some flight projects, conversion between Spacecraft Clock Time (SCLK) and ET requires use of an LSK file as well as a SPICE Spacecraft Clock Coefficients Kernel (SCLK).

LSK files are a generic product, produced by the Navigation and Ancillary Information Facility (NAIF) at JPL. At any given time there is only one LSK file that is current

1.4.1 Data Source, Destination and Transfer Method

An LSK file may be created or modified on any computer having a text editing capability. A new LSK file is always made by adding a new data line to an existing LSK file, and then updating the appropriate metadata.

LSK files provided to a flight project are typically placed in the project's general database or on a SPICE server to allow access by a wide assortment of customers. SPK files are transferred to the project's database or SPICE server using file transfer protocol (ftp) or direct copy.

1.4.2 Labeling and Identification

LSK files may begin with pertinent descriptive information, generally called metadata. This could include label information that would subsequently be used in the construction of SFDU K-header labels or Planetary Data System (PDS) labels. Where used, the specific content and structure of these labels will be determined by the flight project or the PDS.

The LSK file naming convention will be selected by the file producer (NAIF), or by the flight project. It is recommended that LSK file names use ".TLS" or ".tls" as the file name extension.

1.4.3 Assumptions and Constraints

Applications programs should read data from LSK files only by using the appropriate subroutines provided in the NAIF Toolkit. Refer to Applicable Document No. 1 for a detailed discussion of how to use LSK files.

Section 2
Environment

2.1 Hardware Characteristics and Limitations

In excess of 650 Kbytes of memory is required to utilize the NAIF Toolkit on a CPU that does not provide virtual memory. A PC running DOS will not be able to use the Toolkit. With that one exception, NAIF software should work properly on any machine that correctly supports the ANSI FORTRAN 77 or ANSI C standard.

The SPICE Toolkit (either FORTRAN or C) has been built and tested on numerous platforms. It normally is delivered with all included library and program modules built and ready to use. In some cases the delivery script provided with the Toolkit goes through a complete build process.

2.2 Interface Medium and Characteristics

LSK files may be transferred between computers using any text transfer mechanism that preserves the resultant file as a text file.

2.3 Deformatting

LSK files are simple text files that may be used without preparation unless the file has been wrapped in SFDU structures. If the file exists as an SFDU the SFDU wrappers must first be removed using some TMOD utility or other means.

2.4 Calling Sequence

Data in LSK files are accessed using modules provided in the SPICE library (SPICELIB or CSPICE) found in the SPICE Toolkit. Figure 2-1 pictorially summarizes these uses. See Applicable Document Nos. 1 and 2 for a full discussion and examples of accessing and using data in LSK files.

LSK files are also used by several NAIF Toolkit programs, such as SPACIT and some of the cookbook programs. The User's Guides for these programs indicate if an LSK file is needed.

2.5 Failure Protection, Detection and Recovery Features

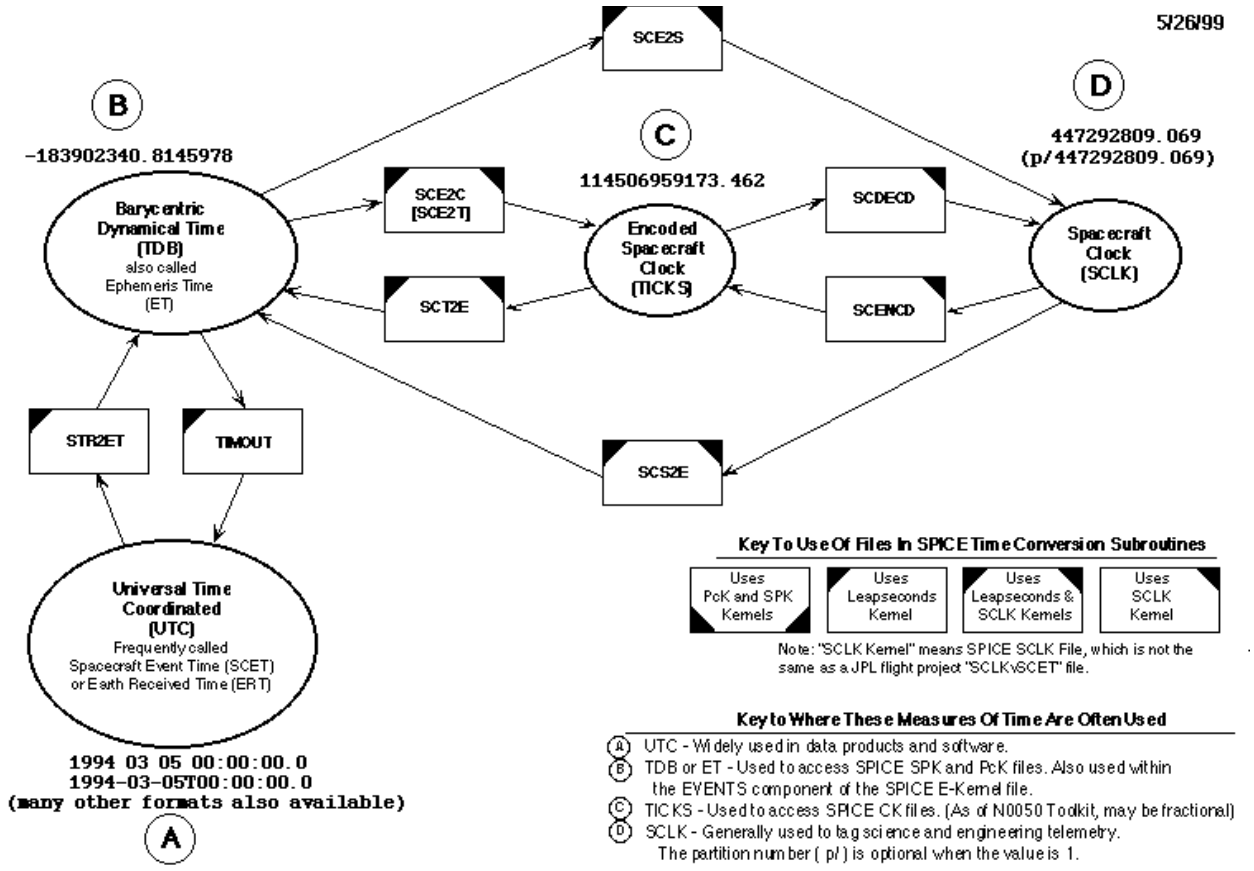
N/A

2.6 End-Of-File Convention

LSK files are terminated with the normal text end of file convention of the computer on which they are produced.

2.7 Utility Programs

The NAIF Toolkit contains a utility program , CHRONOS, that uses LSK and other SPICE kernels to accomplish a large set of time conversions.



Time Conversions Available Within SPICE - Partial Set

Figure 2-1
Time Conversion Subroutines Available within the SPICE Toolkit

Section 3
Data Flow Characteristics

3.1 Operational Characteristics

3.1.1 Generation Method and Frequency

LSK files are text format files containing only ASCII data. They are constructed or updated using a text editor. LSK files can be structured as CCSDS Standard Format Data Units (SFDU) where so required.

An LSK file is normally generated by updating the current LSK file. An update is effected by adding a record accounting for a new leapsecond as announced by the International Earth Rotation Service (IERS). Internal label information that documents when and by whom an update was made, and any product unique identifiers, must be revised at the same time.

3.1.2 Time Span of Product

An LSK file is applicable until such time as a new leapsecond declared by the IERS takes effect. New leapseconds generally take effect on January 01 at 00:00:00, and occasionally on July 01 at 00:00:00. These updates are not deterministic.

WARNING - WARNING - WARNING - WARNING - WARNING

The need to add (or subtract) a leapsecond cannot be predicted and is announced by the IERS only a few months in advance of the effective date. SPICE LSK files accessed by SPICELIB software are **not** designed to return a warning flag or to cause application program termination at the next likely date for a new leapsecond to take effect. **The user is responsible for ensuring that the LSK file in use is current.**

3.2 Data Volume

An LSK files requires about 5 Kbytes.

3.3 Flow Rate

An updated LSK is provided once every six months, maximum.

Section 4

Detailed Data Object Definition

4.1 Structure and Organization Overview

LSK files are text format files as defined in Applicable Document No.1.They may or may not include SFDU structures. LSK files should include informative internal labels (metadata).

If an SFDU version of an LSK file has been received, SPICE software will ignore the SFDU records.

NAIF Toolkit software provided to read an LSK file uses the text format LSK file; there is not a binary equivalent as is the case for SPICE SPK and CK files.

4.2 Data Format and Definition

The next sections describe the structure of LSK files. Under most circumstances those who intend only to read an LSK file need understand few if any structure details: the user's interface to an LSK file is through SPICELIB or CSPICE module argument lists. Examples of this interface are found in Applicable Document No. 1.

4.2.1 LSK File Format

An LSK file contains a small amount of numeric data given in KEYWORD = VALUE structures. The data section, delimited by a \begindata token, may be preceded (or followed) by explanatory text delimited with a \begintext token. A typical SPICE LSK kernel file might be structured as follows.

```
\begintext
    (explanatory text)
\begindata
    (LSK data, in K=V notation)
```

4.2.2 Sample LSK File

```
LEAPSECONDS KERNEL FILE
================================================================================

Modifications:
--------------
```

1998, Jul 17 WLT Modified file to account for the leapsecond that will occur on December 31, 1998.

1997, Feb 22 WLT Modified file to account for the leapsecond that will occur on June 30, 1997.

1995, Dec 14 KSZ Corrected date of last leapsecond from 1-1-95 to 1-1-96.

1995, Oct 25 WLT Modified file to account for the leapsecond that will occur on Dec 31, 1995.

1994, Jun 16 WLT Modified file to account for the leapsecond on June 30, 1994.

1993, Feb. 22 CHA Modified file to account for the leapsecond on June 30, 1993.

1992, Mar. 6 HAN Modified file to account for the leapsecond on June 30, 1992.

1990, Oct. 8 HAN Modified file to account for the leapsecond on Dec. 31, 1990.

Explanation:

The contents of this file are used by the routine DELTET to compute the time difference

[1] DELTA_ET = ET - UTC

the increment to be applied to UTC to give ET.

The difference between UTC and TAI,

[2] DELTA_AT = TAI - UTC

is always an integral number of seconds. The value of DELTA_AT was 10 seconds in January 1972, and increases by one each time a leap second is declared. Combining [1] and [2] gives

[3] DELTA_ET = ET - (TAI - DELTA_AT)

= (ET - TAI) + DELTA_AT

The difference (ET - TAI) is periodic, and is given by

[4] ET - TAI = DELTA_T_A + K sin E

where DELTA_T_A and K are constant, and E is the eccentric anomaly of the heliocentric orbit of the Earth-Moon barycenter. Equation [4], which ignores small-period fluctuations, is accurate to about 0.000030 seconds.

The eccentric anomaly E is given by

[5] E = M + EB sin M

where M is the mean anomaly, which in turn is given by

[6] $M = M_0 + M_1 t$

where t is the number of ephemeris seconds past J2000.

Thus, in order to compute DELTA_ET, the following items are necessary.

```
DELTA_TA
K
EB
M0
M1
DELTA_AT      after each leap second.
```

The numbers, and the formulation, are taken from the following sources.

1) Moyer, T.D., Transformation from Proper Time on Earth to Coordinate Time in Solar System Barycentric Space-Time Frame of Reference, Parts 1 and 2, Celestial Mechanics 23 (1981), 33-56 and 57-68.

2) Moyer, T.D., Effects of Conversion to the J2000 Astronomical Reference System on Algorithms for Computing Time Differences and Clock Rates, JPL IOM 314.5--942, 1 October 1985.

The variable names used above are consistent with those used in the Astronomical Almanac.

```
\begindata

DELTET/DELTA_T_A       =   32.184
DELTET/K               =    1.657D-3
DELTET/EB              =    1.671D-2
DELTET/M               = (  6.239996D0   1.99096871D-7 )

DELTET/DELTA_AT        = ( 10,   @1972-JAN-1
                           11,   @1972-JUL-1
                           12,   @1973-JAN-1
                           13,   @1974-JAN-1
                           14,   @1975-JAN-1
                           15,   @1976-JAN-1
                           16,   @1977-JAN-1
                           17,   @1978-JAN-1
                           18,   @1979-JAN-1
                           19,   @1980-JAN-1
                           20,   @1981-JUL-1
                           21,   @1982-JUL-1
                           22,   @1983-JUL-1
                           23,   @1985-JUL-1
                           24,   @1988-JAN-1
                           25,   @1990-JAN-1
```

```
26,   @1991-JAN-1
27,   @1992-JUL-1
28,   @1993-JUL-1
29,   @1994-JUL-1
30,   @1996-JAN-1
31,   @1997-JUL-1
32,   @1999-JAN-1 )
```