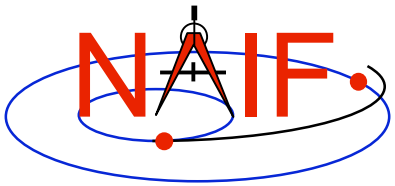
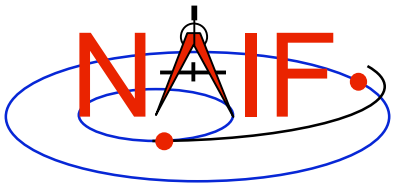


Navigation and Ancillary Information Facility

Leapseconds and Spacecraft Clock Kernels

LSK and SCLK

March 2006



SPICE Time Conversion Kernels

Navigation and Ancillary Information Facility

In most cases one or two kernel files are needed to perform conversions between supported time systems.

- **LSK - The leapseconds kernel is used in conversions between ephemeris time (ET/TDB) and UTC.**

- **SCLK - The spacecraft clock kernel is used in conversions between spacecraft clock time (SCLK) and ephemeris time (ET/TDB).**

The Leapseconds Kernel (LSK)

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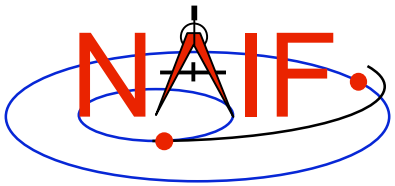
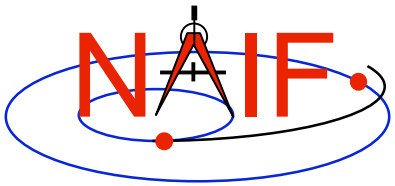
The leapseconds kernel contains a tabulation of all the leapseconds that have occurred, plus additional terms.

- **Used in ET <=> UTC and in ET <=> SCLK conversions.**
  - **Utility programs: *spkmerge*, *chronos*, *spacit*, etc.**
  - **Subroutines: STR2ET, ET2UTC, TIMOUT, etc.**
- **As with all SPICE kernels, load it with a FURNSH call.**
- **NAIF updates the LSK when a new leapsecond is announced by the International Earth Rotation Service (IERS).**
  - **The latest LSK file is always available from the NAIF server.**
  - **Announcements are made via the "spice_announce" system.**
    - **» http://naif.jpl.nasa.gov/mailman/listinfo/spice_announce**



Out of Date LSKs

- **An out-of-date leapseconds kernel can still be used successfully for conversions that occur at epochs prior to the epoch of the first missing leapsecond.**
  - **Any conversions of epochs after the missing leapsecond will introduce inaccuracies in multiples of one second.**
- **Using the latest leapseconds kernel to perform conversions at epochs more than 6 months beyond the last leapsecond listed may result in an inaccuracy if, later on, a new leapsecond is declared by the IERS.**



The Spacecraft Clock Kernel (SCLK)

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The spacecraft clock kernel contains data to perform conversions from SCLK to other time systems.

- **It is required by Toolkit utilities and routines that utilize SCLK time.**
  - **For example, the SPICE CK subsystem makes heavy use of spacecraft clock time.**
- **As with all SPICE kernels, call FURNSH to load it.**
- **Ensure you have the latest SCLK file for your spacecraft since these kernels are updated rather frequently.**
  - **Updated SCLK files are usually maintained on a flight project's database.**

SCLK File Example

Navigation and Ancillary Information Facility

```
\begindata

SCLK_KERNEL_ID             = ( @1999-08-02/10:53:19.72 )
SCLK_DATA_TYPE_82          = ( 1 )
SCLK01_TIME_SYSTEM_82      = ( 2 )
SCLK01_N_FIELDS_82         = ( 2 )
SCLK01_MODULI_82           = ( 4294967296 256 )
SCLK01_OFFSETS_82          = ( 0 0 )
SCLK01_OUTPUT_DELIM_82     = ( 1 )
SCLK_PARTITION_START_82    = ( 1.7772134886400E+11 )
SCLK_PARTITION_END_82      = ( 1.0995116277750E+12 )
SCLK01_COEFFICIENTS_82     = (

    0.0000000000000E+00     -6.3119514881600E+08     1.0001400000000E+00
    1.2098765056000E+10     -5.8393434781600E+08     1.0000900000000E+00
    2.0171981312000E+10     -5.5239834681600E+08     1.0001200000000E+00
    2.8245197568000E+10     -5.2086234581600E+08     1.0001100000000E+00
    4.4413748224000E+10     -4.5770394481600E+08     1.0000800000000E+00
              .                       .                       .
              .                       .                       .
              .                       .                       .
)

\begintext
```

Clock Type

Time system ID:

1 --> TDB, Barycentric Dynamical Time

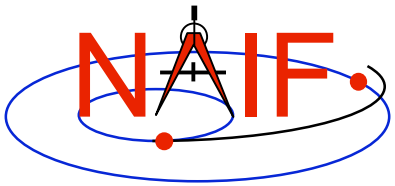
2 --> TDT, Terrestrial Dynamic Time

Encoded clock readings at partition start and stop.

SCLK value

TDT or TDB value corresponding to SCLK value

Clock Rate (seconds per most significant component)



Forms of SCLK Time Within SPICE

- SCLK time in SPICE is represented in two different ways.
  - character string
  - double precision (DP) number (called “ticks” within SPICE)
- A SCLK character string is composed of one or more cascading integer numbers – similar to a digital clock.
  - This form is what is generally produced from time-tags in downlinked telemetry.
- A SCLK value encoded as a DP number (“ticks”) is used internal to SPICE.
  - Because it’s easy to convert this to other time systems, such as ET.

Sample SCLK String - 1

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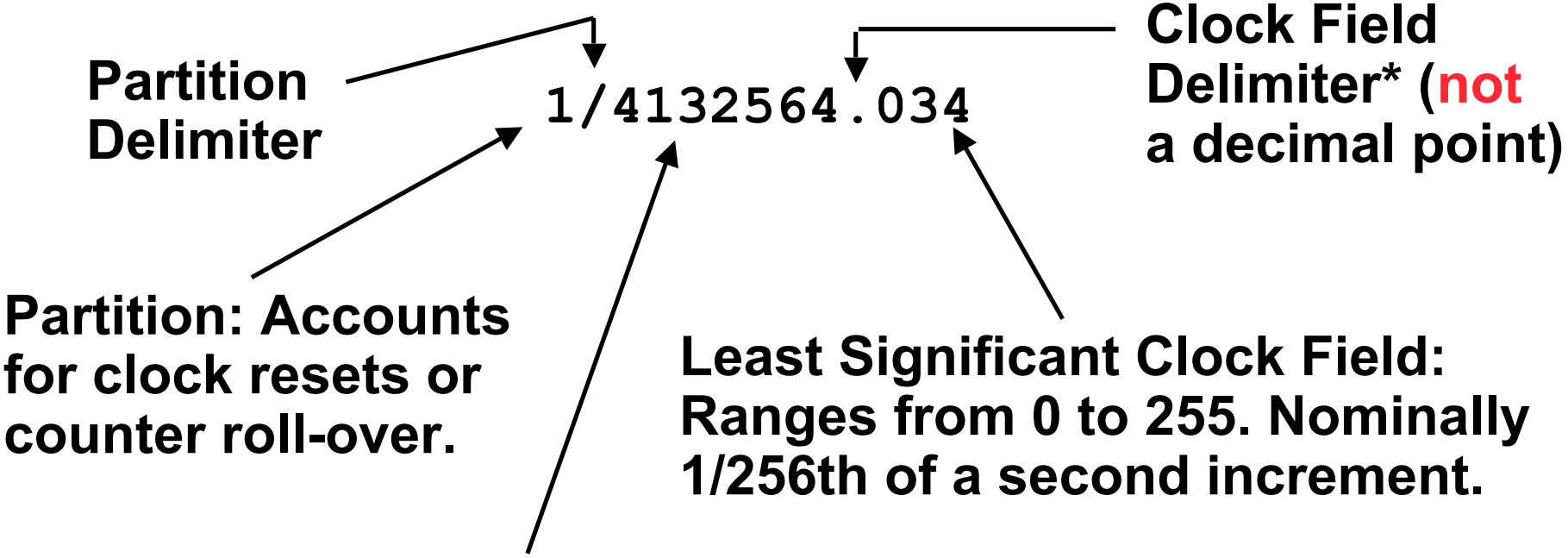
The Cassini orbiter SCLK time string consists of three fields separated by delimiters.



* Several SCLK delimiter characters are available in SPICE. See “SCLK Required Reading” for details.

What is a Partition?


```
1/4132564.034
```

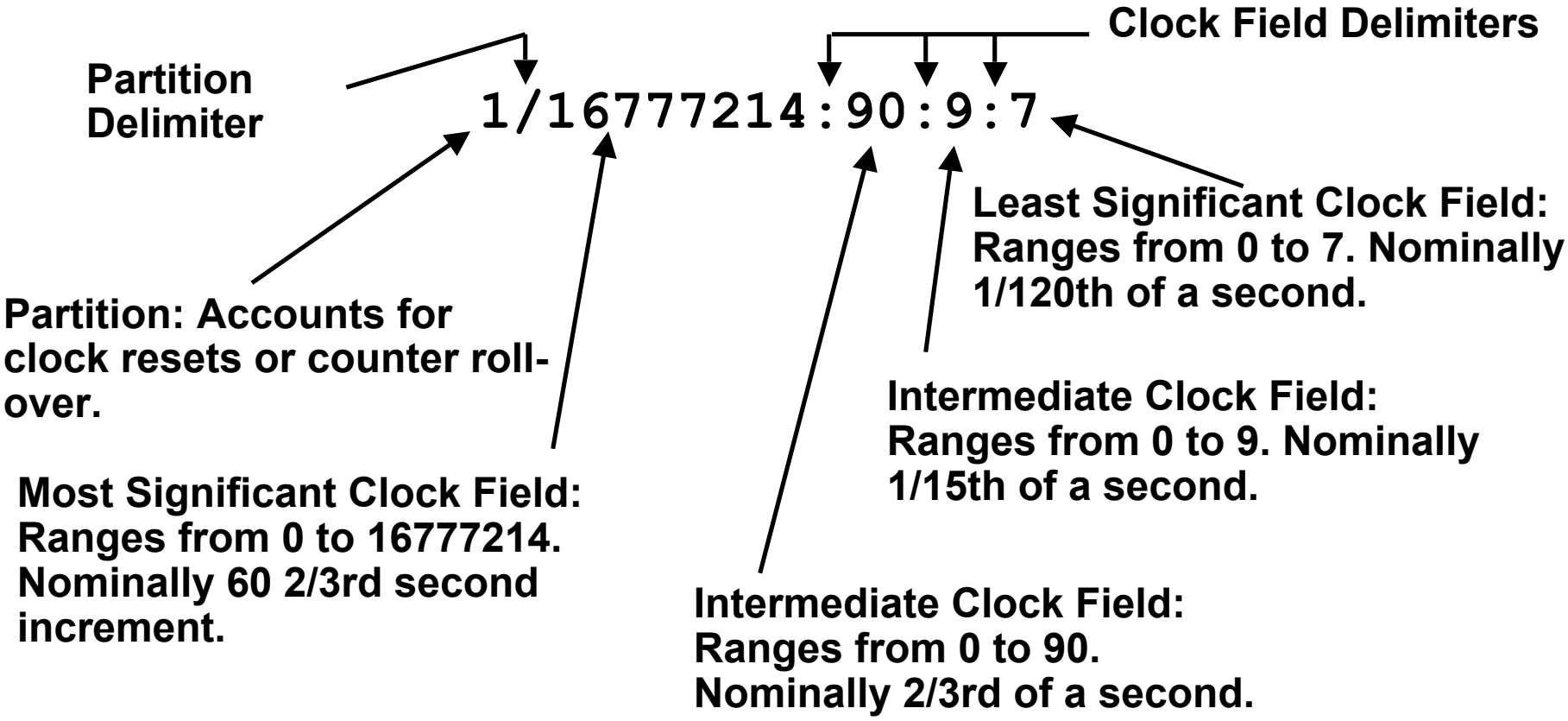
The portion of the SCLK string circled above describes the partition to which the remaining portion of the string is related.

- **A partition is a NAIF-created construct to handle spacecraft clock rollovers or resets.**
- **When referring to epochs in the first partition, the leading '1/' may be safely omitted.**
  - **This is normally the case for modern spacecraft.**

Sample SCLK String - 2

Navigation and Ancillary Information Facility

The Galileo spacecraft SCLK time string consists of five fields separated by delimiters.



Sample SCLK Strings - 3

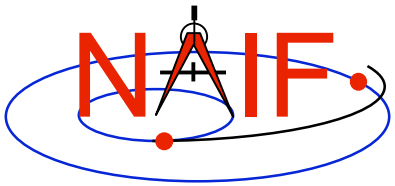
The following are examples of SCLK strings from missions using SPICE.

- **Cassini**
  - `1/1334314108.134`
- **DS1**
  - `1/67532406.010`
- **Galileo**
  - `1/16777214:90:9:7`
- **Genesis**
  - `1/666230496.204`
- **MGS**
  - `1/655931592.103`
- **MPF**
  - `1/559627908.058`
- **Mariner 9**
  - `1/11542909`
- **Mars Odyssey**
  - `1/687231994.091`
- **NEAR**
  - `1/40409721942`
- **Stardust**
  - `1/697451990.042`
- **Viking 1&2**
  - `1/32233616`
- **Voyager 1&2**
  - `1/05812:00:001`
- **Mars Express**
  - `1/0090979196.29713`
- **Venus Express**
  - `1/0033264000.50826`
- **Rosetta**
  - `1/0101519975.65186`

Encoded SCLK Ticks

The representation of SCLK time in the SPICE system is a double precision encoding of a SCLK string.

- **The units of this encoding are "ticks since spacecraft clock start".**
  - **The time corresponding to tick "0" is mission dependent and does not necessarily relate to launch time.**
- **A tick is the smallest increment of time that a spacecraft clock measures. For example, in the case of the Cassini orbiter this is nominally 1/256th of a second.**
- **Encoded SCLK increases continuously independent of leapseconds, clock resets, counter rollovers.**



SCLK Interface Routines

Navigation and Ancillary Information Facility

SCLK based time conversions can be effected through the use of the following routines:

```
SCS2E (SC, SCLKCH, ET)          (SCLK String-> ET)
SCE2S (SC, ET, SCLKCH)          (ET-> SCLK String)

SCT2E (SC, SCLKDP, ET)          (Encoded SCLK-> ET)
SCE2C[1](SC, ET, SCLKDP)        (ET-> Continuous Encoded SCLK)

SCENCD(SC, SCLKCH, SCLKDP)      (Encode SCLK)
SCDECD(SC, SCLKDP, SCLKCH)      (Decode SCLK)
```

1. An earlier routine, **SCE2T**, that provided ET --> SCLK, should no longer be used; NAIF recommends use of **SCE2C** instead.