

Navigation and Ancillary Information Facility

IDs and Names

for Physical Objects and Reference Frames

March 2010



Overview

Navigation and Ancillary Information Facility

- **Summary of naming/numbering schemes used in SPICE**
- **Naming/numbering of physical objects**
- **Naming/numbering of reference frames**
- **Connection between the schemes**

Caution: users sometimes confuse the ID assigned to an object and the ID(s) assigned to a reference frame or frames associated with that object. Read on for details.



Overview

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- **SPICE uses IDs and names to identify:**
 - physical objects
 - reference frames
- **A name is a text string; an ID is an integer number**
- **The naming/numbering schemes for physical objects and for frames are **independent****
 - This means that in general **SPICE does not make any assumptions about frame names/IDs based on the physical objects' names/IDs and vice versa**
 - » There are some exceptions though; they will be mentioned later



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Names and IDs associated with Objects



Object IDs/Names

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- **Names and IDs are assigned to the following types of **physical objects**:**
 - **Natural bodies -- planets, satellites, comets, asteroids**
 - **Artificial bodies -- spacecraft, spacecraft structures, science instruments, individual detectors within science instruments, DSN stations**
 - **Any other point, the location of which can be known within the SPICE context**
 - » **Barycenters of solar system and planetary systems, landing sites, corners of solar arrays, focal points of antennas, etc.**
- **A single ID is assigned to each physical object, but multiple names can be associated with (map to) that ID**
 - **On input, the names are treated as synonyms**
 - **On output, the name that was last associated with the ID is used**



Object IDs -- How Used

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- **Physical object IDs** are used:
 - in **kernels** as data identifiers:
 - » **SPKs** -- to identify a body and its center of motion
 - » **text PCKs** -- in keywords associated with a body
 - » **IKs** -- in keywords associated with instrument/detector
 - » **FKs** -- to specify the center for computing LT correction, and to identify the body in PCK-based frames
 - » **FKs** -- to identify target and observer in dynamic frames specifications
 - » **SCLKs** -- normally the SCLK ID used in keywords is the negative of the spacecraft's ID (thus a positive integer)
 - » ... and more...



Object IDs -- How Used

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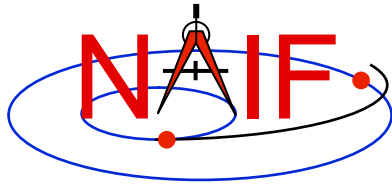
- **Physical object IDs** are used:
 - in some APIs as input and/or output arguments:
 - » Older SPK routines -- SPKEZ, SPKEZP, SPKGEO, ...
 - » Older derived geometry routines -- ET2LST, ...
 - » Older PCK routines -- BODVAR, BODMAT, ...
 - » IK routines -- GETFOV, indirectly in G*POOL, ...
 - » SCLK routines -- SCE2C, SCT2E, ...
 - » Coverage routines -- SPKOBJ, SPKCOV, CKOBJ, CKCOV
 - » ... and more...



Object Names -- How Used

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- Physical object **names** are used in the following APIs as input and/or output arguments:
 - » Newer SPK routines -- SPKEZR, SPKPOS
 - » Newer derived geometry routines -- SINCPT, ILUMIN, SUBPNT, SUBSLR, ...
 - » Newer PCK routines -- BODVRD, ...
- Physical object **names** are **not** used as data identifiers within kernels.



Object IDs/Names -- How Defined

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- **Name/ID mappings used by SPICE may be defined in two places**
 - **Inside the Toolkit:** hard-coded in the source code
 - » See NAIF_IDS.REQ for a complete listing of built-in (default) assignments
 - **In text kernels**
 - » You may define additional mappings using **KEYWORD = VALUE** assignments. For example, for a spacecraft:
 - NAIF_BODY_NAME += ('spacecraft_name')*
 - NAIF_BODY_CODE += (spacecraft_ID_number)*
 - » These assignments exist most often in FKs (e.g. DI, GNS, M01, MER, SIRTF), sometimes in IKs (e.g. CASSINI, MGS), but can be placed in any text kernel
 - » Normally text kernels are used to define name/ID mappings for instruments, their subsystems/detectors and other spacecraft structures
 - See comments and the actual data sections in a text kernel for the complete listing of the names/IDs defined in that kernel
 - » Mappings defined in text kernels take **precedence** over those defined in Toolkit source code.

* See Kernels Required Reading for information about the “+=” operator



Object IDs/Names

Spacecraft and Ground Stations

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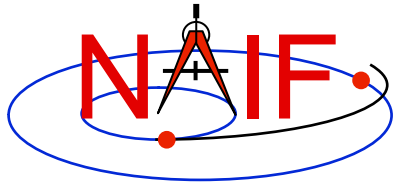
- **Spacecraft (negative numbers)**
 - Within NASA, this number is generally the negative of the numeric ID assigned by the NASA control authority at GSFC
 - -6 ‘PIONEER-6’, ‘P6’
 - -7 ‘PIONEER-7’, ‘P7’,
 - -82 ‘CASSINI’, ‘CAS’
 - -94 ‘MARS GLOBAL SURVEYOR’, ‘MGS’
 - ...
 - Unfortunately sometimes NASA re-uses a number
 - » This will happen with increasing frequency in the future
 - » Probably a new scheme is needed
- **DSN ground stations (399000 + station number)**
 - 399005 ‘DSS-05’
 - ...
 - 399066 ‘DSS-66’
- **Non-DSN stations (398000 + some integer 0 to 999)**
 - 398990 ‘NEW_NORCIA’
 - ...



Object IDs/Names -- Planets

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- **Sun and Solar System Barycenter (10 and 0)**
 - 0 'SOLAR SYSTEM BARYCENTER', 'SSB'
 - 10 'SUN'
- **Planetary system barycenters (numbers from 1 to 9)**
 - 1 'MERCURY BARYCENTER'
 - 2 'VENUS BARYCENTER'
 - 3 'EARTH MOON BARYCENTER', 'EMB', ...
 - 4 'MARS BARYCENTER'
 - ...
 - 9 'PLUTO BARYCENTER'
- **Planet-only mass centers (planet barycenter ID * 100 + 99)**
 - 199 'MERCURY'
 - 299 'VENUS'
 - 399 'EARTH'
 - 499 'MARS'
 - ...
 - 999 'PLUTO'

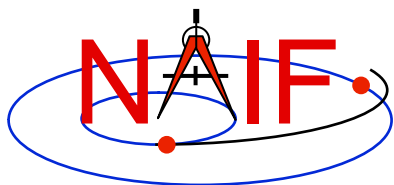


Object IDs/Names -- Satellites

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- **Satellites (planet barycenter ID*100 + number <1... 98>)**
 - 301 'MOON'
 - 401 'PHOBOS'
 - 402 'DEIMOS'
 - 501 'IO'
 - ...
 - 901 'CHARON', '1978P1'

See the **BACKUP** section for details about
how to handle more than 98 satellites.



Object IDs/Names Comets & Asteroids

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- **Periodic Comets (1000000 + number)**

- 1000001 'ARENDA'
- 1000002 'ARENDA-REGAUX'
- ...
- 1000032 'HALE-BOPP'

- **Numbered Asteroids (2000000 + asteroid number)**

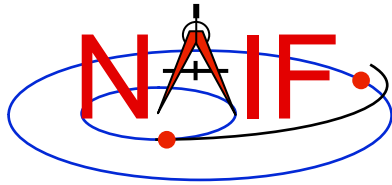
- 2000001 'CERES'
- 2000004 'VESTA'
- ...
- 2009969 'BRAILLE', '1992KD'
- There are a few exceptions; see NAIF_IDS.REQ



Object IDs/Names -- Instruments

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- **Science Instruments (s/c ID*1000 - inst. number)**
 - A number should be picked for EVERY instrument, instrument subsystem or detector, or spacecraft structure, the parameters for which are to be stored in IKs, or the location of which is to be stored in SPKs
 - Instrument numbers are picked from the range 0...999. The only requirement is that they must be unique
 - ...
 - -82760 'CASSINI_MIMI_CHEMS'
 - -82761 'CASSINI_MIMI_INCA'
 - -82762 'CASSINI_MIMI_LEMMS1'
 - -82763 'CASSINI_MIMI_LEMMS2'
 - ...
 - -82001 'CASSINI_SRU-A'
 - -82002 'CASSINI_SRU-B'
 - -82008 'CASSINI_SRU-A_RAD'
 - -82009 'CASSINI_SRU-B_RAD'
 - ...



Object IDs/Names -- Mapping APIs

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- **SPICE provides two routines to map physical object IDs to names, and vice versa**

- To get the ID for a given physical object name:

CALL BODN2C (NAME, ID, FOUND)

CALL BODS2C (NAME, ID, FOUND)

(This is a more general version as compared to BODN2C. Use this one.)

- To get the name for a given physical object ID:

CALL BODC2N(ID, NAME, FOUND)

- If the “FOUND” flag returned by either of these routines comes back FALSE, then the input ID or name cannot be mapped



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Names and IDs associated with Reference Frames



Frame IDs/Names

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- **Names and IDs are assigned to the following kinds of **reference frames****
 - Inertial frames
 - Body-fixed frames
 - Spacecraft and instrument frames
 - Topocentric frames
 - Any other reference frame for which the orientation may be needed to compute observation geometry
- **Unlike for objects, only a single ID and a single name are assigned to each **reference frame****
 - “Aliases” for a frame name can only be set up by defining new zero-offset frames with their own unique names and IDs



Frame IDs/Names -- How Used

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- **Reference frame IDs** are used
 - in the following kernels as data identifiers:
 - » FKs -- to “glue” frame definition keywords together
 - » SPKs -- to identify base reference frames
 - » PCKs -- to identify base reference frames
 - » CKs -- to identify base reference frames
 - in the following APIs as input and/or output arguments:
 - » Almost nowhere -- users rarely or never need to deal with or be aware of reference frame IDs
- **Reference frame names** are used
 - as arguments in all high level APIs that require a reference frame to be specified on the input
 - » Derived geometry routines -- SINCPT, ILUMIN, SUBPNT, ...
 - » Frame transformation routines -- PXFORM, SXFORM
 - » SPK routines -- SPKEZR, SPKPOS, ...
 - Frame names are NOT used as data identifiers within kernels



Frame IDs/Names -- How Defined

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- **The reference frame name/ID mappings used by the SPICE system are defined in two places**
 - **Built into the Toolkit:** hard-coded in source code
 - » For inertial frames
 - » For body-fixed frames defining the orientation for planets and most satellites
 - » See **FRAMES REQUIRED READING** for a complete listing
 - **In text kernels:** provided by **KEYWORD=VALUE** sets
 - » Almost always in FKs (DI, GNS, M01, MER, SIRTF, ...), very rarely in other kernels, but can be in any text kernel
 - (For example during operations MGS frames were defined in IKs and SCLK)
 - » Text kernels define spacecraft frames, instrument frames, spacecraft subsystem frames, DSN station frames, etc.
 - See comments/data sections in a text kernel for the complete listing of the frames defined in that kernel



Frame IDs/Names -- Inertial and Body-fixed

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The samples of frame **IDs** shown below are shown for completeness. Users would rarely if ever need to know or use them.

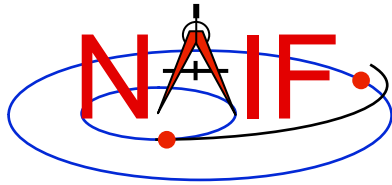
- Inertial frames (positive integers starting at 1)
 - 1 'J2000'
 - ...
 - 16 'MARSIAU'
 - 17 'ECLIPJ2000'
 - ...
- Body-fixed frames (positive integers starting at 10001)
 - 10001 'IAU_MERCURY_BARYCENTER'
 - ...
 - 10011 'IAU_MERCURY'
 - ...
 - 10020 'IAU_MOON'
 - ...
 - 10081 'EARTH_FIXED'
 - ...



Frame IDs/Names -- Spacecraft and Instrument

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- **IDs for frames associated with spacecraft, spacecraft structures, and instruments are usually:**
 - s/c ID times 1000 minus an arbitrary number
- **As example, for Cassini:**
 - **Spacecraft frame (ID and name)**
 - 82000 'CASSINI_SC_COORD'
 - **Spacecraft structure frame (ID and name)**
 - 82001 'CASSINI_SRU-A'
 - **Instrument frames (ID and name)**
 - 82760 'CASSINI_MIMI_CHEMS'
 - 82761 'CASSINI_MIMI_LEMMS_INCA'
 - 82762 'CASSINI_MIMI_LEMMS1'
 - 82763 'CASSINI_MIMI_LEMMS2'
 - 82764 'CASSINI_MIMI_LEMMS_BASE'
 - 83765 'CASSINI_MIMI_LEMMS_ART'
 - ...
- **SPICE users would rarely if ever need to know or use frame IDs; you'll use the associated frames name instead.**



Frame IDs/Names -- Mapping APIs

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- **SPICE provides two routines to convert (map) reference frame IDs to names, and vice versa**

- To get the ID for a given reference frame name:

```
CALL NAMFRM( NAME, ID )
```

- To get the name for a given reference frame ID:

```
CALL FRMNAM( ID, NAME )
```

- If the ID or name cannot be mapped, these routines return zero and an empty/blank string respectively.

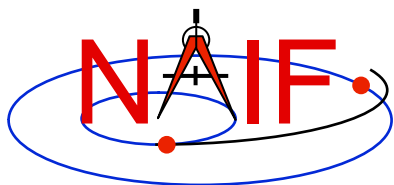
- **Users will rarely if ever need to call these routines.**



Name/ID Schemes Connections

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- **Although physical object and reference frame naming/numbering schemes are independent, in practice there is a lot of overlap in the way **objects** and **frames** are named and numbered**
- **This overlap is due to the following reasons**
 - **Conventions adopted over the course of SPICE implementation**
 - » **Example: PCK-based body-fixed frames for planets and satellites are named 'IAU_<body name>'**
 - **However, the IDs of these **frames** have nothing in common with the IDs of the **objects** (bodies) for which these frames are defined**
 - **The need for the object and frame IDs to be unique**
 - » **For this reason both the instrument (**object**) IDs and the instrument **frame** IDs are derived from the ID of the spacecraft on which the instrument is flown**
 - **The need for the object and frame names to be meaningful**
 - » **For this reason the instrument **frame** names normally contain both the name of the spacecraft and the name of the instrument**



“Odd Ball” Cases

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- **CK IDs**

- Historically IDs used in CKs are called structure IDs but in reality they are much more closely related to frames than to physical objects
- To find which frame is associated with a particular CK ID, look through FK for a frame whose `_CLASS_ID` keyword is set to the CK ID
 - » In practice, for CK-based frames both the frame ID and frame `_CLASS_ID` are set to the CK ID

- **SCLK IDs**

- Because most spacecraft have only one on-board clock, the SCLK ID of that clock is the same as the spacecraft ID
- Should a spacecraft carry more than one independent clock, unique SCLK IDs for these other clocks would be needed
 - » Normally the ID of an additional clock will be set to the ID of the instrument, of which that clock is a part
- SCLK IDs are used in SCLK APIs (must be provided by the user) and by the frames subsystem when it reads CKs to determine orientation of CK-based frames (gets SCLK ID from `CK_*_SCLK` keyword provided in the frame definition or computes it by dividing CK ID by 1000)



Name/IDs Example -- CASSINI (1)

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	<u>Objects IDs/Names</u>		<u>Frames IDs/Names</u>	
Ephemeris objects	10	'SUN'	1	'J2000'
	399	'EARTH'	10013	'IAU_EARTH'
	699	'SATURN'	10016	'IAU_SATURN'
	601	'MIMAS'	10039	'IAU_MIMAS'
	602	'ENCELADUS'	10040	'IAU_ENCELADUS'
Spacecraft and its structures	-82	'CASSINI'	-82000	'CASSINI_SC_COORD'
	-82001	'CASSINI_SRU-A'	-82001	'CASSINI_SRU-A'
CDA instrument	-82790	'CASSINI_CDA'	-82790	'CASSINI_CDA'
			-82791	'CASSINI_CDA_ART'
			-82792	'CASSINI_CDA_BASE'
CAPS instrument	-82820	'CASSINI_CAPS_IMS'	-82820	'CASSINI_CAPS'
	-82821	'CASSINI_CAPS_ELS'	-82821	'CASSINI_CAPS_ART'
	-82822	'CASSINI_CAPS_IBS_DT1'	-82822	'CASSINI_CAPS_BASE'
	-82823	'CASSINI_CAPS_IBS_DT2'		
	-82824	'CASSINI_CAPS_IBS_DT3'		



Name/IDs Example -- CASSINI (2)

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- **The lists provided on the previous page are by no means complete**
 - There are many more Saturnian satellites and other natural bodies of interest to the Cassini mission, each having an associated frame
 - There are many more instruments on the Cassini spacecraft, with multiple frames associated with each of them
- **To find names and IDs associated with these objects and frames, users should refer as follows**
 - For names/IDs of natural objects: **NAIF_IDS.REQ**
 - For names/IDs of Cassini instruments and their subsystems: **IK files**
 - » For other missions this information is in the mission's **FK file**
 - For names of inertial frames and body-fixed frames associated with natural bodies: **FRAMES.REQ**
 - For names of the reference frames associated with the Cassini spacecraft, its subsystems and instruments: **FK file**



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Backup

**How to handle more than 98
satellites for one planet**



Object IDs/Names -- Satellites (2)

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- **The scheme described for satellites can accommodate only 98 natural satellites. How do we handle more than 98?**
 - For IAU provisional assignments, use “psbbb” also, where:
 - » p = planet barycenter ID
 - » s = separator, set equal to “5”
 - » bbb = satellite number
 - Start with the next available unused IAU two-digit number with a “0” pre-pended, when we elect to put this scheme into effect
 - Increment by one thereafter
 - For IAU permanent assignments, use “psbbb” where:
 - » p = planet barycenter ID
 - » s = separator, set equal to “0”
 - » bbb = satellite number
 - Use “099” for the first new permanent assignment after “p98” from the current range is used



Object IDs/Names -- Satellites (3)

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- The satellite extended numbering scheme described on the previous page attempts to, but may not be able to, maintain consistency in the last three digits as the boundary between 98 and 99 is crossed.
 - This is because the IAU sometimes changes the numbering order of new satellites when migrating from provisional to permanent status.
- It has been suggested that some JPL entity maintain a public web page showing the history of all assignments.
 - (Not done so far...)
- It is recommended that any SPK file made using provisional IDs be trashed (or hidden away) when a new file using permanent IDs is obtained.
 - If no new file is expected, the *bspidmod* program can be used to replace provisional ID(s) with official ID(s) in the old file