



Navigation and Ancillary Information Facility

IDs and Names

April 2023



Topics

Navigation and Ancillary Information Facility

- **Summary of naming/numbering schemes used in SPICE**
- **Naming/numbering of objects**
- **Naming/numbering of reference frames**
- **Naming/numbering of DSK surfaces**
- **Connection between the schemes**
- **Oddball cases: SCLK and CK IDs**
- **Some examples**



Overview - 1

Navigation and Ancillary Information Facility

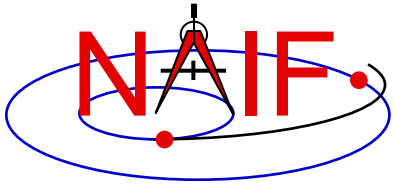
- **SPICE uses IDs and names to identify:**
 - objects
 - reference frames
 - digital shape kernel (DSK) surfaces
- **An ID is an integer number**
- **A name is a text string**
- **IDs are used primarily as data identifiers inside SPICE kernels**
 - Users rarely have to use IDs
- **Names are used primarily as input and output arguments in SPICE software interfaces (APIs)**
 - Users deal with lots of names



Overview - 2

Navigation and Ancillary Information Facility

- The schemes used for assigning IDs and names to objects and to reference frames are **independent!**
 - This means that, in general, SPICE does not make any assumptions about reference frame names and IDs based on associated object names and IDs
 - » There are some exceptions; they will be mentioned later



Navigation and Ancillary Information Facility

Names and IDs associated with Objects



Object IDs and Names

Navigation and Ancillary Information Facility

- A single ID is assigned to an **object** of any of the following types:
 - 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, such as:
 - » barycenters of solar system and planetary systems, landing sites, corners of solar arrays, focal points of antennas, etc.
- One or more names can be assigned to that same object
- Within SPICE software there is a 1-to-MANY mapping between the ID and the object's name(s)
 - On input, the names are treated as synonyms
 - On output, the name that was last associated with the ID is returned



Object IDs: Where Used? - 1

Navigation and Ancillary Information Facility

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



Object IDs: Where Used? - 2

Navigation and Ancillary Information Facility

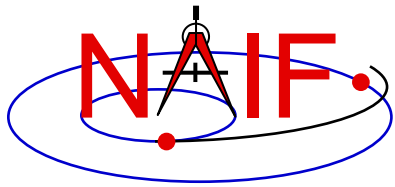
- Object **IDs** are used in some APIs as input and/or output arguments:
 - » in older SPK routines -- SPKEZ, SPKEZP, SPKGEO, ...
 - » in older derived geometry routines -- ET2LST, ...
 - » in older PCK routines -- BODVAR, BODMAT, ...
 - » in IK routines -- GETFOV, indirectly in G*POOL, ...
 - » in SCLK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



Object Names – Where Used?

Navigation and Ancillary Information Facility

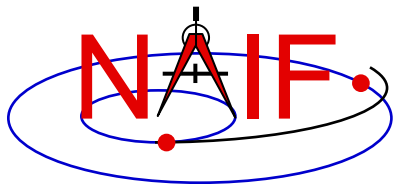
- Object **names** are used in the high-level user APIs as input and/or output arguments:
 - » in newer SPK routines -- SPKEZR, SPKPOS
 - » in newer derived geometry routines -- SINCPT, ILUMIN, SUBPNT, SUBSLR, LIMBPT, TERMPT, LATSRF ...
 - » in high-level Geometry Finder routines – GFPOSC, GFDIST, GFSEP, GFILUM, ...
 - » in newer PCK routines -- BODVRD, ...
- Object **names** are **not** used as data identifiers within kernels



Object IDs and Names – Where Defined?

Navigation and Ancillary Information Facility

- **Object name-to-ID mappings used by SPICE may be defined in two places**
 - **Built into Toolkit software:** hard-coded in source code
 - » See NAIF_IDS.REQ for a complete listing of these built-in (default) assignments
 - **In text kernels**
 - » Normally used to define name/ID mappings for instruments, their subsystems/detectors and 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
 - » These assignments exist most often in FKs (e.g. MER, MEX, JUNO, MSL), sometimes in IKs (e.g. CASSINI, MGS), but could be placed in any text kernel
 - Mappings defined in text kernels take precedence over those defined in Toolkit source code

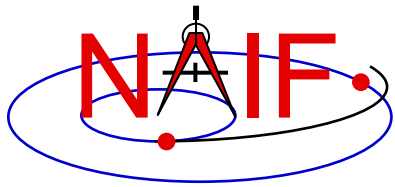


Examples of Object IDs and Names

Spacecraft and Ground Stations

Navigation and Ancillary Information Facility

- **Spacecraft (negative numbers)**
 - For spacecraft supported by DSN, this number is the negative of the DSN spacecraft ID
 - -6 'PIONEER-6', 'P6'
 - -64 'OSIRIS-REX', 'ORX'
 - -82 'CASSINI', 'CAS'
 - Unfortunately, sometimes DSN re-uses a number
 - » For example, -18 for MGN and LCROSS, -53 for MPF and M01
 - NAIF does not assign NAIF IDs to spacecraft not tracked by DSN
 - » Projects not using DSN are free to choose NAIF IDs themselves
 - » NAIF recommends such IDs to be in -9999 ... -1000 range
- **DSN ground stations (399000 + station number)**
 - 399005 'DSS-05'
 - ...
 - 399066 'DSS-66'
- **Non-DSN stations (398000 + some integer 0 to 999)**
 - 398990 'NEW_NORCIA'
 - ...



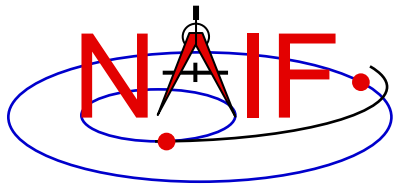
Examples of Object IDs and Names

Planets

Navigation and Ancillary Information Facility

- **Solar System Barycenter and Sun* (0 and 10)**
 - 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' (Within SPICE Pluto is still treated as a planet!)
- **Planet-only mass centers (planet barycenter ID * 100 + 99)**
 - 199 'MERCURY'
 - 299 'VENUS'
 - 399 'EARTH'
 - 499 'MARS'
 - ...
 - 999 'PLUTO' (Within SPICE Pluto is still treated as a planet!)

* Barycenter: the center of mass of a system (collection) of two or more bodies, each of which orbits that point.
See the SPK tutorial for details.



Examples of Object IDs and Names

Satellites

Navigation and Ancillary Information Facility

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

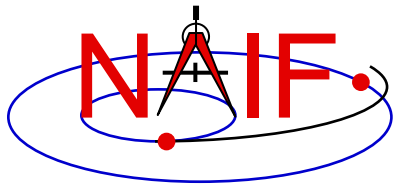


Examples of Object IDs and Names

Comets

Navigation and Ancillary Information Facility

- **Periodic Comets (1 million + sequence number)**
 - 1000001 'AREND'
 - 1000002 'AREND-REGAUX'
 - ...
 - 1000032 Periodic comet with sequence number 999,999
- **Sequence number is assigned by JPL's Solar System Dynamics Group (SSD)**
- **1,000,000..1,999,999 range accommodates 1 million comets**
 - Sufficient as currently there are less than 10,000 known comets
- **One can search the Solar System Dynamics (SSD) small body database for comet NAIF IDs (SPK IDs) :**
https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/

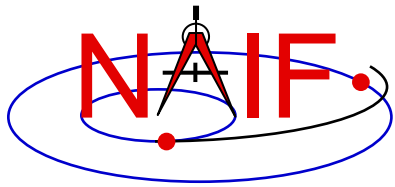


Examples of Object IDs and Names

Original Schema for Asteroids

Navigation and Ancillary Information Facility

- **Numbered Asteroids (2 million + IAU asteroid number)**
 - 2000001 'CERES'
 - ...
 - 2999999 Asteroid with IAU number 999,999
- There are three exceptions, for Gaspra, Ida and Dactyl
 - » See NAIF_IDS.REQ
- **2,000,000...2,999,999 range accommodates only 1 million asteroids**
 - Not sufficient as there are already 900,000+ known asteroids
 - New schema allowing more objects is described on the next two pages
 - The original schema above is still valid for the first 1 million asteroids
- **One can search the SSD small body database for original asteroid NAIF IDs (SPK IDs) :**
https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/



Examples of Object IDs and Names

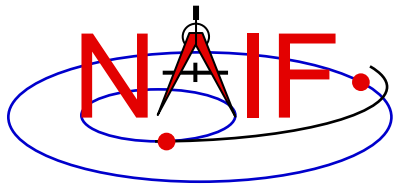
New Schema for Minor Planets¹

Navigation and Ancillary Information Facility

- Different schemas are used for singular minor planets and for multiple minor planet systems
- Singular minor planets² with an official IAU number (20 million + IAU minor planet number)
 - 20000001 'CERES'
 - ...
 - 49999999 Minor planet with IAU number 29,999,999
- 20,000,000...49,999,999 range accommodates 30 million objects
 - Sufficient assuming expected discovery rates for upcoming surveys
- One cannot yet search SSD small body database for “new schema” minor planet NAIF IDs

¹ Minor planets can be asteroids, trojans, centaurs, Kuiper belt objects, trans-Neptunian objects and dwarf planets

² Numbered objects are those having permanent IAU-assigned IDs



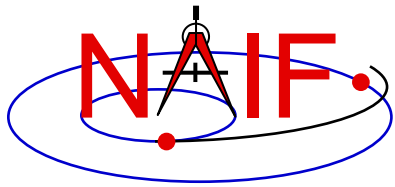
Examples of Object IDs and Names **New Schema** for Minor Planets¹

Navigation and Ancillary Information Facility

- **Barycenter of a multiple minor planet² system (20 million + IAU number of primary minor planet in the system)**
 - 20065803 'DYDIMOS BARYCENTER'
- **Primary minor planet of a multiple minor planet system (920 million + IAU number of primary minor planet in the system)**
 - 920065803 'DYDIMOS'
- **Moons in a multiple minor planet system ([1- 8]20 million + IAU number of primary minor planet in the system)**
 - 120065803 'DIMORPHOS'
- **One cannot yet search SSD small body database for “new schema” minor planet NAIF IDs**

¹ Minor planets can be asteroids, trojans, centaurs, Kuiper belt objects, trans-Neptunian objects and dwarf planets

² Numbered objects are those having permanent IAU-assigned IDs



Examples of Object IDs and Names

Instruments

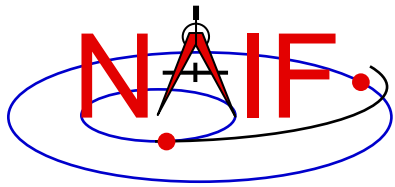
Navigation and Ancillary Information Facility

the “minus” sign

- **Science Instruments (s/c ID*1000 - instrument number)**

- An instrument 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 within each mission

- ...
- -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

Navigation and Ancillary Information Facility

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

- To get the ID for a given object name:

CALL BODN2C (NAME, ID, FOUND)

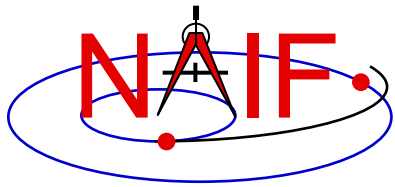
CALL BODS2C (NAME, ID, FOUND)

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

- To get the name for a given 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



Adding New or Additional Object Name-to-ID Mappings

Navigation and Ancillary Information Facility

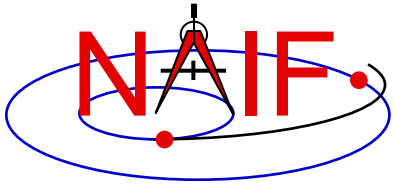
- You may define new or additional name-to-ID mappings using assignments inside any text kernel.
- For example, for a spacecraft:

```
NAIF_BODY_NAME    += ( 'my_spacecraft_name'      )  
NAIF_BODY_CODE    += (  my_spacecraft_ID          )
```



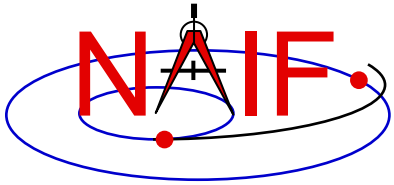
Note the combination of + and =

- See “NAIF_IDs Required Reading” for details
- Caution: the object name length is limited to 36 characters



Navigation and Ancillary Information Facility

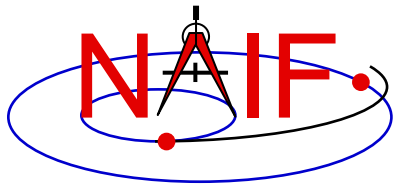
Names and IDs associated with Reference Frames



Frame IDs and Names

Navigation and Ancillary Information Facility

- A single ID and a single name are assigned to a **reference frame** of any of the following types
 - 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



Frame IDs and Names – Where Defined?

Navigation and Ancillary Information Facility

- The reference frame name-to-ID mappings used by the SPICE system are defined in two places
 - **Built into Toolkit software**: 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 placed in FKs
 - » Rarely placed in other kernels, but could be in any text kernel
 - (For example during operations MGS frames were defined in IKs and SCLK)
- Unlike for objects, only one name may be directly associated with a **reference frame ID**
 - However, an “alias” for a given reference frame can be established by defining a new, zero-offset frame with its own unique name and ID



Frame IDs and Names – Where Used?

Navigation and Ancillary Information Facility

- Reference frame **IDs** are used in the following kernels as data identifiers
 - » in FKs -- to “glue” frame definition keywords together
 - » in SPKs -- to identify base reference frames
 - » in PCKs -- to identify base reference frames
 - » in CKs -- to identify base reference frames
 - » in DSKs -- to identify reference frames
 - Reference frame IDs are **not** used as input and/or output arguments in any high level user APIs
- Reference frame **names** are used
 - as arguments in all high level APIs that require a reference frame to be specified as an input
 - » in derived geometry routines -- SINCPT, ILUMIN, SUBPNT, ...
 - » in frame transformation routines -- PXFORM, SXFORM
 - » In SPK routines -- SPKEZR, SPKPOS, ...
 - Frame names are **not** used as data identifiers within kernels

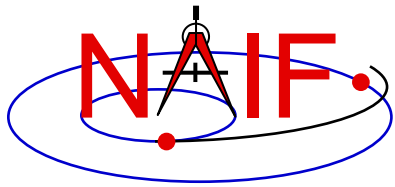


Examples of Frame IDs and Names

Inertial and Body-fixed

Navigation and Ancillary Information Facility

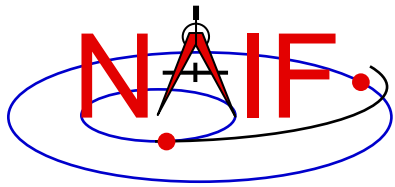
- Inertial frames (positive integers starting at 1)
 - 1 'J2000'
 - ...
 - 17 'ECLIPJ2000'
 - ...
- Body-fixed frames (positive integers starting at 10001)
 - ...
 - 10012 'IAU_VENUS'
 - 10013 'IAU_EARTH'
 - 10014 'IAU_MARS'
 - ...
 - 10020 'IAU_MOON'
 - ...
 - 13000 'ITRF93'
 - ...
- **NOTE: SPICE users would rarely if ever need to know or use the frame IDs; you use only the frame names**



Examples of Frame IDs and Names Spacecraft and Instrument

Navigation and Ancillary Information Facility

- IDs for frames associated with spacecraft, spacecraft structures, and instruments are usually defined as:
s/c ID times 1000 minus an arbitrary number
- Examples based on 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'
 - ...
- **NOTE: SPICE users would rarely if ever need to know or use the frame IDs; you use only the frame names**



Frame IDs/Names -- Mapping APIs

Navigation and Ancillary Information Facility

- **SPICE provides two routines NAMFRM and FRMNAM 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.
- **SPICE also provides the CCIFRM routine to get the frame name, ID, and center associated with a given frame class and class ID**
CALL CCIFRM (FRCLSS, CLSSID, FRCODE, FRNAME, CENT, FOUND)
 - This routine is used for determining attributes of frames associated with frame class IDs used in CK and binary PCK files.
- **Note: SPICE users will rarely if ever need to call these routines**



Navigation and Ancillary Information Facility

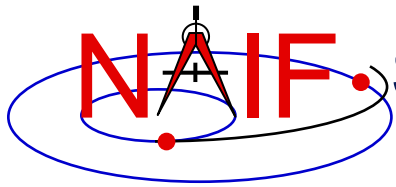
Names and IDs associated with DSK Surfaces



Surface IDs and Names

Navigation and Ancillary Information Facility

- A single ID is assigned to each DSK topography data set for a particular body
 - this ID is called **DSK surface ID** or simply **surface ID**
- One or more names can be associated with that surface ID
 - These names are called **DSK surface names** or simply **surface names**
- Within SPICE software there is a 1-to-MANY mapping between the surface IDs and names
 - On input, the names are treated as synonyms
 - On output, the name that was last associated with the ID is returned



Surface IDs and Names – Where Defined?

Navigation and Ancillary Information Facility

- The surface name-to-ID mappings used by the SPICE system are defined in text kernels
 - usually in FKs
 - using these triplets of keywords that include the ID of the body, placing the name-to-ID mapping in the body's “namespace”

```
NAIF_SURFACE_NAME += ( 'my_surface_name' )  
NAIF_SURFACE_CODE += ( my_surface_ID      )  
NAIF_SURFACE_BODY += ( body_ID            )
```



Note the combination of + and =

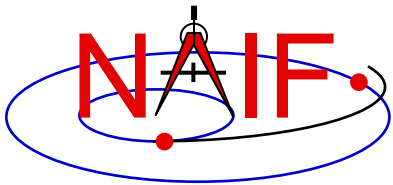
- Since surface name-to-ID mappings are defined within a body's “namespace”, the same surface names and IDs can be used for other bodies if desired



Surface IDs and Names – Where Used?

Navigation and Ancillary Information Facility

- **Surface **IDs** are used as data identifiers:**
 - inside DSK files
 - in some mid-level DSK APIs -- DSKXV, DSKXSI
 - in place of surface names in the METHOD argument in derived geometry routines
- **Surface **names** are used as topography data set identifiers in all high-level, DSK-enabled APIs:**
 - in derived geometry routines -- SINCPT, ILUMIN, SUBPNT, ...
 - in topography sampling routine -- LATSRF
 - in Geometry Finder routines -- GFOCLT



Surface IDs and Names – Example

Navigation and Ancillary Information Facility

- Surface name-ID mappings for ROSETTA targets

DSK Surface Name	ID	Body ID	
=====	=====	=====	
ROS_CG_M004_NSPCESA_N_V1	11000	1000012	(comet C-G)
ROS_CG_K250_NSPCESA_N_V1	11001	1000012	
...			
ROS_CG_M001_OSPGDLR_N_V1	24003	1000012	
ROS_CG_M004_OSPGDLR_N_V1	24004	1000012	
...			
ROS_LU_K003_OSPCLAM_N_V1	1000	2000021	(asteroid Lutetia)
ROS_LU_K006_OSPCLAM_N_V1	1001	2000021	
...			
ROS_LU_M003_OSPCLAM_N_V1	1011	2000021	
...			
ROS_ST_K020_OSPCLAM_N_V1	1000	2002867	(asteroid Steins)

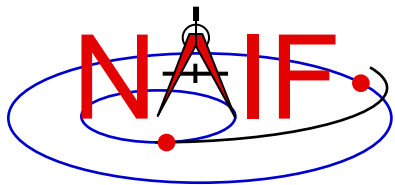
Note: the ROSETTA DSK surface name-ID schema appears rather cryptic because of the need to accommodate multiple shape model versions from multiple producers for three different targets.



Surface Name/ID Mapping APIs

Navigation and Ancillary Information Facility

- **SPICE provides four routines to convert (map) surface IDs to names, and vice versa**
 - To get the surface ID for a given surface name and body name:
CALL SRFS2C(SRFSTR, BODSTR, CODE, FOUND)
 - To get the surface ID for a given surface name and body ID:
CALL SRFSCC(SRFSTR, BODYID, CODE, FOUND)
 - To get the surface name for a given surface ID and body name:
CALL SRFCSS(CODE, BODSTR, SRFSTR, FOUND)
 - To get the surface name for a given surface ID and body ID:
CALL SRFC2S(CODE, BODYID, SRFSTR, FOUND)
- **If the “FOUND” flag returned by either of these routines comes back FALSE, then the input ID or name cannot be mapped**



Connections between Objects and Frames

Navigation and Ancillary Information Facility

- Although object and reference frame naming/numbering schemes are independent, there is nevertheless much 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

Navigation and Ancillary Information Facility

- **CK IDs**

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

- **SCLK IDs**

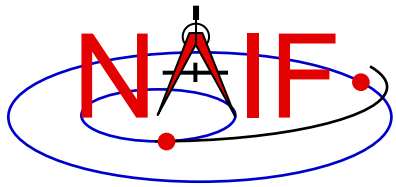
- Because most spacecraft have only one on-board clock, the SCLK ID of that clock is simply the spacecraft ID. This SCLK ID is used by SPICE APIs. **Caution: the negative of the SCLK ID is used in SCLK kernel keywords.**
- Should a spacecraft carry more than one independent clock, unique SCLK IDs for 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)

Navigation and Ancillary Information Facility

	<u>Objects</u> IDs/Names			<u>Frames</u> IDs/Names	
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)

Navigation and Ancillary Information Facility

- **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 Cassini instruments: Cassini IKs
 - » For other missions this information is in the mission's FK
 - For names of the reference frames associated with the Cassini spacecraft, its subsystems and instruments: the Cassini FK
 - For names of inertial frames and body-fixed frames associated with natural bodies: `FRAMES.REQ`
 - For names/IDs of natural objects: `NAIF_IDS.REQ`