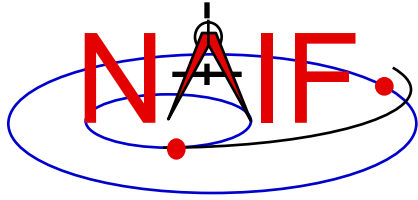**Navigation and Ancillary Information Facility**

IDL Interface to CSPICE "Icy"

How to Access the CSPICE library from the Interactive Data Language (IDL)©
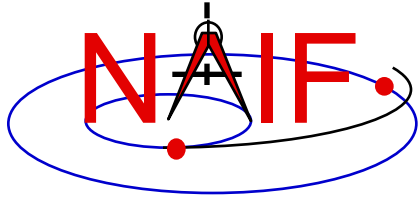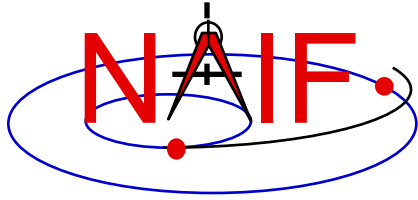
April 2016

Topics

- **Icy Benefits**
- **How does it work?**
- **Distribution**
- **Icy Operation**
- **Vectorization**
- **Simple Use of Icy Functionality**

Icy Benefits

- **Ease of use: Icy operates as an extension to the IDL language regime.**

- **Icy supports more than three-hundred CSPICE routines.**

- **Icy calls usually correspond to the call format of the underlying CSPICE routine, returning IDL native data types.**

- **Icy has some capability not available in CSPICE such as vectorization.**

- **CSPICE error messages return to IDL in a form usable by the *catch* error handler construct.**
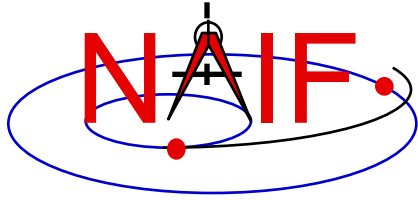
How Does It Work? (1)

- **The IDL environment includes an intrinsic capability to use external routines.**

  – **Icy functions as an IDL Dynamically Loadable Module (DLM). A DLM consists of a shared object library (icy.so/.dll) and a DLM text definition file (icy.dlm).**

    » **The shared library contains a set of IDL callable C interface routines that wrap a subset of CSPICE wrapper calls.**

    » **The text definition file lists the routines within the shared library and the format for the routine's call parameters.**

- **Using Icy from IDL requires you register the Icy DLM with IDL to access the interface routines. Several means exist to do so.**

  – **On Unix/Linux, start IDL from the directory containing icy.dlm and icy.so**
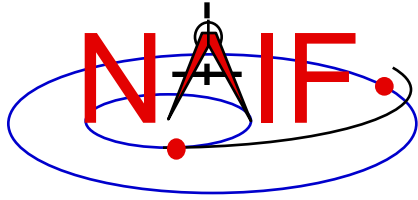
How Does It Work? (2)

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- **From the IDL interpreter (or from a command script), execute the dlm_register command:** IDL> dlm_register,'*_path_to_directory_containing_icy.dlm_*'

    » **Examples (Unix and Windows):**

        » `IDL> dlm_register, '/naif/icy/lib/icy.dlm'`

        » `IDL> dlm_register, 'c:\naif\icy\lib\icy.dlm'`

- **Copy icy.dlm and icy.so or icy.dll to IDL's binary directory:**

    {The IDL install directory}/bin/bin.*user_architecture*

    » **Examples (Unix and Windows):**

        » `cp icy.dlm icy.so    /Applications/exelis/idl/bin/bin.darwin.x86_64/`

        » `cp icy.dlm icy.dll  C:\Program Files\Exelis\idl83\bin\bin.x86_64\`

- **Append to the IDL_DLM_PATH environment variable the directory name containing icy.dlm and icy.so or icy.dll:**

    `setenv IDL_DLM_PATH "<IDL_DEFAULT>:_path_to_directory_containing_icy.dlm_"`

    Caveat: with regards to the Icy source directory, *icy/src/icy*, do not invoke IDL from the directory, do not register the directory, and do not append to IDL_DLM_PATH the directory. This directory contains an "icy.dlm" but no "icy.so."

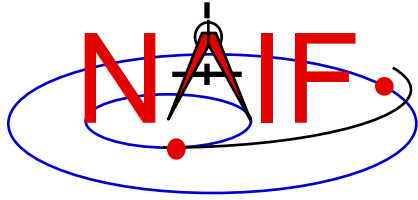**Navigation and Ancillary Information Facility**

When a user invokes a call to a DLM routine:

1. IDL calls…

2. the interface routine in the shared object library, linked against…

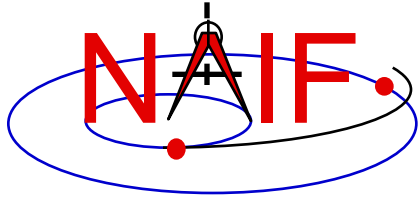**3. CSPICE, which performs its function and returns the result…**

4. to IDL…

… transparent from the user's perspective.

Icy Distribution

- **NAIF distributes the Icy package as an independent product analogous to SPICELIB and CSPICE.**

- **The package includes:**
  - **the CSPICE source files**
  - **the Icy interface source code**
  - **platform specific build scripts for Icy and CSPICE**
  - **IDL versions of the SPICE cookbook programs, *states*, *tictoc*, *subpt*, and *simple***
  - **an HTML based help system for both Icy and CSPICE, with the Icy help cross-linked to CSPICE**
  - **the Icy shared library and DLM file. The system is ready for use after installation of these files**

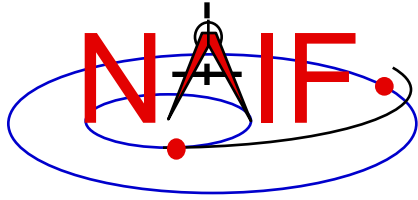- **Note: You do not need a C compiler to use Icy.**

- **A user may occasionally encounter an IDL math exception:**

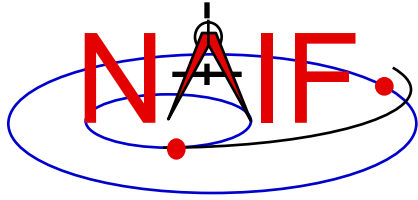 `% Program caused arithmetic error: Floating underflow`

  - **This warning occurs most often as a consequence of CSPICE math operations.**

- **In all known cases, the SIGFPE exceptions caused by CSPICE can be ignored. CSPICE assumes numeric underflow as zero.**

  - **A user can adjust IDL's response to math exceptions by setting the `!EXCEPT` variable:**

    » `!EXCEPT = 0` **suppresses the SIGFPE messages, and even more (e.g. a fatal error).**

    » `!EXCEPT = 1,` **the default, reports math exceptions on return to the interactive prompt.**

    - **NAIF recommends this be used.**

    » `!EXCEPT = 2` **reports exceptions immediately after executing the command.**

- **A possible irritant exists in loading kernels using the `cspice_furnsh` function.**
  - **Kernels are loaded into your IDL session, not into your IDL scripts. This means:**
    - » **loaded <u>binary</u> kernels remain accessible ("active") throughout your IDL session**
    - » **data from loaded <u>text</u> kernels remain in the kernel pool (in the IDL memory space) throughout your IDL session**
  - **Consequence: some kernel data may be available to one of your scripts even though not intended to be so.**
    - » **You could get incorrect results!**
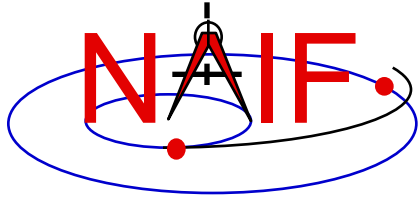   - » **(If you run only one script during your IDL session, there's no problem.)**

– **Mitigation: two approaches**

» **Load all needed SPICE kernels for your IDL session at the beginning of the session, paying careful attention to the files loaded and the loading order (a later loaded kernel has higher precedence)**

- **Convince yourself that this approach will provide ALL of the scripts you will run during this IDL session with the appropriate SPICE data**

» **At or near the end of every IDL script you write:**

- **provide a call to** `cspice_unload` **for each kernel loaded using** `cspice_furnsh,` **or**

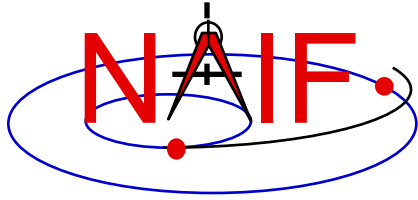- **provide a call to** `cspice_kclear` **to remove ALL kernel data from the kernel pool loaded using** `cspice_furnsh`

Icy Vectorization (1)

- **Several common Icy functions include use of vectorized arguments, a capability not available in C or FORTRAN toolkits.**
  - **Note: IDL indexes arrays using a base value of zero as opposed to FORTRAN, which uses a base value of one.**
    - » **Example: access the first element of an IDL 1xN array using array[0], the second element using array[1], etc.**

- **Example: use Icy to retrieve state vectors and light-time values for 1000 ephemeris times.**
  - **Create an array of 1000 ephemeris times with step size of 10 hours, starting from July 1, 2005.**

```
cspice_str2et, 'July 1, 2005', start
et = dindgen( 1000 )*36000.d + start
```

- Retrieve the state vectors and corresponding light times from Mars to earth at each `et,` in the J2000 frame, using LT+S aberration correction:
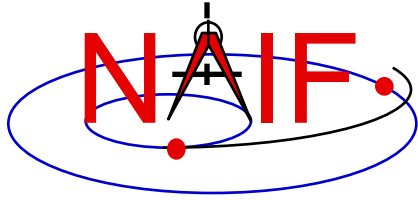
```
cspice_spkezr, 'Earth', et, 'J2000', 'LT+S', 'MARS', state, ltime
```

- Access the *ith* state 6-vector corresponding to the *ith* ephemeris time with the expression

```
state_i = state[*,i]
```

- Convert the ephemeris time vector `et` from the previous example to UTC calendar strings with three decimal places accuracy.

```
format = 'C'
prec   = 3
cspice_et2utc, et, format, prec, utcstr
```
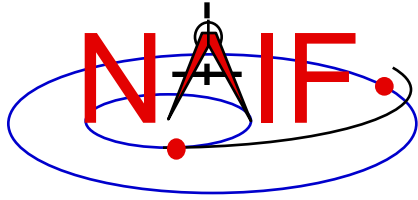
- The call returns `utcstr`, **an array of 1000 strings each *ith* string the calendar date corresponding to** `et[i]`. **Access the *ith* string of utcstr corresponding to the *ith* ephemeris time with the expression**

```
utcstr_i = utcstr[i]
```

- **Convert the position components of the N state vectors to latitudinal coordinates (the first three components of a state vector - IDL uses a zero based vector index).**

```
cspice_reclat, state[0:2,*], radius, latitude, longitude
```

- **The call returns three double precision variables of type Array[1000] (vectorized scalars):** `radius, latitude, longitude.`

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- **As an example of using Icy with vectorization, calculate and plot, in the J2000 inertial frame, the trajectory of the Cassini spacecraft from June 20 2004 to December 1 2005.**

```
;; Construct a meta kernel, "standard.tm", which will be used to load the needed
;; generic kernels:  "naif0011.tls," "de421.bsp," and "pck00010.tpc."

;; Load the generic kernels using the meta kernel, and a Cassini spk.

cspice_furnsh, 'standard.tm'
cspice_furnsh, '/kernels/cassini/spk/030201AP_SK_SM546_T45.bsp'

;; Define the number of divisions of the time interval and the time interval.
STEP = 10000
utc  = [ 'Jun 20, 2004', 'Dec 1, 2005' ]
cspice_str2et, utc, et
times = dindgen(STEP)*(et[1]-et[0])/STEP + et[0]

cspice_spkpos, 'Cassini', times, 'J2000', 'NONE', 'SATURN BARYCENTER', pos, ltime

;; Plot the resulting trajectory.
x = pos[0,*]
y = pos[1,*]
z = pos[2,*]
iplot, x, y, z

cspice_kclear
```
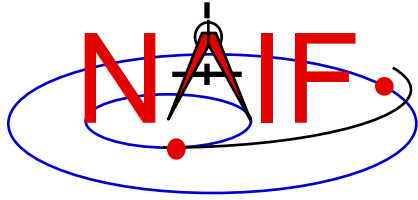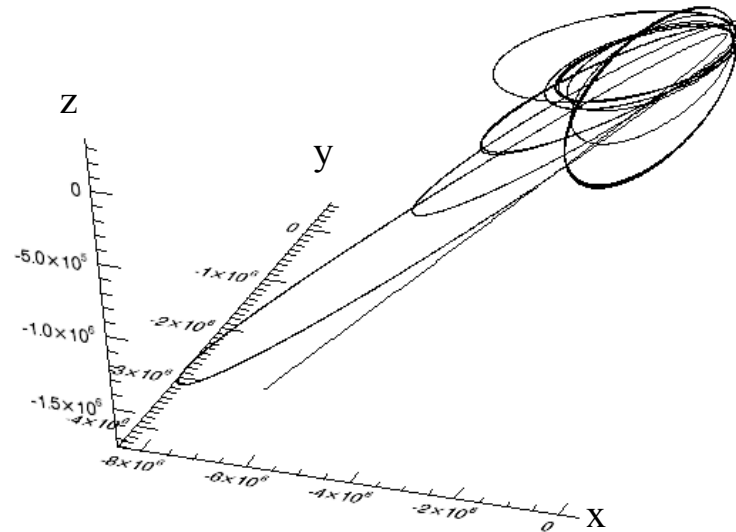
Trajectory of the Cassini spacecraft, in the J2000 frame, from June 20 2004 to Dec 1 2005