

## SPICE Newsletter

September 2015

### Next SPICE Toolkit Release

NAIF is focusing on the first official release of part of the "new" Digital Shape Kernel (DSK)—that portion using a tessellated plate model for small, irregularly shaped bodies—as the driver for the next (version N66) Toolkit release. The end of CY2015 is our target for this release, but this is subject to interruptions from assorted other activities.

### Digital Shape Kernel (DSK) Subsystem

We continue pressing forward on completing implementation of the tessellated plate model portion of the Digital Shape Kernel. We're also doing some work on the digital elevation model component, but this portion is further behind.

Long ago we made an alpha-test version of the tessellated plate portion of DSK available to interested users. The alpha-test DSK Toolkits have to be overlaid with a patch that fixes a bug and adds some additional functionality. Contact someone at NAIF if you're interested in using the alpha-test DSK Toolkit, or if you did not overlay the patch.

As a reminder, the source shape data for any DSK come from outside of NAIF—the SPICE DSK sub-system simply provides a standard way of packaging shape data and then computing a variety of observation geometry based on those shapes, similar to the way SPICE works with the more traditional tri-axial shape models.

You can learn more about the Digital Shape Kernel by reading the "Shape model preview" tutorial available from the NAIF website: <http://naif.jpl.nasa.gov/naif/tutorials.html>. The file name is "37\_shape\_model\_preview."

### JNI Spice

In February of 2010 NAIF announced the availability of an alpha-test version of Java Native Interface (JNI) Toolkits. We very much want to finally "graduate" JNISpice to official status, but that is not likely to happen very quickly. (Work on DSK takes precedence.) The good news is that the alpha-test JNISpice Toolkits seem to work very well; they just don't yet have the full functionality nor the complete documentation found in the official Toolkits.

### New Toolkit Architecture

NAIF conducted a small study focused on if and how we could/should provide a "modern" Toolkit, and in so doing, migrate away from the Fortran 77 Toolkit as our baseline. Such a "modern" toolkit would most likely be based on a language not currently supported by NAIF, such as C++, and would likely provide some measure of thread safety and perhaps object oriented architecture. A variety of other changes (improvements) would hopefully also be embraced. We discussed this idea with local navigation software colleagues, and we surveyed the known user community—people who have registered with the "spice\_announce" Mailman system. The survey provided rather modest feedback—some 23 persons out of the 500+ signed up with "spice\_announce" provided input. We also considered comments we've heard in various other venues in recent years.

Based in part on customer feedback the NAIF Group decided we must first complete a number of other, ongoing development efforts such as JNISpice and the DSK subsystem. We also found there is substantial interest in NAIF first providing an official, up-to-date Python Toolkit.

(Several SPICE users are freely offering their own, partial implementations; see note below under Python SPICE.) And we realize we need to learn a good deal more about C++ or any other possible target language, as well as about thread safety and object oriented design. Consequently we will not be embarking on such a "Toolkit modernization task" right now; we will study the issue further, as time permits, and see what comes of this.

### **Python SPICE**

Some work was done long ago on a NAIF instance of Python wrappers for CSPICE, but there has been no advancement since then. Some SPICE users have made their own, partial versions of a Python-CSPICE interface that they seem willing to freely share. Two of these are:

Andrew Annex: <https://github.com/AndrewAnnex/SpiceyPy>

Mark Showalter: <https://github.com/SETI/pds-tools> ("cspice")

Probably there are still others: one could inquire about such using the "spice\_discussion" Mailman list.

In any case, it seems quite likely NAIF will attempt to implement this product line before possibly embarking on a "Toolkit modernization" task.

### **WebGeocalc Tool (WGC)**

The WebGeocalc tool (<http://naif.jpl.nasa.gov/naif/webgeocalc.html>), providing a GUI interface to a SPICE geometry engine within a client-server architecture, is getting use from around the globe. That's the good news. The somewhat bad news is that it seems too many attempted WGC computations fail. The reasons for these failures are numerous, but erroneous time inputs and requests for a computation outside the time span of available kernels are the most common. Nevertheless, the percentage of failed computations is slowly decreasing and the percentage of users who ultimately get the answer they are seeking seems to be increasing. NAIF will consider if some tweaks to the WGC interface might help reduce the number of failed computations due to erroneous user inputs. (WGC produces a daily log file showing computation attempts and the resultant success or failure status. Each such record is associated with the IP address from which the computation originated so that NAIF can get a general idea of the makeup of the WGC user community.)

### **Cosmographia Visualization Tool**

With the help of three summer students the JPL/NAIF Cosmographia development team has made substantial progress on further evolving this mission visualization tool in support of the SPICE user community. A number of new SPICE-based functions have been added, a number of bugs have been fixed, a tool to aide in the writing or editing of JSON catalog files used to help control Cosmographia has been implemented, a prototype Python-based scripting capability has been added, and an on-line Cosmographia User's Guide and allied video tutorials have been produced. Once we have all these pieces in place we'll send out an announcement via "spice\_announce." (The current version of Cosmographia and allied products is available here: <http://naif.jpl.nasa.gov/naif/cosmographia.html>. Give it a try if you're interested in mission visualization, but then wait for the next release before diving in deep.)

### **SPICE-Aware Tools**

With co-operation from many of our customers we assembled a "SPICE-Aware Tools List." Perhaps you'll find some useful entries in this list. Look for it here:

<http://naif.jpl.nasa.gov/naif/links.html>. If you'd like to have "your tool" added to this list, send an email to charles.acton (at) jpl.nasa.gov.

## **Generic Satellite SPKs**

NAIF continues to receive new (improved) generic satellite ephemeris files from JPL's Solar System Dynamics group. They arrive at irregular and unpredictable times. We post these to the appropriate spot on our server:

[http://naif.jpl.nasa.gov/pub/naif/generic\\_kernels/spk/satellites/](http://naif.jpl.nasa.gov/pub/naif/generic_kernels/spk/satellites/) ,

move the older versions to a sub-directory (./a\_older\_versions), and update the three kernel summary text files (aa\_summaries, aa\_spk\_production\_dates\_by\_alpha, aa\_spk\_production\_dates\_by\_date). The file named "aa\_summaries" is probably the most useful of these three, showing for each ephemeris file the time span covered, the objects included, and the center of motion for each object.

Which SPICE ephemeris objects are found in which SPK files is a consequence of how the ephemeris producer processes his data. Remember, you can "load" multiple SPK files into your program in order to have access to the full set of satellites for a given planet(s).

For your convenience, each of these satellite SPKs also includes the location of the planet itself, the planetary system barycenter, the earth and earth-moon barycenter, and the sun.

Within SPICE Pluto is still treated as a planet. (This might change one of these days.)

If you need to brush up on SPK terminology or functionality, take a look at the SPK tutorial found on the NAIF website: <http://naif.jpl.nasa.gov/naif/tutorials.html>. The file name is "19\_spk".

## **A Change to Comet and Asteroid SPKs made by HORIZONS**

People interested in using SPICE SPK files for studies or missions involving comets or asteroids often generate their own SPK(s) using JPL's HORIZONS small-body ephemeris generator (<http://ssd.jpl.nasa.gov/x/spk.html>), then download the SPK(s) to their own computer for use in a local program. Up through "now" (September 2015) such SPKs have been made in the Type 1 SPK format. But very shortly HORIZONS will switch to use of the new Type 21 SPK format that allows for more precise ephemeris representation in some cases. Once this change is made, users of HORIZONS-generated comet or asteroid SPKs will need to re-link their SPICE-aware programs to Toolkit Version N65, or later in order to be able to read these new SPKs. One need NOT change one's code, just re-link to the N65 Toolkit's ready-built library. Since SPICE Toolkits are designed to be fully backwards compatible, making this upgrade should not be a problem. The many Toolkit environments supported by NAIF are found under here: <http://naif.jpl.nasa.gov/naif/toolkit.html>. Be very careful to pick the Toolkit environment that matches your computing system!

## **SPK as an IAU Ephemeris Standard**

During its recent General Assembly meeting the International Astronomical Union (IAU), Commission 4 Working Group on Standardizing Access to Ephemerides and File Format Specifications, formally accepted use of the SPICE SPK format as its recommendation for comparing planetary ephemerides. There are three ephemeris-producing groups associated with this Working Group: the Institut de Mécanique Céleste de Calcul des Éphémérides (IMCCE) in France (INPOP ephemeris), the Institute of Applied Astronomy (IAA) in Russia (EPM ephemeris), and the Solar System Dynamics Group (SSD) at NASA/JPL (Developmental Ephemeris, or DE for short). SPICE was originally built to accommodate the JPL DE ephemeris, but some extensions have been made to handle the other two formats as well. Both IMCEE

and IAA have means to produce their ephemerides in SPK format.

A new Ephemeris Commission was formed during the General Assembly meeting. Perhaps this commission will consider extending the planetary ephemeris recommendation noted above to using the SPK format for satellites, comets and asteroids (TBD).

### **NAIF Support of the new IAU Fundamental Standards Commission.**

At the IAU General Assembly a new Fundamental Standards Commission was formed, with the objective of promoting and educating folks on the IAU's various standards.

( <http://www.iau.org/submissions/newcommissions/detail/70/> ) NAIF is a member of the organizing group for this commission—we hope to help the IAU with its objectives pertaining to solar system missions, and at the same time, have SPICE become a better purveyor of IAU standards.

### **New Dynamic Frames Kernels**

For many years NAIF has had on its work list the goal of producing a generic, dynamic reference frames kernel. See the SPICE dynamic frames tutorial for an explanation of dynamic frames. <http://naif.jpl.nasa.gov/naif/tutorials.html>. The file name is "24\_dynamic\_frames."

(Note: many people use the term "coordinate system" where SPICE uses "reference frame.") Dynamic frames—certain reference frames for which the principal axes are based on directions computed from ephemeris or body orientation—can be used to better understand the physical phenomena pertaining to the solar system and spacecraft used to explore it.

A draft of such a dynamic frames kernel was produced by an ESA colleague during the Mars Express primary mission time frame. NAIF has now embarked on producing an official generic dynamic frames kernel set. This is a challenging undertaking: deciding which dynamic frames to implement, how (algorithmically) to implement them, what data to use in implementing them, and how to name them are all questions to be resolved. We hope to offer this new dynamic frames kernel in the near future.

### **SPICE Live Training**

The NAIF Team conducted a SPICE beginner's class in Maryland, in October 2014. We've started to receive inquiries about when will be the next class, so we're now looking into this. We'll keep you posted via "spice\_announce." (It will likely be held in the Pasadena, CA area, either late this winter or spring of 2016.)

ESA's ExoMars TGO mission asked NAIF to plan on giving a SPICE training class somewhere in Europe, and probably after launch (TBC). That class might be opened to folks outside of the ExoMars project, but this is for ESA to decide.

No other foreign training classes involving NAIF are currently identified.

A Russian colleague is conducting some SPICE training at educational institutions in Moscow.

NAIF believes that an advanced training class could be helpful to some SPICE users, but finding the time to prepare the needed tutorials and programming lessons is a challenge. One day we'll get to it, especially if enough SPICE users push us in this direction.

### **SPICE Self Training**

NAIF believes the live classes taught by NAIF team members have been quite useful. But given the infrequent occurrence of the classes as well as students' challenges to attend one of these,

a self-training alternative was needed. To support self-training NAIF has published a typical class agenda and the shortened tutorials and lessons used in the live classes. The difference between the shortened tutorials and the standard ones available from the NAIF website is that many of the class tutorials have been reduced in scope and depth to just highlight the key points covered during a class. The lessons provided in the self-training packages are the same as used in the live classes, these being a subset of those available from the NAIF website. Anyone interested in working through the self-training materials can find the needed information on the "Self-training" link on the NAIF website:  
[http://naif.jpl.nasa.gov/naif/self\\_training.html](http://naif.jpl.nasa.gov/naif/self_training.html).

### **NAIF Website Updates**

NAIF continues to make updates to its website in hopes of better serving the planetary science community. We also post announcements there, some of which are not sent to the "spice\_announce" Mailman distribution list. If you are a frequent user of SPICE you might make a point of checking the announcements page, <http://naif.jpl.nasa.gov/naif/announcements.html>, every month or two.

### **SPICE for Heliophysics**

In mid-May NASA's Heliophysics Division released a draft Cooperative Agreement Notice (CAN) pertaining to proposals for enhancing the Heliophysics Data Environment. Being somewhat aware that SPICE is already used somewhat in this domain, NAIF contemplated proposing to this CAN to more fully infuse SPICE into Heliophysics research. Discussions with a number of scientists who are involved in this domain and have some familiarity with SPICE suggested NAIF making a proposal could be a good thing. However, realizing how much work is already in our backlog, it seems inadvisable to propose to take on still more. The infusion of SPICE capabilities into Heliophysics can informally grow to whatever extent scientists and engineers involved therein choose to push it.

### **SPICE for NASA Human Exploration and Operations**

There has been some use of SPICE within the NASA Human Exploration and Operations Mission Directorate (HEOMD) mission planning activities at Johnson Space Center. NAIF doesn't know much about this, but is happy if SPICE can be useful in this domain. It is noted that SPICE software, while seeming to be quite well tested, has not been through any of the rigors required for human-rated applications.

### **Selecting an Ancillary Data System**

This set of charts notes important points in selecting a methodology for providing ancillary data to a flight project. It also notes advantages and disadvantages of using SPICE. Of course it does so with absolutely no bias! ☺

[http://naif.jpl.nasa.gov/naif/Ancillary\\_Data\\_Production.pptx](http://naif.jpl.nasa.gov/naif/Ancillary_Data_Production.pptx)

We note that use of SPICE is not a requirement of NASA's Planetary Science Division, nor of any other NASA or foreign entity.

## **Flight Projects Using SPICE**

For those curious about where SPICE is being used, here is a summary of what we know. (We have some reason to believe the use of SPICE is more extensive than this.)

All current NASA planetary projects are using SPICE; we guess this will be true for Europa and Mars2020 as well. A number of NASA projects from other science disciplines are also using SPICE (e.g. Solar Probe Plus and Soil Moisture Active and Passive).

Selection of the next NASA Discovery proposal(s) that will move to implementation will come along next year. It seems quite possible it or they will elect to use SPICE, but this is TBD.

ESA's Mars Express, Venus Express, and Rosetta missions continue to offer SPICE versions of ancillary data as an alternative to the official ancillary data files. Caution: production of the SPICE archives for these missions lags behind production of the science data archives. More information is available here: <http://www.cosmos.esa.int/web/spice>.

ESA has stated it will use SPICE on ExoMars TGO, BepiColombo, JUICE and Solar Orbiter.

JAXA's Akatsuki mission to Venus and Hayabusa-2 mission to asteroid 1999 JU<sub>3</sub> reportedly intend to use SPICE for science support. A bit more information is available here: <http://darts.isas.jaxa.jp/planet/spice/index.html.en>.

ISRO made some use of SPICE on its Chandrayan-1 mission, but these data are apparently not yet openly published. NAIF has heard that ISRO's Mars Orbiter Mission (MOM) is using SPICE, and will release these data to ISSDC registered users after a validation and peer review period. It is looking as though there could be some use of SPICE on the joint NASA/ISRO NISAR earth observation mission (TBC).

We can speculate that future Russian planetary missions (ExoMars 2018, Venera-D, Luna-Glob) might consider once again trying SPICE, but there's been no specific conversation about this, and NAIF is precluded from having any bilateral discussions. The Russian SPICE website is here: [http://spice.ikiweb.ru/index\\_en.html](http://spice.ikiweb.ru/index_en.html).

NAIF is precluded from having bilateral involvement with the Chinese Space Agency, so we are unaware if there is any use of SPICE on their solar system or other missions.

Please advise if you find any errors or omissions in the summary above.

A table summarizing SPICE use by flight projects is available: [http://naif.jpl.nasa.gov/naif/SPICE\\_Users.pdf](http://naif.jpl.nasa.gov/naif/SPICE_Users.pdf).

## **Looking For a New Team Member**

There is some possibility NAIF could obtain funds sufficient to hire a new, permanent staff member to join the existing four-person team. If you know of someone who might be interested in this possibility, please point him/her to this job description:

<http://naif.jpl.nasa.gov/naif/possiblenewhire.pdf>.



## Getting Information on SPICE

If you have a question best answered by NAIF staff, please see our [Getting Help](#) webpage:  
<http://naif.jpl.nasa.gov/naif/gettinghelp.html>

If you have a question likely answerable ONLY by a SPICE user—not a NAIF staffer—then use the "[spice\\_discussion](#)" Mailman system:

[https://naif.jpl.nasa.gov/mailman/listinfo/spice\\_discussion](https://naif.jpl.nasa.gov/mailman/listinfo/spice_discussion).

Inputs to "spice\_discussion" are now moderated.

The "[spice\\_announce](#)" Mailman system is reserved for use by NAIF staff to make announcements that seem fairly important and of broad interest. We try to limit the use of this notification system.

NAIF's "[Announcements](#)" web page is used more often than is "spice\_announce" for assorted announcements. <http://naif.jpl.nasa.gov/naif/announcements.html>

## Your Feedback

NAIF is always interested to hear your suggestions for improving SPICE capabilities and NAIF operations. Contact anyone at NAIF or communicate with any of the Planetary Data System management listed below.

Mr. William Knopf, NASA PDS Program Exec [william.knopf-1 \(at\) nasa.gov](mailto:william.knopf-1@nasa.gov)

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## Programmatic Update

NAIF was not included in the recent re-competition of PDS nodes. Presumably this means NAIF will be in business for at least another five years, although perhaps subject to successfully completing a NASA Senior Review at some point.