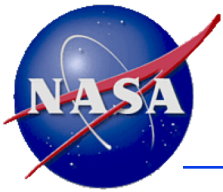


Navigation and Ancillary Information Facility

Trivial Example of Using WebGeocalc (WGC)

Computing Distances Between Objects

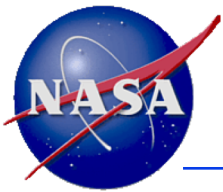
March 2018



WebGeocalc Overview

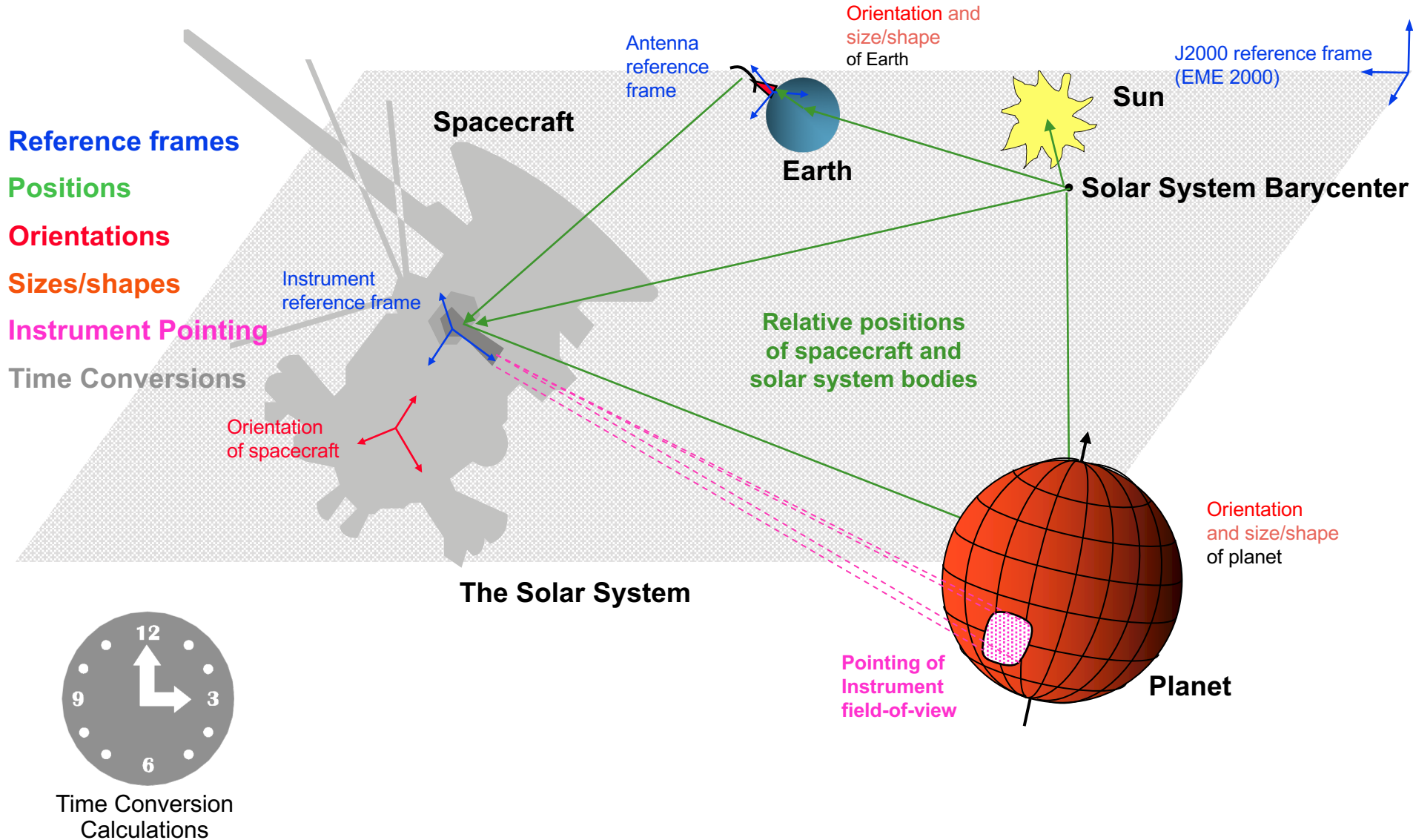
Navigation and Ancillary Information Facility

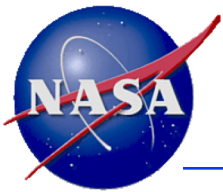
- **WebGeocalc (WGC) provides a graphical user interface (GUI) to a SPICE server running a geometry computation engine.**
 - The server has access to SPICE kernels containing ancillary data.
 - WGC has been programmed to be able to make quite a few typical SPICE kinds of computations.
 - Using WGC to make observation geometry computations is easier than having to write your own program that incorporates some SPICE Toolkit software.



What are Ancillary Data?

Navigation and Ancillary Information Facility

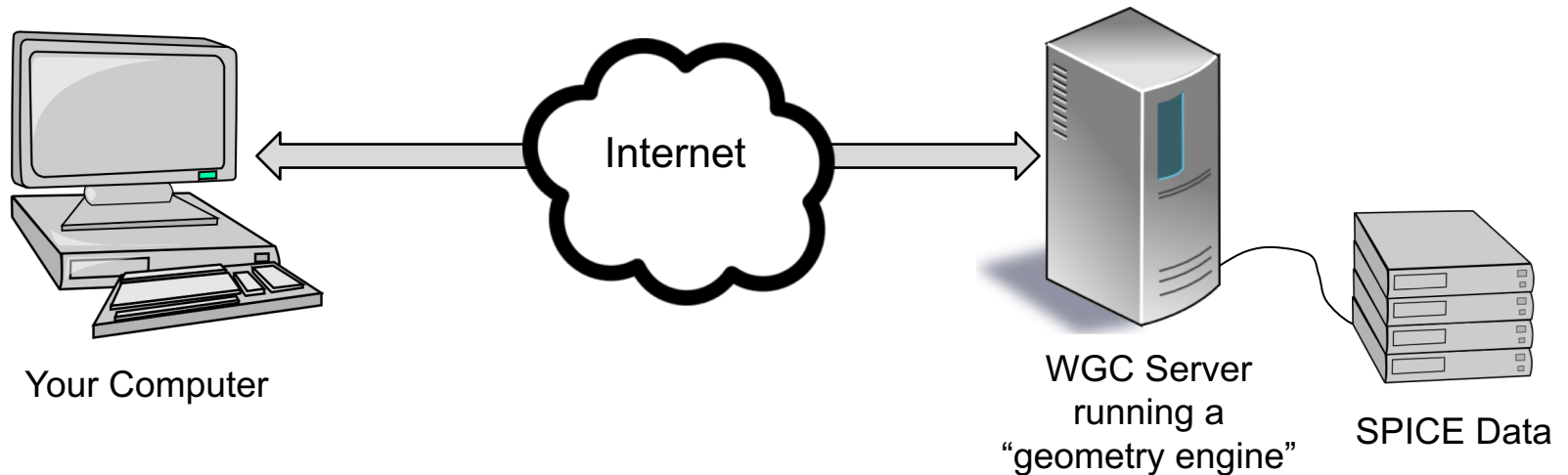


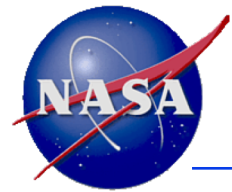


Architecture

Navigation and Ancillary Information Facility

- **WGC uses a client-server architecture**
 - The user needs only a computer running a web browser.
 - The browser connects via Internet to a WGC “computation engine” running on a server.
 - » The WGC server has access to a variety of SPICE kernel files.

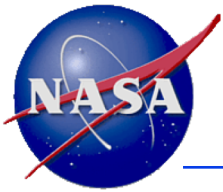




Using WebGeocalc

Navigation and Ancillary Information Facility

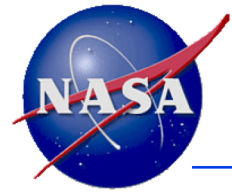
- **WGC makes it “easy” to do many kinds of SPICE computations.**
 - You need not write a program using SPICE Toolkit software.
 - Instead, open a web browser and use standard GUI widgets to:
 - » read a variety of HELP statements (if just learning to use WGC)
 - » select the computation desired
 - » select the data to be used in your computation
 - » specify the computation details
 - » press the “CALCULATE” button
 - Your results, possibly including some plots, appear in your browser window.



A Very Simple Example

Navigation and Ancillary Information Facility

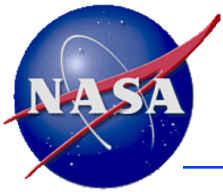
- **We'll compute the distance between two "ephemeris objects" over a time range.**
 - One of the objects will be designated as the "target" and the other object as the "observer."
- **If you've read a bit about SPICE, you'll know that in SPICE terminology an "ephemeris object" is anything whose position & velocity are provided using a SPICE-style ephemeris—a SPICE SPK file.**
 - Examples: planets, satellites, spacecraft
 - You can read about ephemeris objects and SPK files here:
 - » http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Tutorials/pdf/individual_docs/18_spk.pdf



Possible Differences

Navigation and Ancillary Information Facility

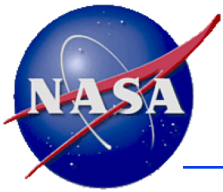
- **Your results could differ somewhat from those shown in this presentation if:**
 - the planet ephemeris used in the “solar_system_kernels” data set currently used by WebGeocalc (WGC) is different from the one used when this example was produced
 - new leap seconds have been declared and the leapseconds kernel used in the “solar_system_kernels” data set has been updated as compared to the one used when this example was produced
 - a future upgrade of the WGC server’s math libraries results in round off of a last digit differently as compared to the round offs made when this example was produced



Your Problem Statement

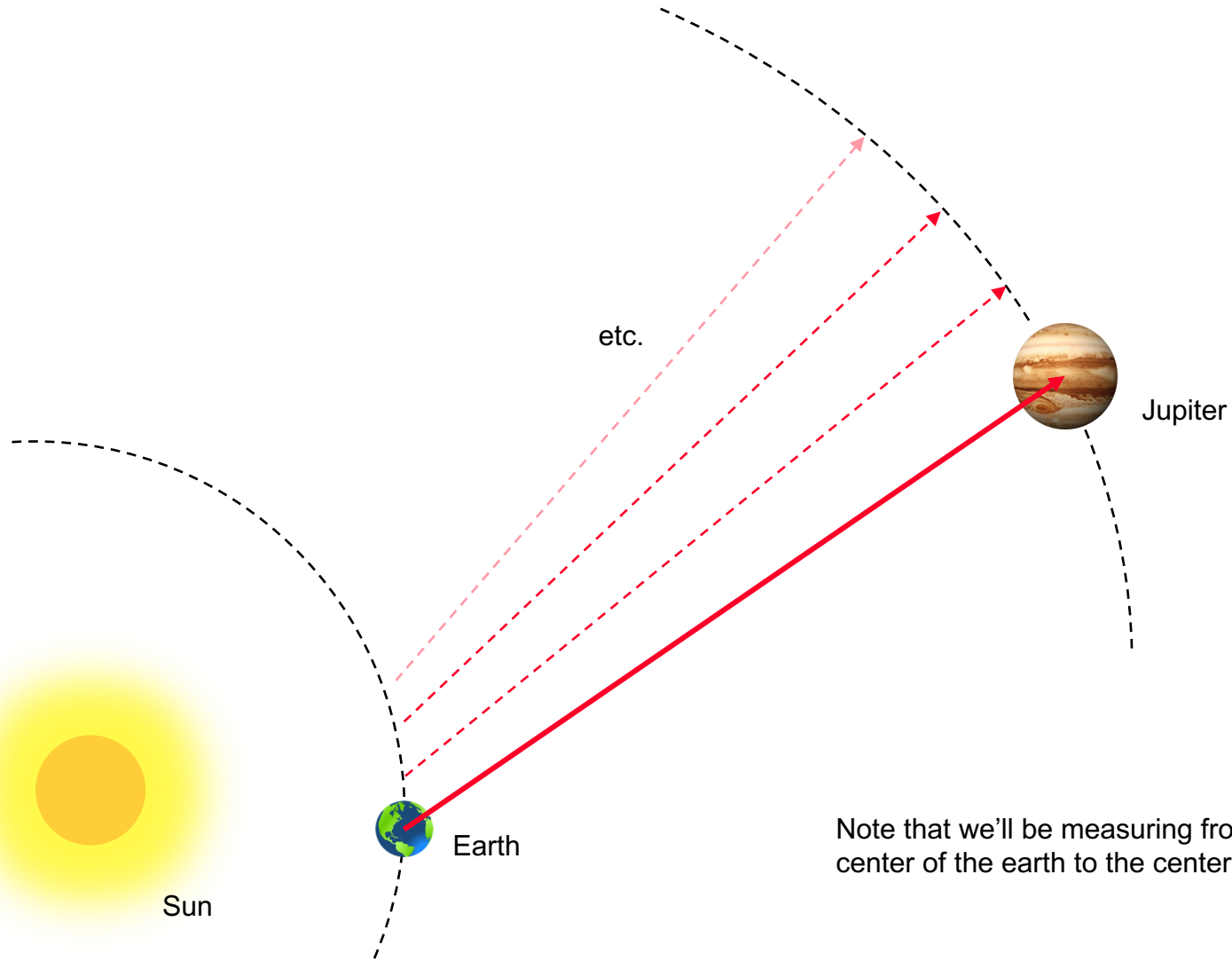
Navigation and Ancillary Information Facility

- **You wonder what is the range from Earth to Jupiter in the period Jan 01, 2015 to Jan 01, 2020?**

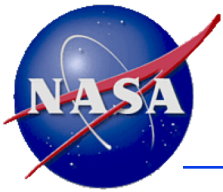


Find the Distance Between Earth and Jupiter from Jan 01, 2015 to Jan 01, 2020

Navigation and Ancillary Information Facility



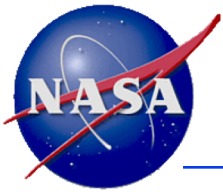
Note that we'll be measuring from the center of the earth to the center of Jupiter



Before Diving In...

Navigation and Ancillary Information Facility

- The “About the Data” link available on the WGC pages (upper-right corner) contains very important information about the data available to WGC. **It’s a bit long but be sure to read this!**
 - “About the Data” also links to a WGC tutorial, and to a glossary of terms.
- If you are new to using SPICE, some of the on-line SPICE tutorials might be helpful, especially:
 - » Conventions
 - » Time
 - » SPK
 - » Geometry finder
- These and many other SPICE tutorials are found here:
 - » <http://naif.jpl.nasa.gov/naif/tutorials.html>
- Keep these in mind if you get stymied.



Getting Started

Navigation and Ancillary Information Facility

- **Open a web browser and start WebGeocalc**
 - <https://wgc.jpl.nasa.gov:8443/webgeocalc/>
- **You'll see a list of the calculations available, in three categories.**

Geometry Calculator

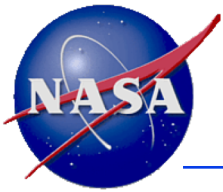
State Vector	Calculate the position and velocity of a target with respect to an observer.
Angular Separation	Calculate the angular separation between two targets as seen from an observer.
Angular Size	Calculate the angular size of a target as seen from an observer.
Frame Transformation	Calculate the transformation between two reference frames.
Illumination Angles	Calculate the emission, phase and solar incidence angles at a point on a target as seen from an observer.
Sub-solar Point	Calculate the sub-solar point on a target as seen from an observer.
Sub-observer Point	Calculate the sub-observer point on a target as seen from an observer.
Surface Intercept Point	Calculate the intercept point of a vector or vectors on a target as seen from an observer.
Orbital Elements	Calculate the osculating elements of the orbit of a target body around a central body.

Geometric Event Finder

Position Finder	Find time intervals when a coordinate of an observer-target position vector satisfies a condition.
Angular Separation Finder	Find time intervals when the angle between two bodies, as seen by an observer, satisfies a condition.
Distance Finder	Find time intervals when the distance between a target and observer satisfies a condition.
Sub-Point Finder	Find time intervals when a coordinate of the sub-observer point on a target satisfies a condition.
Occultation Finder	Find time intervals when an observer sees one target occulted by, or in transit across, another.
Surface Intercept Finder	Find time intervals when a coordinate of a surface intercept vector satisfies a condition.
Target in Field of View	Find time intervals when a target intersects the space bounded by the field-of-view of an instrument.
Ray in Field of View	Find time intervals when a specified ray is contained in the space bounded by an instrument's field-of-view.


Time Calculator

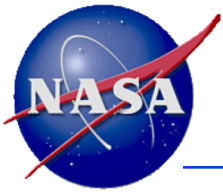
Time Conversion	Convert times from one time system or format to another.
---------------------------------	--



Getting Started

Navigation and Ancillary Information Facility

- **Under the Geometry Calculator category, select the “State Vector” calculation.**
 - The combination of position and velocity are often referred to as “state.”
- **Under the calculation title you’ll see a brief statement of what this calculation does:**
 - “Calculate the position and velocity of a target with respect to an observer.”
 - This calculation also returns the distance between the objects.
- **If you click on the help button to the right of this explanation  a more detailed description of the calculation will be shown, along with a graphic representation of the calculation.**
 - Click on the small arrow next to the help button to close the help text and drawing.

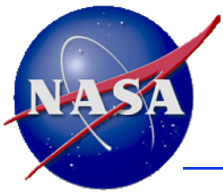


Selecting the Data

Navigation and Ancillary Information Facility

- The generic kernels contained in the “Solar System Kernels” data set should provide the needed data.
- Using the “Kernel selection” drop-down menu use your mouse to highlight “Solar System Kernels.”
 - If you hold down your cursor over the “Solar system kernels” menu item for a couple of seconds you’ll see a pop-up tool-tip display showing the time span covered by this kernel set: in this case it’s 1950 to 2050.* So this data set certainly covers the time span of interest to you.
- When you release your cursor, “solar system kernels” will have been selected.
 - “Solar system kernels” appears in the drop down menu, and “Solar System Kernels kernel set” appears in the right-side panel entitled “Kernels Selected.”
 - You could hover your cursor over “Solar System Kernels kernel set” in the Kernels Selected panel to again see the pop-up tool-tip showing the time period covered.

* The “Solar System Kernels” data set is a bit of a special case: the various kernels in this collection have widely varying coverage. The span 1950 to 2050 works for all kernels in this collection; some have a much longer time span.



Start Filling in your Inputs

Navigation and Ancillary Information Facility

State Vector

Calculate the position and velocity of a target with respect to an observer. ? ▶

Kernel selection:

Solar System Kernels

Target:

JUPITER

Observer:

EARTH

Reference frame:

J2000

Aberration Correction

Light propagation: ☒ None ☐ To observer ☐ From observer ? ▶

Light-time algorithm: Converged Newtonian ? ▶

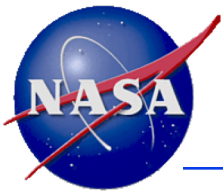
Stellar aberration: ☒ Include stellar aberration correction ? ▶

The “Solar System Kernels” data set provides WGC with the generic (mission-independent) planetary ephemeris (SPK), and the latest leap seconds (LSK), and still more.

Pick Jupiter as your target and earth as the observer. (For this simple example you could have done just the opposite: it doesn’t matter.) Note the auto-complete feature that shows you the available (allowed) inputs—scroll down and pick the item you want.

Many WGC calculations, including this one, can take one-way light time into account. For simplicity, let’s not do so in this example, so pick “None” as the aberration correction.

Many WGC calculations, including this one, need to know the reference frame to be used in the output. Since you only want to compute distance, the reference frame doesn’t matter. Pick the most commonly used frame: J2000.



Continue Filling in your Inputs

Navigation and Ancillary Information Facility

Input Time

Time system: ? ▶

Time format: ? ▶

Input times: ☐ Single time ☒ Single interval ☐ List of times ☐ List of intervals

Start time: ? ▶

Stop time: ? ▶

Time step: ? ▶

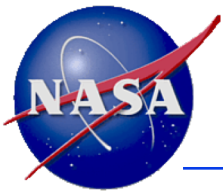
Use the UTC time system for inputting your start and stop times, since this is the most commonly used system.

Select calendar format for entering start and stop times.

Enter the desired start and stop times in calendar format. WGC can understand many, but not all, possible forms. Some valid examples are shown.

Pick a step size; WGC will compute the Earth-Jupiter range at each of these steps. If the step size is too large, your results may be too sparse for your needs. If your step size is very small, the calculation may run very long, or it may be rejected by WGC.



2015 JAN 01 13:24:12
2015/01/01 13:24:12
01 JAN 2015 13:24:12.016
2015-01-01T13:24:12
Jan 01, 2015
jan 01 2020
2015-001/13:24:12.016 (Day of year form)




Complete Filling in your Inputs



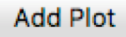
Navigation and Ancillary Information Facility



Select the coordinate system in which you'd like your output. In this simple example all you want is the distance, so most of the offered options will work. Let's keep it simple by leaving it set to the default: Rectangular.

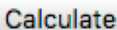
State representation: Rectangular  

Plots

Time series plots: ☒ Distance ☒ Speed ☐ X ☐ Y ☐ Z ☐ dX/dt ☐ dY/dt ☐ dZ/dt 

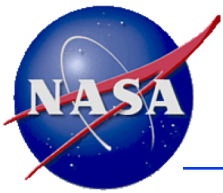
X-Y plots: X: Distance  vs. Y: Distance  

Error handling: Stop on error  



WGC allows you to specify what action to take if it is unable to complete your request. In most cases it is best to leave this set to the default: "Stop on error."

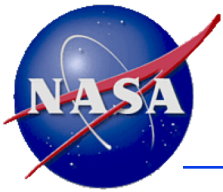
For this calculation WGC offers the option of creating plots of Distance and Speed as a function of time. Check one or both of these boxes if you like.



“Calculate”

Navigation and Ancillary Information Facility

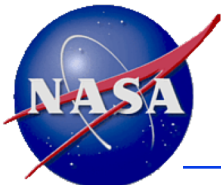
- **Press the Calculate button and see what happens!**
 - If you left out an input, or you provided an unusable or erroneous input, a red warning message will be displayed.
 - » In this case fix the problem and press “Calculate” again.
- **If your inputs are all acceptable, WGC will grey the screen and display a small window showing the progress of your calculation.**
- **When done, your results will be displayed below your inputs.**



Your Results

Navigation and Ancillary Information Facility

- **When the calculation is completed, WGC will display:**
 - a summary of your inputs,
 - your numeric results, and
 - any optional plots you may have requested.
- **If your numeric results exceed about 14 time steps, the results will be contained in a vertically scrollable window.**
- **If your numeric results contain more items per time step than fit in the window's width, the output window will be horizontally scrollable.**



Numeric Results

Navigation and Ancillary Information Facility

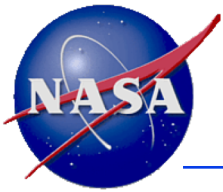
Your results (time and distance), plus more.

Tabular Results

Click a value to save it for a subsequent calculation.

	UTC calendar date	Distance (km)	Speed (km/s)	X (km)	Y (km)
1	2015-01-01 00:00:00.000000 UTC	679839255.43889670	20.58529796	-532328089.75084590	38382228
2	2015-01-02 00:00:00.000000 UTC	678307155.89371290	20.42686465	-530575479.98548615	38357674
3	2015-01-03 00:00:00.000000 UTC	676809646.35130210	20.26981015	-528830790.62009580	38337125
4	2015-01-04 00:00:00.000000 UTC	675347080.61656570	20.11896969	-527094591.76724380	38320550
5	2015-01-05 00:00:00.000000 UTC	673920191.20643380	19.97093404	-525367709.96064070	38307940
6	2015-01-06 00:00:00.000000 UTC	672529457.75237420	19.82609435	-523650746.89099370	38299280
7	2015-01-07 00:00:00.000000 UTC	671175514.65879510	19.68728254	-521944538.74841890	38294548
8	2015-01-08 00:00:00.000000 UTC	669858964.27274880	19.54914097	-520249699.36066140	38293743
9	2015-01-09 00:00:00.000000 UTC	668580455.76147950	19.41656454	-518567132.68917745	38296836
10	2015-01-10 00:00:00.000000 UTC	667340646.10364710	19.28492721	-516897638.89629070	38303816
11	2015-01-11 00:00:00.000000 UTC	666139886.22825250	19.16089947	-515241840.09391385	38314644
12	2015-01-12 00:00:00.000000 UTC	664978884.18018040	19.03891524	-513600549.10511110	38329311

Note the scroll bars

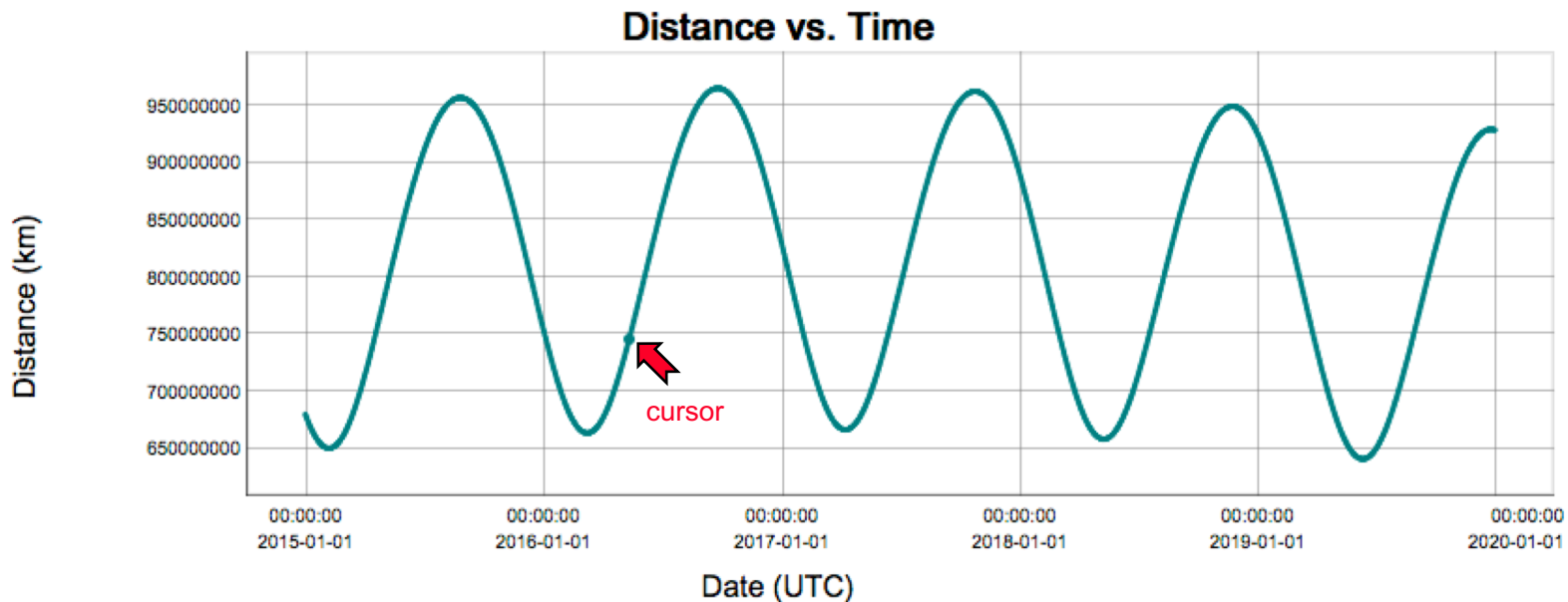


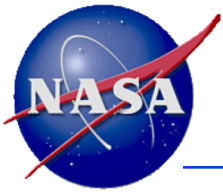
Optional Plot: Distance vs. Time

Navigation and Ancillary Information Facility

- If you hold your (**red**) cursor over any plotted point, the X and Y values will be displayed in the upper-right corner.

2016-05-11 23:59:59.0000 745684823.50364100

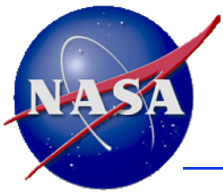




Examining Your Results

Navigation and Ancillary Information Facility

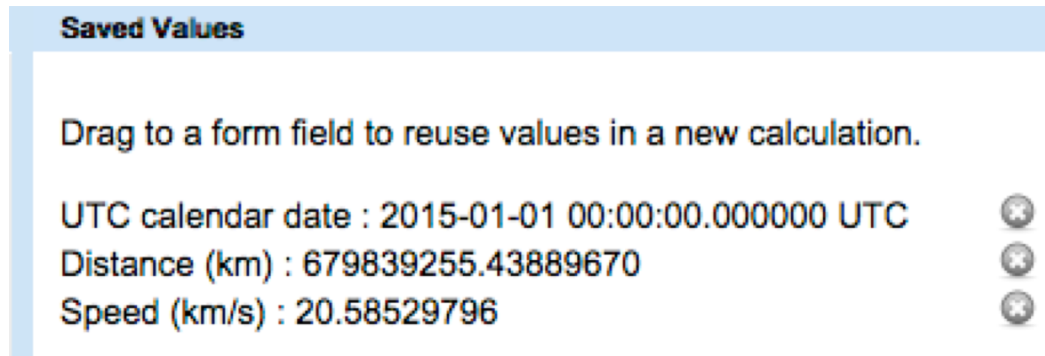
- **You can scroll through the table of numeric results to find the distance to Jupiter at any of the time steps.**
- **You can hover your cursor over a plot to see the time and distance or speed value at any point.**
 - **To make examination of the plot easier, you could click and drag your cursor horizontally or vertically over a portion of the plot to zoom in.**
 - » **This can be repeated multiple times.**
 - **Click “Prior zoom” to back out one zoom step.**
 - **Click “Reset Zoom” to jump back to the original plot.**



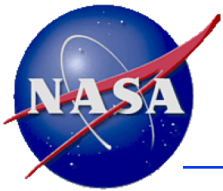
Saving Individual Numbers Inside WGC

Navigation and Ancillary Information Facility

- **You can save any value appearing in the table of numeric results by simply clicking on the value of interest.**
 - That value will then appear in the “Saved Values” window on the right side of the WGC screen
 - For example, if you clicked on the date, distance and speed values in the very first output row, the “Saved Values” window would look something like this:



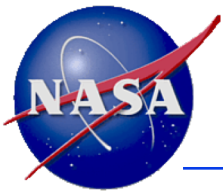
- You could later drag any of these saved values to an input field of a subsequent WGC calculation, a process called “chaining.”
 - » Clicking the ✕ icon deletes that value from the saved results.



Downloading Output

Navigation and Ancillary Information Facility

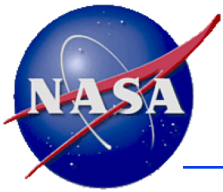
- **You can download the entire table of numeric output by clicking on the “Download Results” button appearing directly underneath the “Results” title.**
 - You’ll be given three formatting options:
 - » Excel
 - » Comma separated values
 - » Plain text
 - This option can be helpful if you wish to use the results in another application, or if you wish to include the results in a presentation or document.
- **You can download any of the optional plots by pressing the “Download Plot” button appearing just above the plots.**
 - The plots will be downloaded to your computer in PNG format, ready for inclusion in a presentation or document.



What You've Learned

Navigation and Ancillary Information Facility

- **Each input has associated HELP text.**
- **WGC will display an error message in red font in a red box whenever it detects a problem.**
- **When a named kernel set is used, an auto-complete feature helps you pick valid objects and reference frames. (This also applies to instruments, when an instrument is involved.)**
- **The numeric results panel will contain a scroll bar if the number of lines exceeds approximately 14.**
- **Many calculations offer optional plotting, with available zoom features. Your cursor can be used to determine the coordinates for a given point.**
- **You can save numeric results for use later on.**
- **You can download plots for use elsewhere.**



Limitations of WebGeocalc

Navigation and Ancillary Information Facility

- **While WGC offers a good deal of capability, it does not allow one to do everything possible when using SPICE APIs in one's own program. Most particularly:**
 - a limited set of SPICE computations are built-in to WGC
 - WGC can use only those SPICE kernels available on the host server
 - the auto-complete feature available for some fill-in boxes works only for SPICE data sets configured for use in WGC: it does not work for kernels selected using the MANUAL process.
 - WGC is set up to disallow very time consuming computations