STK Tutorial

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Contents

OVERVIEW

This tutorial presents exercises that will assist you in developing a solid understanding of the basic functions in STK as well as a brief introduction to some of STK's more advanced features and functions. The tutorial is intended to help you develop a context in which to place the fine details of STK as you begin to work with the program and its modules. Use the demo scenarios shipped with STK and the tutorial that follows to become familiar with the basic structure of STK as well as its functions and features.

Licenses Needed

This tutorial requires that you be licensed for the STK Professional Edition.

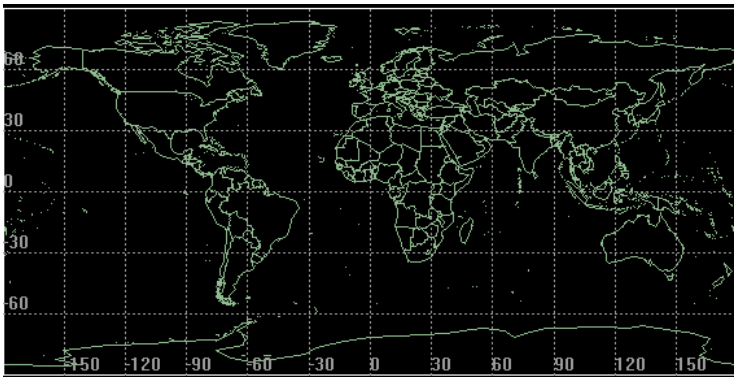
Although this tutorial introduces the user to many of the features available in STK, it addresses only a small sampling of STK functionality. For a complete explanation of all STK functions, please consult the STK Online Help system or take one of our extensive training classes.

Creating the STKTutorial Scenario

Note: To ensure that you do not accidentally overwrite your previous work, save each scenario in a separate folder and name the folder with the same name as the scenario.

The scenario is the highest-level object in STK; it includes one or more 2D and 3D Graphics windows and contains all other STK objects (e.g., satellites, facilities, etc.). This section of the tutorial guides you through the process of creating and populating a scenario.

1. Start STK.
2. To create a new scenario, click the  (Create a New Scenario) icon in the Welcome to STK! window. The STK: New Scenario Wizard will appear. This is a window designed to help streamline the process of creating, saving, and organizing scenario files.
3. Rename the scenario STKTutorial.
4. You can add a unique description so that you can remember the reason you created this scenario. Enter "Learning the basics of STK."
5. Set the Analysis Period Start Time to 1 Jul 2007 12:00:00.000 UTCG.
6. Set the Analysis Period End Time to 2 Jul 2007 12:00:00.000 UTCG.
7. Click OK. A 2D and 3D Graphics window appears. Also the Insert STK Objects window appears.



Note:	For publication purposes, 2D Graphics colors have been reversed. In most instances, the 2D Graphics window is a color-on-black display.

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Tip:	To change the size of the 2D or 3D Graphics window, click and hold the mouse button on any of the corners and drag the window border. When you release the mouse button, the window re-sizes. The aspect ratio of the map projection is preserved automatically by STK, by creating blank space in the window when its size does not fit the correct ratio. Click the (2:1 Aspect Ratio) button on the 2D Graphics toolbar to resize the window to eliminate this blank space.

You are now ready to start building a scenario.

Setting the STKTutorial Environment

Before performing any tasks in STK, you need to set parameters that will affect all aspects of your scenario as it is built.

Setting Application Properties

First, we will set some application parameters for STK. These high-level parameters affect every object within the application, regardless of the scenario currently open.

1. To set parameters for the STK application, click Edit Preferences… on the Insert STK Objects window.
2. In the window that appears, select **Save/Load Prefs**:
3. In the Ephemeris frame, verify that Save Vehicle Ephemeris is on and Binary Format is off.
4. Verify that Save Accesses is disabled.
5. Verify that Auto Save is on.
6. Verify that Save Period is set to 300 sec (5 min).
7. Click OK to apply any changes and to dismiss the Preferences window.

Saving the Scenario

Before proceeding to the next section, save the STKTutorial scenario.
Select Save from the File menu or click the (Save) button. This saves the scenario and all the objects you created and defined for the scenario, including the properties that you entered or selected.

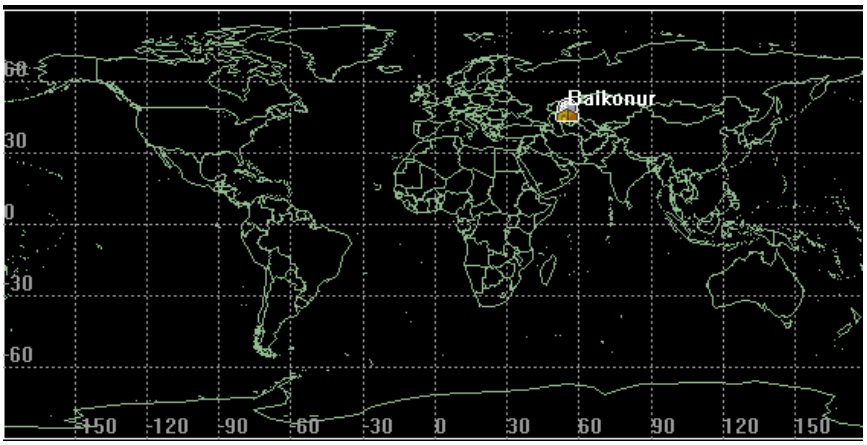
Creating Facilities

Now you are ready to populate the scenario with various objects. Start with facilities such as ground stations, launch sites and tracking stations.

1. Bring up the Insert STK Objects window. If the Insert STK Objects window is not shown, click the Insert STK Objects button ( ) on the default toolbar.
2. Select Facility ( ) in the Scenario Objects field.
3. Select Define Properties.
4. Click Insert... This will bring up the properties for the facility.

Defining Facilities

1. Select the Basic – Position page.
2. On the Position page, ensure that the Type is set to Geodetic.
3. Set Latitude to `48.0` and Longitude to `55.0`. Leave Altitude at its default setting of `0`.
4. Select the Basic - Description page.
5. Enter a Short Description, such as "Launch Site."
6. Enter a Long Description, such as "Launch site in Kazakhstan. Also known as Tyuratam."
7. Click OK.
8. Select the Facility in the Object Browser.
9. Click F2 to rename the facility to Baikonur.



10. Use the procedures described above to add the facilities listed in the following table (Don't worry about the Long Description).

Table 1. Settings for Perth & Wallops facilities

Name	Latitude	Longitude	Altitude	Short Description
Perth	-31.0	116.0	0.0	Australian Tracking Station
Wallops	37.8602	-75.5095	-0.0127878	NASA Launch Site/Tracking Station

11. When you finish defining each facility, click OK.

The Facility Database

Now you will use the Facility Database to add two more facilities to the scenario.

1. Bring up the STK Insert STK Objects window.
2. Select Facility ( ) in the Scenario Objects field.
3. Select Select From Facility Database in the Select A Method field.
4. Click Insert… This will bring up the Facility Database.
5. Click Advanced…
6. Turn on the Network option and select NASA DSN as the Network.
7. Click OK.
8. Scroll to the bottom of the list in the *Facility Database Search Results* window and highlight Santiago and WhiteSands. (Select one of them, then hold down the CTRL key and click on the other.)

9. Click Insert to add the facilities.

10. Click Close on the Facility Database.

11. Open the *Basic Properties* window for the Santiago facility and select Description.

12. Note that the Long Description field includes position and other data about the facility.

Note: When objects are inserted using any of the databases shipped with STK, descriptions are automatically generated for the objects.

13. Click OK or Cancel.

14. Close the Insert STK Object window.

Setting 2D Graphics Attributes

A variety of 2D graphics properties can be set for a facility in STK.

1. Select a facility whose color you would like to change—e.g. because it does not show up clearly against the background.

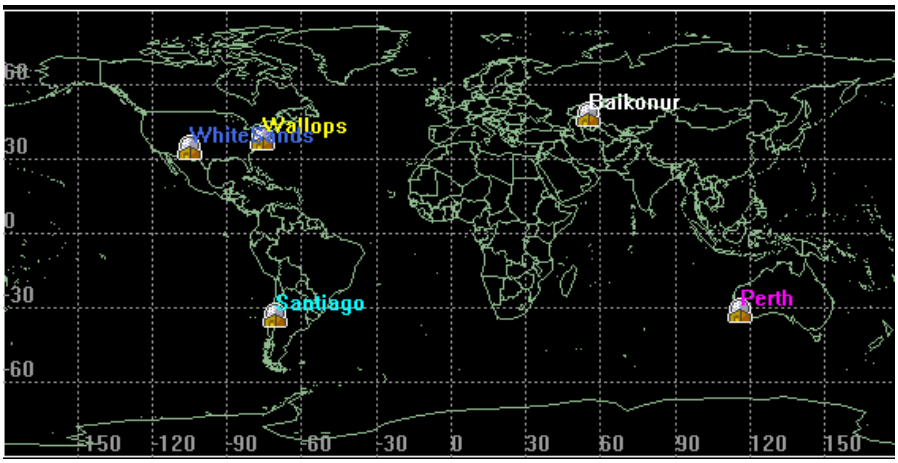
2. Open the facility's Properties by clicking the Properties button () in the Object Browser toolbar.

3. Select the 2D Graphics - Attributes page.

4. Select the desired color.

5. Click OK.

6. Repeat steps 1-2 for any other facilities whose color you wish to change.



Creating a Target

The target for this exercise is a glacier field over North America. You are going to insert the target using the Object Catalog.

1. Insert a target ( ) from the Object Catalog ( ).
2. Change the target's name to Iceberg.
3. Open the Iceberg's Properties Browser.
4. On the Position page, verify that the Type is set to "Geodetic".
5. Enter a Latitude of 74.91 and a Longitude of -74.5.
6. Open the Description page and enter a short description, such as "Only the tip of the Iceberg."
7. Click OK.

Creating a Ship

STK objects include three types of great arc vehicles—aircraft, ships and ground vehicles. In this exercise you will create a ship.

1. Insert a ship ( ) from the Object Catalog, and change its name to Cruise.
2. Open the Cruise's Properties Browser.
3. On the Route page, ensure the Start Time is set to your default scenario start time.
4. Ensure the Propagator is set to GreatArc.
5. Ensure the Route Calculation Method is set to Smooth Rate.

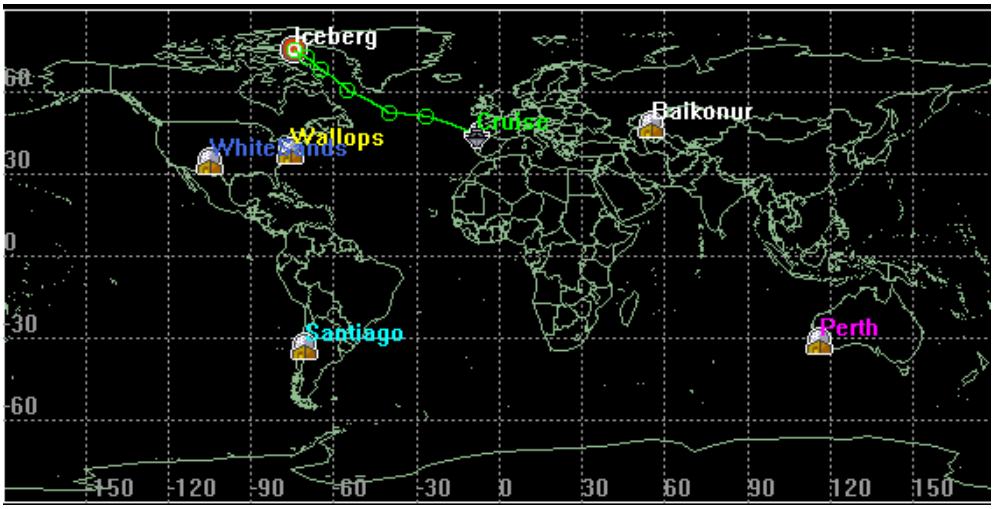
   Note: Once you enter a Rate and Start Time for a great arc vehicle, STK automatically calculates the Stop Time and displays it in a read-only field.

6. Enter the waypoint values shown in the following table for the ship in the waypoints table. To insert a line of data, click the Insert Point button.

Table 2. Ship waypoints

Latitude	Longitude	Altitude	Speed
44.1 deg	-8.5 deg	0.0 km	.015 km/sec
51.0 deg	-26.6 deg	0.0 km	.015 km/sec
52.1 deg	-40.1 deg	0.0 km	.015 km/sec
60.2 deg	-55.0 deg	0.0 km	.015 km/sec
68.2 deg	-65.0 deg	0.0 km	.015 km/sec
72.5 deg	-70.1 deg	0.0 km	.015 km/sec
74.9 deg	-74.5 deg	0.0 km	.015 km/sec

7. Select the Basic - Attitude page.
8. Ensure ECF velocity alignment with radial constraint is selected.
9. Open the **2D Graphics - Route** page.
10. Make certain that Show Turn Markers is turned on, and click OK.
11. In the Animation toolbar, click the (Reset) button, and look at the 2D Graphics window.



Displaying and Modifying a Model

All objects in STK are represented in the **3D Graphics** window by models. There are default models for standard objects, as well as models designated for specific objects that you might import into a scenario, such as the Cruise Liner, which we will be examining in this exercise. For any object in STK, you can change the model to something other than what is initially assigned to it.

1. Open the **Properties Browser** for the Cruise.

2. Select **3D Graphics - Model.**
3. In the Model frame, verify that Show is enabled, and that Scale is set to 0.0.
4. In the Detail Thresholds frame, disable Use.
5. To change the model, click the ellipsis button  in the Model File field.
6. Browse to the model cruise_liner.mdl.
7. Click Open.
8. Click OK.
9. Select the **3D Graphics** window
10. Click View From/To () in the 3D Graphics window toolbar.
11. In the View From field, select the Cruise. The Cruise Liner will also become highlighted in the View To field.
12. Click OK.
13. The Cruise Liner should now appear front and center in the **3D Graphics** window.

Creating Satellites

Now you will add a few satellites to the scenario, namely an Earth Resources Satellite (ERS1), a Space Shuttle and two Tracking & Data Relay (TDRS) satellites.

Using the Orbit Wizard

The STK *Orbit Wizard* provides a quick and easy way to generate a variety of frequently used satellite orbit patterns.

1. Click the Insert Object () button to bring up the Insert STK Object window.
2. Select Satellite () in the Scenario Object field.
3. Select Orbit Wizard () in the Select A Method field.
4. Click Insert… to launch the Orbit Wizard.
5. Select Geosynchronous as the Type.
6. Set the Satellite Name to TDRS.
7. Ensure the Subsatellite point is set to -100 deg.
8. Ensure the Use Scenario Time Period option is on.
9. Click OK on the Orbit Wizard.

Using the Satellite Database

STK is shipped with a rich and extensive set of satellite databases, together with an interface to make it easy to find and propagate the satellite of interest. Here you will use the Satellite Database to define a second TDRS satellite for your scenario.

1. Bring up the Insert STK Object window.
2. Select Satellite () in the Scenario Object field.
3. Select *Select from Database* in the Select A Method field.
4. Click Insert…

You can quickly generate a list of all TDRS satellites in the database. To quickly generate that list of TDRS satellites, you can use an asterisk (*) as a wild card in the Common Name field. Let's try this.

5. Turn On the Common Name field.
6. Type TDRS* in the text field.
7. Turn Off the SSC Number option.
8. Click Search to perform a search for all active TDRS satellites.
9. In the search results window, select TDRS 3.
10. Click the Time Period… button.
11. Ensure the Use Scenario Time Period is selected.

12. Click OK.

13. Click Insert Satellite.

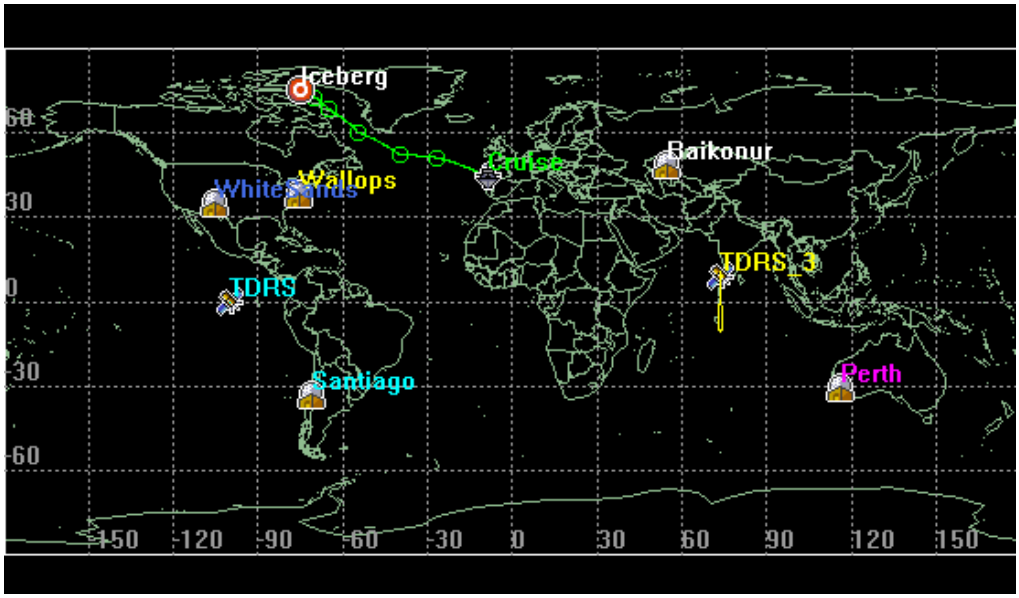
14. For this step you need an active Internet Connection. If you do not have an internet connection, you need to click the Advanced… button in the Satellite Database. Turn On *Use Default Satellite Database*. Click OK. This will allow you to enter the TDRS_3 satellite into the scenario.

15. Click Close in the *Satellite Database* window.

16. Close the Insert STK Object Tool.

17. Rename the satellite to TDRS_3.

If the 2D Graphics window does not show your new TDRS satellites, click the (Reset) button.



Note: The ground tracks for both satellites display in the 2D Graphics window as specks since they are in geostationary orbit.

Defining Orbital Parameters

A great variety of satellite orbits can be propagated using the *Orbit Wizard* and Satellite Database. In addition, STK allows you to define any satellite orbit precisely using a number of propagators and force models. You will now add two satellites to the scenario using the J4 Perturbation propagator, which accounts for secular variations in the orbit elements due to Earth oblateness.

1. Create a new satellite using Insert STK Objects.

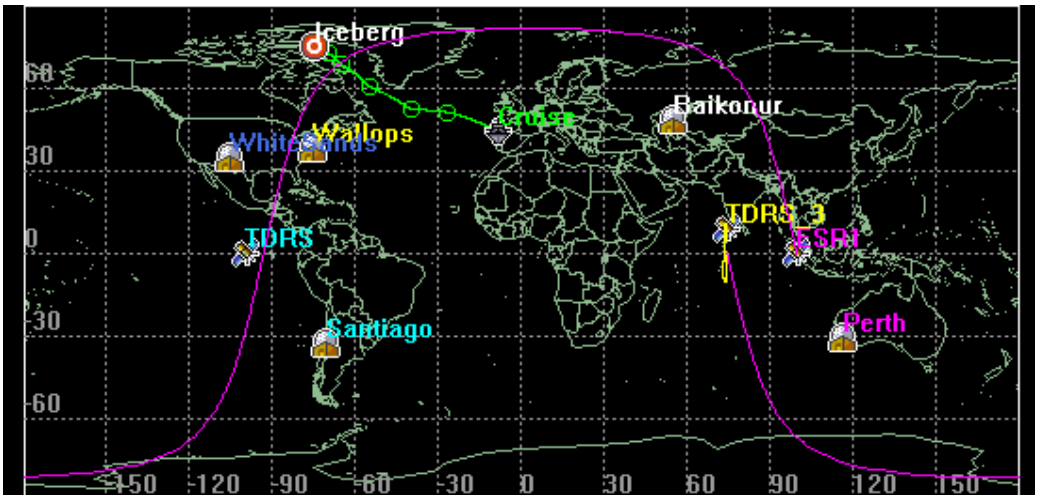
2. Select Satellite ( ) in the Scenario Objects field.

3. Select Define Properties in the Select A Method field.
4. Click Insert… to launch the Properties page.
5. Select the Basic – Orbit page.
6. Select J4 Perturbation as the Propagator.
7. Enter the orbital parameters for ERS1, found in the following table. Use the down-pointing arrow to change the default RAAN (Right Ascension of the Ascending Node) option to Lon Ascn Node (Longitude of Ascending Node) before entering the values listed in the table.

Table 3. Orbital elements for ERS1

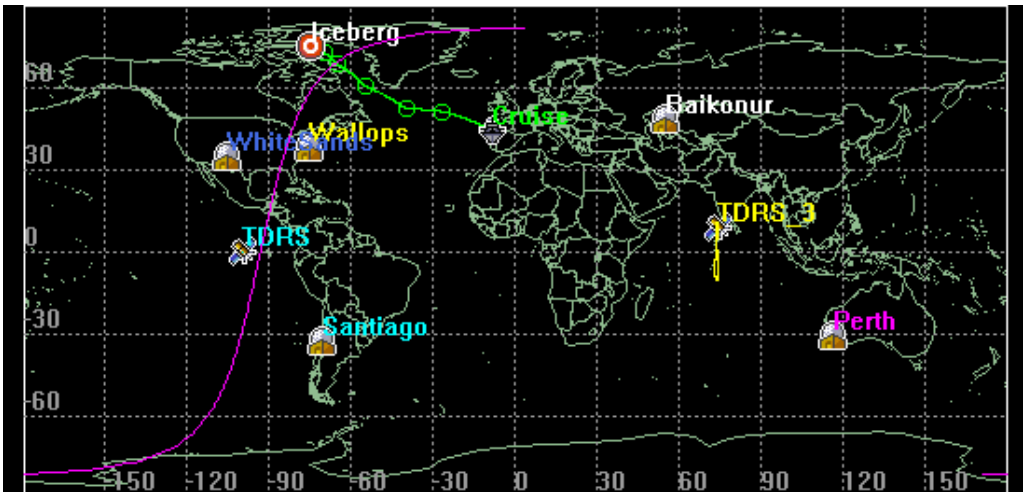
Orbital Element	Setting
Start Time	Use Scenario Analysis Period
Stop Time	Use Scenario Analysis Period
Step Size	60.00
Orbit Epoch	Scenario Default Start Time
Coordinate Type	Classical
Coordinate System	J2000
Semimajor Axis	7163.14 km
Eccentricity	0.0
Inclination	98.50 deg
Argument of Perigee	0.0 deg
Lon Ascn Node	99.38 deg
True Anomaly	0.0 deg

8. When you finish, click Apply, and then click the (Reset) button.
9. Rename your satellite ERS1.
10. Your 2D Graphics window should look like this:



11. Open the satellite's 2D Graphics - Pass page.

12. To display only the descending side of the orbit, change Visible Sides from Both to Descending and click Apply.



13. Observe the change in the 2D Graphics window.

14. When you finish, return the Visible Sides option to Both and click OK.

15. Bring up the Insert STK Objects window.

16. Select Satellite ( ) in the Scenario Object field.

17. Select Define Properties in the Select A Method field.

18. Click Insert… to launch the Properties page.

19. On the **Orbit** page for the Shuttle, select J4Perturbation as the Propagator.

20. Use the down-pointing arrow to change the default setting of Semimajor Axis to Apogee Altitude. The default Eccentricity option will automatically change to Perigee Altitude.

21. Use the down-pointing arrow to change the default setting of RAAN to Long Of Ascending Node.

22. Enter the orbital elements for the Shuttle as given in the following table.

Table 4. Orbital elements for the Shuttle

Orbital Element	Setting
Start Time	Use Scenario Analysis Period
Stop Time	Use Scenario Analysis Period
Step Size	60.0 sec
Orbit Epoch	Default Start Time
Coordinate Type	Classical
Coordinate System	J2000
Apogee Altitude	370.4 km
Perigee Altitude	370.4 km
Inclination	28.5 deg
Argument of Perigee	0.0 deg
Long of Ascending Node	-151.0 deg
True Anomaly	0.0 deg

23. When you finish, click OK.

24. Rename the new satellite Shuttle.

25. Open the **Properties Browser** for the Shuttle.

26. Select **3D Graphics - Model.**

27. In the Model frame, verify that Show is enabled, and that Scale is set to 0.0.

28. In the Detail Thresholds frame, disable Use.

29. To change the model, click the ellipsis button  in the Model File field.

30. Browse to the model shuttle-05.mdl.

31. Click Open.

32. Click OK.

33. Select the **3D Graphics** window

34. Click View From/To ( ) in the 3D Graphics window toolbar.

35. In the View From field, select the Shuttle. The Shuttle will also become highlighted in the View To field.

36. Click OK.

2D Graphics Properties

You have already become acquainted with the Pass page of the satellite's **2D Graphics** properties. Now you will use the Shuttle to experiment with further graphics features.

1. Open the Properties Browser for the Shuttle, and select the **2D Graphics - Attributes** page.

2. Change the Line Style to dashed and the Marker Style to Plus, and click Apply.

3. Now select the 2D Graphics - Contours page.

4. Turn On the Show option for Elevation Contours.

5. In the Level Attributes area, click Remove All to remove any existing entries from the Level list.

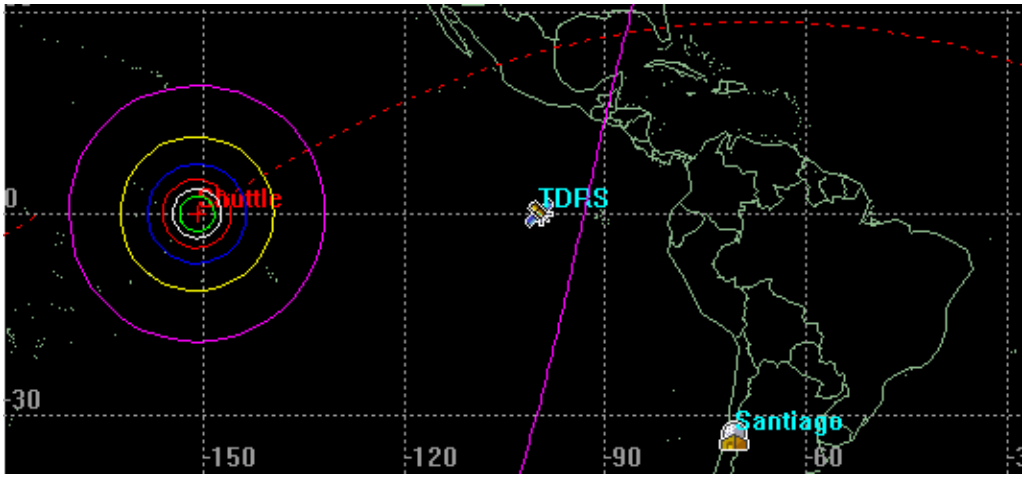
6. In the Level Adding area, make sure the Add Method is set to Start, Stop, Step, then enter 0, 50 and 10 for the Start, Stop and Step values, and click Add.

7. In the Level list, highlight the first level (0.00) and turn OFF the ShowLabel field. Change the Color and/or Line Style and/or Line Width if you wish.

8. Repeat step 7 for the remaining levels.

9. Click OK.

10. To see the contour levels, click the (Reset) button. Zooming in will provide a better view.



11. When you finish, zoom out to a normal 2D Graphics view.

Note: To zoom in on a region in the 2D Graphics window, click the (Zoom In) button in the graphics window, place the mouse pointer in one corner of the region of interest, hold down the left mouse button, and drag the pointer to the opposite corner of the selected region. You can do this repeatedly. To restore the full 2D Graphics window view, click the (Zoom Out) button as often as necessary.

Map Projections

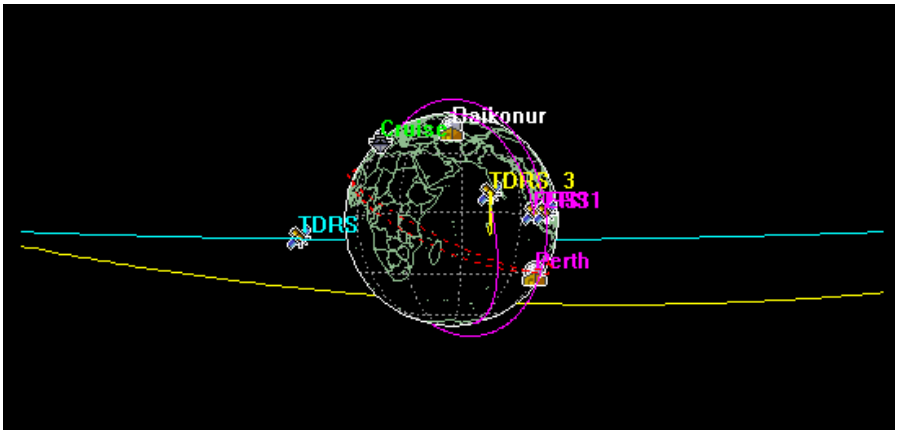
In this section of the Tutorial you will create a second 2D Graphics window and become acquainted with some of the map projections available with STK.

Creating a New 2D Graphics View

1. From the **View** menu, select Duplicate 2D Graphics Window → 2D Graphics 1 – Earth.
2. When the second 2D Graphics window appears, move it so that you can see both 2D Graphics windows at once.

Note: It may be helpful to float one of the 2D Graphics windows so that you can move it out of the workspace. Simply right-click on the window's title bar, select Floating from the choices presented, hold down the CTRL key, and drag the window to the desired location.

3. Select the new 2D Graphics window, and click the button in the 2D Graphics window to launch its *2D Graphics* properties window.
4. Open the Projection page.
5. In the Projection Format frame, change the Type to Perspective.
6. Set the Display Coordinate Frame to ECI.
7. In the Center field, enter Latitude of `-3.418 deg.`
8. `Enter` the Longitude of 54.99 deg.
9. Enter `35000` km as the Altitude.
10. Click OK to view the changes in the 2D Graphics window. If the satellite orbits do not appear, click the (Reset) button.



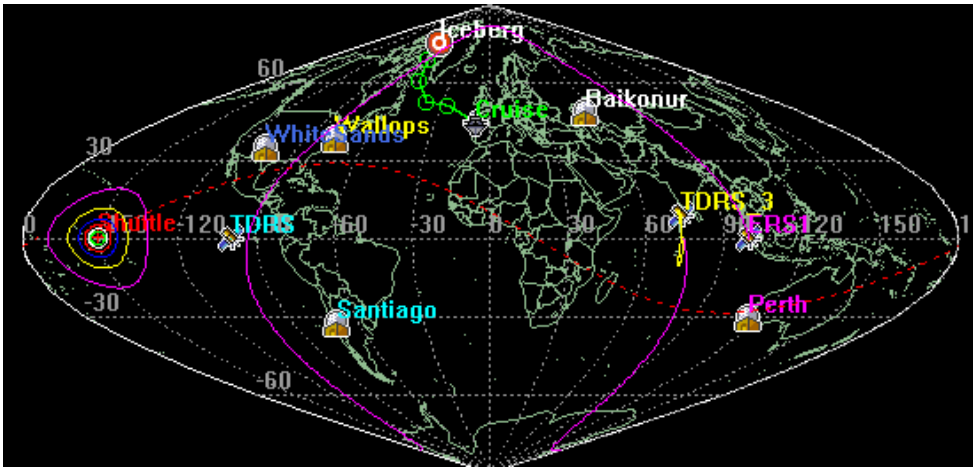
Sampling Map Projections

1. Select the original 2D Graphics window (2D Graphics - Earth), and click the button to display its properties.

2. Move the *2D Graphics properties* window into a position where you can see it and the 2D Graphics window simultaneously.

3. Open the Projection page and open the Type list in the Projection Format frame.

4. Select any other projection (such as the Sinusoidal projection shown below), and click Apply to see it in the 2D Graphics window.



5. Browse through the available projections by repeating Step 4 for each projection listed in the dropdown list.

6. When you finish, restore the first 2D Graphics window to Equidistant Cylindrical, and click OK to dismiss the *2D Graphics properties* window.

Adding an Area Target

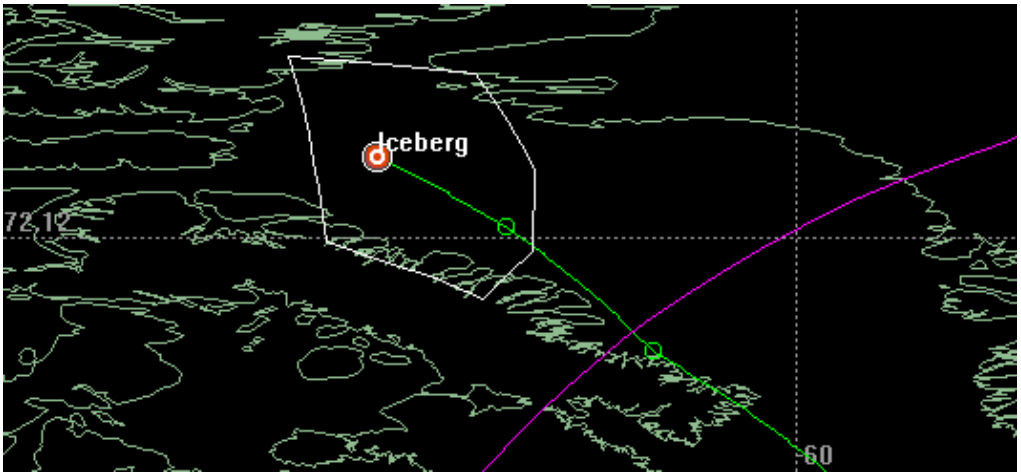
Area targets are used to define geographical regions of interest on the ground. Let's assume that the Cruise ship has run into the Iceberg. You will now create an area target that defines the search area for survivors.

1. Insert an area target () from the Object Catalog, and name it SearchArea.
2. Launch the area target's *Properties Browser*, and open the **2D Graphics - Attributes** page.
3. Set the Marker Style to None.
4. Turn Off the Inherit from Scenario, Show Label and Show Centroid options.
5. Open the **Basic - Boundary** page.
6. Click the Add button to insert a boundary point. Double-click the field under Latitude and enter the value `78.4399`. Similarly, double-click the field under Longitude and enter a value of `-77.6125`.
7. Repeat step 6 until you have entered all of the boundary points in the following table:

Table 5. Area target boundary points

Latitude	Longitude
77.7879	-71.1578
74.5279	-69.0714
71.6591	-69.1316
70.0291	-70.8318
71.9851	-76.3086

8. Click Apply when done.
9. Now open the Basic - Centroid page.
10. Turn off the Auto Compute Centroid option.
11. Set the Position Type to Spherical.
12. Enter `74.9533` as the Latitude, `-74.5482` as the Longitude, and `6358.186790` as the Radius.
13. Click OK.
14. Zoom the 2D Graphics window in on the region around the area target; then, when you are finished, zoom out again.



Using the 3D Object Editor

Facilities, area targets, and great arc vehicles can have their boundaries or routes edited directly within the **3D Graphics** window using the **3D Object Editor**. This exercise explores the basics of using the **3D Object Editor**.

1. In the **View** menu, select the Toolbars → 3D Object Editing toolbar.

2. Select the **3D Graphics** window.

3. Click Home View  on the 3D Graphics Toolbar to set your view to the default position.

Let's zoom in on the region around the area target in the 3D Graphics window.

4. Click and hold the left mouse button, then move your mouse around in the 3D Graphics window to rotate the globe.

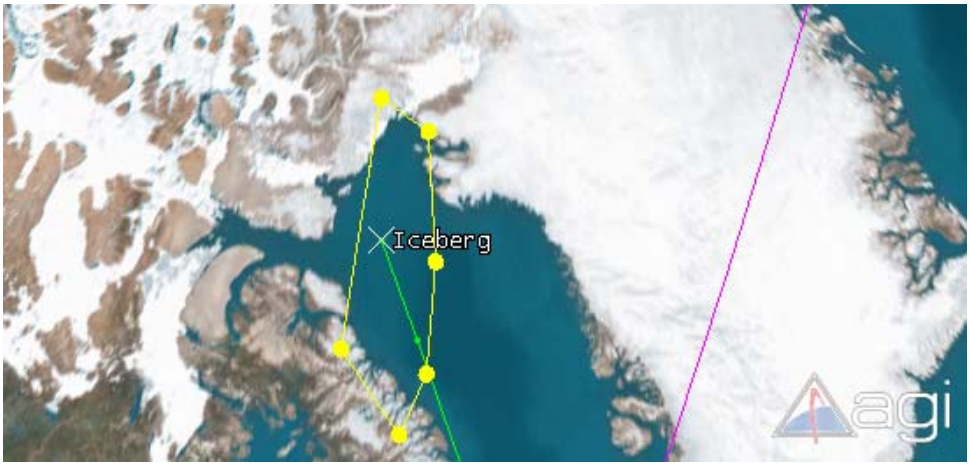
5. Click and hold the right mouse button, then move your mouse forward and backward to zoom in and out.

6. Now Zoom In on the region around the area target.

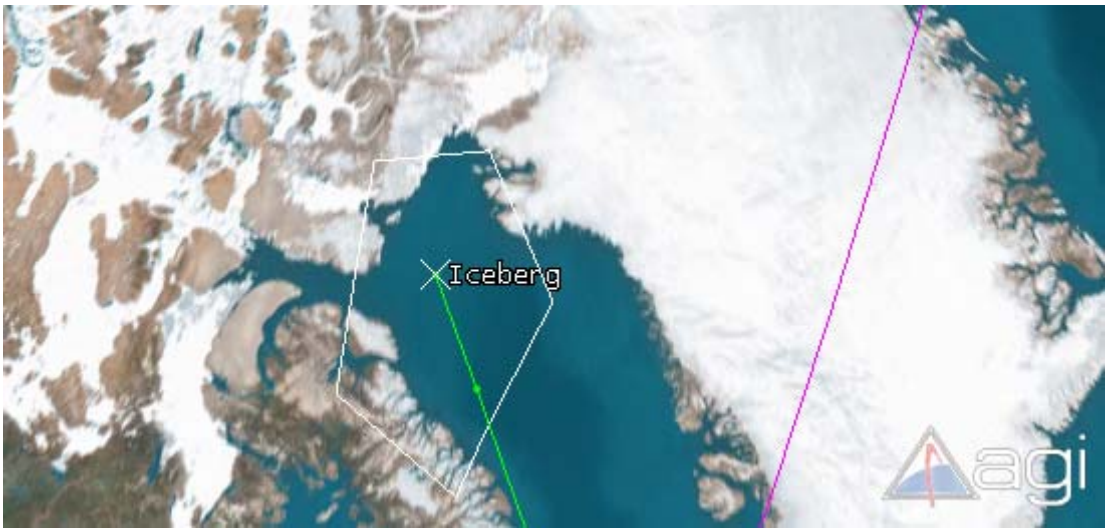
7. In the 3D Object Editing toolbar, select Area Target/SearchArea from the drop-down menu.

8. Click Object Edit Start/Accept  to begin editing the SearchArea area target in the **3D Graphics** window. The boundary points of the SearchArea area target are now highlighted in the **3D Graphics** window.

9. By clicking and dragging with the mouse, expand the SearchArea area target's boundaries to encompass a larger area. Notice that while editing the object, the usual mouse controls for manipulating the view in the **3D Graphics** window function normally.



10. Click Object Edit Start/Accept  to apply the changes. The area target now has new boundaries.



Working with the 3D Graphics Toolbar – Managing Views

In this exercise, you will learn to **establish custom views that will be more useful or appealing than the default view**. The default view in the **3D Graphics** window, called the Home View, is an Earth-centered inertial position and direction. You can change the Home View and add other views in the **3D Graphics** window using the 3D Graphics Toolbar. The ability to change the camera position and the view direction or camera reference point can be very helpful in analyzing a scenario. When you create and store a view, the view is a part of the scenario and can be utilized in any number of **3D Graphics** windows that you open within the scenario. The following steps will guide you through the basics of setting and storing views in the 3D Graphics window.

1. Click Home View  on the 3D Graphics Toolbar to set your view to the default position.

2. Click View From/To  on the 3D Graphics Toolbar.
3. In the Reference Frame section, select *Earth Fixed Axes* and click OK.
4. In the **3D Graphics** window, rotate the view so that the White Sands facility is roughly centered.
5. Click Stored Views  in the 3D Graphics window.
6. Click New to add the current view to the list of stored views.
7. Double-click the new view and rename it "Fixed Axes".
8. Click OK.
9. Animate the scenario again. Notice that this time the camera position remains fixed on the White Sands facility, revolving in sync with the Earth. Using this view we can observe the impact of our scenario on the White Sands facility for the entire period.
10. Reset the animation.
11. Click View From/To  on the 3D Graphics Toolbar.
12. In the View From field, select the ERS1 satellite. The ERS1 satellite will also become highlighted in the View To field. Click OK.
13. Manipulate the view in the **3D Graphics** window so that the surface of the Earth becomes visible beneath the ERS1 satellite.
14. Click Stored Views  on the 3D Graphics Toolbar.
15. Click New to add the current view to the list of stored views.
16. Double-click the new view and rename it "ERS1", then click OK.
17. Animate the scenario again. Notice that this time the view follows the ERS1 satellite as it orbits the Earth.
18. Reset the animation.
19. Use the Stored Views  drop down to cycle through your images.
20. When you are finished cycling through the stored views, click Home View  .

21. You can also change the view perspective by holding the shift key and double-clicking on an object on the **3D Graphics** window. This will have the same effect as setting the view to and from the object by using the View From/To button.

22. Other important 3D Graphics Toolbar features include:

    - Viewpoint Control buttons – Finer  , Coarser  , and Toggle  . The Finer and Coarser Viewpoint Control buttons adjust mouse sensitivity from the default, while the Toggle Viewpoint Control button resets mouse sensitivity to the default.

    - View Pilot – The View Pilot button  launches a small control panel that allows you to make small, incremental adjustments to the view. If this option is not on your 3D Graphics window toolbar, click the Toolbar Options drop down (). Select Add or Remove buttons → 3D Graphics. You will see the View Pilot option.

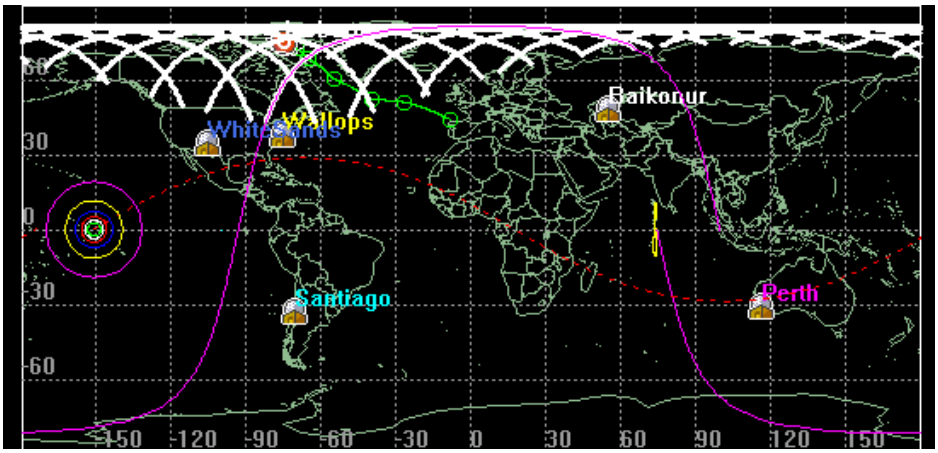
    - Camera Control –The Camera Control button  is an advanced animation feature that is not covered in this tutorial.

Calculating Access

Now you will calculate access from the ERS1 satellite to the area target to determine whether the satellite can view any of the wreckage and help in the search efforts.

1. In the Object Browser, highlight ERS1, right-click the mouse, and select Access.

2. When the *Access* window appears, select SearchArea in the Associated Objects list and click Compute. Portions of the satellite's ground track are highlighted in the 2D Graphics window to indicate periods of access to the area target.



3. Now click Access… in the Reports area to view an Access Summary Report. As you can see, there are several periods of access.

4. Close the report.

5. In the *Access* window, click the Remove Access button, and then click Close.

Working with Sensors

In this exercise you will first attach sensors to a satellite and experiment with sensor pointing types. Then you will attach a sensor to a ground facility and limit its visibility to objects a certain distance above the horizon.

Defining and Pointing Sensors

1. With the ERS1 satellite selected in the Object Browser, insert a sensor ( ) from the Object Catalog. Name the new sensor Horizon.

2. Launch the sensor's *Properties Browser*, and open the **Definition** page.

3. Make sure the Sensor Type is set to Simple Conic and the Cone Angle is 90 deg.

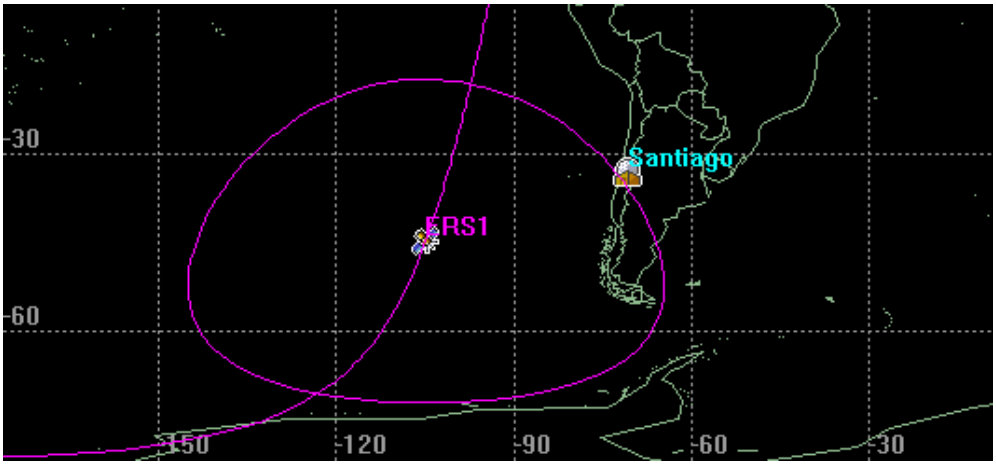
4. Select the Basic - Pointing page of the sensor's properties.

5. You want to point the sensor straight down relative to the ERS1 satellite. To do this, verify that the Pointing Type is set to Fixed and Elevation is set to 90 deg.

6. Click OK.

7. Unclutter the 2D Graphics window a bit by removing the Shuttle's contour graphics. Open the **2D Graphics - Contours** page for the Shuttle, turn off the Show option for Elevation Contours, and click OK.

8. In the first 2D Graphics window (2D Graphics - Earth), click the (Reset) button, and then click the (Animate Forward) button. Note the graphics representing the Horizon sensor's field of view (shown here zoomed).



9. Stop the animation by clicking (Reset) or (Pause).

10. Launch the sensor's Properties Browser, and open the **Definition** page. Change the Cone Angle to 45 deg.

11. Open the **3D Graphics – Attributes** page and enable Translucent Lines.

12. Select **3D Graphics - Pulse**.

13. In the Parameters frame, turn on the Show option.

14. Ensure the Amplitude is set to 0.5.

15. Set the Pulse Length to 2000 km.

16. Set the Frequency value to Slow.

17. Set the Value to 0.083 Hz.

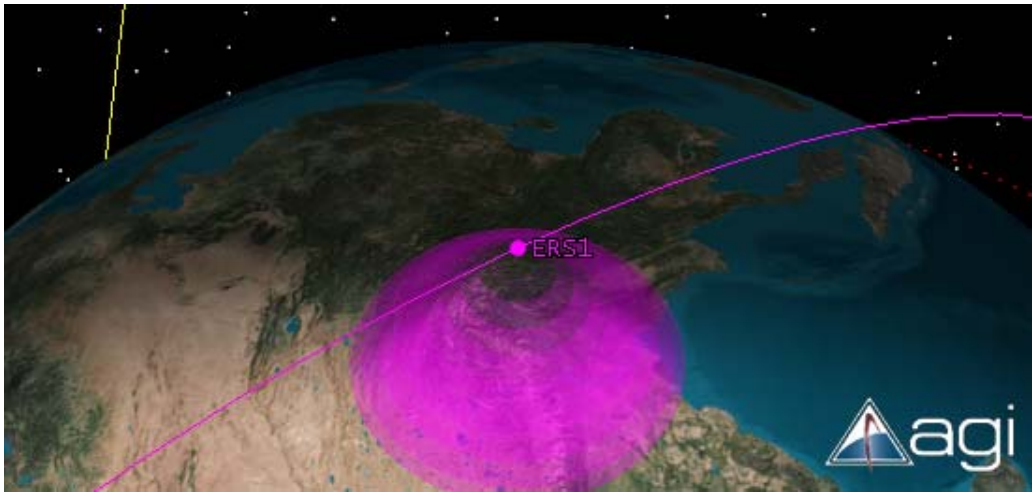
18. Click Ok.

19. Click View From/To on the 3D Graphics Toolbar.

20. In the View From field, select the ERS1 satellite. The ERS1 satellite will also become highlighted in the View To field. Click OK.

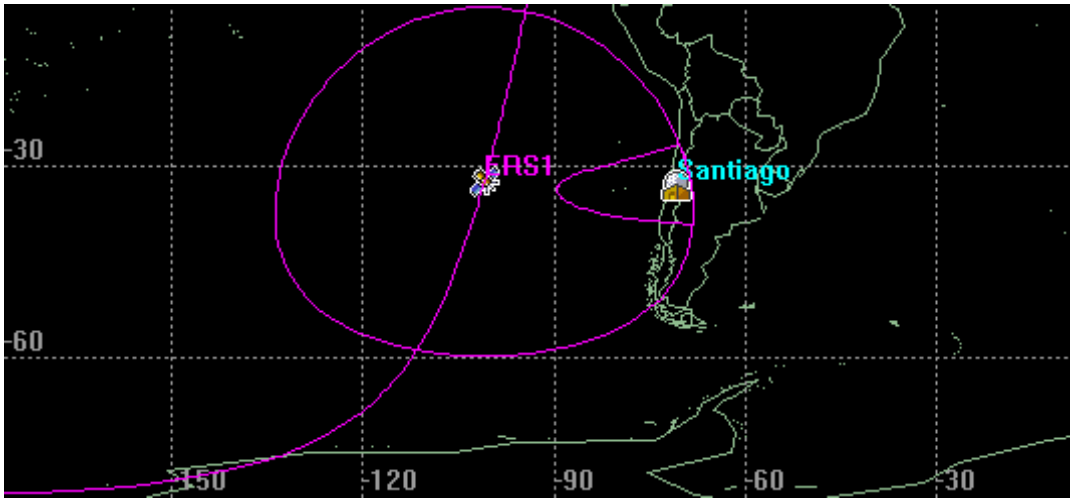
21. In the **3D Graphics window**, adjust the view so that you can get a good look at the satellite in reference to the Earth's surface, such as the following image depicts.

22. Animate the scenario and watch the sensor's projection as the satellite travels along its orbit.



23. Reset the animation.

24. Bring up Horizon's Properties.
25. Select the **3D Graphics – Pulse** page.
26. Disable Show in the Parameters section.
27. Open the **Definition** page.
28. Set the Cone Angle to 90 deg.
29. Click OK to dismiss Horizon's Properties.
30. Click Home View  on the 3D Graphics Toolbar to set your view to the default position.
31. Add another sensor to the ERS1 satellite and name it Downlink.
32. Open the new sensor's **Definition** page.
33. Select Half-Power as the Sensor Type
34. Set the Frequency to `0.85` GHz and the dish Diameter to `1.0` meter. STK computes the half-angle for you.
35. Open the Basic - Pointing page.
36. Change the Pointing Type to Targeted and the Boresight Type to Tracking.
37. Select the Baikonur facility in the Available Targets list.
38. Move () Baikonur to the Assigned Targets list.
39. Repeat Step 15 for each facility until all the facilities appear in the Assigned Targets list.
40. Click OK.
41. Animate the scenario and let the animation run until the ERS1 satellite moves over the Santiago facility (shown here zoomed).

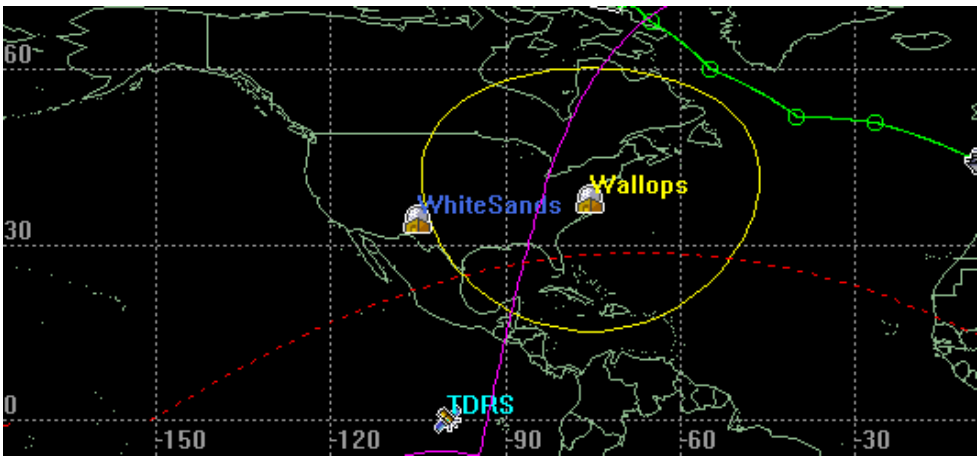


42. Click the (Reset) button to stop the animation.

Limiting a Sensor's Visibility

Now you will attach sensors to a couple of ground facilities and limit their visibility.

1. Attach a sensor to the Wallops facility and name it FiveDegElev
2. Open the new sensor's Basic - Definition page.
3. Set the Sensor Type to Complex Conic.
4. Set the Inner Half Angle value to `0` deg
5. Set the Outer Half Angle value to `85 deg`.
6. Set the Minimum Clock Angle to `0 deg`.
7. Set and the Maximum Clock Angle to `360 deg`.
8. Open the Basic - Pointing page, and make sure that the Pointing Type is set to Fixed and that Elevation is set to `90 deg`.
9. Open the 2D Graphics Projection page.
10. Set the Maximum Altitude to `785.248 km` and the Step Count to `1`.
11. Click OK.



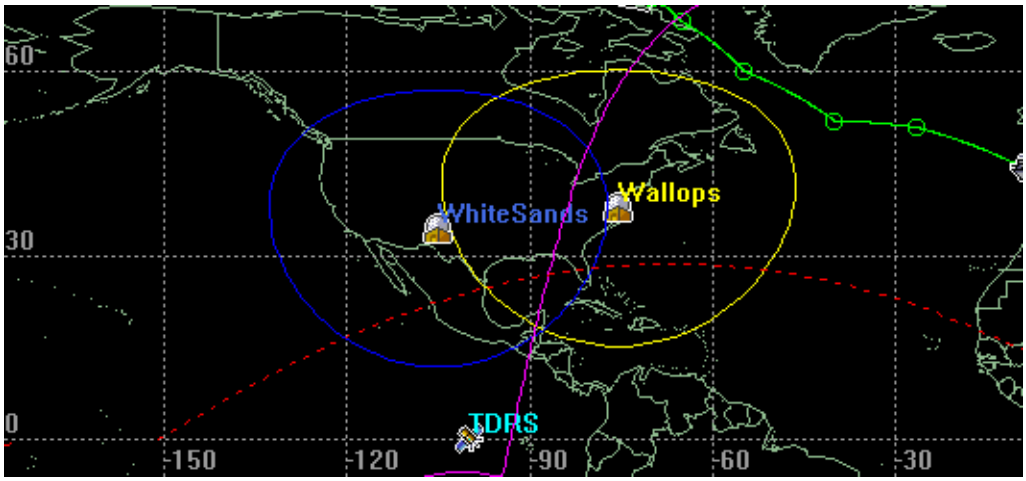
12. You can reuse the new sensor. Highlight the FiveDegElev sensor in the Object Browser and select Copy from the Edit menu.

13. Now highlight the WhiteSands facility in the Object Browser window and select Paste from the Edit menu.

14. Open the 2D Graphics - Attributes page for the new sensor.

15. Set the Color to the same color of the WhiteSands facility. This will ensure the fields of view of the sensors attached to the WhiteSands and Wallops facilities are more clearly distinguishable.

16. Click OK.



17. Click the (Reset) button if necessary to display the new color.

Static & Dynamic Display of Data

The reporting and graphing capabilities of STK make it easy to display and analyze data developed during a scenario. Also, data that changes over the scenario's time period can be displayed dynamically in the course of animation.

Reports & Graphs

This exercise illustrates one of the many standard report and graph options that are shipped with STK.

> Note: In addition to standard report and graph styles, STK makes it easy to create custom reports and graphs to suit your particular analytical or operational needs.

1. Highlight the ERS1 satellite in the Object Browser, right-click the mouse, and select the Report & Graph Manager.
2. Select Satellite as the Object Type.
3. Select ESR1.
4. Turn Off Show Graphs.
5. Select Solar AER from the Styles list.
6. Click Generate.
7. A report is generated, showing the azimuth, elevation and range of the Sun with respect to the ERS1 satellite at one-minute intervals throughout the satellite's time period.
8. Close the report, but do not close the Report & Graph Manager.
9. Turn Off Show Reports.
10. Turn On Show Graphs.
11. Select Solar AER in the *Styles* window.
12. Click Generate.
13. The data that was previously presented in a report is now displayed in graph form.
14. To change the color and/or other properties of any of the graph elements, right-click on a graph element.
15. When the Report & Graph context menu appears, select *Customization Dialog*.
16. In the Customization Dialog window, make any desired changes to Color, Style or any other graph property.

17. Click OK to dismiss the Customization Dialog window.

18. Close the Report & Graph Manager.

Dynamic Displays & Strip Charts

STK provides two ways to display data dynamically while a scenario is animating: a dynamic display of report-style data, or a strip chart presenting data in graph style.

1. Open the Shuttle Properties.

2. Select 3D Graphics – Data Display.

3. In the Data Display table, turn On the Show option for LLA Position.

4. Click OK.

5. Select the **3D Graphics** window

6. Click View From/To ( ) in the 3D Graphics window toolbar.

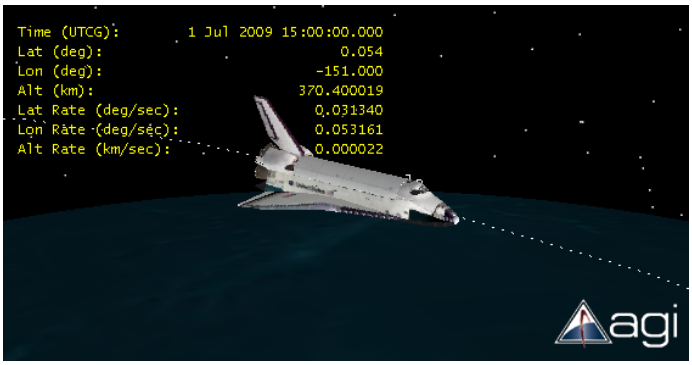
7. In the View From field, select the Shuttle. The Shuttle will also become highlighted in the View To field.

8. Click OK.

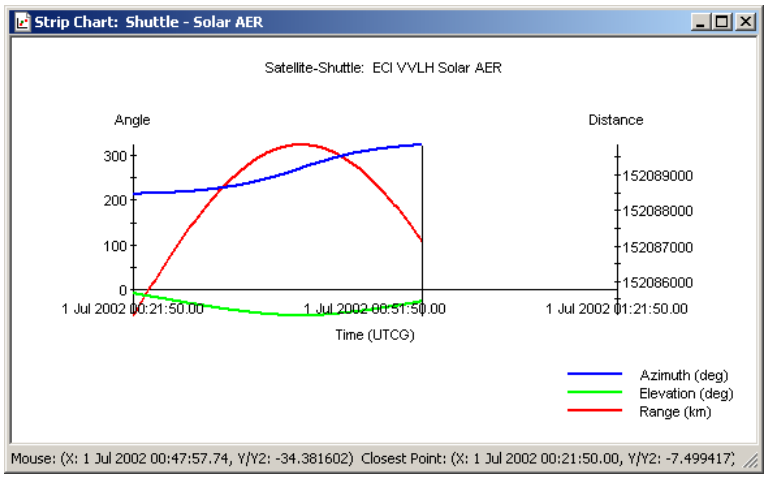
9. A dynamic display appears, with entries for time, latitude, longitude, altitude and corresponding rate data.

10. Animate the scenario. The Shuttle's positional and rate values will change as the animation progresses.

11. Pause the animation when the Shuttle is at or near its northernmost position in the 3D Graphics window. The displayed value for latitude should be in the vicinity of 28.5 deg. This corresponds to the Inclination that was set for the Shuttle when you defined its **Orbit** properties.



12. Click the (Reset) button.
13. Bring up the Report & Graph Manager.
14. Select Satellite as the Object Type.
15. Select Shuttle.
16. Ensure the Show Reports option is turned off.
17. Select Solar AER in the Styles Field.
18. Turn On Dynamic Display/Strip Chart.
19. Click Generate.
20. Position the strip chart window so that you can see it and the first 2D Graphics window simultaneously and animate the scenario.



Note: Once the animation starts, graph elements will begin to appear on the graph. These graph elements can be modified by using the same procedure as for the graphs in the preceding section.

21. The strip chart shows azimuth, elevation and range information from the satellite to the Sun. Note that the range (distance) varies over a span of about 11500 km, representing the difference between the positions in its orbit nearest to and most distant from the Sun.
22. Click the (Reset) button.
23. Close the strip chart.
24. Click Close to dismiss the *Report & Graph Manager* window.

Setting Constraints

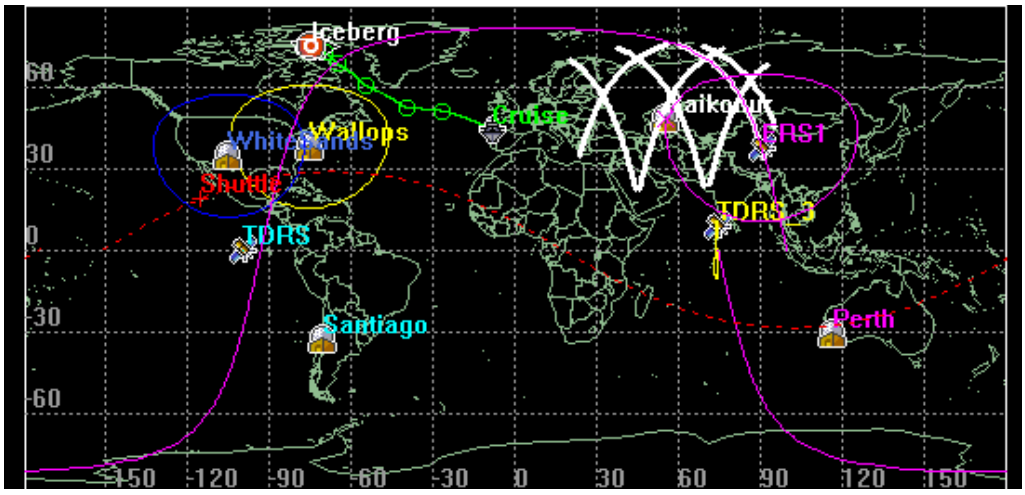
In this section you will experiment with just two of the many ways in which STK allows you to constrain objects and thereby refine your analysis. In both cases you will impose constraints on the Horizon sensor attached to the ERS1 satellite.

1. Highlight the Horizon sensor (attached to the ERS1 satellite) in the STK Object Browser, right-click the mouse, and select Access Tool.

2. Select the Baikonur facility in the *Associated Objects* window, and click Compute.

Note: Do not dismiss the Access window.

If you view the 2D Graphics window, you will see the ground track of the ERS1 satellite has been highlighted to indicate periods of access between the ERS1 satellite and the Baikonur facility.

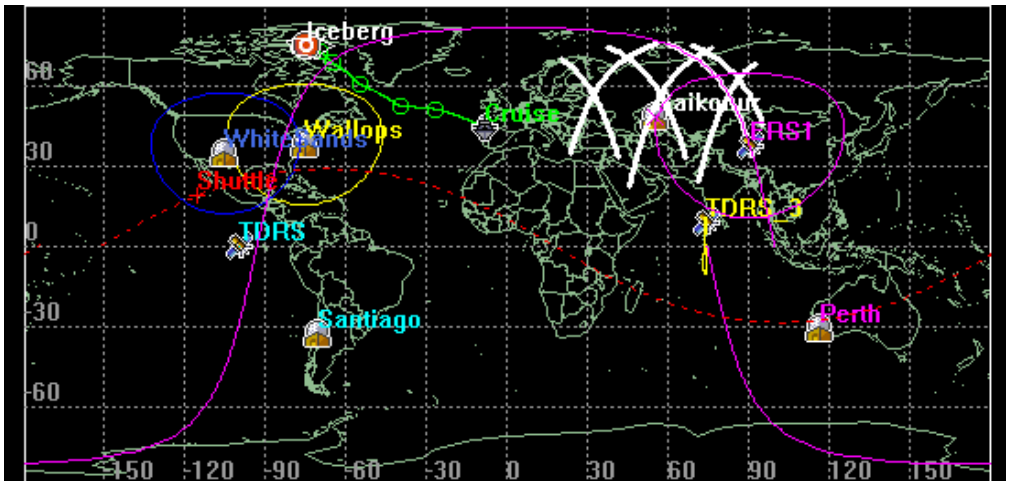


3. Now, with the Horizon sensor still highlighted in the Object Browser, launch the sensor's *Properties Browser*, and select the Constraints - Sun page.

4. Turn on the Min(imum) option for Sun Elevation Angle, and set the value to 10 deg.

5. Ensure you have the 2D Graphics window in view so you can see the change immediately.

6. Click Apply, and note the change in access graphics in the 2D Graphics window.

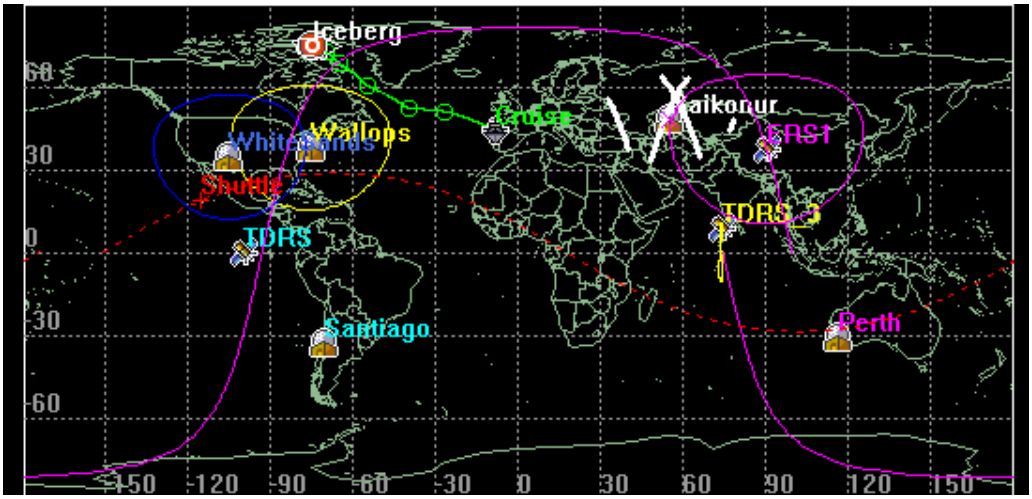


7. Experiment with other values for Sun elevation angle, such as 0 deg, 5 deg, 15 deg and 20 deg, clicking Apply each time to see the results.

8. Turn off the Min(imum) option for Sun Elevation Angle, and then open the Constraints - Basic page.

9. Turn on the Max(imum) option for Range, and set the value to 2000 km.

10. Click Apply, and observe the impact on access graphics in the 2D Graphics window.



11. Experiment with other values for maximum range, such as 1500 km, 1000 km and 500 km, clicking Apply each time to see the results.

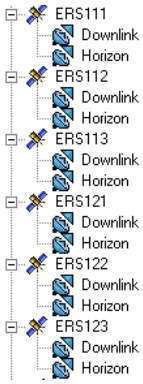
12. When you are finished, turn off the Max(imum) option for Range, and click OK to dismiss the *Properties Browser*.

13. Click the Remove Access button in the *Access* window, and then click Close to dismiss the window.

Creating a Walker Constellation

Finally, you will become acquainted with a tool that allows you quickly to define and propagate a constellation of systematically spaced satellites with circular orbits having the same inclination and period. We will use the ERS1 satellite as a "seed" to generate the constellation.

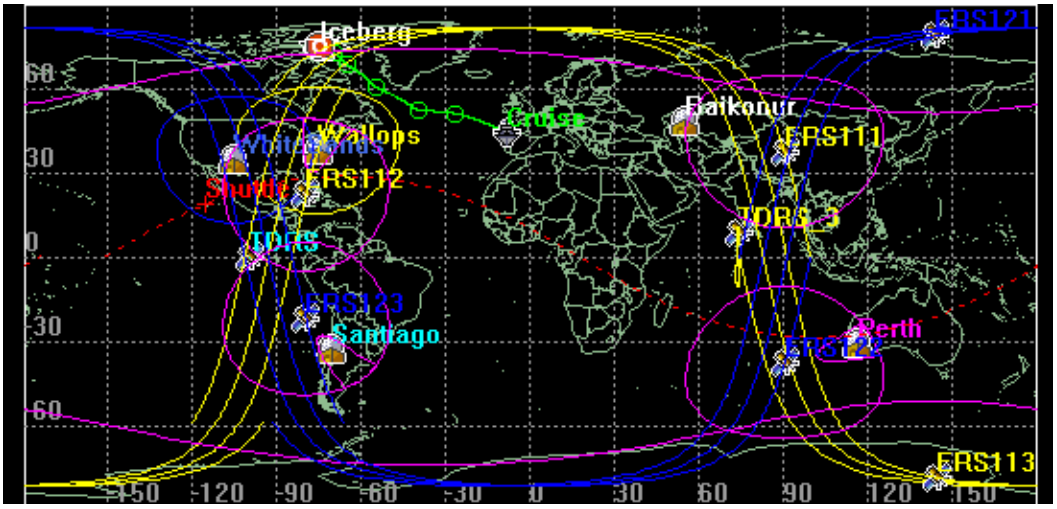
1. Select the ERS1 satellite in the Object Browser window, launch its *Properties Browser*.
2. Open the Basic - Orbit page.
3. Change the Stop Time for the satellite to default start time + six (6) hours.
4. Click OK.
5. With the ERS1 satellite still highlighted, right-click the mouse and select Satellite → Walker…
6. In the window that appears, make certain that Delta is selected as the Type.
7. Set Number of Planes to 2.
8. Set Number of Sat(ellite)s per Plane to 3.
9. Set the Inter Plane Spacing to 1.
10. Ensure that RAAN Spread is set to `360 deg`.
11. Ensure the Color by Plane option is turned on.
12. Uncheck Create unique names for sub-objects.
13. Click Create Walker.



14. Six new satellites appear in the Object Browser, each with an automatically generated name based on the name of the seed satellite. Each of the newly created satellites has two sensors with the same properties as those of the sensors attached to the seed satellite.

15. Close the Walker Tool dialog.

16. Click the (Reset) button, and animate the scenario.



17. Observe how the (targeted) Downlink sensor pattern appears in the 2D Graphics window as each satellite passes near a facility.

18. Click the (Reset) button.

Conclusion

This concludes the tutorial. But we barely scraped the surface. As you undoubtedly noticed while working through these exercises, for each properties page you opened, for each menu item you selected, for each option you tried out, and for each tool you used, there were many dozens we had to skip over.

So, why not take another voyage through the tutorial, this time exploring some detours and browsing through some of the many properties pages, menus and tools you find along the way?