STK Fundamentals

Version 9
Overview

Welcome to the STK Fundamentals training course. This course is a collection of instructor-led exercises that provide hands-on experience with a variety of the features and functions on which STK is built. It will familiarize the first-time user with the AGI Graphical User Interface (GUI); introduce them to some of the various land, sea, air, and space objects; their associated properties, and tools; and leave them with a basic understanding of the capabilities that are a part of the Satellite Tool Kit (STK) ® software suite.

This is not a comprehensive guide to any of the products that make up the STK Product Suite. The full scope of the STK Product Suite is far too broad to address in a single day course. When you complete this course, you will have the knowledge that you need to navigate the software and access additional resources including the STK Help system, which contains in-depth information about operating STK and all of its associated modules and add-ons.

This course will focus on the core modules that are commonly used to perform various types of analysis. In order to complete the exercises herein you must have a fully functional copy of the following products:

- STK Professional Edition
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In this exercise you will create a simple scenario that will help you get acquainted with navigating through the STK Graphical User Interface (GUI) and achieve some key objectives. Upon completion, you will be able to:

- Understand the questions that STK answers: Where am I? What can I see? When can I see it?
- Use the Orbit Wizard.
- Insert and position an object using an STK database.
- Move around in the 2D and 3D Graphics windows.
- Calculate a simple line-of-sight access.
Problem Statement

It is said that the Molniya orbit is a great way to spy on the United States. During such a spacecraft’s two (2) twelve (12) hour daily orbits, how many hours a day can a Molniya satellite actually see Washington?

BREAK IT DOWN

You have some information that may be helpful. Here’s what you know:

- There are two “players” in the scenario—a spacecraft traveling in a Molniya orbit and the city of Washington.
- A Molniya orbit has two (2) twelve (12) hour daily orbits.
- You want to know if and when a Molniya satellite can “see” Washington.

SOLUTION

Build an STK scenario that allows you to calculate a simple line-of-sight access between a spacecraft traveling in a Molniya orbit and Washington, D.C. so that you can tell at what points along the spacecraft’s orbit it can “see” Washington.

Welcome To STK!

The first thing you need to do is launch STK, and create a new scenario.

1. Double-click the STK icon ( ) on the desktop.

   Everything in STK begins with a scenario. A scenario is STK’s name for an instance of an analytical or operational task being modeled using STK. In STK a scenario is represented by an icon of an idealized “scene”. The STK scenario creates the context, or environment, within which all other objects in the scenario exist. You can create an unlimited number of scenarios with STK, however only one scenario can be open at a time.

   When STK launches, the Welcome to STK! dialog (the Welcome Dialog) will appear. Using the options available here, you can create new scenarios, open existing scenarios, access the STK Help System, or exit the STK application.
Table 1. Welcome to STK!

![Welcome to STK!](image)

2. Click the *Create a New Scenario* button.

The *Welcome Dialog* also provides an option to disable this feature in the event that you prefer to create and manage scenarios manually. If the *Welcome Dialog* dialog were disabled, you could create a new scenario by either:

- Clicking the *New* button ( ) on the *Default* toolbar, or
- Selecting the *New* ( ) option from the *File* menu.

**FIGURE 1-1. Scenario icon**

Create a Scenario

When you click the *Create a New Scenario* button, the *New Scenario Wizard* appears. You can input basic information about the scenario here. Let’s set the basic parameters for scenario creation now.

1. Enter the following in the *New Scenario Wizard*:

```table
<table>
<thead>
<tr>
<th>Create a New Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open a Scenario</td>
</tr>
<tr>
<td>Learn About STK</td>
</tr>
<tr>
<td>Exit STK</td>
</tr>
<tr>
<td>Do not show me this again</td>
</tr>
</tbody>
</table>
```
When Can I Spy On Washington From a Molniya Satellite?

**ANALYSIS PERIOD**

Every scenario requires that you define the times during which the conditions that you set for your world, and the objects in your world, will be relevant. The *analysis period* defines the *epoch* and the *start* and *stop* times of your scenario. The analysis period defines the general time span (a range of several hours, days, or weeks) for analysis.

By default, times are displayed in UTCG. That being the case, the analysis period will vary based on the time zone to which your computer is set. You can change the time unit to LCLG to display the analysis period in your current local time. Let's try it.

1. Click the unit selector (🕒) beside the scenario start time.
2. Select *LCLG* from the menu that appears.

* What is the current local time?

STK provides a user-editable default analysis period for every new scenario. Since you are not concerned with determining when Molniya can see Washington, D.C. on a specific day at a specific time, but are instead just doing some general analysis, you can accept the default analysis period for this example.

1. When you finish, click *OK* to dismiss the *New Scenario Wizard*.
2. When the scenario loads, click *Save*.
3. Verify the scenario name and location and click *Save*.

Once a *scenario* is saved the first time, it will be saved to the same location every time you click the *Save* button. The *Save* button is always available, and

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>See_DC</td>
</tr>
<tr>
<td>Description</td>
<td>Can a Molniya satellite spy on Washington, D.C.?</td>
</tr>
<tr>
<td>Location</td>
<td>C:\Documents and Settings\Student\My Documents\STK 9</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>Leave the default analysis period. Noon today local time displayed in UTCG (based on your computer time zone) for 24 hours.</td>
</tr>
</tbody>
</table>
always saves the entire scenario, regardless of the window or object that is selected.

GET OFF ON THE RIGHT FOOT—STAY ORGANIZED

Once you begin working with STK, you may create and save several scenarios with many objects in a short time. The most helpful technique to manage your scenario files is to save each scenario into its own folder, and give the folder and the scenario file (*.sc) the same name as in the example above. You’ll find that this simple rule of thumb will help you to manage your scenarios more efficiently for the following reasons:

- It decreases the likelihood that you will accidentally overwrite your previous work, especially if you have objects with the same names in different scenarios (e.g. several satellites named LEO).
- It helps keep your work organized, so that it is easier to find a given scenario later.
- It makes it easier to share your scenarios with others.

When you use the New Scenario Wizard to create a new scenario, STK will automatically create a new directory in your default user directory (C:\Documents and Settings\Student\My Documents\STK 9) with the same name that you input for the scenario name and store all of your scenario files as described above. While the folder is created in the new directory, the scenario is not saved until you actually save the scenario.

Scenarios

The scenario itself is saved as an object (*.sc) and each object within the scenario (e.g., satellites, facilities, planets, stars, receivers and transmitters, etc.) is saved individually.
When you create a new scenario, STK updates the Object Browser to include the new scenario and creates the appropriate visualization windows. Once in the Object Browser the objects can be named and properties can be applied.

THE PROPERTIES BROWSER

Each STK object and visualization window has its own set of properties, which are organized into categories (e.g., Basic, 2D Graphics, Constraints, etc.). Customizing properties creates a meaningful environment for the other objects in your scenario. The properties used to define STK objects are organized in the Properties Browser. When you open the Properties Browser you will see the properties for whatever object or visualization window is selected in the STK Workspace.

ACCESSING OBJECT PROPERTIES

There are several ways to access object and window properties. You can access object properties on one of the following ways:

• Double-click the object in the Object Browser.
• Right-click the object in the Object Browser or visualization window (2D or 3D), and select Properties ( ) from the menu that appears.
• Select an object in the Object Browser, and click the Properties ( ) button.

**Scenario Basic Properties**

*Scenario* properties customize the conditions of your scenario. Customizing properties creates a meaningful environment for the other objects in your scenario. Take a look at the rest of the scenario *Basic properties*.

1. Double-click *See_DC ( )* in the Object Browser to open its properties ( ).

<table>
<thead>
<tr>
<th>Properties</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td>Define the epoch and start and stop times that apply throughout the scenario. Control the animation cycle, animation step definition, and the intervals between refresh updates in the graphics windows. Values set here can be overridden at the subordinate level for certain objects.</td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td>Establish the default settings for all units of measure used for display and data input purposes in a scenario. Selections made here can be overridden locally for a specific object or for an entire class of objects.</td>
</tr>
<tr>
<td><strong>Database</strong></td>
<td>Set defaults for available databases.</td>
</tr>
<tr>
<td><strong>Earth Data</strong></td>
<td>Select an Earth Orientation Parameters (EOP) file.</td>
</tr>
<tr>
<td><strong>Terrain</strong></td>
<td>Import and display terrain elevation data for facility and target azimuth-elevation mask and position.</td>
</tr>
<tr>
<td><strong>Global Attributes</strong></td>
<td>Allows the configuration of warning messages for missiles, satellites, and Aircraft Mission Modeler objects.</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Record useful information about your scenario.</td>
</tr>
</tbody>
</table>

2. Select the *Time* page.
   • Are the *Start* and *Stop* times set to those that you set when you created the scenario?

3. Select the *Description* page.
   • Is the description that you provided when you created the scenario in the *Description* page?
4. When you finish, click Cancel to dismiss the scenario properties without making any changes.

**Insert STK Objects Tool**

When a scenario is created, the Insert STK Objects tool appears automatically unless the Do not show me this again option is enabled. From here, you can begin the object creation and insertion process. The Insert STK Objects tool makes it easy to insert and configure some of the most commonly used individual objects. The left-hand pane lists commonly used STK objects. When you select an object on the left, all of the methods available for introducing that class of object will be listed on the right. The process and data that you will have to provide will depend on the object class and introduction method selected.

**FIGURE 1-3. Insert STK Objects tool**

The Insert STK Objects tool can be customized using the options available on the New Object page of the Application Preferences.

1. Click the Edit Preferences... button.
2. Select the New Object page.
3. Locate the Define Default Creation Methods area.
The *Objects* list contains all of the available objects in STK. When an object is selected, all of the available methods for creating and configuring that object display in the *Method* list to the right. You can include or exclude options from the *Insert STK Objects tool* by selecting them in the list and enabling or disabling the *Show object in insert new object tool*.

4. When you finish, click *Cancel* to dismiss the *New Object* preferences page.

**Model a Spacecraft**

Now you have a model of a meaningful “world”, but your world has no objects. You still need a spacecraft traveling in a Molniya orbit. In STK, the satellite object is used to model the properties and behavior of a vehicle in orbit around a central body.

1. Select the following in the *Insert STK Objects tool*:

   | **TABLE 1-3. Insert satellite** |
   |-------------------------------|------------------|
   | **OPTION**                    | **VALUE**        |
   | Select an Object To Be Inserted: | Satellite        |
   | Select a Method:              | Orbit Wizard     |

2. Click the *Insert...* button.

When you click the *Insert...* button, the *Orbit Wizard* will appear.

**The Orbit Wizard**

The *Orbit Wizard* is a satellite level tool designed to assist you in creating any one of several standard orbits or designing your own satellite orbit. The configurable options available will depend on the orbit *Type* selected.
The orbit types available are outlined below.

<table>
<thead>
<tr>
<th>ORBIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular</td>
<td>Circular orbits have a constant radius.</td>
</tr>
<tr>
<td>Critically Inclined</td>
<td>Critically Inclined orbits maintain perigee at a fixed latitude. The line of apsides does not change over time.</td>
</tr>
<tr>
<td>Critically Inclined, Sun Sync</td>
<td>Critically Inclined Sun Synchronous orbits combine the features of both basic types of orbits. The orbit uses a retrograde inclination of 116.565 degrees. The satellite will pass overhead at the same local time for each revolution and has a perigee which remains at a fixed latitude.</td>
</tr>
<tr>
<td>Geosynchronous</td>
<td>A satellite in a stationary orbit will remain fixed in the sky above the specified fixed longitude.</td>
</tr>
<tr>
<td>Molniya</td>
<td>Molniya orbits are highly eccentric, meaning that there is a large difference between the altitude at apogee and the altitude of perigee. Molniya orbits are also critically inclined. This keeps the perigee of the orbit in the Southern Hemisphere. Molniya orbits also have a long dwell time in the extreme latitude regions of the Northern Hemisphere.</td>
</tr>
<tr>
<td>Orbit Designer</td>
<td>With this option, you can create any orbit you wish.</td>
</tr>
</tbody>
</table>
WHEN CAN I SPY ON WASHINGTON FROM A MOLNIYA SATELLITE?

TABLE 1-4. Orbit types

<table>
<thead>
<tr>
<th>ORBIT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeating Ground Trace</td>
<td>Orbits with repeating ground traces are useful when identical viewing conditions are desired at different times to detect changes. The ground trace may be caused to repeat every day or to interweave from day to day before repeating.</td>
</tr>
<tr>
<td>Repeating Sun Sync</td>
<td>Sun Sync orbits with repeating ground traces are useful when identical viewing and lighting conditions are desired at different times to detect changes. The ground trace may be caused to repeat every day or to interweave from day to day before repeating. The orbit repeats the ground coverage cycle and passes overhead at approximately the same local time for each revolution.</td>
</tr>
<tr>
<td>Sun Synchronous</td>
<td>The effect of the oblateness of the Earth is used to cause the orbit plane to rotate at the same rate at which the Earth moves in orbit about the Sun. Thus, at the equator, the satellite passes overhead at the same local time for each revolution.</td>
</tr>
</tbody>
</table>

No matter which Type of orbit you select, the Orbit Wizard lets you change the satellite analysis period as well as configure and preview satellite graphics before the object is introduced into the scenario.

1. When the Orbit Wizard appears, select the following:

   TABLE 1-5. Orbit Wizard options

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Molniya</td>
</tr>
<tr>
<td>Satellite Name</td>
<td>SpySat</td>
</tr>
</tbody>
</table>

2. Accept all other default values.
3. Click OK.

- Can you see SpySat in the Object Browser? The 2D Graphics window? 3D?

Model Washington

It looks like you have one more object to model--Washington. STK provides two objects that can be used to model a point-of-interest on the surface of the central body--Facilities (☐) and Targets (☒). Facilities and targets are almost identical in properties and behavior. Often, facilities and targets are used to differentiate between friendly and unfriendly sites, where a facility marks a friendly site, and a target marks an unfriendly site.
**INSERT THE FACILITY**

Facilities can be positioned and repositioned in a variety of ways. For this example, you’ll use an entry from the *STK City Database*.

1. Return to the *Insert STK Objects tool*.
2. Select the following:

   3. Click the *Insert*... button.

**The STK City Database**

Several comprehensive databases are shipped with STK for your use. The *City Database* contains thousands of cities around the world. Individual city information includes the exact location of the city. You will use the *City Database* tool to model *Washington, D.C*.

1. When the *City Database Search* tool appears, set the following:

   2. Click *Search*.

   3. When the search results appear, select *Washington* (City Name) *District of Columbia* (Province).

   4. Click the *Insert* button.

   5. Close the *City Database Search* tool.

---

*When a predefined object is imported from an STK databases (satellite, facility, city or star), information about that object is automatically written to its Long Description.*
6. You don’t need to create any more objects, so you can close the Insert STK Objects tool now if you like.

2D and 3D Visualization

Two of the most powerful and indispensable STK tools are the 2D (STK Basic Edition) and 3D Graphics (STK Professional and Expert Editions) windows. Using them, you can visualize your scenario in a dynamic 2D and/or 3D environment. Time can be animated forward, backward, and in real-time to display space- and ground-based object positions, coverage areas, visibility status, lighting conditions, and much more.

1. Bring the 2D Graphics window to the front.
2. Advance the animation a few steps until SpySat is clearly visible.

3. Bring the 3D Graphics window to the front.
SpySat's object marker is positioned according to the current animation time in both windows, and its ground (2D) and orbit tracks (2D and 3D) are clearly visible.

**Animation Properties**

*Animation* properties are part of the *Scenario Basic - Time properties*. Using *Animation* properties you can define the animation cycle, step definition and the intervals between refresh updates in the *2D* and *3D Graphics* windows.

**Animation Cycle**

The *animation cycle* defines a portion of the scenario that you wish to see in motion when you animate. Movement of objects within a scenario during any portion of the *analysis period* that do not fall within the *animation cycle* will not display in the visualization windows.

1. *Play* (▶) the animation, and watch as *Molniya* (❖) travels along its path.
2. *Pause* (❚❚) the animation at any point.

**Animation Toolbar**

The *Animation* toolbar provides controls that allow you to set your scenario in motion in all *2D* and *3D Graphics* windows.
FIGURE 1-7. Animation toolbar

Take a look at the Animation toolbar. Notice the date and time display in the editable field on the toolbar. This is the current animation time. Whenever you reset the animation, the animation time also resets. If you edit the animation date and time here, STK will move all objects so that they are positioned according to the new animation time.

You can also use the Decrease Time Step ( ) and Increase Time Step ( ) buttons to change the pace of the animation. The animation time step will increase or decrease incrementally each time you click one of the buttons.

3. Try using the Step in Reverse ( ) and Step Forward ( ) buttons to move SpySat ( ) along its path a step at a time.

The current step displays in the lower right hand corner of the STK Workspace in the taskbar. The time step should also display 3D Graphics window as an annotation by default.

FIGURE 1-8. STK taskbar

If your satellite disappears, you have animated beyond the analysis period for the scenario or that object. Reset the animation to restore your objects to their proper place in time.

Moving Around in 2D and 3D

There are several ways to manipulate the view in the 2D and 3D Graphics windows. Take a moment to try moving around and focusing on objects.

Magnify an area on the map

The Zoom In button can be used to magnify a portion of the selected 2D Graphics window or graph.

1. Reset ( ) the animation.
2. Step Forward ( ) until SpySat ( ) is clearly visible.
3. Select the 2D Graphics window.
4. Click the **Zoom In** button (Zoom In) on the **Default** toolbar.
5. Click and hold the left mouse button and drag it over the area of the map around **SpySat** (SpySat) in the **2D Graphics** window.
6. **Zoom** (Zoom) as many times as needed until **SpySat** (SpySat) is clearly visible.

**FIGURE 1-9. 2D View: SpySat marker**

As you can see, **SpySat** is represented by a generic marker in the **2D Graphics** window.

**ZOOM TO SPYSAT**

STK provides tools for changing your perspective in the **3D Graphics** window. It is often helpful to view the events in a scenario from the perspective of a particular object. Use the **Zoom To** to center the view in the **3D Graphics** window on **SpySat**, and get a better look at the satellite model.

1. Bring the **3D Graphics** window to the front.
2. Right-click **SpySat** in the **Object Browser** or in the **3D Graphics** window.
3. Select **Zoom To**.
4. Check the **3D Graphics** window. **SpySat** (SpySat) is now the focal point.

**MOUSE AROUND IN 3D**

You can use the mouse to move around in the **3D Graphics** window. Use the mouse to zoom and rotate in the **3D Graphics** window to get a better look at the satellite object model.
• Click and hold the left mouse button, then move your mouse around in the 3D Graphics window to rotate the focal point.
• Click and hold the right mouse button, then move your mouse forward and backward to zoom in and out.

FIGURE 1-10. 3D View: SpySat model

In the 3D Graphics window, SpySat is represented by a 3D model.

You can also focus the 3D Graphics window on an object-of-interest by holding down Shift on your keyboard and double-click on the object-of-interest in the 3D Graphics window.

RESTORE THE VIEW

1. Reset the animation.
2. Select the 3D Graphics window, and click the Home View button on the 3D Graphics toolbar to restore the default Earth-centered view.
3. Select the 2D Graphics window, and click the Zoom Out button on the Default toolbar as many times as necessary to return the map to its original view.

Report Positional Data

Using the visualization windows, you were able to see the location of SpySat and watch its position change over time, but suppose you needed more
detailed data about how *SpySat*’s position or orbital parameters will change over time?

STK includes a number of *Data Provider* tools with which you can report and display data about objects in one of the four available formats—*Report*, *Dynamic Display*, *Graph*, or *Strip Chart*.

1. Click the *Report & Graph Manager* button ( ) on the *STK Tools* toolbar.
2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object Type</strong></td>
<td>Satellite</td>
</tr>
<tr>
<td><strong>Object (Below Object Type)</strong></td>
<td><em>SpySat</em></td>
</tr>
<tr>
<td><strong>Show Reports</strong></td>
<td>On</td>
</tr>
<tr>
<td><strong>Show Graphs</strong></td>
<td>Off</td>
</tr>
<tr>
<td><strong>Style</strong></td>
<td>Classical Orbit Elements</td>
</tr>
<tr>
<td><strong>Generate as</strong></td>
<td>Report/Graph</td>
</tr>
</tbody>
</table>

3. Click *Generate*...

STK will generate and display a text report that provides a representation of the *SpySat*’s orbital elements.

4. Using the data in the report, answer the following:

   • What is the inclination of *SpySat* over time?

5. When you finish, close the *Classical Orbit Elements* report.
6. Close the *Report & Graph Manager* ( ).

---

### When Can SpySat “See” Washington?

You have added two objects to your scenario—one satellite object representing *SpySat* and one facility object representing *Washington, D.C.* Now, you need to determine when *Washington, D.C.* is within the *SpySat*’s line of sight.

Calculating object-to-object visibility in STK is called *access*. STK will calculate the times one object can *access*, or “see”, another object based on position and availability information that considers timing and constraints if necessary. An
Access is defined by the two objects for which the access is computed and is calculated FROM the object that is “looking” for another object TO the object that it is “looking for”. Once an access is calculated, it maintains a close relationship with the defining objects. If either of the defining objects is changed in such a way that the access times may be altered, the access is automatically recomputed. Also, if either of the defining objects is removed from the scenario, the access is automatically removed.

Now determine when SpySat can “see” Washington by calculating a simple access. A simple access will calculate an unconstrained line-of-sight between the two objects in your scenario.

1. Click the Access Tool button ( ) on the STK Tools toolbar.

When you open the Access tool, you can select both the object from which access will be calculated and the object(s) to which access will be calculated. The object FROM which access will be calculated is selected using the Access for: option, and all objects TO which access can be calculated is selected in the Associated Objects list. You can select the object(s) TO which you’d like to calculate access by selecting them in the list.

2. Ensure that the Access for option says SpySat. If not, use the Select Object... option to select SpySat as the from access object.
3. Select Washington ( ) in the Associated Objects list.
4. Click Compute.

Now, take another look at Washington in the Associated Objects list. Washington is now bold, and an asterisk * appears next to the object to indicate that access has been calculated to that object.

**Access Graphics**

Whenever an access occurs during animation, each object is outlined and a line connects SpySat to Washington. The line provides a clear visual representation of object-to-object visibility.

1. Position the 2D and 3D Graphics windows so that you can see them both clearly.
2. Play ( ) the animation.

* Can you identify accesses from SpySat to Washington?
A portion of SpySat’s ground track is now thicker and marked in the same color as Washington’s object label. Whenever SpySat is within any marked portion of its path, it will be able to “see” Washington.

3. **Pause ( )** the animation when SpySat ( ) has access to Washington ( ).

**FIGURE 1-11. 3D View: Access from SpySat to Washington**

- Can you spot any unexpected accesses?

**FIGURE 1-12. 2D View: Accesses from SpySat to Washington**
Report Access Times

Well, access has been calculated, and you can even see that access occurs in the 2D and 3D Graphics windows, but that doesn’t tell you what you need to know. You need to know exactly WHEN access occurs. Data providers can return information about when AND where accesses occur.

1. Select the Access tool ( ) to bring it to the front.
2. Click the Access... button in the Reports area.

STK will generate and display an access report. The access report lists the start and stop time for each instance that SpySat can “see” Washington.

3. Take a look at the access report, and answer the following questions:
   - How many periods of access are there?

REPORT DATA TOOLS

The Report Data window contains tools that allow you to adjust the report style while the report is open. Let’s take a look at the options available on the Access report that you created.

<table>
<thead>
<tr>
<th>BUTTON</th>
<th>FUNCTION</th>
<th>BUTTON</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Save As Text" /></td>
<td>Save As Text</td>
<td><img src="image" alt="Refresh" /></td>
<td>Refresh</td>
</tr>
<tr>
<td><img src="image" alt="Save As .csv" /></td>
<td>Save As .csv</td>
<td><img src="image" alt="Global Report Units" /></td>
<td>Global Report Units</td>
</tr>
<tr>
<td><img src="image" alt="Print" /></td>
<td>Print</td>
<td><img src="image" alt="Save As Quick Report" /></td>
<td>Save As Quick Report</td>
</tr>
<tr>
<td><img src="image" alt="Find" /></td>
<td>Find</td>
<td><img src="image" alt="Save Change to Style" /></td>
<td>Save Change to Style</td>
</tr>
<tr>
<td><img src="image" alt="Copy" /></td>
<td>Copy</td>
<td><img src="image" alt="Help" /></td>
<td>Help</td>
</tr>
</tbody>
</table>

START AND STOP TIMES AND STEP

Using the Start and Stop times in the report header, you can limit the data to a selected portion of the analysis period. The default period for the report is the analysis period. You can also adjust the step to report data in coarser (increase the step) or finer (decrease) increments.
REPORT UNITS

Take a look at the first access.

- When does the first access occur?
- What is the duration of the first access?

That’s a lot of seconds. It really doesn’t seem to make sense to report this length of time in seconds, does it? What you’d like to know, is how many hours that is. Can you figure how each duration translates to hours? You don’t need to.

1. Select the access report to bring it to the front.
2. Click the Global Report Units button (¶) at the top of the report.
3. When the Units dialog appears, select Time in the Dimensions list. You will see that the default time unit is set to Seconds (sec).
4. Select Hours (hr) from the New Unit Value list.
5. Click OK to save the change and dismiss the Units window.
6. Return to the access report.

Look at the duration values. They’ve all been converted to hours.

Now, you can answer the question that you set out to solve.

- For how many hours in one twenty-four hour period could you spy on Washington, D.C. from a satellite in a Molniya orbit?

7. When you finish, close the access report.

Where Is SpySat When He “Sees” It?

The access report that you created assures you that SpySat can indeed “see” Washington, and even tells us WHEN SpySat can “see” Washington; but suppose, for instance, you are operating some sort of collection sensor attached to SpySat and you want to know where to point the sensor during access. You’d need to know WHERE SpySat is with respect to Washington when access occurs. Access data can also give you this information.

1. Select the Access tool (a) to bring it to the front.
2. Click the AER... button in the Graph area.
STK will generate and display an _AER_ report. The _AER_ report gives the azimuth, elevation, and range of _SpySat_, relative to Washington, during each period of access.

3. Use the _AER_ report to answer the following questions:
   - When is _SpySat_ furthest from/closest to Washington?
   - What is the minimum/maximum distance from which _SpySat_ can “see” Washington?

**Where Should Washington Look To See SpySat?**

Turn things around. Suppose you’re in Washington, and you want to know where you can look to “see” _SpySat_. In this case, you would need to calculate access FROM Washington TO _SpySat_.

1. Select the _Access_ tool ( ), to bring it to the front.
2. Click the _Select Object..._ button.
4. Click OK.
5. Select _SpySat_ ( ) in the _Associated Objects_ list.
6. Click the _AER..._ button in the _Reports_ area.
7. Use the two _AER_ reports to answer the following questions:
   - Is the distance between Washington and _SpySat_ different from Washington’s perspective?
   - Would you be able to answer your original question if you had calculated data FROM Washington TO _SpySat_? How can you tell?

8. Close any open reports.

**When You Finish**

1. _Save_ ( ) your work.
2. Close the scenario ( ).
3. Leave _STK_ ( ) open.
When Can I Spy On Washington From a Molniya Satellite?
In this exercise, you will define and assess a real-world problem, and then model and analyze that problem in STK. Upon completion, you will be able to:

- Understand the STK paradigm, Scenario Basic properties, and the Properties Browser.
- Build a scenario that models a real-world problem.
- Use object Constraints properties to model real-world limitations.
- Use 2D & 3D Graphics to visualize real-world constraints.
Problem Statement

It’s exciting to be able to see a satellite moving in the night sky - even more so when it’s the International Space Station (ISS). You’d like to determine when you can see the ISS from your present location (call it MyTown) when it flies overhead within the next three (3) weeks.

BREAK IT DOWN

You have some information that may be helpful. Here’s what you know:

• You will start looking for ISS tomorrow.
• You are interested in passes that occur over the next three weeks (21 days).
• You can see ISS with the naked eye from the ground when it is illuminated.
• You can see ISS with the naked eye when it is dark on the ground.
• When you are on the ground trying to see something in space, the lower you look along the horizon, the more atmosphere you have to look through and the better the chance that something will be in the way.

It is often effective, when building STK scenarios, to start from the ground and work your way up. Make an outline of how you might build an STK scenario.

I. Model the World
   A. Define the analysis period of interest
   B. Save the scenario to a unique folder
   C. Add Terrain and imagery

II. Populate the World
   A. Model facilities, cities, targets, and area targets
   B. Model ground vehicles, ships, and submarines
   C. Model aircraft and air breathing missiles
   D. Model missiles, launch vehicles, and satellites

III. Personalize Your World
   A. Model payloads (sensors or radar) and comms (transmitters and receivers)
   B. Set Constraints
   C. Set Accesses, Chains, and Coverage
IV. Analyze the Relationship of Objects in Your World
   A. Where am I?
   B. What can I see?
   C. When can I see it?

SOLUTION

Build a scenario that allows you to calculate a simple line-of-sight access between *MyTown* and the *International Space Station (ISS)* that considers lighting and elevation limitations.

Scenario Analysis Period

You can set the scenario analysis period by typing *Now*, *Today*, *Tomorrow*, or +/- a specified number of days or weeks in the appropriate fields. These settings reference the current date and time based on your computer's internal clock. If you save a scenario that includes these settings, the analysis period is updated every time the scenario is opened to correspond to the current date and time.

This scenario might be used a hundred times from various locations at various times. The specific date isn’t important. It is more important that you get information that lets you know when you can see the ISS right now. That being the case, it seems like it might be a real time saver to set the scenario start time to *Today*.

Let’s try it!

1. Click the *Create a New Scenario* button.
2. Enter the following in the *New Scenario Wizard*:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Where_Is_ISS</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>When will ISS be visible over the next three (3) weeks?</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>C:\Documents and Settings\Student\My Documents\STK 9</td>
</tr>
</tbody>
</table>

3. Right click in the *Analysis Period* text box to reveal the floating menu.
4. Set the *Start Time* to *Today*.
5. Set the *Stop Time* to +21 days.
Where Is the Space Station Now?

• If the default start of the analysis period is already today’s date at noon (displayed in UTCG), why do I need to change it to “Today”?

6. When you finish, click OK.
7. When the scenario loads, click Save ( ).

A folder with the same name as your scenario is created for you in the location specified above.

8. Verify the scenario name and location and click Save.

Model MyTown

The Insert STK Objects tool offers a variety of methods for introducing different types of facilities. For this example, it will be sufficient to mark the location of the city where you are right now, or MyTown. An easy way to introduce a city is to create the object using a predefined database object from the STK City Database.

1. Bring the Insert STK Objects tool ( ) to the front.

![By default, new facilities are inserted at the latitudinal and longitudinal coordinates of AGI headquarters near Philadelphia. If you are at AGI headquarters, select Insert Default as the method to position the facility at that location.]

2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Facility</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Select From City Database</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.
4. Query the City Database to find a database entry that matches the city where you are currently taking this class.
5. Use that entry to insert an STK facility object representing MyTown into the current scenario.
6. Close the City Database Search tool.
Renaming Objects

STK provides a variety of options for renaming objects in the Object Browser.

- Select the object, and then click the name of the object to make it editable.
- Right-click the object and select Rename from the context menu that appears.
- Select the object in the Object Browser, and click the F2 button on your keyboard.

Use one of the methods outlined above to rename the new facility MyTown.

1. Select the facility in the Object Browser.
2. Click the F2 button on your keyboard.
3. Rename the facility MyTown.

Model ISS

You can also introduce predefined satellite models based on database entries.

1. Return to the Insert STK Objects tool.
2. Select the following:

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Satellite</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Select From Satellite Database</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.

The STK Satellite Database

The Satellite Database is another database tool shipped with STK for your use. The unclassified Satellite Database that comes with basic STK is published by USSTRATCOM. This database contains positional data for thousands of satellites in the form of two-line element sets (TLEs). You will use the Satellite Database tool to model ISS.

See if you can find a database entry for ISS, and use it to insert an STK satellite object.
Where Is the Space Station Now?

1. When the *Satellite Database Search* tool appears, set the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name</td>
<td>On</td>
<td>ISS</td>
</tr>
<tr>
<td>SSC Number</td>
<td>Off</td>
<td>N/A</td>
</tr>
<tr>
<td>TLE Source</td>
<td>N/A</td>
<td>Online: AGI Server</td>
</tr>
</tbody>
</table>

2. Click *Search*.

   By default, when you insert a satellite using *Satellite Database* entries, ephemeris is propagated using the analysis period and the SGP4 propagator.

3. Select the *ISS* entry (25544).

4. Click *Insert* to insert an STK satellite object ( ) representing *ISS* into the scenario.

5. Close the *Satellite Database Search* tool.

6. You don’t need to create any more objects, so you can close the *Insert STK Objects tool* ( ) now if you like.

**SATellite PROPERTIES**

Let’s take a look at the properties for the satellite imported from the database.

1. Double-click *ISS_25544* ( ).

2. Ensure that the *Basic - Orbit* page is selected.

3. Click the *Preview*... button in the *TLE Source* area.

   A window that displays the two-line element (TLE) information that will be used to propagate the SGP4 satellite will appear. Feel free to discuss the various TLE data with your instructor.

4. When you finish, click OK to dismiss the *TLE Preview* window. Leave *ISS_25544*’s ( ) properties open.

**When Can I See ISS From My Town?**

You have two objects in your scenario, one satellite representing *ISS* and one facility representing *MyTown*. You need to know when *ISS* is within *MyTown’s* line of sight. Calculate a simple access to determine when you can see the *ISS*. 
1. Click the Access tool button ( ) on the STK Tools toolbar.
2. Set the Access For option to MyTown ( ).

The Access For object will automatically be set to the object selected in the Object Browser.

3. Select ISS_25544( ) in the Associated Objects list.
4. Click the Access... button in the Reports area.

Access is automatically computed when you generate any type of Access report, graph, or display. You do not need to click the Compute button before generating data from the Access tool.

STK will generate and display an Access report. The Access report that you created tells you WHEN access occurs. Knowing when to look for ISS is helpful, but you also want to know where to look for ISS. See if you can determine WHERE ISS is with respect to MyTown when access occurs.

5. Select the Access tool ( ) to bring it to the front.
6. Click the AER... button in the Reports area.
7. Close the Access tool ( ).
8. Leave the Access and AER reports open.

The Access report lists the start and stop time for each instance that ISS is within MyTown’s line of sight. The AER report gives the azimuth, elevation, and range of ISS during each period of access.

9. Take a look at the Access and AER reports that you created.
10. Note the answers to these questions:

   • How many accesses are there?
   • What is the total duration of all the accesses?
   • What is the elevation range of the accesses?

Model Real World Conditions

According to the information that you have, you can only see ISS with the naked eye from the ground when it is in direct sun and when it is dark in MyTown. Take another look at the times when MyTown can see ISS.

• Are these access times useful to you?
How can you ensure that STK will only provide access times that meet your criteria?

In order to model realistic system limitations, STK provides constraints. Constraints allow you to place limitations on the performance of objects. STK provides several different types of constraints. The types of constraints available will depend on the object on which the constraint is being imposed.

All constraints work in an AND configuration meaning that when multiple constraints are set, they must all be satisfied in order for an access to occur (e.g., Basic constraints AND Sun constraints AND Temporal constraints,... must all be satisfied in order for an access to occur). If any single constraint is violated, that access is invalidated.

Add a Constraint To the ISS

Your list says you can only see ISS with the naked eye from the ground when the spacecraft is in direct sun. You need to exclude access that occur when ISS is NOT in direct sunlight because although it will pass over you, it won’t be illuminated such that you will be able to see it from the ground with the naked eye.

Sun Constraints

You can use a Sun constraint to model this limitation. Sun Constraints enable you to impose lighting constraints based on the position of the Sun and Moon. When a Lighting option is set, it indicates that access to an object, which uses one or more constraints, is valid only under these specified lighting conditions.

1. Open ISS_25544’s properties.
2. Select the Constraints - Sun page.
3. Enable the Lighting option towards the bottom of the page.
4. Select Direct Sun from the adjacent list.
5. Click OK to accept the changes, and dismiss ISS_25544’s properties.

When Can I See ISS?

The lighting constraint ensures that ISS will be considered in your analysis only when it is in direct sun. See how that has affected your access.
WHERE IS THE SPACE STATION NOW?

1. Bring the Access...report to the front.
2. Refresh ( or F5) the Report Data window.
3. Bring the AER...report to the front.
4. Refresh ( or F5) the Report Data window.
5. Take a look at the access and AER reports that you created.
6. Note the answers to the following questions:
   • How many accesses are there?
   • What is the total duration of the accesses?
   • Do accesses occur during daylight hours?

CHANGE TO LOCAL TIME

Your default report access times are in Universal Time (UTCG). You want to change the time to the local time. This will simulate the current conditions in MyTown.

1. Select the AER report to bring it to the front.
2. Click the Report Units button ( ) at the top of the Report Data window.
3. When the Units dialog appears, select DateFormat in the Units list. You will see that the default time unit is set to Gregorian UTC (UTC G).
4. Select Gregorian LCL (LCLG) from the Change Unit Value list.
5. Click OK to save the change and dismiss the Units window.

Gregorian LCL is dependent on your system clock and time zone. If MyTown is located in a time zone other than the one your computer is set to, the resulting access times would be invalid.

7. Take a look at the access and AER report.
   • Now, do accesses occur between sunset and sunrise?

Add Constraints To MyTown

Your list says you can only see ISS with the naked eye when it is dark in MyTown. You need to exclude accesses that occur during daylight hours in MyTown because, although the ISS will pass over you, it won’t be dark enough in MyTown to spot ISS from the ground with the naked eye.
SUN CONSTRAINTS FROM THE GROUND

For your analysis, you need MyTown to be available only at night. To model the lighting conditions you need to impose a separate constraint on MyTown based on the position of the Sun.

1. Open MyTown's properties.
2. Select the Constraints - Sun page.
3. Enable the Lighting option.
4. Select Umbra (no sun light) from the adjacent list.
5. Click Apply. Do not close the properties.

WHEN CAN I SEE ISS WITH MYTOWN CONSTRAINED?

Constraining MyTown ensures that it will be considered in your analysis only when it is totally shadowed from the sun. Check to see how that has affected access to ISS.

1. Bring the Access...report to the front.
2. Refresh (or F5) the Report Data window.
3. Bring the AER...report to the front.
4. Refresh (or F5) the Report Data window.
5. Take a look at the access and AER reports that you created.
6. Note the answers to the following questions:
   - How many accesses are there?
   - What is the total duration of the accesses?
   - How did applying a lighting constraint to MyTown affect accesses?
   - At what elevation does the first access occur?

BASIC CONSTRAINTS

You know that when you are on the ground trying to see something in space the lower you look along the horizon the more atmosphere you have to look through and the better the chance that something will be in the way. To help avoid the elevation angle problem, STK allows you to put an elevation angle constraint on a ground-based location. A good typical minimum elevation is 6-8 degrees, but it can be more depending on the area, the surrounding terrain, and even buildings.
To model a more realistic representation of MyTown's availability, impose a minimum elevation angle constraint.

1. Return to MyTown's properties.
2. Select the Constraints - Basic page.
3. Enable the Min option in the Elevation Angle area.
4. Enter 6 deg in the adjacent textbox.
5. Click OK to accept the changes, and dismiss MyTown's properties.

**WHEN CAN I SEE ISS?**

The elevation angle constraint models a more realistic representation of MyTown's availability. Check to see how that has affected the number of accesses.

1. Bring the Access...report to the front.
2. Refresh (F5) the Report Data window.
3. Bring the AER...report to the front.
4. Refresh (F5) the Report Data window.
   - How many accesses are there?
   - What is the total duration of the accesses?
   - How did applying an elevation angle constraint to MyTown affect accesses?

5. When you finish, close all open report windows.

**Where Am I?**

Now, you have data that lets you know exactly where and when to look for ISS from MyTown, but wouldn't it be nice if you could visually identify when the accesses occur and when the constraints that you’ve set are valid? That would give you a nice visual representation of accesses.

**ACCESSING WINDOW PROPERTIES**

Suppose you wanted to change the properties of a visualization window itself? What if you needed to adjust the lighting display in the window and not just for an object, or change the central body? Every visualization window (2D and 3D) has its own properties just like STK objects. Properties for
windows have their own Properties Browser which is accessed in the same manner as object properties.

You can access window properties on one of the following ways:

- Right-click anywhere in the window, and select Properties ( ) from the menu that appears.
- Click the Properties ( ) button on the toolbar that corresponds to the window whose properties you would like to access.

DISPLAY CONSTRAINTS
You can set lighting conditions in the 2D Graphics window that will provide a visual representation of how the lighting constraints that you set are affecting the objects in your scenario.

1. Select the 2D Graphics window to bring it to the front.
2. Open the 2D Graphics window properties ( ).
3. Select the Lighting page.
4. Enable the Sunlight - Show Outline option.
5. Enable the Subsolar Point - Show option.
6. Click OK.

When you display outlines on the map in the 2D Graphics window, lighting conditions are displayed on the surface of the Earth. ISS is several kilometers above the Earth, so the times at which it crosses the solar terminator in the 2D Graphics window will not be exact, but they do provide a general idea of the lighting conditions for ISS. If you want to display exact lighting for ISS, you can use the 3D Graphics window.

GET MOVING!
The ISS object marker is positioned according to the current animation time in both windows, and its ground and orbit tracks are clearly visible.

1. Ensure that the 2D and 3D Graphics window are clearly visible in your STK Workspace.
2. Play ( ) the animation.
3. Watch as your objects move along in the 2D Graphics window as animation progresses.
• Can you identify the approximate times when ISS moves in and out of periods of sunlight?

1. *Reset* the animation again
2. *Play* the animation.
3. *Pause* the animation when you see an access.

![FIGURE 2-1. 2D View: Access from MyTown to ISS](image)

4. Now, check the time in the *Animation* toolbar.

![FIGURE 2-2. Animation toolbar during access from MyTown to ISS](image)

• Does that time show up on your access report?

   *The time of access will be different in your report because your scenario is based on relative time (Today +\-).*


**SET YOUR 3D GRAPHICS WINDOW TO ISS**

1. *Reset* the animation.
2. Right-click *ISS_25544* in the *Object Browser*.
3. Select *Zoom To*.
4. Mouse around in the window to get a better look at *ISS_25544*.
The ISS satellite looks quite different than the default satellite. If you load a satellite using the *Satellite Database* tool, information for the inserted satellite appears on the *Description* page of its basic properties, and when available, the appropriate 3D model is also loaded.

**FIGURE 2-3. 3D View: ISS model**

5. *Play (▶)* the animation.

- Is ISS always in sunlight when access occurs?

**Save Your Work**

1. *Reset (●)* the animation.
2. *Save (●)* your work.
3. Close the scenario (يبة).
4. Leave *STK (●)* open.
How Is the Reception On My Satellite Radio Outside the Continental U.S.?

In this exercise, you will define and assess a real-world problem, and then model and analyze that problem in STK. Upon completion, you will be able to:

- Understand and manipulate 2D object and window properties.
- Model and manipulate multiple objects simultaneously.
- Model a region-of-interest on the surface of the central body.
- Model land- and sea-based Great Arc vehicles.
- Define and manipulate a vehicle route.
- Use the Message Viewer and Status Bar to aid in definition and analysis of an object.
Problem Statement

In this exercise, you’re going to take a little trip. You are a naval officer who just graduated from the Naval Post Graduate School in Monterey, CA. You got a Sirius XM Radio for graduation. After graduation, you need to drive from Monterey to San Diego to ship out for Nagasaki, Japan on the USS Iwo Jima. You have a friend who lives on the Big Island of Hawaii. The USS Iwo Jima is scheduled to dock briefly on the Big Island. You’d like to know if you’ll be able to use your new satellite radio in Nagasaki or should you leave it on the Big Island with your friend?

Break It Down

You have some information that may be helpful. Here’s what you know:

• You will leave Monterey today at noon local time (displayed in UTCG) on graduation day.
• To get to San Diego, you will drive down the Pacific Coast Highway traveling at about 50 m.p.h.
• Your trip to San Diego from Monterey will take about seven and a half (7.5) hours.
• You ship out of San Diego for Nagasaki tomorrow morning at 8 a.m. local time (displayed in UTCG).
• The USS Iwo Jima will dock on the Big Island of Hawaii briefly.
• Your friend lives on the Big Island of Hawaii.
• Your satellite radio must be able to communicate with the satellite radio Sirius XM Radio satellites XM-3 (Rhythm), XM-4 (Blues), SIRIUS-1, SIRIUS-2, SIRIUS-3 to work.

Solution

Build a scenario representing your travels from Monterey to Nagasaki. This will include two separate trips—the trip from Monterey to San Diego, and then from San Diego to Nagasaki (including a momentary port on the Big Island of Hawaii), and then determine if your new satellite radio will work for the duration of your trip.

Create a Scenario

If everything goes according to schedule:
You leave Monterey Today at noon (displayed in UTCG).
It takes about seven and a half (7.5) hours to get from Monterey to San Diego.
It takes a little over nine (9) days to get from San Diego to Nagasaki, Japan.
You make a short stop on the Big Island of Hawaii while aboard the USS Iwo Jima.

It looks like a ten (10) day analysis period should be more than enough time to encompass all that you need to accomplish.

1. Click the Create a New Scenario button.
2. Enter the following in the New Scenario Wizard:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Rock_the_Boat</td>
</tr>
<tr>
<td>Description</td>
<td>How’s the Reception On My Satellite Radio Outside the Continental U.S.?</td>
</tr>
<tr>
<td>Location</td>
<td>C:\Documents and Settings\Student\My Documents\STK 9</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>Default (today at noon local time) to + 10 days</td>
</tr>
</tbody>
</table>

3. When you finish, click OK.
4. When the scenario loads, click Save.

A folder with the same name as your scenario is created for you in the location specified above.

5. Verify the scenario name and location and click Save.

**Model Locations On the Ground**

You have a world, and a defined period for analysis. You need to add objects that model locations and vehicles that you’ll need. According to what you know there are four locations of interest on the ground:

1. Monterey
2. San Diego
3. The Big Island of Hawaii
4. Nagasaki
How Is the Reception On My Satellite Radio Outside the Continental U.S.?

Use the object insertion tool to model facility objects representing the start (**Monterey**) and destination (**San Diego**) locations for the first leg of your journey, as well as your final destination (**Nagasaki**). These entries should also be available via the **STK City Database**.

1. Bring the *Insert STK Objects tool* to the front.
2. Select the following:
   
   **TABLE 3-2. Object insertion options**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Facility</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Select From City Database</td>
</tr>
</tbody>
</table>
   
3. Click the *Insert...* button.

**CALIFORNIA CITIES**

First, let's add your start location--**Monterey, California** and your destination location--**San Diego, California**.

1. When the *City Database Search* tool appears, set the following:

   **TABLE 3-3. City search criteria**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Name</td>
<td>On</td>
<td>*</td>
</tr>
<tr>
<td>Province</td>
<td>On</td>
<td>California</td>
</tr>
<tr>
<td>Country</td>
<td>Off</td>
<td>N/A</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

   *Enabling the Auto Select Color option ensures that each city is assigned a unique color for display in the visualization windows.*

2. Click *Search*.
3. You may get a warning telling you that only the first 2000 results will display in the search window. Click *OK* to dismiss the warning.
4. When the search results appear, hold down the *Ctrl* key and select the **Monterey** entry and the **San Diego** entry.
5. Click the *Insert* button.
HOW IS THE RECEPTION ON MY SATELLITE RADIO OUTSIDE THE CONTINENTAL U.S.?

NAGASAKI

Now add your final destination location--Nagasaki, Japan.

1. Return to the City Database Search tool.
2. Set the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Name</td>
<td>On</td>
<td>Nagasaki</td>
</tr>
<tr>
<td>Province</td>
<td>On</td>
<td>Nagasaki</td>
</tr>
<tr>
<td>Country</td>
<td>Off</td>
<td>N/A</td>
</tr>
</tbody>
</table>

3. Click Search.
4. When the search results appear, select the Nagasaki entry.
5. Click Insert
6. When you finish, close the City Database Search tool.

MODEL A REGION-OF-INTEREST

Now, you need to model the location of your ship’s first stop as well as the location where your friend lives--the Big Island of Hawaii. Assume that if you leave your satellite radio with your friend in Hawaii, they’ll want to use it all over the island (e.g., at the beach, in the car, etc.) and not just in one city. That being the case, you’ll want to model the entire Big Island of Hawaii.

Just as STK provides objects that can be used to represent a specific point-of-interest on the surface of the central body, it also provides an object that can be used to model a region-of-interest on the surface of the central body-- an area target ( ).

1. Return to the Insert STK Objects tool ( ).
2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Area Target</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Select Countries And US States</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.
STK comes with predefined area target objects representing all countries and each of the U.S. states. These predefined objects can be imported into an STK scenario and used to represent various regions-of-interest on the surface of the central body. You’ll use one of the predefined area targets to model the Big Island of Hawaii.

4. When the selection dialog appears, select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries</td>
<td>Off</td>
</tr>
<tr>
<td>US States</td>
<td>On</td>
</tr>
<tr>
<td>Other Features</td>
<td>Off</td>
</tr>
</tbody>
</table>

5. Locate and select Hawaii, United States in the list.
6. Enable the Primary Area Only option in the Insert area.

Hawaii is a collection of islands represented by several different area targets in STK--each island, including the Big Island, is a separate polygon. Selecting Primary Areas Only during the creation process, will insert only one area target representing the Big Island of Hawaii when you click the Insert button. If you had selected All Areas, an area target representing each one of the Hawaiian islands would be imported when you click Insert.

7. Click the Insert button.
8. Close the area target selection dialog.

Get a Better Look!

Sometimes it is helpful, or even necessary, to remove background distractions from the visualization window when using them to define objects. Up until now, you’ve used 2D Graphics properties to define the display of objects in the 2D Graphics window.

Zoom To It!

1. Bring the 3D Graphics window to the front.
2. Zoom To the Hawaii ( ) area target in the 3D Graphics window.
3. Mouse around until you get a clear view of the Big Island.
4. Look at the outline of the Hawaii area target against the globe in the 3D Graphics window.

• Why doesn’t the outline of the Hawaii area target match the imagery on the globe?

The predefined area targets that are shipped with STK are now based on GIS data making them incredibly accurate. The background image laid on the globe in the 3D Graphics window, although very accurate, is simply an image overlay and not as accurate as the GIS shapefile.

2D GRAPHICS WINDOW DETAILS

Details control the appearance of the map in the 2D Graphics window. Change the map background and turn on some borders so that you can focus on the locations of interest more clearly.

1. Open the 2D Graphics window properties button ( ).
2. Select the Details page.
3. Select RWDB2_Provincial_Borders (state boundaries) in the Items list.
4. Select a new map background using the Image option in the Backgrounds area.
5. Click Apply each time you select a new map background to see it in the 2D Graphics window.
6. After exploring some of the available map backgrounds, disable the Image option.
7. Click OK.

The map image will be removed from the map, and the 2D Graphics window will have a solid background. Only objects and outlines will be visible.

2D ZOOM

The first portion of your journey has you driving from Monterey to San Diego. Before you define the route from Monterey to San Diego, get a better look at those two locations. Looking at this from a “world view” it’s really difficult to separate the two California locations. They look like they’re all bunched up on top of each other.

Zoom In on the map in the 2D Graphics window so that Monterey and San Diego are clearly visible but distinctly separate. This will help you pinpoint the beginning and end of your route more accurately.

1. Select the 2D Graphics window.
2. Click the Zoom In button ( ) on the Default toolbar.
3. Click and hold the left mouse button and drag it over the area of the map around Monterey ( ) and San Diego ( ) in the 2D Graphics window.

CHANGE THE FACILITY MARKER STYLE

Now, your objects stand out on the map more, but it’s still hard to pinpoint the exact locations of Monterey, San_Diego, and Nagasaki. Change the
appearance of the facility markers in the 2D Graphics window so that the facility model isn’t covering the location marker.

1. Hold down the Ctrl key on your keyboard.
2. While holding the Ctrl key down, select all three facilities ( ) in the Object Browser.
3. Click the Properties button ( ) on the Default toolbar to open the properties for all three objects.
4. Select the 2D Graphics - Attributes page.
5. Change the Marker Style option to * (asterisk).
6. Click OK.

Much better. Now, you can really pinpoint the location of your first two points-of-interest. It should look something like this:

**FIGURE 3-3. 2D View: Zoom to California**

---

**Ground Vehicles In STK**

It looks like you’ve defined all relevant points-of-interest on the ground, but now you need a way to get from point to point. You need to model the various vehicles that will take you from Monterey to Nagasaki.

You’ll use ground vehicles to move around on the ground in STK. Great Arc vehicles travel along the surface of the central body. The route of a Great Arc vehicle is defined with respect to the central body at a specified altitude. Three types of Great Arc vehicles—aircraft, ships, and ground vehicles—are available in STK.
When you insert an undefined vehicle object, essentially you insert an empty shell. Although all STK objects are inserted with default properties defined, vehicles must be “propagated” before they become active because they are moving objects. To propagate means to cause to move in some direction, so when you propagate a Great Arc vehicle it has a defined route.

Three types of propagators are available for Great Arc vehicles:

<table>
<thead>
<tr>
<th>PROPAGATOR</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GreatArc</td>
<td>The Great Arc propagator is used exclusively for Great Arc vehicles in STK. It defines a point-by-point path over the surface of the central body with position and altitude defined at each point.</td>
</tr>
<tr>
<td>STKExternal</td>
<td>The STKExternal propagator is available for all vehicles in STK. It allows you to read the ephemeris for a vehicle from a file. The file must be in ephemeris file format (*.e). A detailed description of the ephemeris file format can be found in STK Help.</td>
</tr>
<tr>
<td>RealTime</td>
<td>The Real Time propagator is available for all vehicles in STK. It allows you to propagate vehicle ephemeris using near-real-time data received over a Connect socket.</td>
</tr>
</tbody>
</table>

Model Ground Transportation

Your first vehicle will take you from Monterey to San Diego. Here’s what you know:

- You will leave Monterey today at noon local time (displayed in UTCG) on graduation day.
- To get to San Diego, you will drive down the Pacific Coast Highway traveling at about 50 m.p.h.

You’ll travel the first leg of your journey in some sort of car or truck. In STK, ground vehicles can be used to model vehicles, such as automobiles, trucks, and trains. You’ll insert an STK Ground Vehicle to model the truck in which you will be cruising down the Pacific Coast Highway to San Diego.

1. Return to the Insert STK Objects tool ( ].
2. Select the following:
3. Click the Insert... button.
4. Rename the new ground vehicle object Hot_Rod.

When STK creates an object using the Define Properties method, it will automatically open its properties for you.

**DEFINE A ROUTE**

Route properties for Great Arc vehicles allow you to define the path that the vehicle will follow.

1. Bring the new vehicle’s properties to the front.
2. Ensure that the Basic - Route page is selected.
3. Ensure that the Propagator option is set to GreatArc.
4. With the Route page open, click the Monterey marker on the map in the 2D Graphics window to begin Hot_Rod’s route.

When the Route page is open, every time you click on the map in the 2D Graphics window, STK will define a waypoint along the vehicle’s route that corresponds to the coordinates on the map. The waypoint will be recorded in the table at the bottom of the Route page. Each row of values in the table describes a single waypoint in the vehicle’s route.

5. Return to the Route page.
6. Double-click the Speed entry for the first waypoint to make it editable.
7. Change the Speed value to 50 mi/hr. Don’t forget to include the mi/hr unit abbreviation.

*Mph is not an acceptable abbreviation. STK will not accept values followed by mph. Enter values in miles per hour using the mi/hr unit abbreviation.*

8. Press the Enter key on your keyboard.
The speed value will automatically be converted to kilometers per second (the default Distance and Time Units set at the scenario level). All subsequent points will use the new speed.

9. Click the * San_Diego marker to end Hot_Rod's ( ) route.

**REFINE YOUR ROUTE**

Take a look at Hot_Rod's route in the 2D Graphics window. It appears that, to get from * Monterey to * San_Diego you will have to drive through the ocean for a bit. How about you fix that.

**FIGURE 3-4. 2D view: Hot_Rod's route**

1. Return to the Route page.
2. Select the first waypoint in the table.
3. Click the Insert Point button to the right of the table. A new waypoint will be added below the first point.
4. Select the new point in the table.
5. Enable the Clicking on map changes current point option below the table.
6. Click somewhere on that map along the vehicle's ( ) route to add a point that brings the vehicle out of the ocean.
7. Click OK.
FIGURE 3-5. 2D view: Hot_Rod’s adjusted route

8. Play (▶) the animation, and watch as Hot_Rod (₿) moves along its route.

Where Am I?

While zoomed in on an area in the 2D Graphics window it’s easier to distinguish your California locations but your other points-of-interest are out of your view.

1. Reset (▶) the animation.
2. Restore the view (🔍) in the 2D Graphics window.

The Center Of The Universe

Earlier, you removed distractions from the map background and locations that you’ll need to pinpoint on the map, but some of your points-of-interest are on opposite sides of the world. Projection properties control the display of the central body in the 2D Graphics window. Changing the map center can give you a better perspective of where your points-of-interest are relative to each other. Recenter the map in the 2D Graphics window.

1. Select the 2D Graphics window.
2. Click the Properties button (⚙️) on the 2D Window Defaults toolbar.
3. Select the Projection page.
4. Ensure that Click on New Center Point option is selected in the Select Map Center area.
5. Bring the 2D Graphics window to the front being careful not to click on the map.

When the Projection page is open, every time you click on the map in the 2D Graphics window, STK will center the view on the location that you select.

6. Click somewhere west of California in the Pacific Ocean on the map in the 2D Graphics window to recenter the view.

7. Click OK.

8. Zoom In ( ) on the map in the 2D Graphics window so that you can see all of your locations.

**FIGURE 3-6. 2D View: Recentered zoom of Pacific Ocean**

Ship Out

You still need a way to get from San Diego to Nagasaki. Model the USS Iwo Jima using an STK ship object.

Here’s what you know:

- You ship out of San Diego for Nagasaki tomorrow morning at 8 a.m. local time (displayed in UTCG).
- The USS Iwo Jima will dock on the Big Island of Hawaii briefly.

1. Return to the Insert STK Objects tool ( ).
2. Select the following:

<table>
<thead>
<tr>
<th>TABLE 3-9. Create a ship</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option</strong></td>
</tr>
<tr>
<td>Select an Object To Be Inserted:</td>
</tr>
<tr>
<td>Select a Method:</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.

**VEHICLE TIME PERIODS**

Vehicles in a scenario may have a defined period of their own, so that they are available for only a portion of the scenario, as illustrated in Figure 3-7.

![Figure 3-7. Time relationships]

You’re only interested in *Iwo Jima* from the time you board it to leave for *Nagasaki*, so you can limit its availability to that portion of the scenario.

1. Ensure that the *Basic - Route* page is selected.
2. Change the vehicle *Start Time* to tomorrow morning at 8 am (12:00 UTCG), since that is the time you ship out.
3. Click *Apply*.

**CHART A COURSE**

Use *Iwo Jima’s Basic - Route* properties to **chart a course** from *San Diego* to *Nagasaki*.

1. Ensure that the *Propagator* option is set to *GreatArc*. 
2. With the Route page open, click *San_Diego’s marker on the map in the 2D Graphics window. This is the first waypoint in Iwo_Jima’s ( ) route.
3. Now, click Hawaii ( ) on the map in the 2D Graphics window.
4. End the route by clicking *Nagasaki’s marker.
5. Note the time that you arrive in Nagasaki.
6. When you finish, click OK.
7. Rename the new ship ( ) Iwo_Jima.

Where In the World Am I?

Can you identify where you are on the globe in the 3D Graphics window? If not, you can use the Show Location of 2D Maps option to locate the zoomed area on the globe in the 3D Graphics window. If the Show Location of 2D Maps option is on, whatever area is zoomed in the 2D Graphics window will be outlined on the globe in the 3D Graphics window.

1. Select the 3D Graphics window to bring it to the front.
2. Click the Properties button ( ) on the 3D Window Default toolbar.
3. Select the Details page.
4. Enable the Show Location of 2D Maps option.
5. Click OK.
6. Click the Home View button ( ) on the 3D Graphics toolbar to restore the default Earth-centered view.
7. Mouse around until you get a good look at the outline of your 2D zoom on the globe.
Can you see the outline marked on the globe in the 3D Graphics window? If you can’t see the outline use the mouse to rotate the globe in the 3D Graphics window until you can.

**You Are Here!**

If you click anywhere along any *Great Arc* vehicle’s route, in the 2D Graphics window, you can return information about that point using one of the following methods:

- Click a point and check the *Status Bar* along the bottom of the *STK Workspace*.
- Click a point, and then double-click the last row in the *Message Viewer*. A message window will pop up displaying information about that point. Each time you click on a point, a new entry will be added to the *Message Viewer*.

**The Message Viewer**

STK uses the *Message Viewer* to display various error and informational messages. The *Message Viewer* is not visible in the *STK Workspace* by default. You can use the *Message Viewer* to return information about any point in a vehicle’s route.

1. Click any point along the route of either *Great Arc* vehicle in the 2D Graphics window.
2. Check the *Status Bar* along the bottom of the *STK Workspace*. 
3. Click the information bubble (1) beside the waypoint information.

OR
1. Extend the View menu on the Menu bar.
2. Select Message Viewer ( ) from the View menu.

You will see a series of informational messages organized in a grid along the bottom of the STK Workspace. You can extend the limits of individual cells in the grid to make all of the information clearly visible if you like. To change the width of a column:

1. Move the mouse to its right-hand border of the column that you wish to resize. The mouse pointer will turn into a vertical sizing bar with arrows ( ).
2. When the sizing bar appears, hold the left mouse button and drag the border to the right to increase the width of the column or to the left to decrease it.

Columns to the right of the selected border will move as the border moves, without themselves being resized.

3. Try using the Status Bar and the map to return information about individual waypoints, and answer the following questions:

• What time will you arrive in Hawaii?
• in Nagasaki?
• When do you cross the international date line?
• Approximately how long did each leg of your journey take?

**Measure Distance on the Map**
The 2D Graphics window also has a Measure tool with which you can measure the distance between any two points on the map. When you use the Measure tool, the shortest distance between two points will be returned via an entry in the Message Viewer.

Try using the Measure tool to get an idea of the distance between Monterey and San_Diego.

1. Make sure the Message Viewer ( ) is visible in the STK Workspace.
2. Click Measure ( ) on the 2D Graphics toolbar.
3. Hold the left-mouse button down, and drag the mouse between *Monterey* and *San_Diego*.
4. Release the mouse button.
5. Double-click on the last entry in the *Message Viewer* ( ). A message window containing the shortest distance between the two points, the central angle, and the azimuth bearing, will pop-up.
6. Use the *Measure* ( ) tool to answer the following questions:
   • Approximately how far is it from Monterey to San Diego?
     • San Diego to Hawaii?
     • Hawaii to Nagasaki?
     • San Diego to Nagasaki?
     • The east coast to the west coast of the Big Island?
7. When you finish, close the *Message Viewer* ( ).

**Get Moving!**

1. *Play* ( ) the animation.
2. *Pause* ( ) the animation when *Hot_Rod* ( ) gets to *San_Diego* ( ).
   *Hot_Rod* ( ) will stay in that position until you reset or play again. If you resume animation, *Hot_Rod* ( ) disappears because no positional data exists for it beyond its arrival time in *San Diego* ( ).
3. If you go too far, try using the *Step in Reverse* ( ) to back *Hot_Rod* ( ) up.

FIGURE 3-9. 2D View: *Hot_Rod* in San Diego
WHERE’S MY RIDE?

Where is Iwo_Jima? Look at the current animation time in the Animation toolbar. You’ve arrived in San_Diego, but it is not quite time to ship out yet. Iwo_Jima’s not here.

1. Advance to the second part of your trip by editing the time in the Animation toolbar so that it is after Iwo Jima’s expected arrival (8 a.m. local time tomorrow).
2. Press the Enter key on your keyboard.

3. Play ( ) the animation again.

4. When you finish, Reset ( ) the animation.

Where’s that Sirius Rhythm and Blues?

XM and SIRIUS were originally two different satellite service providers. The XM Satellite Radio service originally used two satellites Rock (XM-1) and Roll (XM-2). They have since launched two new satellites Rhythm (XM-3) and Blues (XM-4) and powered down the two original satellites which are now used as backups.
So, under normal circumstances, my *Sirius XM Radio* would rely on the two active *XM* satellites and the three active *SIRIUS* satellites. That means you need to include all five active satellites in our analysis. Let’s add those now.

**Rhythm & Blues**

First, add the XM radio satellites.

1. Return to the *Insert STK Objects tool*.
2. Select the following:

   **TABLE 3-10. Insert satellite**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Satellite</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Select From Satellite Database</td>
</tr>
</tbody>
</table>

3. Click the *Insert...* button.
4. When the *Satellite Database Search* tool appears, set the following:

   **TABLE 3-11. Satellite search criteria**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name</td>
<td>On</td>
<td>Rhythm</td>
</tr>
<tr>
<td>SSC Number</td>
<td>Off</td>
<td>N/A</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

5. Click *Search*.
6. When the search results appear, select *Rhythm* (official name *XM-3*).
7. Click *Insert*.
8. Now, change the search criteria as follows:

   **TABLE 3-12. Satellite search criteria**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name</td>
<td>On</td>
<td>Blues</td>
</tr>
<tr>
<td>SSC Number</td>
<td>Off</td>
<td>N/A</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

9. When the search results appear, select *Blues* (official name *XM-4*).
10. Click *Insert*. 
SIRIUS SATELLITES

Now, add the SIRIUS radio satellites.

1. Change the search criteria as follows:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name</td>
<td>On</td>
<td>Sirius</td>
</tr>
<tr>
<td>SSC Number</td>
<td>Off</td>
<td>N/A</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

2. Click Search.

When the search results appear, you’ll see several satellites that have SIRIUS in their name listed. Some of those satellites are owned by the U.S. based SIRIUS satellite radio company. The others are owned by a Swedish company which provide the Nordic countries and the Baltic states, with TV, radio, data and communications. Since, you only want the U.S. satellites, you’ll need to determine which is which.

• How can you see more information about each of the search results?

By default, the search results provide each satellites common name, SSC number, and official name.
You can edit the display of your search results by adding or removing columns from the results table. Let’s add another column of data that will help us sort the results.

1. Right-click in the headings area for the search results.
2. Select Owner from the menu that appears.
3. Select the three satellites whose owner is US (SIRIUS-1, SIRIUS-2, and SIRIUS-3).
4. Click Insert.
6. You don’t need to create any more objects, so you can close the Insert STK Objects tool now if you like.
Get a Better Look!

When XM and SIRIUS were different companies they had very different ideas about how to provide the best coverage which is obvious when you look at the SIRIUSly different orbits of the sister satellites.

1. Position the 2D & 3D Graphics windows so that you can clearly see them both in the STK Workspace.

All of the radio satellites are positioned according to the current animation time in both windows, and its ground (2D) and orbit tracks (2D and 3D) are clearly visible.

2. First, let’s take a look at the 3D Graphics window.

XM has two high-powered satellites in geostationary orbit above the equator—Rhythm (white) and Blues (blue).

SIRIUS does not use geostationary satellites. The three SIRIUS satellites (orange and yellow) fly in highly elliptical geosynchronous orbits in a 24-hour orbital period.

The ground tracks for the SIRIUS satellites show up nicely on the map in the 2D Graphics window. Let's take a look.
The two original companies also used very different satellites, which you can see by bringing the 3D models in focus. Let’s take a look.

1. Bring the 3D Graphics window to the front.
2. Make Blues_29520 ( ) the focal point in the 3D Graphics window.
3. Now, change the view so that one of the SIRIUS satellites ( ) is the focal point.
How Is the Reception On My Satellite Radio Outside the Continental U.S.?

FIGURE 3-15. 3D View: XM satellite models

SIRIUS XM Access

In 2007, XM and Sirius merged. The merger combined the two radio services and created a single satellite radio network proving satellite radio service across North America. That being the case, you are not concerned with maintaining a signal as you drive down the coast of CA; however, you’re not sure if you will be able to maintain a signal as you traverse the ocean. If you have access to any of these five satellites during your voyage, you can maintain some radio service.

- Has the merger expanded the area from which you can receive a signal?
- If they were still two companies, which one would have been able to provide you service closest to Nagasaki?
- Do I have to calculate access to all of those different satellites separately and compare the results?

No. Fortunately, STK allows you to compute access FROM one object TO multiple objects in the same scenario. Let’s use that capability to determine when you can see how many satellites, if any, from the Iwo Jima during our voyage.

1. Open the Access tool ( ).
2. Set the following:

FIGURE 3-15. 3D View: XM satellite models
How is the reception on my satellite radio outside the continental U.S.?

3. Click the Access… button in the Graphs area.

**FIGURE 3-16. Graph: Access from Iwo Jima to SIRIUS XM Radio**

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access for</td>
<td>Iwo_Jima</td>
</tr>
<tr>
<td>Associated Objects</td>
<td>Select all of the satellites:</td>
</tr>
<tr>
<td></td>
<td>BLUES_29520</td>
</tr>
<tr>
<td></td>
<td>RHYTHM_28626</td>
</tr>
<tr>
<td></td>
<td>SIRIUS-1_26390</td>
</tr>
<tr>
<td></td>
<td>SIRIUS-2_26483</td>
</tr>
<tr>
<td></td>
<td>SIRIUS-3_26626</td>
</tr>
</tbody>
</table>

XM satellites are in orbits designed to provide gap-free coverage anywhere within the contiguous U.S., the southern tip of Alaska, and in the southern part of Canada. The three SIRIUS satellites broadcast directly to the consumer's receiver, but due to the highly elliptical orbit only two of them broadcast at any given time. The access graph makes this obvious. Accesses for the XM satellites (Rhythm and Blues) is uninterrupted but not as far reaching. Access to the SIRIUS satellites has gaps but reaches much further than the XM satellites.

The exact time that access starts and ends is not as obvious on a graph as it would be on a report, but the data for five different satellite is much easier to
How Is the Reception On My Satellite Radio Outside the Continental U.S.?

compare side by side on a graph. If you want to see the exact times for any of the access intervals in the graph, rest your cursor on that interval line.

**FIGURE 3-17.** Graph: Access times

4. Use the graph to answer the following questions:

- What time do you arrive in Nagasaki?
- Do you have access to any of the satellites at the time of your arrival in Nagasaki?
- If they were still two separate companies, which would have been the better choice for long distance voyages outside the U.S.? Inside the U.S.?

**Constrain Iwo Jima**

You have one more consideration. You can not realistically access a satellite that is right along the horizon as you sail across the ocean. Let's make our analysis a bit more realistic by restricting line of sight access to those which are at least ten degrees above the Iwo Jima.

1. Open *Iwo Jima's* properties.
2. Select the *Constraints - Basic* page.
3. Enable the *Min* option in the *Elevation Angle* area.
4. Enter *10 deg* in the adjacent textbox.
5. Click OK to accept the changes, and dismiss *Iwo Jima's* properties.
REFRESH

1. Bring the Access graph to the front.
2. Refresh (or F5) the Report Data window.
3. Use the graph to answer these questions.
   - Do you have access to any of the satellites when you arrive in Nagasaki?
   - Will you leave your radio with your friend in Hawaii or take it with you to Nagasaki?
   - What time do you lose access to the satellites?
4. When you finish, close your access graph.
5. Leave the Access tool ( ) open.

Get Moving!

The graph tells you what time you lose access, but do you know exactly where you are when you lose access? Let’s see if you can get a look at where exactly Iwo Jima is when you lose access to the satellites.

1. Position the 2D and 3D Graphics windows so that you can see them both clearly.
2. Play ( ) the animation.
   - Can you visually determine when you lose all access with the SIRIUS XM Radio satellites?

You could continue to let the animation play until the first access occurs, but there is an easier way to “fast forward” the animation to an access period. Let’s try it now.

1. Bring the Access tool ( ) to the front.
2. Set the following:
How Is the Reception On My Satellite Radio Outside the Continental U.S.?

3. Click the Access… button in the Reports area.
4. Right-click the last access time from the access report.
5. Select Start Time --> Set Animation Time from the context menu.
6. Position the 2D and 3D Graphics windows so that you can see them both clearly.

3D View: Iwo Jima last access

• How far from Nagasaki are you when you lose access?

When You Finish

2. Close the Access tool ( ).
3. Save your work.
4. Close the scenario ( ).
5. Leave STK ( ) open.
How Is the Reception On My Satellite Radio Outside the Continental U.S.?
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?

In this exercise you will define and assess an unauthorized aircraft’s flight through sensitive airspace. You will then model and analyze that problem in STK. Upon completion, you will be able to:

- Model an airborne Great Arc vehicle.
- Use a sensor object to model various stationary and moving instruments.
- Use Access to detect an aircraft’s flight.
- Create a Viewer Data File (VDF) using STK’s publishing capability.
Problem Statement
You are working for the FAA and your boss is concerned about the possibility of an unauthorized aircraft flying from Havana to Cape Canaveral. Your boss wants you to examine an early warning detection system in Miami that works in concert with an existing tracking radar attached to a satellite (Icarus) traveling in a low-earth orbit (LEO). You want to send this scenario to your colleagues and supervisors at both Miami and Cape Canaveral. Keep in mind, they do not have STK.

Break it Down
You have some information that may be helpful. Here’s what you know:

• You need an early warning detection system that will “catch” the unauthorized aircraft flying to Cape Canaveral from Havana, Cuba at an altitude of 10,000 feet.
• You can use the Icarus satellite to monitor the Havana airport and any aircraft that penetrate sensitive airspace.
• You know that Icarus is equipped with both a fixed field-of-view radar and another radar that can gimbal to track objects, but you need to determine which system will track intruders more efficiently.
• You need to design a radar net over Miami.

Solution
Model a scenario that allows you to consider and compare all of your system options. Simulate an aircraft traveling from Havana to Cape Canaveral and determine which portion of the aircraft's route can be tracked by the various radars.

Create a Scenario
The first thing you need to do is create a scenario.

1. Click the Create a New Scenario button.

You need to define the times during which the conditions that you set for your world, and the objects in your world, will be relevant. You will only be sampling a small portion of the day--just enough time to fly from Havana to Cape Canaveral. Three hours should more than cover it.
Enter the following in the *New Scenario Wizard*:

**TABLE 4-1. New Scenario Wizard options**

<table>
<thead>
<tr>
<th><strong>OPTION</strong></th>
<th><strong>VALUE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Rum_Runner</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Can I detect a rum runner in route from Havana to Cape Canaveral?</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>C:\Documents and Settings\Student\My Documents\STK 9</td>
</tr>
<tr>
<td><strong>Analysis Period</strong></td>
<td>Change the default analysis period so that it spans only three hours.</td>
</tr>
</tbody>
</table>

2. When you finish, click **OK**.
3. When the scenario loads, click **Save**.

A folder with the same name as your scenario is created for you in the location specified above.

4. Verify the scenario name and location and click **Save**.

So, now you have a world. Before you can build the early warning system simulation, you'll populate the world with all the “players” - you’ll add *Cape Canaveral*, *Miami*, *Havana*, and an aircraft to fly through your tracking systems.

### Model The Plane’s Target

The *Facility Database* is yet another database available for use in STK. Let's launch a query and see if you can find a database entry for *Cape Canaveral*.

1. Return to the *Insert STK Objects tool*.
2. Select the following:

**TABLE 4-2. Create target location**

<table>
<thead>
<tr>
<th><strong>OPTION</strong></th>
<th><strong>VALUE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Select an Object To Be Inserted:</strong></td>
<td>![Target]</td>
</tr>
<tr>
<td><strong>Select a Method:</strong></td>
<td>![Select From Facility Database]</td>
</tr>
</tbody>
</table>

3. Click the *Insert...* button.
The STK Facility Database

The Facility Database catalogs known facilities which are part of ground station networks. See if you can find a database entry for the Cape_Canaveral site, and use it to model a target object representing your destination location.

QUERY THE FACILITY DATABASE

1. When the Facility Database Search tool appears, enter the following:

   **TABLE 4-3. New target search criteria**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Name</td>
<td>On</td>
<td>Cape Canaveral</td>
</tr>
<tr>
<td>Color</td>
<td>On</td>
<td>Red</td>
</tr>
</tbody>
</table>

2. Click the Search button.
3. When the search results appear, double-click the Cape_Canaveral entry to insert it into the scenario.

Model Destinations

See if you can find a database entry for Miami and Havana, and use them to model STK facility objects representing the city where your boss wants you to place the early warning system (Miami) and the aircraft’s home port (Havana).

1. Return to the Insert STK Objects tool.
2. Select the following:

   **TABLE 4-4. Insert facility from database**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Facility</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Select From City Database</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.

ADD CITIES

Query the STK City Database for Miami and Havana.
1. When the City Database Search tool appears, enter the following criteria:

   **TABLE 4-5. New city search criteria**

<table>
<thead>
<tr>
<th>Option</th>
<th>State</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Name</td>
<td>On</td>
<td>Miami</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

2. Click Search.
3. When the search results appear, double-click the Miami, Florida entry to insert it in the scenario.
4. Change the search criteria as follows:

   **TABLE 4-6. New city search criteria**

<table>
<thead>
<tr>
<th>Option</th>
<th>State</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Name</td>
<td>On</td>
<td>Havana, Cuba</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

5. Click Search.
6. When the search results appear, double-click the Havana, Cuba entry to insert it in your scenario.
7. When you finish, close the City Database Search tool.

### Model the Intruder

Your next “player” is an aircraft that you’ll use to model a possible attacker. In STK, an aircraft is an airborne Great Arc vehicle.

1. Return to the Insert STK Objects tool.
2. Select the following:

   **TABLE 4-7. Create aircraft**

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Aircraft</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Define Properties</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?

GET A BETTER LOOK

1. Bring the 2D Graphics window to the front.
2. Zoom In (Zoom In) around Havana (Havana) and Cape_Canaveral (Cape_Canaveral).

FIGURE 4-1. 2D View: Zoom to Cape Canaveral and Havana

DEFINE A ROUTE

Of course, an aircraft doesn’t travel on the central body at zero (0) altitude the way that a ship or ground vehicle would, but its route is also defined with respect to the central body at a specified altitude.

1. Ensure that the Basic - Route page for the new aircraft (New Aircraft) is selected.
2. Ensure that the Propagator option is set to GreatArc.
3. With the Route page open, click Havana (Havana) on the map in the 2D Graphics window.
4. Go back to the aircraft’s (Aircraft) properties (Aircraft Properties).
5. Double-click the altitude field for the first waypoint to make it editable.
6. Change the Altitude value to 10000 ft.
7. Press the Enter key on your keyboard. The altitude value will automatically be converted to kilometers (the default distance unit set at the scenario level).

Don’t forget to include the ft unit abbreviation.
8. Click Cape_Canaveral on the map in the 2D Graphics window. A second way point (at 3.048 km altitude) will be entered in the table on the Route page.

![FIGURE 4-2. 2D View: Rogue aircraft’s route](image)

9. Click OK.

10. Rename the new aircraft Rogue_Aircraft.

Model a LEO Satellite

There is only one more “player” to add to your scenario - the satellite that you are going to use to try to track the rouge aircraft as it runs for Cape_Canaveral.

1. Return to the Insert STK Objects tool.
2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Satellite</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Orbit Wizard</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.
4. Change the following values:
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?

5. Click OK.

**ZOOM TO ICARUS**

Use the *Zoom To* option to center the view in the 3D Graphics window on *Icarus*, so that you will have a birds eye view of our camera angles as you add them.

1. *Zoom To the Icarus* ( ) satellite in the 3D Graphics window.
2. Mouse around in the window to get a good view of *Icarus’s* ( ) perspective of the Earth.

**TABLE 4-9. Icarus’s definition properties**

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Repeating Ground Trace</td>
</tr>
<tr>
<td>Satellite Name</td>
<td>Icarus</td>
</tr>
<tr>
<td>Longitude of the First Ascending Node</td>
<td>-90 deg</td>
</tr>
</tbody>
</table>

**Model Instruments**

It looks like you have all the “players” loaded in your scenario. It’s time to design your early warning detection system. You’ll use sensors to model the various components that make up the system.
An *STK sensor* object can be used to represent the field-of-view, the overall volume of space in which radar looks, of such instruments as optical or radar sensors, receiving or transmitting antennas, and lasers. Sensor objects model generic payloads and as such must be a child, or subordinate, object of a facility, target, or vehicle object.

**Fixed Sensors On Moving Objects**

The default STK sensor model will create a nice representation of a sensor with a fixed field-of-view. Attach a sensor to *Icarus*, and see if you can detect the *rouge aircraft* as it makes its move on *Cape Canaveral*.

1. Return to the *Insert STK Objects tool*.
2. Select the following:
3. Click the *Insert* button.

When you select an *Attached Object* for insertion, STK requires that you select the parent object for the object being created. In this example, you want to attach the first sensor that you’ll create to the *Icarus* satellite.

1. Select *Icarus* in the *Select Object* dialog.
2. Click *OK*.
3. When the new sensor appears in the *Object Browser*, rename it *Fixed*.

The default sensor that STK creates when you introduce a sensor object is a simple conic sensor with a 45 degree cone angle. The default sensor view is fixed at zero (0) degrees azimuth and 90 degrees elevation which is nadir pointing. When a sensor object is attached to a moving object it points with respect to the parent object’s reference frame. A fixed sensor is always pointing in a fixed direction with respect to its parent object.

**GET A BETTER LOOK**

1. Bring the *3D Graphics* window to the front.
2. Mouse around to get a clear view of the fixed sensor’s field-of-view.

FIGURE 4-4. 3D View: Fixed sensor field-of-view

GET MOVING!

1. Compute Access (ċ) between Fixed (❑) and the Rogue_Aircraft (❖).
2. Position the 2D and 3D Graphics windows so that they are both clearly visible.
3. Reset (❑) the animation.
4. Play ( חב) the animation, and watch as Icarus (❖) travels along its path.
5. When you finish, reset (❑) the animation.
   • Were there visible accesses between the fixed sensor and the rogue aircraft?
6. Bring the Access tool (ċ) to the front.
7. Generate an Access report.

According to your data, Fixed can’t see the rogue aircraft coming at all. Well, that didn’t work so well. Try again with a targeted sensor.

8. After reviewing the data, close the report window.
Moving Sensors On Moving Objects

When you attached the first sensor, you used the default fixed pointing type. In reality, most satellites can gimbal their sensors to track other objects (stationary and moving). STK provides a variety of sensor definition and pointing types that allow you to model this type of movement.

1. Return to the Insert STK Objects tool.
2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Sensor</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Define Properties</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.
4. Select Icarus in the Select Object dialog.
5. Click OK.

**Targeted Sensor Definition**

To create a sensor that will move to target the Rogue Aircraft, you'll again, use the Simple Conic type, but this time, you'll make the cone angle much smaller. You don’t need a large field-of-view because the sensor is targeted directly at the object-of-interest.

1. When the sensor’s properties open, ensure that the Basic - Definition page is selected.
2. Set the following Definition properties:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Simple Conic</td>
</tr>
<tr>
<td>Cone Angle</td>
<td>5 deg</td>
</tr>
</tbody>
</table>

3. Click Apply.
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?

SENSOR POINTING

Targeted sensors track other objects. A targeted sensor is positioned with respect to the parent object, but instead of pointing in a fixed direction, it will move about so that its boresight is always pointing in the direction of the object that it targets. Let’s use a targeted sensor so it can monitor the rogue aircraft at all times.

1. Select the Basic - Pointing page.
2. Set the following Pointing properties:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Type</td>
<td>Targeted</td>
</tr>
<tr>
<td>Boresight Type</td>
<td>Tracking</td>
</tr>
</tbody>
</table>

3. Select the Rogue_Aircraft ( ) in the Available Targets list.
4. Click the button to move Rogue_Aircraft ( ) to the Assigned Targets list.
5. Click on the Target Times... button.

This is an easy way to see if access exists between the targeted sensor and its targeted object/objects without actually computing access.

• When does access to the rouge aircraft begin?

6. Click OK to close the Target Times window.

   If you want to change the color of the Targeted sensor, you can do so by going to the 2D Graphics Attributes page.

7. Click OK.
8. Rename the new sensor ( ) Targeted.

GET A BETTER LOOK

1. Position the 2D and 3D Graphics windows so that you can see them both clearly.
2. Play ( ) the animation.
CAN I DETECT A ROGUE AIRCRAFT IN ROUTE FROM HAVANA TO CAPE CANAVERAL?

FIGURE 4-5. 3D View: Targeted sensor field-of-view

- Can you see the targeted sensor’s field-of-view?
- Why does the targeted sensor’s field-of-view disappears from time to time?
- Were there visible accesses between the targeted sensor and the rogue aircraft at the time the aircraft is taking off?

WHAT CAN TARGETED SEE?

1. Compute $Access(\text{Tg})$ FROM $Targeted(\text{Tg})$ TO the $Rogue_{Aircraft}(\text{RA})$.
2. Generate an $Access\ Graph(\text{AG})$.

FIGURE 4-6. Graph: Access from Targeted to the Rogue_Aircraft

3. Use access data to answer the following questions:
• Can Havana “see” the potential intruder?
  • Is the Rogue_Aircraft’s entire flight detectable?
• If not, during what portion of the Rogue_Aircraft’s flight is it detectable?
  • For how long?

4. Close the Access Graph ( ).
5. Close the Access tool ( ).

Change Your Perspective

1. Zoom to Miami ( ) in the 3D Graphics window.
2. Mouse around until you get a clear view of Miami ( ).

Fixed Sensors On Stationary Objects

Now that you know Icarus can monitor the rogue aircraft shortly after takeoff, and can then pass this information back down to the ground. To complete your early warning detection system, you need to model the radar “net” in Miami. First, you’ll simulate a stationary radar dome attached to Miami.

In the previous examples, you attached sensors to moving objects to model a tracking system. Sensors can also be used to model instruments attached to stationary objects, such as facilities and targets. Fixed sensors attached to stationary objects also point with respect to the parent object’s reference frame. Since stationary objects never change position or direction, a fixed sensor will always point in a fixed direction with respect to the parent object.

1. Return to the Insert STK Objects tool ( ).
2. Use the Define Properties method to attach a sensor ( ) to Miami ( ).
3. Rename the new sensor ( ) Radar_Dome.

RADAR DOME DEFINITION

1. When the sensor’s ( ) properties ( ) open, ensure that the Basic - Definition page is selected.
2. Set the following Definition properties:
CAN I DETECT A ROGUE AIRCRAFT IN ROUTE FROM HAVANA TO CAPE CANAVERAL?

3. Click Apply.

**CONSTRAIN RADAR DOME**

The sensor created here is similar to the fixed sensor attached to *Icarus*, but it has a larger field-of-view, and instead of pointing straight down this one points straight up from the *Miami* facility. It has an up looking field-of-view that covers everything above *Miami*. That’s not very realistic. Let’s limit its range so that the field-of-view spans a constrained area around Miami.

1. Select the *Constraints - Basic* page.
2. In the *Range* area, enable the *Max.* option.
3. Enter 200 km in the adjacent textbox.
4. Click *Apply*.

**PROJECTION DISPLAY**

*2D Graphics Projection* properties for sensors control the display of sensor projection graphics in the *2D Graphics* window. Sensors attached to facilities and targets differ in their display behavior from those attached to vehicles. The intersections of vehicle-based sensors with the Earth are displayed during animation.

The *Extension Distances* option indicates whether the sensor’s field-of-view crossings at specified distances are computed and displayed in the *2D Graphics* window. When the sensor display is set to project to the range constraint, STK projects the sensor field-of-view to the maximum range specified on the *Basic Constraints* properties page for the facility or target.

1. Select the *2D Graphics - Projection* page.
2. Set the following *Extension Distances* options:

---

### TABLE 4-14. Radar Dome definition properties

<table>
<thead>
<tr>
<th><strong>OPTION</strong></th>
<th><strong>VALUE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Simple Conic</td>
</tr>
<tr>
<td>Cone Angle</td>
<td>90 deg</td>
</tr>
</tbody>
</table>

3. Click *Apply*. 

---
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?

TABLE 4-15. Radar Dome extension distances

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>On</td>
</tr>
<tr>
<td>Project To</td>
<td>Use Range Constraint</td>
</tr>
</tbody>
</table>

3. Click OK.

GET A BETTER LOOK

1. Ensure that the view is set on Miami ( everywhere).
2. Mouse around to get a better look at the radar dome.

FIGURE 4-7. 3D View: Radar Dome sensor attached to Miami

WHAT CAN RADAR DOME SEE?

Can you see the radar dome that you modeled?

1. Play ( ) the animation.
2. Watch as the Rogue_Aircraft travels from Havana to Cape_Canaveral.
   • Did you see the Rogue_Aircraft enter and then exit the radar dome?
3. When you finish, Reset ( ) the animation.
**WHEN CAN RADAR DOME SEE IT?**

You know that the *Rogue_Aircraft* travels through the radar dome, which constitutes an access, but when do accesses occur? For how long? Check to see.

1. Compute *Access* (\( \text{Access} \)) \text{ FROM } \text{Radar_Dome} \text{ TO the Rogue_Aircraft}.  
2. Position the windows such that the *2D* and *3D Graphics* windows are clearly visible.
3. Position the *2D* and *3D Graphics* windows so that you can see them both clearly.
4. *Play* (\( \text{Play} \)) the animation.

---

*Are there visible accesses between Radar_Dome and the Rogue_Aircraft?*
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?

1. When you finish, Reset the animation.

ACCESS DATA
Generate some hard data to help you determine when and for how long the rogue aircraft is in the dome.

1. Generate an Access graph.

2. Use access data to answer the following questions:
   - Can Radar_Dome detect the Rogue_Aircraft?
   - Is the Rogue_Aircraft’s entire flight detectable?
CAN I DETECT A ROGUE AIRCRAFT IN ROUTE FROM HAVANA TO CAPE CANAVERAL?

- If not, during what portion of the Rogue_Aircraft’s flight is it detectable?
  • For how long?

3. When you finish, close the Access graph.

Moving Sensors On Stationary Objects

Often, the dome created by a sensor is used to model a field-of-view - the overall volume of space in which radar looks. The radar itself often sweeps or scans through that field-of-view in a repeating cycle. The area of space represented by such a scanning or spinning radar at any given instant is its field-of-view. Add another level of fidelity to your scenario and build a sweeping radar beam using a moving sensor.

Just as you were able to track the Rogue_Aircraft using a sensor that moved independent of its parent object, you can also model instruments attached to stationary objects that move independent of the object to which they are attached. Spinning sensors are often used to model radars, push broom sensors, and other instruments that spin, scan, or sweep over time.

1. Use the Define Properties method to attach a second sensor ( ) to Miami ( ).
2. Rename the new sensor ( ) Radar_Sweep.
3. When the Radar_Sweep’s ( ) properties ( ) open, ensure that the Basic - Definition page is selected.
4. Set the following Definition properties:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Complex Conic</td>
</tr>
<tr>
<td>Inner Cone Angle</td>
<td>0 deg</td>
</tr>
<tr>
<td>Outer Cone Angle</td>
<td>90 deg</td>
</tr>
<tr>
<td>Minimum Clock Angle</td>
<td>0 deg</td>
</tr>
<tr>
<td>Maximum Clock Angle</td>
<td>30 deg</td>
</tr>
</tbody>
</table>

5. Click Apply.
**SENSOR POINTING**

The above configuration should create a wedge type field-of-view. Right now, that “wedge” is just pointing straight ahead. You want the wedge to spin and scan the radar dome continuously. Spinning sensor model radars, push broom sensors and other instruments that spin, scan or sweep over time. Let’s take a look.

1. Select the *Basic - Pointing* page.
2. Set the following *Pointing* properties:

<table>
<thead>
<tr>
<th><strong>OPTION</strong></th>
<th><strong>VALUE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pointing Type</strong></td>
<td>Spinning</td>
</tr>
<tr>
<td><strong>Spin Rate (Revs/Min)</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Spin Axis Cone Angle</strong></td>
<td>0</td>
</tr>
</tbody>
</table>

3. Click *Apply*.

*If you want to change the color of the Radar Sweep, you can do so by going to the 2D Graphics Attributes page.*

**CONSTRAIN RADAR SWEEP**

Right now the sweeping radar extends beyond the limits of the radar dome because you haven’t constrained it. Let’s limit the range of the radar so that it scans only the inside of the dome.

1. Select the *Constraints - Basic* page.
2. Enable the *Max.* option in the *Range* area.
3. Enter *200 km* in the adjacent textbox.
4. Click Apply.

**PROJECTION DISPLAY**

1. Select the *2D Graphics - Projection* page.
2. Set the following *Extension Distances* options:
3. Click **OK**.
4. You don’t need to create any more objects, so you can close the Insert STK Objects tool now if you like.

**GET A BETTER LOOK**

1. Use the **Decrease Time Step** button to decrease the time step to one second.
2. **Play** the animation. Notice how Radar_Sweep continuously scans around Miami.

   If your animation time step is an even multiple of your spin rate, you will not see motion of the sensor when you animate.

3. **Reset** the animation.

**FIGURE 4-11.** 3D view: Radar Sweep sensor attached to Miami
WHAT CAN RADAR SWEEP SEE?

1. Compute Access (.) FROM Radar_Sweep (○) TO the Rogue_Aircraft (●).
2. Position the 2D and windows so that they are both clearly visible.

FIGURE 4-12. 2D View: Access from Radar Sweep to Rogue Aircraft

- Are there visible accesses between Radar_Sweep and the Rogue_Aircraft?

WHEN CAN RADAR SWEEP SEE IT?

You know that Radar_Sweep brushes over the Rogue_Aircraft repeatedly as the intruder travels from Havana to Cape_Canaveral, which constitutes access, but when do accesses occur? How many? For how long? Check and see.

1. Return to the Access (.) tool.
2. Generate an Access graph.
Can I Detect a Rogue Aircraft in Route from Havana to Cape Canaveral?

FIGURE 4-13. Graph: Access from Radar Dome to Rogue Aircraft

At first glance, it appears that you have one continuous access, but this is not the case. Because the accesses are so short and close together, you can’t identify the individual accesses from this graph. The Zoom In tool can be used on a graph much like it can be on the 2D Graphics window.

3. Use the Zoom In tool to zoom in on a section of the graph.

FIGURE 4-14. Graph: Zoom In section of the graph

Due to the number of accesses, an access report might be more helpful in providing statistical data on these accesses.

5. Return to the Access tool.
7. Using access data, answer the following questions:
   - Is the Rogue_Aircraft’s entire flight detectable?
   - If not, during what portion of the Rogue_Aircraft’s flight is it detectable?

8. Leave the Access report open. You will need it in a minute.

**LOG YOUR FIRST ALERT**

You want your colleagues to know the instant that the Rogue_Aircraft is caught by Radar_Sweep inside the dome. Let’s store a view that depicts just that.

1. Reposition your view so that Miami is the focal point in the 3D Graphics window, if it is not already.
2. Right-click the first access time from the Access report.
3. Select Start Time --> Set Animation Time from the context menu.
4. Mouse around until you are happy with the view.

The view should show the rouge aircraft breaching the perimeter of the radar dome.

**FIGURE 4-15. 3D View: First access**

5. Click Stored Views on the 3D Graphics toolbar.
6. Click New.
7. Rename View0 FirstAccess.
8. Click OK.
The view of Miami and the associated time are now saved for immediate recall. To recall a view at any time, select it from the drop down menu beside the Stored Views button ( ) on the 3D Graphics toolbar.

Which Radar Sees the Aircraft When?

Return to STK and compare the sensors that had access to the rogue aircraft.

1. Compute access ( ) FROM the Rogue_Aircraft ( ) TO all four sensors ( ).
2. Click the Access button in the Graph area.

3. Use the Access Graph ( ) to answer the following questions:
   - Why doesn’t data for the fixed sensor display on the graph?
   - Can you see the difference between the access times for the various sensors?

5. Close the Access graph.

Share a VDF

Now you want to send this scenario to your colleagues and supervisors at both Miami and Cape Canaveral; however, they do not have STK. You could send them the raw text data, but you would really like for them to be able to
“see” how the different tracking instruments perform. How can they interact with your STK scenario without installing STK?

Simple--your colleagues can download a free copy of AGI Viewer! AGI Viewer enables users of any technical level to view and interact with STK analyses via a VDF files--4D scenes of time-varying STK analyses. These files are created with STK. STK’s publishing capability allows users to save scenarios as VDF files, and share them with anyone, regardless if they have STK or not.

**PACK IT UP**

You’ve stored the view that you want them to see. Now you need to create a VDF file that can be opened using the free AGI Viewer tool.

1. Save the scenario.
2. Select Rum_Runner in the Object Browser.
3. Extend the File menu.
4. Select VDF Setup...
5. Enable the Minimal VDF option.

When the dialog comes up, the Minimal VDF option is off by default. If Minimal VDF is on, STK creates the smallest possible VDF file that can be opened in STK and AGI Viewer. The Minimal VDF option will include only the default data sets in your VDF file. (The default data sets are selected when the Minimal VDF option is enabled.). Clear the Minimal VDF option to include analysis files, globe data files, graphics files, and/or scenario files with the VDF file.

6. Click the Create VDF... button.

STK should default to the same directory where the Rum_Runner scenario is stored. If it does not, locate the Rum_Runner directory that you created earlier.

7. Click Save.

*If you selected the Minimal VDF option, you should open and view the VDF you created to ensure all critical information is included in the file.*

8. Minimize the STK application.
**VIEW ROGUE AIRCRAFT**

It’s always a good idea to review the VDF before you send it.

1. Locate the default user directory where your scenario is saved (C:\My Documents\STK 9).
2. Double-click the Rum_Runner.vdf file. The AGI Viewer application will launch automatically.

The controls at the top of the window work exactly the same as they did in STK.

3. Experiment with playing ( ) and pausing ( ) the animation, zooming, mousing around in the 3D Graphics window, and switching to a Stored Views ( ).

*While there is no View To/From button, you can still focus the 3D window on a particular object by right-clicking and selecting View Object.*

**When You Finish**

1. Close AGI Viewer ( ).
2. Return to STK ( ).
3. Reset ( ) the animation.
4. Restore the view in the 3D Graphics window ( ).
5. Save ( ) your work.
6. Close the scenario ( ).
7. Leave STK ( ) open.
Can I Detect a Rogue Aircraft In Route From Havana to Cape Canaveral?
How Many Satellites Must I Access To Communicate With the GPS Network?

In this exercise you will acquire some new skills that will help you define and assess a real-world problem, and then model and analyze that problem in STK. Upon completion, you will be able to:

- Understand the definition and application of the constellation object in STK.
- Understand the definition and application of the chain object in STK.
- Change a 3D object model file (*.mdl).
- Understand the various types of access data.
- Calculate complex accesses.
Problem Statement

You are going to be involved in an in-flight test utilizing STK. In this experiment, you will be flying in an aircraft and modeling that aircraft's route in STK on a laptop you have brought onboard with you. The analysis you are doing will include feeding real-time GPS positional data on the aircraft into the STK scenario. You have a handheld GPS receiver that you will be using to generate the positional data, as you cannot tap into the aircraft’s main navigational system.

Under normal conditions you know you would have no problem obtaining a GPS positional fix on the aircraft for the duration of its mission. However, the area of the aircraft in which you will be working offers only a small navigation window in the roof for you to mount your handheld GPS receiver. This limits your visibility to the GPS constellation considerably. You can only access those satellites which have at least a 45 degree elevation relative to the aircraft. To obtain a GPS positional fix, you must have access to at least 4 GPS satellites simultaneously.

Also, as you are flying this mission, you will be receiving communications from your experiment support team who are in Omaha, Nebraska. This communication will be sent to the aircraft from Omaha via a low earth orbiting (LEO) satellite.

Break it Down

You have some information that may be helpful. Here’s what you know:

- The aircraft will be receiving instructions from Omaha during the mission.
- You will use a satellite traveling in a circular orbit to communicate instructions from Omaha to the aircraft.
- You will use a handheld GPS receiver.
- You will feed the position data into a laptop running STK.
- You can accurately model the GPS network using the GPS almanac.
- When you attach the GPS receiver to the inside of the window, you can't get a complete horizon to horizon visibility. The field-of-view is restricted to 45 degrees or more above the local horizon of the aircraft.
- You must have simultaneous access with at least four (4) or more satellites in the GPS network at any given time to obtain a positional fix.
- You need to test the efficacy of your system over a 24 hour portion of your aircraft’s route.
SOLUTION

Build a scenario that can be used to determine if and when you have access to at least four (4) members of the GPS network from your aircraft. Your scenario must consider the signal receiving and minimum coverage limitations outlined above.

Create a Scenario

The first thing you need to do is create a scenario. You are modeling a twenty-four (24) hour (STK default) surveillance mission, so you don’t need to change the analysis period.

1. Click the Create a Scenario button.
2. Enter the following in the New Scenario Wizard:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>How_Many_Sats</td>
</tr>
<tr>
<td>Description</td>
<td>How many satellites can I communicate with in the GPS network?</td>
</tr>
<tr>
<td>Location</td>
<td>C:\Documents and Settings\Student\My Documents\STK 9</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>Leave the default analysis period.</td>
</tr>
</tbody>
</table>

3. When you finish, click OK.
4. When the scenario loads, click Save.

A folder with the same name as your scenario is created for you in the location specified above.

5. Verify the scenario name and location and click Save.

Model Omaha

Start building your scenario from the ground up by modeling the city from which your aircraft will be receiving instructions (Omaha).

1. Select the Insert STK Objects tool.
2. Select the following:
How Many Satellites Must I Access To Communicate With the GPS Network?

3. Click the **Insert**... button.

4. When the *City Database Search* tool appears, enter the following criteria:

   **TABLE 5-3. New city search criteria**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Name</td>
<td>On</td>
<td>Omaha, Nebraska</td>
</tr>
<tr>
<td>Auto Select Color</td>
<td>On</td>
<td>N/A</td>
</tr>
</tbody>
</table>

   5. Click the **Search** button.

6. When the search results appear, double-click the *Omaha, Nebraska* entry to insert it in the scenario.

7. Close the *City Database Search* tool.

### Model an Aircraft

Now, go ahead and add the surveillance aircraft from which you want to access the GPS network.

1. Return to the *Insert STK Objects tool*.

2. Select the following:

   **TABLE 5-4. Create target location**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Aircraft</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Define Properties</td>
</tr>
</tbody>
</table>

   3. Click the **Insert**... button.

   4. Rename the new aircraft *Eagle_Eye*.

### Get A Better Look

You will be clicking on the map in the 2D Graphics window to create the aircraft route. Before you begin, let’s zoom in a bit.
HOW MANY SATELLITES MUST I ACCESS TO COMMUNICATE WITH THE GPS NETWORK?

1. Bring the 2D Graphics window to the front.
2. Zoom In (🔍) around North America.
3. With the aircraft properties open, click the mouse anywhere over North America in the 2D Graphics window to mark the starting point of the aircraft’s (✈️) route.
4. Click two more points anywhere over North America.
5. Return to the Basic - Route page and check the time of the last waypoint in the waypoints table. Make sure that it is at least twenty-four (24) hours after the first waypoint. If not, continue inserting waypoints over North America until the route does span twenty-four (24) hours.
6. When you finish, click Apply to save the new route.

**FIGURE 5-1. 3D View: Eagle Eye route**

---

**OBJECT MODELS**

You can use 3D models to represent scenario objects and aid in analyzing and visualizing the relationships among the objects. STK contains detailed 3D models representing objects such as ground stations, aircraft, air strips, satellites, aircraft carriers, and helicopters. Once you specify a model to represent an object, it is graphically displayed in its correct position and orientation, as defined in the object’s Basic properties. Position and orientation can vary over time and can be manually adjusted within the object’s 3D Graphics properties.

Let’s use a model to represent the aircraft in this scenario.
1. Reposition your view so that the aircraft is the focal point in the 3D Graphics window, and zoom in until it is clearly visible.

2. Select the 3D Graphics - Model page. The model file should show aircraft.mdl.

3. Click the ellipsis button beside the Model File option to locate available model files (*.mdl).

4. Select a new model.

5. When you return to the Model page, click Apply.

6. Select the 3D Graphics window to bring it to the front, so that you can see the new model.

7. Experiment with the different models available until you find one that you like.

8. When you finish, click OK to accept the changes.

9. Rename the surveillance aircraft Eagle_Eye.

Model a Circular Orbit

You have a world, the city of Omaha, and a surveillance aircraft with a twenty-four (24) hour route--Eagle_Eye. Let's model the satellite that will be used to communicate instructions from Omaha to Eagle_Eye.

1. Return to the Insert STK Objects tool.

2. Select the following:

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Satellite</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Orbit Wizard</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.

4. When the Orbit Wizard appears, select the following:

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Circular</td>
</tr>
<tr>
<td>Satellite Name</td>
<td>Comm_Sat</td>
</tr>
</tbody>
</table>

5. Accept all other default values.
6. Click OK.

**Complex Accesses**

Let’s change gears for a minute and talk some more about object availability and visibility. The *Access* tool allows you to calculate line-of-sight visibility between two objects of interest in a scenario. More complex scenarios may, however, require more extensive analysis than simple point-to-point access can provide. STK provides additional functionality which contain tools and objects that can be used to calculate more advanced analysis.

- **Access** - Calculates line-of-sight visibility between two objects of interest.
- **Chains** - Chains allows you to calculate multi-hop links in a defined sequence and treat them as a single access. When you build a chain, every link must be met in order for access to be valid. Just like a real chain, if any link fails, the entire chain is broken.
- **STK/Coverage** - STK/Coverage takes the ideas of Access and Chains and extends it to lines and surfaces in three dimensions. Coverage allows you to analyze the global or regional coverage provided by one or more assets (e.g. vehicles, facilities, sensors) while considering all access constraints. Coverage also allows you to analyze coverage of individual objects within an STK scenario as provided by one or more additional objects in the scenario.

**Other Ways to Introduce Objects**

The *Insert STK Objects tool* also provides an option to disable this feature in the event that you prefer to create and configure objects manually. If the *Insert STK Objects tool* were disabled, you could open that tool by either:

- Clicking the *Insert Object* button ( ), or
- Selecting *New...* from the *Insert* menu.

If you prefer to use the *Object Catalog*, you can enable that tool by:

- Clicking the *New Object* button ( ) to launch the *Object Catalog*. 
THE OBJECT CATALOG

All objects that you can add to a scenario are also found in the Object Catalog. The Object Catalog updates dynamically based on your selections in the Object Browser. When you select an object in the Object Browser, the Object Catalog will be populated with all eligible siblings and children of that object. When you introduce an object using the Object Catalog, a generic instance of that selected object is introduced into the scenario. STK configure that object using the standard default properties which vary depending on the object.

FIGURE 5-2. Object Catalog
Using Chains

You have the three main players in the scenario, but you still need to analyze visibility between the three. You know you need to transmit instructions FROM Omaha TO Comm_Sat, and then FROM Comm_Sat TO Eagle_Eye. Instead of calculating two separate line-of-sight accesses for each segment, you can use Chains to create a relationship that will determine if the objects have access based on the order of the sequence.

**INSERT A CHAIN**

1. Use the Object Catalog to insert a new chain (🔗) into the scenario (🔗).
2. Rename the chain Omaha_To_EagleEye.

**DEFINE A SIMPLE CHAIN**

The sequence of the chain is very important because the order in which the objects are listed in the chain is the order in which the accesses are computed. Use the information that you have and the figure below to help determine how the chain should be ordered.

FIGURE 5-3. Omaha to Eagle Eye chain

It looks like your chain should be ordered as follows:

- Omaha
- Comm_Sat
- Eagle_Eye

3. Double-click Omaha_To_EagleEye's (🔗) to open its properties (🔗). The Basic - Definition page should already be selected.
4. Locate the objects listed above in the *Available Objects* list and add them to the *Assigned Objects* list in the order specified.

5. When you finish, click OK.

**Report Chain Accesses**

A chain is complete or active when all of the criteria has been met in the proper sequence. The *Complete Chain Access* report is the chain's equivalent of the access report. It tells you when the chain is complete or active.

1. Right-click *Omaha To EagleEye* in the *Object Browser*.
2. Select the *Report & Graph Manager* item from the menu that appears.
3. Select the following:

   **TABLE 5-7. Complete chain access report**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Type</td>
<td>Chain</td>
</tr>
<tr>
<td>Object (Below Object Type)</td>
<td>Omaha_To_EagleEye</td>
</tr>
<tr>
<td>Show Reports</td>
<td>Off</td>
</tr>
<tr>
<td>Show Graphs</td>
<td>On</td>
</tr>
<tr>
<td>Style</td>
<td>Complete Chain Access</td>
</tr>
<tr>
<td>Generate as</td>
<td>Report/Graph</td>
</tr>
</tbody>
</table>

4. Click *Generate*...

**FIGURE 5-4. Graph: Omaha To Eagle Eye Complete Chain Access**

*If necessary you could see the actual start and stop times for each access interval by mousing over the shaded portions of the graph.*
5. Use the *Complete Chain Access* graph to answer the following questions:

- Will Eagle_Eye have the opportunity to receive data from Omaha?
- How many opportunities occur in this 24 hour period?
- What is the average duration of each communication window?

**WHEN YOU FINISH**

1. Close the *Complete Chain Access* report.
2. Close the Select the *Report & Graph Manager*.

**Model the GPS Network**

You can use the *Load GPS Constellation* creation method to insert a constellation object containing all of the satellites that make up the GPS network and insert those objects into the active scenario.

*A thorough database of historical GPS almanac data can be found at www.celestrak.com.*

1. Return to the *Insert STK Objects tool*.
2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td><img src="satellite.png" alt="Satellite" /></td>
</tr>
<tr>
<td>Select a Method:</td>
<td><img src="constellation.png" alt="Load GPS Constellation" /></td>
</tr>
</tbody>
</table>

3. Click the *Insert...* button.
4. Take a look at the *Object Browser*.

When you use the *Load GPS Constellation* method, all of the satellites that make up the GPS constellation as well as a constellation are inserted into the scenario. Each satellite that is inserted is set to use the scenario analysis period, and is propagated using the GPS propagator. The positional data for the GPS satellites comes from the GPS almanac. The GPS almanac is a set of data that every GPS satellite transmits, and it includes information about the state (health) of the entire GPS satellite constellation, and coarse data on every satellite's orbit. This data is published by 2SOPS (*2nd Space Operations*).
How Many Satellites Must I Access To Communicate With the GPS Network?

Squadron) at Schriever AFB. AGI receives regular almanac updates which are used to keep STK up to date.

You can also import GPS positional data using the Satellite Database option. If you pull GPS data from the Satellite Database, ephemeris is propagated from TLE data using the analysis period and the SGP4 propagator.

Define a Complex Chain

You know you need to access the GPS signal from a receiver within the aircraft, so you will need to know when accesses FROM Eagle_Eye TO GPSConstellation occurs. Although an entire GPS network will be considered in your chain, you need only include Eagle_Eye (the first object in the chain) and GPSConstellation (the last). You do not have to add all of the individual satellites to the chain. When the constellation is included, all objects that make up the constellation are considered.

Define a multi-hop link analysis between Eagle_Eye (a single object) and GPSConstellation (a collection of objects) using another chain.

1. Select the scenario ( ) in the Object Browser.
2. Use the Object Catalog to insert a new chain object ( ).
3. Rename the chain EagleEye_To_GPS.
4. Open EagleEye_To_GPS’s ( ) properties ( ). The Basic - Definition page should already be selected.
5. Locate and double-click Eagle_Eye ( ) in the Available Objects list to add it to the Assigned Objects list.
6. Locate and double-click the GPSConstellation ( ) constellation in the Available Objects list to add it to the Assigned Objects list.
7. Click OK.

Change Your Perspective

1. Bring the 3D Graphics window to the front.
2. Make Eagle_Eye ( ) the focal point in the 3D Graphics window.
3. Mouse around until Eagle_Eye ( ) is clearly visible.
WHAT CAN EAGLE EYE SEE?

1. Play (play) the animation, and watch as Eagle_Eye (rocket) travels along his path.
2. Watch as the access lines between Eagle_Eye (rocket) and each available satellite as Eagle_Eye (rocket) makes and loses access with them.
3. When you finish, Reset (Reset) the animation.

FIGURE 5-5. 3D View: Unconstrained GPS Access to Eagle Eye

- Why are accesses between Eagle_Eye and the satellites in GPS Constellation displayed in the window?
- You didn’t calculate access, did you?

Yes, you did! When you define a chain, you not only define the order of accesses within the chain, but accesses that complete the chain are automatically calculated. If you had objects in the scenario that were not part of the chain, they would not be considered in chain accesses. Accesses could, however, be calculated to and from any member of the chain to any other object in the scenario.

Create a “Window” In the Aircraft

It’s obvious from watching the animation that accesses occur, but how many access are really valid? Eagle_Eye seems to have access with four (4) or more of the GPS satellites at any given point along its route, but you know that you only have a small window in the top of the aircraft for receiving the GPS signal. How can you exclude accesses that aren’t available from that angle?
Look back at the list you made in “Break it Down,” on page 5-2. Your visibility limitation restricts access to those GPS satellites which have a minimum 45 degree elevation angle relative to the aircraft. You could model this by placing an elevation constraint on Eagle_Eye, but that constraint would also be taken into account in your Omaha_To_EagleEye chain. Since the communications link does not have this same restriction, adding the constraint would invalidate the results of that chain. The other option is to use a sensor to model the communications “window” for access to the GPS satellites.

1. Return to the Insert STK Objects tool.
2. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>Sensor</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>Define Properties</td>
</tr>
</tbody>
</table>

3. Click the Insert… button.
4. Select Eagle_Eye in the Select Object dialog.
5. Click OK.
6. Rename the sensor Window.
7. You don’t need to create any more objects, so you can close the Insert STK Objects tool now if you like.

GET A BETTER LOOK

1. Bring the 3D Graphics window to the front.
Can you see the sensor’s field-of-view extending from Eagle_Eye?

2. Go to Windows' properties.
3. Ensure that the Basic - Definition page is selected.

The cone angle is the off-boresight angle. You will adjust the boresight to point straight up 45 degrees relative to the horizon of Eagle_Eye. The restriction yields a 45 degree off-boresight angle, so the default 45 degree cone angle is correct.

**FLIP THAT SENSOR**

The restriction is correct, but the sensor is oriented straight down. You need to reorient the sensor to point up from Eagle_Eye. You’ll have to “flip” the field-of-view. You can do this by pointing the sensor 180 degrees in the other direction.

1. Select the Basic - Pointing page.
2. Set the following Pointing properties:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Type</td>
<td>Fixed</td>
</tr>
<tr>
<td>Elevation</td>
<td>-90 deg</td>
</tr>
</tbody>
</table>

3. Click OK.
By changing the elevation from 90 to -90 degrees, you “flip” the field-of-view a full 180 degrees. Let’s take a look.

4. Bring the 3D Graphics window to the front.

The field-of-view display shows up as the shaded area projecting from the top of the aircraft. It’s obvious that many of your access opportunities will not fall within that 45 degree window. How will you limit accesses such that you only see and report those that fall within the aircraft’s window?

![3D View: Eagle Eye access window display](image)

**FIGURE 5-7. 3D View: Eagle Eye access window display**

**Now, What Can Eagle Eye See?**

The elevation constraint ensures that only accesses that hit the window on *Eagle Eye* will be considered. Check to see how that has affected access. To do that, you’ll need to make some adjustments to the *EagleEye_To_GPS* chain so that you’re calculating access from the window and not from the entire aircraft.

1. Open *EagleEye_To_GPS’s* properties. The Basic - Definition page should already be selected.
2. Reorder the chain as follows:
   - *Window*
   - *GPS Constellation*
3. Click OK.
SENSOR DISPLAY

You really don't need to see the sensor field-of-view now that you’ve restricted access such that you will only display those that hit Eagle_Eye in that window. Let’s quickly remove the graphical display of the sensor field-of-view.

1. Open Window’s ( ) properties ( ).
2. Select the 2D Graphics - Display Times.
3. Change the Display Status to Always Off.
4. Click OK.

GET MOVING!

1. Reset ( ) the animation.
2. Play ( ) the animation, and watch as Eagle_Eye ( ) travels along its path.
3. Take some time to watch the access lines between Eagle_Eye ( ) and each available satellite as Eagle_Eye ( ) makes and loses access with them.

4. Use the 2D and windows and answer the following questions:
   - What happened when you reset the animation?
   - How many accesses do you see?
   - What’s different about the angle of the access lines coming to Eagle_Eye?
   - Does there appear to be four or more accesses at any given time?
5. When you finish, Reset the animation.

Constrain GPS Sats

Looking at access graphics you can see that the number of accesses has been dramatically reduced, but are you sure that Eagle_Eye has access to at least four (4) of the GPS satellites at any given time during the analysis period? You could report data and identify accesses that meet this criteria, or you can constrain the constellation--GPSConstellation--such that at least the specified number of objects in the constellation meet the needs of the chain for a successful access. Using the constraint will ensure that only the necessary data is reported.

1. Open GPSConstellation properties.
2. Select the Constraints - Basic page.
3. Select At Least N from the Restriction list.
4. Enter the number 4 in the adjacent textbox.
5. Click OK.

NOW, WHAT CAN EAGLE EYE SEE?

1. Play the animation, and watch as Eagle_Eye.

• How many accesses do you see, now?
• Does there appear to be four (4) or more accesses at any given time?

FIGURE 5-9. 2D View: GPS access with constraints
2. When you finish, Reset the animation.

Accesses to fewer than four (4) members of GPSConstellation no longer display in the visualization windows, but there still seems to be sporadic accesses. Why don’t you get some hard data that tells you exactly when accesses that meet all of your criteria occur.

Report Chain Accesses

Previously, you used the Complete Chain Access report to ensure that Eagle_Eye could receive instructions from Omaha. Let’s use it again to see exactly when and how often Eagle_Eye has access to GPSConstellation.

1. Right-click EagleEye_To_GPS in the Object Browser.
2. Select the Report & Graph Manager item from the menu that appears.
3. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Type</td>
<td>Chain</td>
</tr>
<tr>
<td>Object (Below Object Type)</td>
<td>EagleEye_To_GPS</td>
</tr>
<tr>
<td>Show Reports</td>
<td>On</td>
</tr>
<tr>
<td>Show Graphs</td>
<td>Off</td>
</tr>
<tr>
<td>Style</td>
<td>Complete Chain Access</td>
</tr>
<tr>
<td>Generate as</td>
<td>Report/Graph</td>
</tr>
</tbody>
</table>

4. Click Generate...
5. Use the Complete Chain Access report to answer the following questions:

- Approximately how many accesses occur between Eagle_Eye and GPSConstellation?
- What portions of the twenty-four (24) hour mission does Eagle_Eye have access to the required number of satellites in GPSConstellation?

If you like, you can change the report units to hours (hrs) instead of seconds (sec). It may make the second question easier to answer.
INDIVIDUAL STRAND ACCESS

The Individual Strand Access report tells you what complete chain access cannot, or which object in the constellation completed the chain and when. The Complete Chain Access tells you WHEN you have a solution. The Individual strand Access tells you WHAT your solution consists of during those time that you have a solution.

1. Return to the Report & Graph Manager.
2. Select Individual Strand Access from the Styles list.
3. Click the Generate... button.
4. Use the Individual Strand Access report to answer the following questions:
   - Can Eagle_Eye see at least four (4) members of GPS_Sat during the twenty-four (24) hour mission?

Save Your Work

1. Close any remaining report windows.
2. Close the Report & Graph Manager.
3. Save your work.
4. Close the scenario.
5. Leave STK open.
How Will I Take Pictures Of The Hiroshima Castle and Relay Them In Near-Real-Time?

In this exercise you will use your STK expertise to define and assess a complex, real-world problem, and then model and analyze that problem. Upon completion, you will have had the opportunity to practice the following skills:

- Evaluating a complex problem and building an STK scenario to analyze that problem.
- Create objects using the Object Catalog.
- Use the STK databases to model objects.
- Define and manipulating object and window properties.
- Analyze and assess data.

You will also have the opportunity to do some things that you haven’t done before, such as:

- Change inheritable properties for multiple objects at the scenario level.
- Add a KML file to the STK 3D Graphics window for visualization.
- Use the AGI Data Federate to create objects in STK
Problem Statement

With the increased global seismic activity, Japanese and U.S. intelligence would like to collect as much visual imagery of possible on Hiroshima Castle. They need to monitor the geography of the area around the castle as well as the structural integrity of the castle.

To do this, you need to take as many pictures of Hiroshima Castle as possible and get them to White Sands or Guam within the next two weeks.

BREAK IT DOWN

You have some information that may be helpful. Here’s what you know:

• It must be daylight in Hiroshima when you take the pictures.
• The cameras attached to Landsat 5 and 7 can take pictures of Hiroshima.
• Each camera has a fifteen (15) degree by four (4) degree rectangular lens.
• You CANNOT downlink directly from Landsat to White Sands.
• You CAN uplink from the Landsat site to TDRS 3, 5, and/or 10.
• You CAN downlink from TDRS 3, 5, and/or 10 to White Sands or Guam.
• Hiroshima Castle is located at 34.40 latitude and 132.46 longitude.
• You have a KML file that models Hiroshima Castle that you want to use in the 3D Graphics window.

SOLUTION

Build a scenario that can be used to determine when you can take near-real-time images of Hiroshima, in the daylight over the next two weeks using the cameras attached to Landsat 5 or 7. After you take the images, you need to uplink to one of the TDRS satellites, and then downlink to your White Sands, NM or Guam site.

Wow, that’s a mouthful! Let’s sketch that out, and see if it makes more sense. It all looks something like this:
Create a Scenario

You will, again, build your analysis from the ground up. First, you need to define the analysis time period of the conditions that you set for your world and the objects in your world. You know that your period of analysis will be two weeks because that’s how long you have to collect the data that you need. Define a two week analysis period.

1. Click the *Create a New Scenario* button.
2. Enter the following in the *New Scenario Wizard*:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Image_Relay</td>
</tr>
<tr>
<td>Description</td>
<td>How will I take pictures of Hiroshima and relay them in near-real-time?</td>
</tr>
<tr>
<td>Location</td>
<td>C:\Documents and Settings\Student\My Documents\STK 9</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>Tomorrow + 14 days</td>
</tr>
</tbody>
</table>
3. When you finish, click OK.
4. When the scenario loads, click Save.

A folder with the same name as your scenario is created for you in the location specified above.

5. Verify the scenario name and location and click Save.

**On the Ground**

The first thing you need to do is model a few locations on the ground. To start, you’ll model:

- The location of *Hiroshima Castle*.
- The *White Sands* site.
- The *Guam* site.

**Model the Target City**

You’ll use the provided information in the *City Database* to model *Hiroshima* as a target, since that’s the location that your cameras will be looking at, or targeting.

1. Return to the *Insert STK Objects tool*.
2. Select the following:

<table>
<thead>
<tr>
<th>TABLE 6-2. Create locations on the ground</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option</strong></td>
</tr>
<tr>
<td>Select an Object To Be Inserted:</td>
</tr>
<tr>
<td>Select a Method:</td>
</tr>
</tbody>
</table>

3. Click the Insert... button.
4. When the *City Database Search* tool appears, enter the following criteria:

<table>
<thead>
<tr>
<th>TABLE 6-3. New city search criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option</strong></td>
</tr>
<tr>
<td>City Name</td>
</tr>
<tr>
<td>Color</td>
</tr>
</tbody>
</table>
5. Click Search.
6. When the search results appear, double-click the first Hiroshima
   (Hiroshima, Hiroshima) entry to insert it in the scenario.
7. Close the City Database Search tool.

Add a KML File

Now that you have entered in the ground location that you want to visualize, you would like to see Hiroshima Castle as a model in the 3D Graphics window. You have a KMZ file that models Hiroshima Castle.

Keyhole Markup Language (KML) is an XML based language scheme for expressing geographic annotation and visualization on existing or future Internet-based, two-dimensional maps, and three-dimensional Earth browsers. KML was developed for use with Google Earth, which was originally named Keyhole Earth Viewer. It was created by Keyhole, Inc. which was acquired by Google in 2004. The name Keyhole is an homage to the KH reconnaissance satellites, the original eye-in-the-sky military reconnaissance system first launched in 1976.

KML is an international standard of the Open Geospatial Consortium. Google Earth was the first program able to view and graphically edit KML files. The KML file specifies a set of features (placemarks, images, polygons, 3D models, textual descriptions, etc) for display in Google Earth, Maps and Mobile, or any other 3D Earth browser (geobrowser) implementing the KML encoding. Each place always has a longitude and latitude. KML files are very often distributed in KMZ files, which are zipped files with a *.kmz extension.

You will need internet access to file the Hiroshima KML file. If you not have internet access, you can find the file in C:\Training\STK\Image_Relay or jump to the section “Model Ground Sites” on page 6-8.

1. Open Internet Explorer.
3. Click the Gallery link.
4. Click the 3D Building link.
5. Locate HiroshimaCastle.kmz. You can typically find this on the second page or you can use the Google Earth search feature.
6. Click the Open in Google Earth button.
7. Click *Save*.
8. Save the file to your desktop.
9. Click *Close* when the download is complete.
10. Click the button to close *Internet Explorer*.

**BRING KML FILE INTO STK**

Now that you have downloaded the KML file, you can bring it into STK for visualization.

1. Bring STK to the front.
2. Open the *Globe Manager*( ).

The *Globe Manager* is used to create a profile for a globe in the 3D Graphics window by applying and managing world background textures (.wtm), image inlays (.jp2 &.pdttx), terrain inlays (.pdtt), specular textures (.wtm) and night light textures (.wtm) from multiple sources, both local and external, including *AGI Globeserver*, to create a globe profile. Profile items can then be set to be displayed or hidden in the 3D Graphics window and organized into sets which can be turned on and off in the 3D Graphics window.

3. Select the *KML* tab.
4. Click the *Open KML Content* ( ) button.
5. Browse to the location of your KML file.
6. Select *HiroshimaCastle.kmz*.
7. Click *Open*.

*You will need an install of STK 9.2 or later.*

It may take a moment for the KMZ file to load into STK.

**VIEW IN 3D GRAPHICS WINDOW**

1. Select the Model in the KML browser.
2. Click the *Zoom To* ( ) button.
3. Mouse around in the 3D Graphics window until you can clearly see Hiroshima Castle.
Adjust the Target

You notice that the model of the castle does not line up with your target. You can adjust the location of the target so it is closer to the actual location.

1. Open Hiroshima’s ( ) properties ( )
2. Select the Basic - Position page.
3. Set the following coordinates:

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>34.403 deg</td>
</tr>
<tr>
<td>Longitude</td>
<td>132.459 deg</td>
</tr>
</tbody>
</table>

4. Click OK.

View in 3D Graphics Window

1. Right-click on Hiroshima ( ) in the Object Browser.
2. Select the Zoom To option.
3. Mouse around in the 3D Graphics window until you can clearly see Hiroshima Castle.
Model Ground Sites

You’ll use the information in the Facility Database to model the sites in your network as facility objects.

1. Return to the Insert STK Objects tool.
2. Select the following:

3. Click the Insert... button.
4. When the Facility Database Search tool appears, enter the following criteria:

5. Click Search.
6. When the search results appear, double-click the White Sands entry to insert it in the scenario.
7. Change the search criteria as follows:

8. Click Search.
9. When the search results appear, double-click the Guam entry to insert it in your scenario.
10. When you finish, close the Facility Database Search tool.
GROUP YOUR GROUND SITES

In your scenario you have the two ground stations used by the TDRS system. In addition to including them in your scenario, you want to group them together for analysis. How do you create a constellation with objects already contained in your scenario? This is not a problem. In addition to having STK create a constellation using objects selected during the object creation process, you can also manually create an “empty” constellation and assign objects yourself. Let’s try it.

1. Use the Object Catalog to create a constellation object ( ).
2. Rename the constellation TDRS_Ground.
3. Open TDRS_Ground’s ( ) properties ( ). The Basic - Definition page should already be selected.
4. Use the Selection Filter to select all of the facilities ( ) in the scenario.
5. With the Selection Filter on, move ( ) all of the facilities in the scenario to the Assigned Objects list.
6. Click OK.

What Is the ADF?

AGI Data Federate (ADF) is a data management system that enables you to share, collaborate, and reuse your STK data across your teams and organizations. ADF provides a central data repository that can be accessed seamlessly from within STK through standard file loading and saving operations. STK provides the capability of search within the ADF and managing the data stored there.

ADF allows for a built-in configuration management and version control system. You can easily work together to manage, share, and modify STK data and publish it on ADF.

You will also know who modified any of your data, when they did it, and why they did it. ADF allows you to track the status and changes throughout the entire life cycle of your data.
How Will I Take Pictures Of The Hiroshima Castle and Relay Them In Near-Real-Time?

CONNECT TO AN ADF SERVER

1. Extend the Edit menu.
2. Select Preferences.
3. Select ADF Servers in the Preferences list.

Before you use the ADF, you will need a user name and a password.

4. Click the Add a new server ( ) button.
5. Set the following options as the ADF Server details:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>AGI ADF Server</td>
</tr>
<tr>
<td>URL</td>
<td><a href="https://adf9.agi.com">https://adf9.agi.com</a></td>
</tr>
<tr>
<td>Default Folder</td>
<td>Blank</td>
</tr>
<tr>
<td>Description</td>
<td>AGI ADF Server</td>
</tr>
<tr>
<td>User Name</td>
<td>Student</td>
</tr>
<tr>
<td>Password</td>
<td>Student</td>
</tr>
<tr>
<td>Confirm Password</td>
<td>Student</td>
</tr>
</tbody>
</table>

6. Click OK on the ADF Server page.
7. Click OK on the Preferences page.

Now that you have connected to the ADF, let's create our Landsat satellites from the ADF.

Model Spacecraft

You have a world, and you've defined all relevant points-of-interest on the ground. Now, it's time to look to the sky. Your scenario still needs:

• The Landsat satellites of interest.

1. Return to the Insert STK Objects tool ( ).
TABLE 6-9. Create satellite

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an Object To Be Inserted:</td>
<td>🌟 Satellite</td>
</tr>
<tr>
<td>Select a Method:</td>
<td>🌟 From AGI Data Federate</td>
</tr>
</tbody>
</table>

1. Click the Insert... button.

MODEL THE LANDSAT SATELLITES

Use the AGI Data Federate to model the Landsat satellite network. You can utilize ADF’s built-in searching capabilities to easily discover and access all the latest and trusted models and data in the repository.

1. Select the Search tab when the AGI Data Federate tool appears.
2. Type Landsat in the All or part of the file name field.
3. Click Search.
4. When the search results appear, select Landsat5.sa.
5. Click Open.

The Landsat 5 satellite has been added to your scenario. You will notice Landsat 5 has the appropriate sensor attached to it.

6. Open Landsat5’s sensor 🌟 properties 🌟.
7. Select the Basic - Definition page.
8. Ensure the following options are set:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Vertical Half Angle</td>
<td>7.5 deg</td>
</tr>
<tr>
<td>Horizontal Half Angle</td>
<td>2 deg</td>
</tr>
</tbody>
</table>

9. Click OK.
10. Follow the same steps to insert Landsat 7 using the AGI Data Federate.

GROUP YOUR LANDSAT SATELLITES

1. Use the Object Catalog to create a constellation object 🌟.
2. Rename the constellation *Landsat_Sats*.
3. Open *Landsat_Sats*’ properties. The *Basic - Definition* page should already be selected.
4. Use the *Selection Filter* to select all of the Landsat satellites in the scenario.
5. With the *Selection Filter* on, move all of the satellites in the scenario to the *Assigned Objects* list.
6. Click OK.

**GROUP THE CAMERAS**

Now, you need to create a constellation for the two cameras that you created because you want them to be considered as a unit also.

1. Use the *Object Catalog* to create a constellation object.
2. Rename the constellation *CamerasFOV*.
3. Open *CamerasFOV*’s properties. The *Basic - Definition* page should already be selected.
4. Use the *Selection Filter* to select all of the sensors in the scenario.
5. With the *Selection Filter* on, move all of the sensors in the scenario to the *Assigned Objects* list.
6. Click OK.

**Model the TDRS Network**

Currently, the Standard Object Catalog in ADF only contains information on imaging satellites (LEO satellites). In the future, more data will be added to the catalog. You can use the Satellite Database Search tool to bring in the TDRS satellites.

1. Return to the *Insert STK Objects* tool.
2. Select the following:

<table>
<thead>
<tr>
<th><strong>TABLE 6-11. Create locations on the ground</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPTION</strong></td>
</tr>
<tr>
<td><strong>Select an Object To Be Inserted:</strong></td>
</tr>
<tr>
<td><strong>Select a Method:</strong></td>
</tr>
</tbody>
</table>

3. Click the *Insert* button.
4. When the *Facility Database Search* tool appears, enter the following criteria:

   **TABLE 6-12. TDRS search criteria**

<table>
<thead>
<tr>
<th><strong>OPTION</strong></th>
<th><strong>STATE</strong></th>
<th><strong>VALUE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Name</strong></td>
<td>On</td>
<td>TDRS</td>
</tr>
<tr>
<td><strong>Auto Select Color</strong></td>
<td>On</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Create Constellation from Selected Satellites</strong></td>
<td>On</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Name</strong></td>
<td>N/A</td>
<td>TDRS_Sats</td>
</tr>
</tbody>
</table>

5. Click *Search*.
6. When the search results appear, select *TDRS 3*, *TDRS 5*, and *TDRS 10*.
7. Click *Insert*.
8. When you finish, close the *Satellite Database Search* tool.

**CHANGE YOUR PERSPECTIVE**

Before you move on, reposition your 3D view to see what you have done.

1. Bring the *3D Graphics* window to the front.
2. **Zoom To the** *Landsat 7* ( ) **satellite so that it is the focal point in the** *3D Graphics* **window.**
3. **Reset** ( ) **the animation.**

**FIGURE 6-3. 3D View: Landsat 7**
Define a Chain of Events

It looks like as well as creating and grouping objects you also need to consider the sequence of events.

For example, it wouldn’t do you much good to be transmitting data before you’ve taken images, and it wouldn’t make sense to downlink from TDRS to Whites Sands before images were transmitted from Landsat to TDRS, would it? You need to define a sequence of events whose definition must be met before access is of any interest to you.

1. Use the Object Catalog to create a chain ( ).
2. Rename the chain Hiroshima_To_Ground.

Now, you need to define the order of access within the chain. Think about how the chain should be ordered:

- Hiroshima must be visible.
- At least one member of the Cameras ( ) constellation must be able to see Hiroshima.
- The Landsat satellites must be able to transmit to TDRS.
- The member of the TDRS_Sats constellation who receives the images can downlink to either White_Sands or Guam.

Not so tough. Make a chain.

3. Open Hiroshima_To_Ground ( ) properties ( ). The Basic - Definition page should already be selected.
4. Move the following objects to the Assigned Objects list in this order:
   - Hiroshima ( ).
   - CamerasFOV ( ).
   - Landsat_Sats ( ).
   - TDRS_Sats ( ).
   - TDRS_Ground ( ).
5. Ensure that the objects are in the Assigned Objects list in the order specified.
6. Click OK.
Constrain Access to Hiroshima

Now, make sure you’ve considered everything before you start your analysis. The first thing that jumps out is the second item--“It must be daylight in Hiroshima when you take the pictures.” How can you ensure that the cameras on the SPOT satellites only take pictures of Hiroshima during daylight hours? To model this, you need to impose a constraint based on the position of the Sun.

1. Open Hiroshima’s properties.
2. Select the Constraints - Sun page.
3. Enable the Lighting option towards the bottom of the page.
4. Select Direct Sun from the adjacent list.
5. Click OK.

Congratulations! That’s everything. Now, you can answer the original question-- *When will you have the opportunity to take pictures of Hiroshima and relay them to White Sands or Guam in near-real-time?*

When Can I see It?

Calculate *Complete Chain Access* to see when the chain is active.

1. Right-click Hiroshima_To_Ground in the Object Browser.
2. Select the Report & Graph Manager item from the menu that appears.
3. Select the following:

<table>
<thead>
<tr>
<th>OPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Type</td>
<td>Chain</td>
</tr>
<tr>
<td>Object (Below Object Type)</td>
<td>Hiroshima_To_Ground</td>
</tr>
<tr>
<td>Show Reports</td>
<td>On</td>
</tr>
<tr>
<td>Show Graphs</td>
<td>Off</td>
</tr>
<tr>
<td>Style (Installed Styles)</td>
<td>Complete Chain Access</td>
</tr>
<tr>
<td>Generate as</td>
<td>Report/Graph</td>
</tr>
</tbody>
</table>

4. Click Generate...
5. Use the *Complete Chain Access* report to answer the following questions:
How Will I Take Pictures Of The Hiroshima Castle and Relay Them In Near-Real-Time?

- Which date has the longest access time?
- What are the most access periods found in one day?

**VISUAL ANALYSIS**

Look at a complete chain access in the 2D and 3D Graphics windows.

1. Right-click the first access time in the Access report.
2. Select Start Time --> Set Animation Time from the context menu.

![The time of access will be different in your report because your scenario is based on relative time (Today +\-).](image)

*FIGURE 6-4. Animation toolbar with access times*

The animation will be set to start at the beginning of the access period.

3. Select the 3D Graphics window to bring it to the front.
4. Click the Home View button ( ) on the 3D Graphics toolbar.
5. Use the mouse to manipulate the view in the 3D Graphics window so that the entire chain access is visible.

*FIGURE 6-5. 3D View: Complete chain access*
WHEN YOU FINISH

2. Return to the Report & Graph Manager.

WHO CAN SEE WHAT WHEN?

Calculate Individual Strand Access to see which object in each constellation, made the chain complete at each step.

1. Select the following:

<table>
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<td>Off</td>
</tr>
<tr>
<td>Style</td>
<td>Individual Strand Access</td>
</tr>
<tr>
<td>Generate as</td>
<td>Report/Graph</td>
</tr>
</tbody>
</table>

2. Click Generate...

The Individual Strand Access report is useful when you’re trying to balance timelines against accuracy of assets. For example, using this report (or graph) would help you determine the impact on your mission should any of the satellites or ground stations become inoperable.

3. Use the Individual Strand Access report to answer the following questions:

- What is the first satellite to image Hiroshima?
- If either of your Landsat satellites became disabled, would you still be able to complete the chain?
- Are all TDRS satellites used? If not, which satellite is not used.

On Your Own

You have now been told to use the SPOT satellites as your imaging satellites instead of Landsat. You now must put together two new system plans that
can still give you comparable results. Design these two systems, and note the possible new resources you would need to use.

Save Your Work

1. Close any remaining report windows.
2. Close the Report & Graph Manager.
3. Save your work.
4. Close the scenario.
5. Close STK.