Where Is the Space Station, Now?

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 in STK. Upon completion, you will have had the opportunity to practice the following skills:

- 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 *MyHouse*) 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 *MyHouse* and the *International Space Station* (*ISS*) that considers lighting and elevation limitations.

Model the World!

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 1. New Scenario Wizard options

Option	Value
Name	Where_Is_ISS
Description	When will ISS be visible over the next three (3) weeks?
Location	`C:\Documents and Settings\<user>\My Documents\STK 10\`
Start	Today
Stop	+ 21 days

You can click the drop-down arrow beside the Start and Stop options,to expose a drop-down menu of available times, dates, formats, and units.

- 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"?

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.

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 My House

The *Insert STK Objects tool* offers a variety of methods for introducing different types of locations. For this example, it will be sufficient to mark the location of your house. We will call the location, *MyHouse*. An easy way to introduce a location is to create the object using the place location address search tool.

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 2. Insert place

Option	Value
Select an Object To Be Inserted:	Place
Select a Method:	Search by Address

3. Click the *Insert...* button.
4. Enter the address where you are currently taking this class or the address of your home.
5. Select your town or address when the search results appear.
6. Click the *Insert Place(s)* button to use that entry to insert an *STK Place* object () representing *MyHouse* into the current scenario.
7. Close the *Insert by Address* search tool.
8. Rename the new *Place* object () *MyHouse*.

Renaming Objects

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

- Select the object, and 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.

Can I See My House on the Bing Maps Overlay?

Now that you have your house inside *STK*, let's take a look at what it might look like in the *2D* and *3D Graphics* window using *Microsoft Bing Maps*.

Through *AGI*'s partnership with *Microsoft*, *STK/TIM* users can stream global high-resolution *Microsoft Bing Maps* raster imagery onto their *STK*, *AGI Viewer*, and *STK Engine* 3D globes. You can select from different data sets (e.g. aerial imagery, roads, etc.) to provide enhanced situational awareness.

1. Bring the *3D Graphics* window to the front.
2. Click the *Microsoft Bing Maps* ( ) icon.
3. Select the *Aerial* option.
4. Click *OK*.

Change Your Perspective

Let's get a closer look at *MyHouse* in the *3D Graphics* window.

1. *Zoom To MyHouse* ( ) in the *3D Graphics* window.
2. Mouse around in the window to get a better look at *MyHouse* ( ).

FIGURE 1. 3D View: MyHouse

Get a Better Look

1. Bring the *2D Graphics* window to the front.
2. *Zoom* ( ) as many times as needed until *MyHouse* ( ) is clearly visible.

FIGURE 2. 2D View: MyHouse

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 3. Insert satellite

Option	Value
Select an Object To Be Inserted:	Satellite
Select a Method:	From Standard Object Database

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* (*TLE*). You will use the *Satellite Database* tool to model *ISS*.

Let's see if you can find a database entry for ISS, and use it to insert an *STK* satellite object ( ).

1. When the *Satellite Database Search* tool appears, select the *Local* tab.
2. Set the following in the Satellite Search Criteria:

TABLE 4. Satellite search criteria

Option	State	Value
Common Name	On	ISS
SSC Number	Off	N/A
Propagation TLE Source	N/A	Online: AGI Server

3. Click *Search*.

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

4. Select the *ISS* entry (25544).
5. Click *Insert* to introduce an *STK* satellite object () representing *ISS* into the scenario.
6. Close the *Satellite Database Search* tool.
7. 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.
5. Leave *ISS_25544*'s () properties open.

When Can I See ISS From My House?

You have two objects in your scenario, one satellite representing *ISS* and one facility representing *MyHouse*. You need to know when *ISS* is within *MyHouse's* line-of-sight. Calculate a simple access to determine when you can see the *ISS*. You will be looking for an azimuth as close to 90 degrees as possible. This represents when the ISS is directly overhead. Perfect for viewing the bright space station.

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

2. Set the *Access For* option to *MyHouse* ( ).

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 *MyHouse* 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 *MyHouse*'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 *MyHouse*. Take another look at the times when *MyHouse* 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.

Constrain 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.

Sky Lighting

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 ( ).

Now, 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.

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 *MyHouse*.

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* (*UTCG*).
4. Select *Gregorian LCL* (*LCLG*) from the *Change Unit Value* list.
5. Click *OK* to save the change and dismiss the *Units* window.
6. Return to the *Access* report.

Gregorian LCL is dependent on your system clock and time zone. If MyHouse 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?

Constrain MyHouse

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

Ground Lighting

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

1. Open *MyHouse*'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 From MyHouse?

Constraining *MyHouse* 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 MyHouse affect accesses?
- At what elevation does the first access occur?

Elevation Angle 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 *MyHouse's* () availability, impose a minimum elevation angle constraint.

1. Return to *MyHouse'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 *MyHouse's* () properties ().

Now, When Can I See ISS?

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

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.

- How many accesses are there?
- What is the total duration of the accesses?
- How did applying an elevation angle constraint to MyHouse 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 *MyHouse*, 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.

Lighting Conditions in the 2D Graphics Window

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!

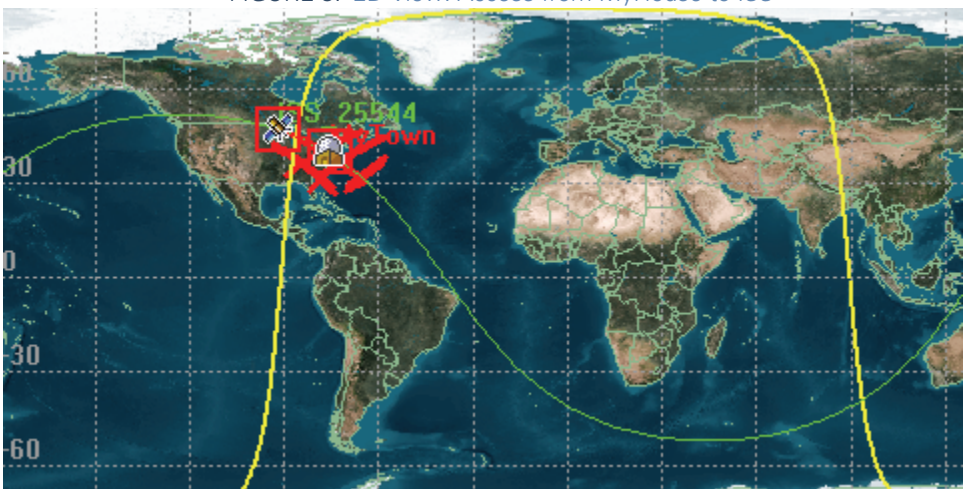
The *ISS* object marker is positioned according to the current animation time in both windows, and its ground and orbit tracks are clearly visible.

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 3. 2D View: Access from MyHouse to ISS



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

FIGURE 4. Animation toolbar during access from MyHouse to ISS

- 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 +\-).

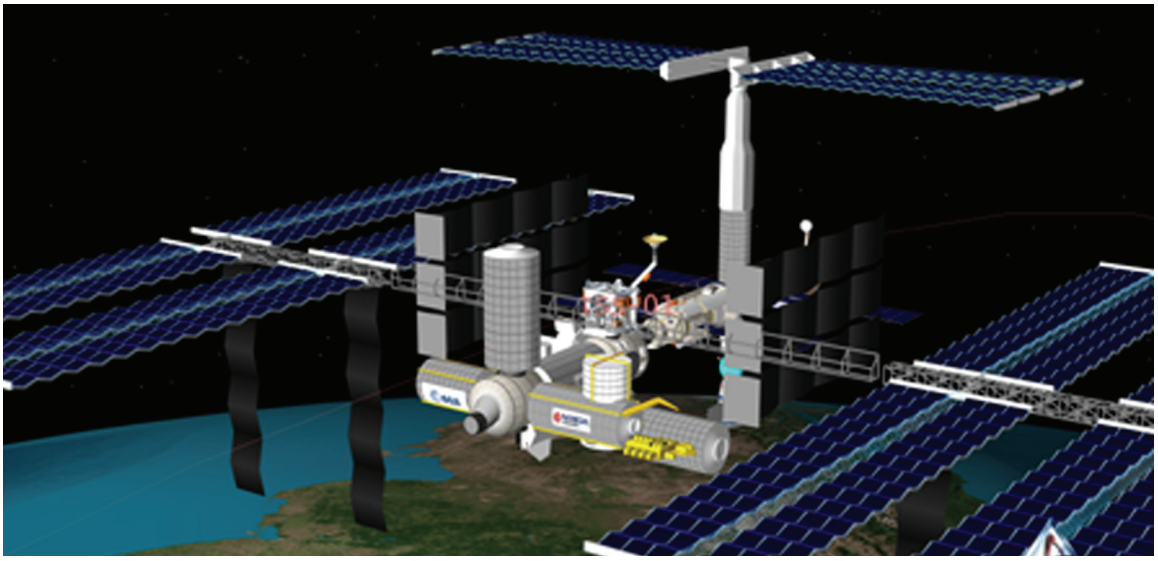
5. Close any remaining *Report Data* windows.

Change Your Perspective

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 5. 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 ().
4. Leave *STK* () open.