Coverage Tutorial Using the Object Model

This tutorial shows how to use the STK Object Model to set up a simple coverage analysis, performing tasks for which you might otherwise use Connect or the Ansys Systems Tool Kit® (STK®) digital mission engineering software GUI. Source code is given in C# and Visual Basic.NET. Familiarity with Microsoft Visual Studio and STK are presumed.

Source Code Location: The source code for this tutorial is in the following text file:

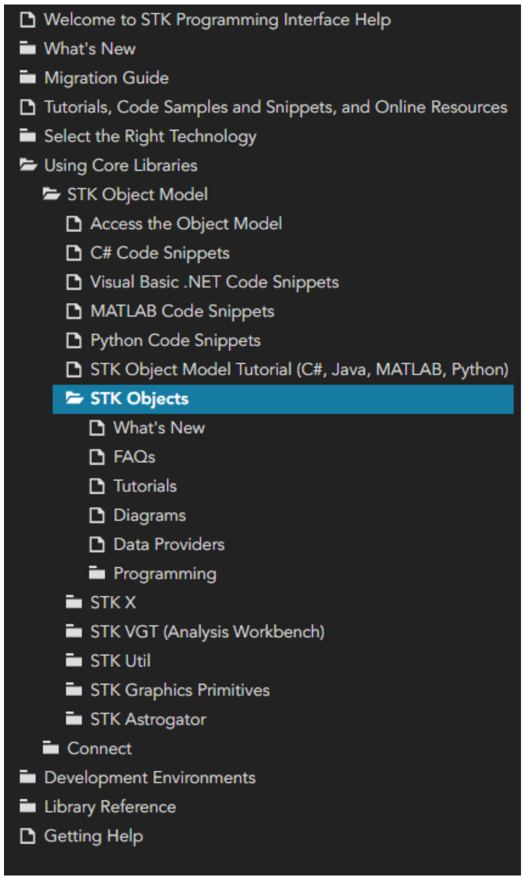
```
<Install Folder>\Help\STK\LinkedDocuments\OM_CoverageTutorial.txt
```

The code is broken into sections corresponding to the sections in this tutorial. Within each section, the C# and VB.NET code are presented in separate subsections.

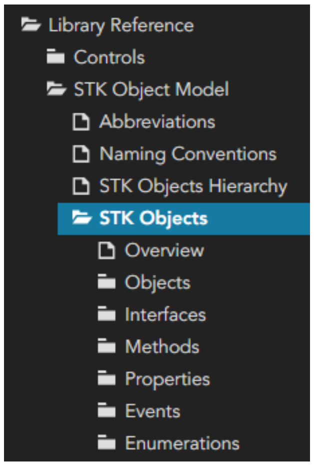
Where to get help

Before proceeding with this tutorial, take a moment to familiarize yourself with the parts of the STK Programming Interface Help system that relate to the Object Model and STK X.

In the Contents tab of the Help system, navigate to Using Core Libraries → STK Object Model → STK Objects.


- Welcome to STK Programming Interface Help
- What's New
- Migration Guide
- Tutorials, Code Samples and Snippets, and Online Resources
- Select the Right Technology
- Using Core Libraries
  - STK Object Model
    - Access the Object Model
    - C# Code Snippets
    - Visual Basic .NET Code Snippets
    - MATLAB Code Snippets
    - Python Code Snippets
    - STK Object Model Tutorial (C#, Java, MATLAB, Python)
    - STK Objects
      - What's New
      - FAQs
      - Tutorials
      - Diagrams
      - Data Providers
      - Programming
    - STK X
    - STK VGT (Analysis Workbench)
    - STK Util
    - STK Graphics Primitives
    - STK Astrogator
  - Connect
- Development Environments
- Library Reference
- Getting Help

In addition to these introductory sections, the Library Reference for STK Objects is broken down into subsections for the various types in the library.



Try this: To find help for the AgStkObjectRoot class discussed above, click Library Reference → STK Object Model → STK Objects and scroll down the alphabetical list until you find the entry entitled "AgStkObjectRoot". Click AgStkObjectRoot to display a page containing a diagram with several links, including a link to Root (IAgStkObjectRoot Object). From that page you can access a page that lists all the members (methods and properties) of the interface associated with the AgStkObjectRoot object. Similarly, you can find help for any other object or interface, as well as any method, property or enumeration.

A quick way to find help on a given type is to use the Search tab of the Help system. For example, suppose you are interested in the AgECoordinateSystem enum. If you enter "AgECoordinateSystem" in the search field and click List Topics, a list of pages containing that term appears. Click on the Title heading to order the list alphabetically, and the entry for AgECoordinateSystem will appear at the top. Click that entry to display a page defining the enum and listing its members.

> **TIP**: Keep the STK Programming Interface Help system open to the Search tab while you are working through this tutorial. Then you can copy and paste the names of interfaces, enumerations, etc. into the search field to learn more about their meaning and usage.
>
> **NOTE**: It is not necessary to have STK running to display the Help system. To launch Help, simply open the Windows Start Menu and navigate to AGI STK ODTK 13 → STK 13 - Programming Interface Help.

In addition to the Object Model (STK Objects and STK Util), you may find it useful to refer to help on STK X controls.

One final note on the STK Programming Interface help: In addition to help on programming issues, the help provides information about the real-world context in which the application is to be used. For example, the help page for the SpinAxisConeAngle property tells you that it is writable, is of the Variant data type, and belongs to the IAgSnPtSpinning interface. In addition, it tells you that the property represents "the cone angle used in defining the spin axis; i.e., the angle between the spin axis and the sensor boresight." This latter information is useful in deciding whether and how to use the property in your application, but it is necessarily somewhat sketchy, since the help is mainly intended to provide guidance on programming issues. However, in the STK Help System, there is generally more information. For example, the help page for “Spinning Sensor Pointing” not only gives more detailed context information but also includes a drawing of spin axis geometry that illustrates the spin axis cone angle quite clearly.

> **TIP**: For real-world context information on the Object Model types that you use in your application, do not rely solely on the brief definitions in the Object Model help. Refer also to the STK Help System.

Starting Visual Studio and creating your project

You will use two STK X controls for this tutorial. To add these controls and to use the STK Object Model, you must add the following COM references to your project:

- STK Objects – a COM Library containing types, interfaces, events and classes representing various aspects of the STK application structure.
- STK Util – a library containing objects and enumerations shared by the STK Objects and STK X type libraries.
- STK X – a collection of COM components and ActiveX controls that use STK Engine technology.

Here are the steps to set up your project and add the necessary references:

1. Start Visual Studio and click on TFileT and then New TProjectT.
2. Under the TInstalledT templates, navigate to Templates, select either Visual Basic or C#, then in the Windows page choose TWindows Forms ApplicationT. Configure the rest of your project settings as you see fit. In this tutorial, CoverageTutorialT is used as the project name.
3. Once your new project has loaded, open the Solution Explorer in the View tab, right-click on the project name, and then select Properties.
4. Click on the Build tab in the properties panel if using C#. Go to the Compile tab for Visual Basic
5. For C#, in the **Platform target** field, select “x64”, and then close the properties panel. For Visual Basic, in the **Target CPU** field, select “x64”, and then close the properties panel.

Adding references

1. In the Solution Explorer window on the top right of the screen, right-click References and select Add Reference…

2. In the popup Reference Manager window, select the Browse tab on the left and then click the Browse… button on the bottom right of the window.

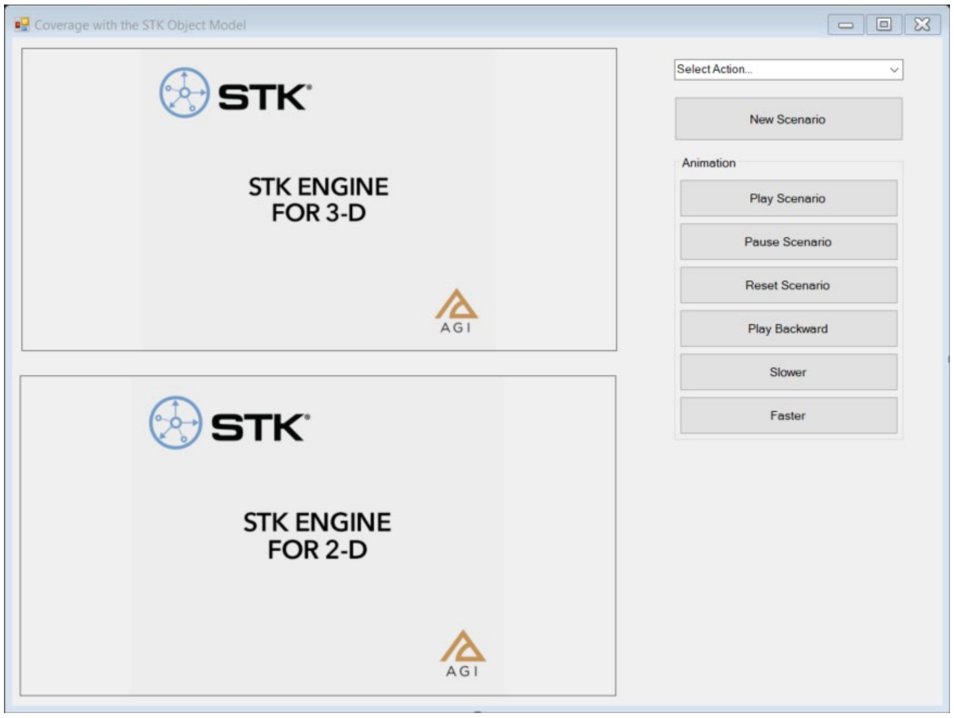
3. A File Explorer window will open. Navigate to the same directory as earlier, “C:\Program Files\AGI\STK_ODTK 13\bin\Primary Interop Assemblies”, and Ctrl + click to add AGI.STKObjects.Interop.dll, AGI.STKUtil.Interop.dll, AGISTKVgt.Interop.dll, and AGI.STKX.Interop.dll.

4. Click Add to close the File Explorer and then click OK to close the Reference Manager window. You should now see these DLLs listed under References.

5. Select the AGI.STKX.Interop reference, and then in the Properties window, change Embed Interop Types to “False”.

Add STK X controls to your form

Before you begin writing Object Model code, use the design view in Visual Studio to draw the user interface for your custom application. When you are finished, the GUI you create will look something like this:



The application that you create allows the user to:

- Create a Scenario and display it in 2D and 3D windows.

- Control the animation of the scenario.
- Select various actions from a combo box: define a coverage region, compute coverage, select a figure of merit and display the quality of coverage graphically in the 2D and 3D windows.

Here are the steps to create the GUI:

1. Display the automatically-generated TForm1T in design view and stretch the form so that it is approximately square and substantially fills the available workspace (with Visual Studio maximized). Display its properties page and change the TText Tproperty from “Form1” to “Coverage with the STK Object Model”.
2. If the Toolbox is not already displayed, select it from the **View** menu.
3. Right click inside the toolbox's General section and select "Choose Items..." from the context menu.
4. On the ".NET Framework Components" tab, click the browse button and browse to the following location: <STK Install Folder>/bin/Primary Interop Assemblies.
5. Select the AGI.STKX.Controls.Interop.dll and click the Open button.
6. Click the OK button. The controls are now ready to be drag and dropped onto your Windows form.
7. From the Form1T design view, find AxAgUiAxVOCntrlI in the Toolbox, and draw a rectangular shape in the upper left region of your form. Do the same thing with the AxAgUiAx2DCntrl in the lower left region of the form.
8. Place a ComboBox in the upper right corner of the form.
9. Display the properties page for the ComboBox, change its Text property to "Select Action…". Afterwards, set the Enabled property to False – the code in the .txt file will enable this after a new scenario is created.
10. Place a button below the ComboBox and change its Text property to "New Scenario".
11. Place a GroupBox below the "New Scenario" button and stretch it so that it will accommodate 6 buttons, arranged vertically. Change its Text property to "Animation".
12. Arrange 6 buttons vertically in the GroupBox. Set the Enabled property for all of the buttons to False. Starting with the top button and working down, set the Text properties of the buttons to:
    - Play Scenario
    - Pause Scenario

- Reset Scenario
- Play Backward
- Slower
- Faster

This completes the artistic part of this exercise. Now, on to coding with the Object Model.

Setting the scene for the coverage analysis

Add the Core of the STK Object Model to your project

Refer to OM_CoverageTutorial.txt for the code segments to be added in this section.

Begin by adding statements at the beginning of the code (*using* in C#, *Imports* in VB.NET) to gain access to the types defined in the STK Objects and STK Util libraries.

Next, define and initialize an instance of AgStkObjectRoot, the top level object in the Object Model hierarchy, which exposes a set of methods and properties that you will find indispensable in implementing the Object Model in your application. To name just 3 examples, this class includes the following methods:

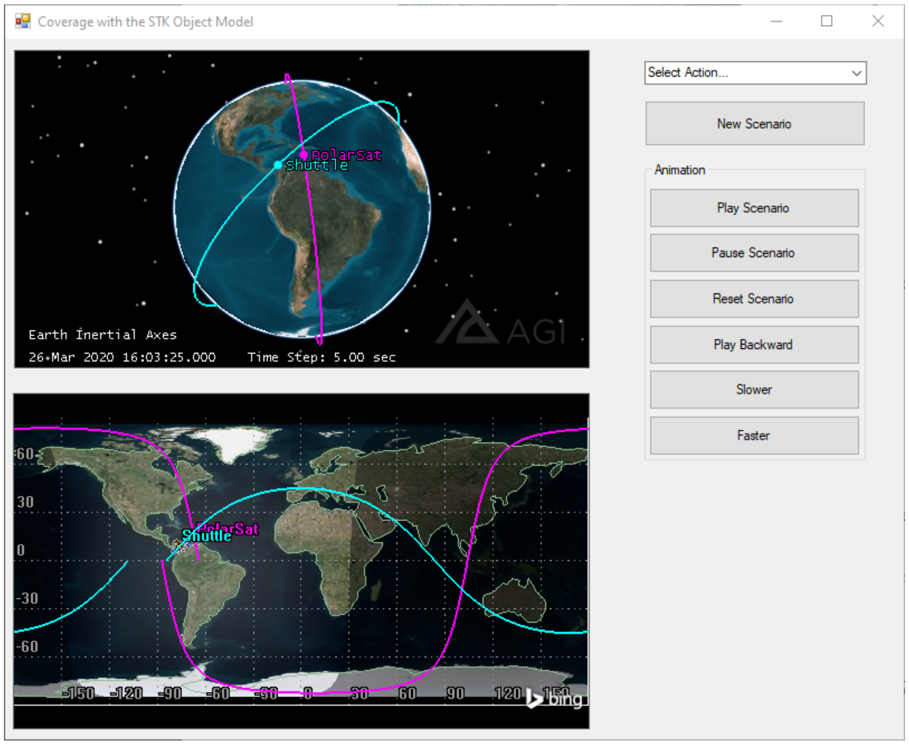
- NewScenario(): creates a new STK scenario.
- LoadScenario(): loads a scenario file on a specified path.
- ExecuteCommand(): takes a string representing a Connect command as an argument and executes the command.

Finally, add the OnFormClosing method to close STK Object root properly, as indicated in OM_CoverageTutorial.txt.

Creating and populating a scenario

Referring to OM_CoverageTutorial.txt, add a function to create a new scenario to the main body of the Form1 class and populate it with two satellites. Then add a call to that function to the Click event for button you created.

At this point you should be able to build and run your application. Click the button to display the 3D Globe and 2D Map:



More detailed discussion of the interfaces, methods and properties made available by the Object Model for creating and configuring satellites can be found in *STK Tutorial Using the Object Model*.

Animating the scenario

Add the appropriate method of the AgStkObjectRoot object to the appropriate Click method of each of the animation buttons that you drew on Form1:

TButton text	TCode in Click methodT
Play Scenario	root.PlayForward()
Pause Scenario	root.Pause()
Reset Scenario	root.Rewind()
Play Backward	root.PlayBackward()
Slower	root.Slower()
Faster	root.Faster()

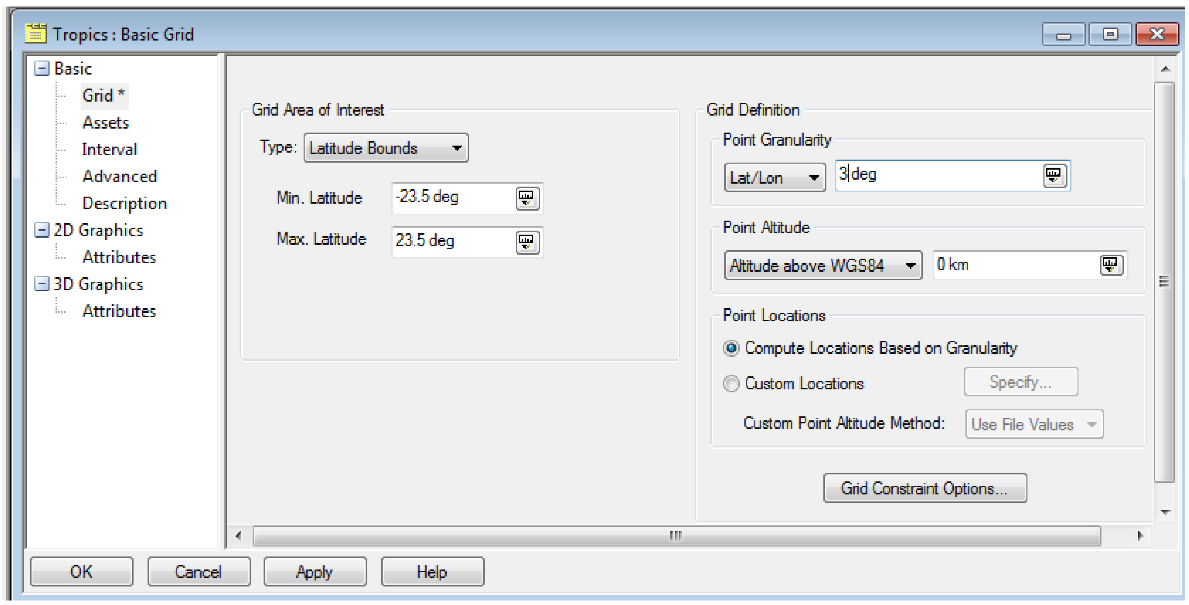
If you are coding in C#, of course, you need to add a semicolon (;) to each of those method statements.

Build and run the application, create a scenario, experiment with the animation controls, and observe the results in your 2D and 3D displays.

Coverage with the Object Model

Creating a Coverage Definition

In the STK application GUI, a coverage grid is defined using the coverage definition's Basic - Grid page. Here, for example, using Latitude Bounds, a grid is defined to cover a tropical region (between 23.5 deg north and south of the Equator), with a resolution of 3 deg between grid points:



Type: Latitude Bounds
Min. Latitude: -23.5 deg
Max. Latitude: 23.5 deg
Point Granularity: Lat/Lon 3 deg
Point Altitude: Altitude above WGS84 0 km
[✓ Compute Locations Based on Granularity] Custom Locations
Custom Point Altitude Method: Use File Values

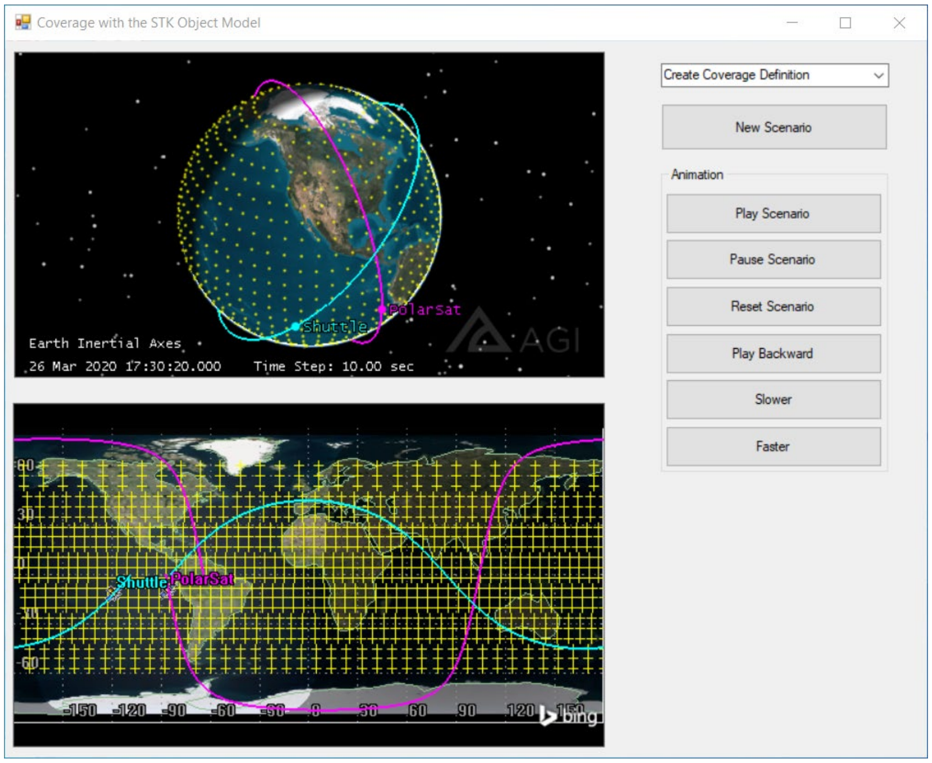
In this exercise we have broken the process of creating a coverage definition, defining its bounds and setting its resolution into three methods, so that we can see the effect of each separately.

Referring to OM_CoverageTutorial.txt, the coverage definition is created with a single line of code, invoking the New method of the IAgStkObjectCollection interface, which takes as arguments an enumeration member representing the class of the new object (in this case AgESTKObjectType.eCoverageDefinition) and an instance name ("Tropics"). The Children property is used to indicate that the new object is a child of the current scenario.

A variable representing the coverage definition needs to be added to the Form1 class, where it will be available for use by other methods in that class. At this juncture, you will also add (to the Form1 class constructor) the code needed to populate the combo box. Finally, you will add to the SelectedIndexChanged method of the combo box a call to the CreateCovDef() method.

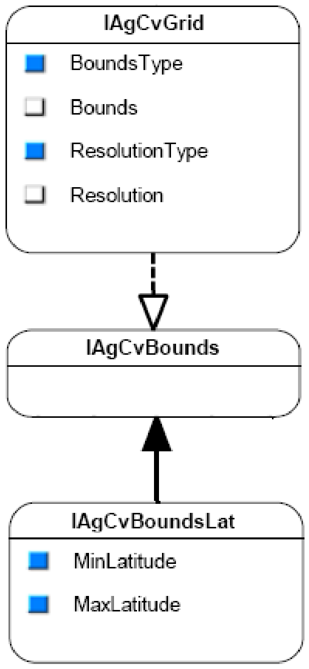
> NOTE: The SelectedIndexChanged() method includes calls to the BeginUpdate() and EndUpdate() methods of the AgStkObjectRoot class. The BeginUpdate() method suspends graphic updates, which helps speed up processing of a block of code. The graphic updates are then carried out in a batch when you invoke EndUpdate().

Now build and run the application, create a scenario, and select Create Coverage Definition from the combo box:



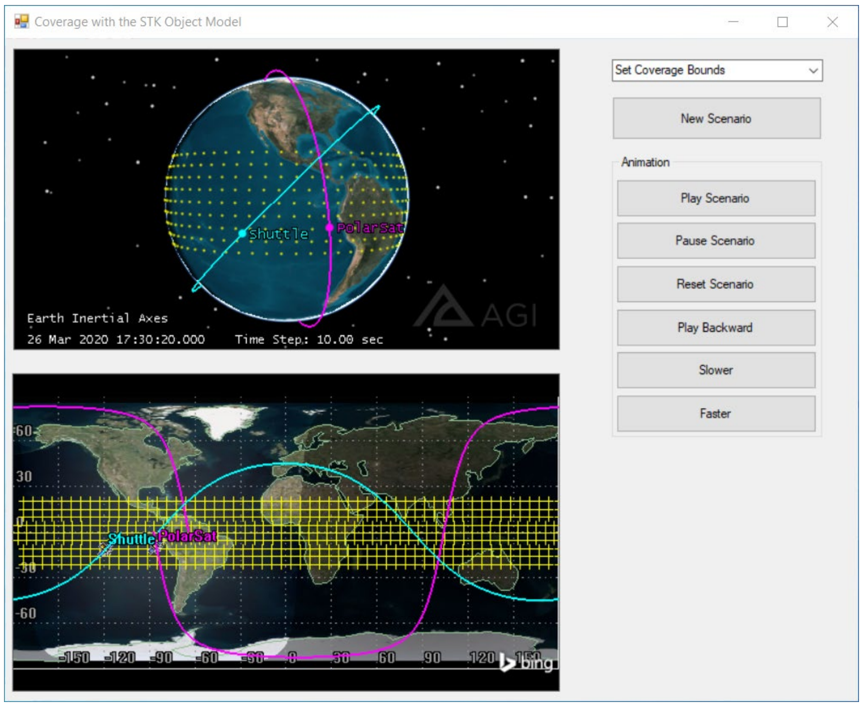
Setting coverage bounds

The CoverageBounds() method gets the reference to the IAgCvGrid interface from the coverage definition's Grid property, then it configures the IAgCvBoundsLat interface of the Bounds property of IAgCvGrid. Latitude bounds are then set using the MaxLatitude and MinLatitude properties of IAgCvBoundsLat.



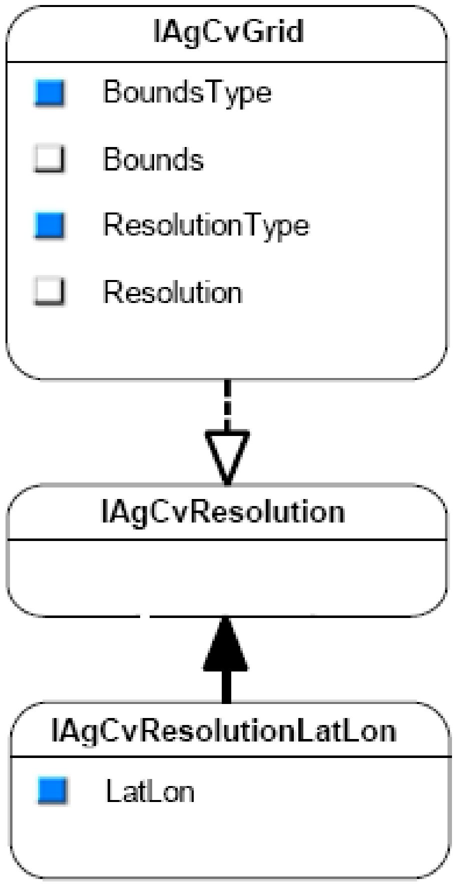
Again, add a variable to the Form1 class and update the SelectedIndexChanged() method.

Now build and run the application, create a scenario, and select Create Coverage Definition and Set Coverage Bounds from the combo box:



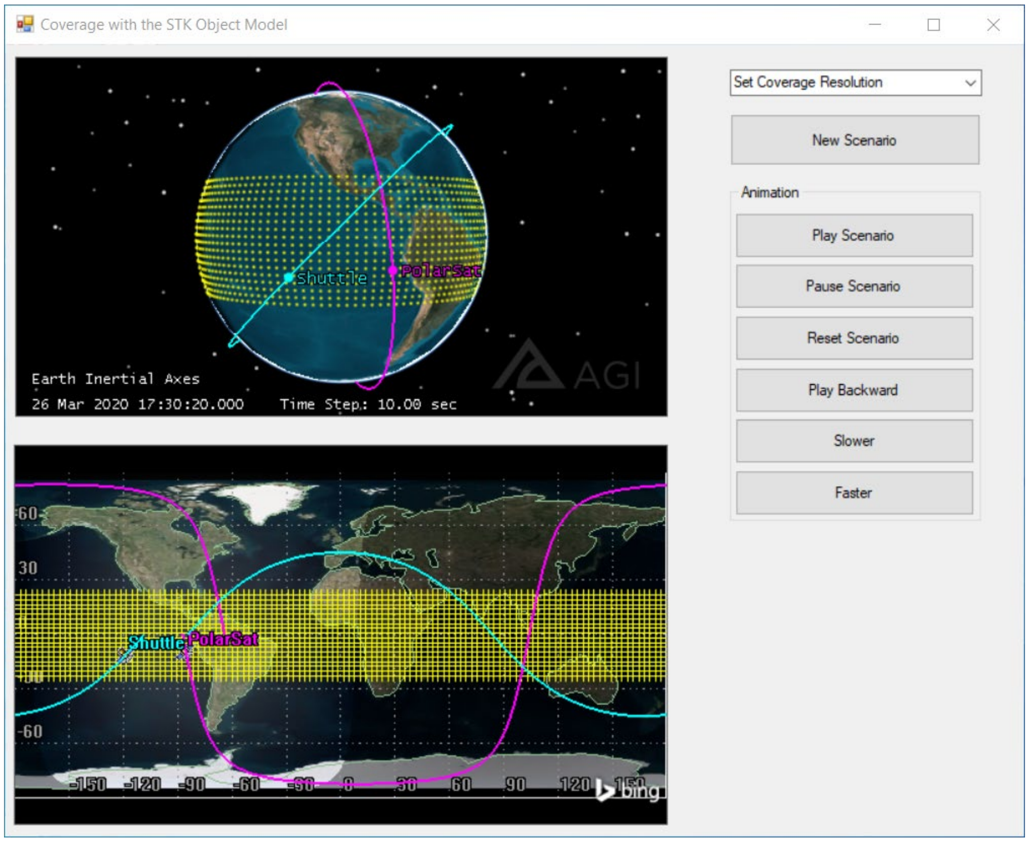
Setting coverage resolution

The CoverageResolution() method uses only one interface, IAgCvResolutionLatLon, which is initialized to the Resolution property of the IAgCvGrid instance that was introduced with our CoverageBounds() method. (This is why you had to declare the variable representing that instance at the Form1 level.)



Using the LatLon property of IAgCvResolutionLatLon, set the resolution to 3 deg.

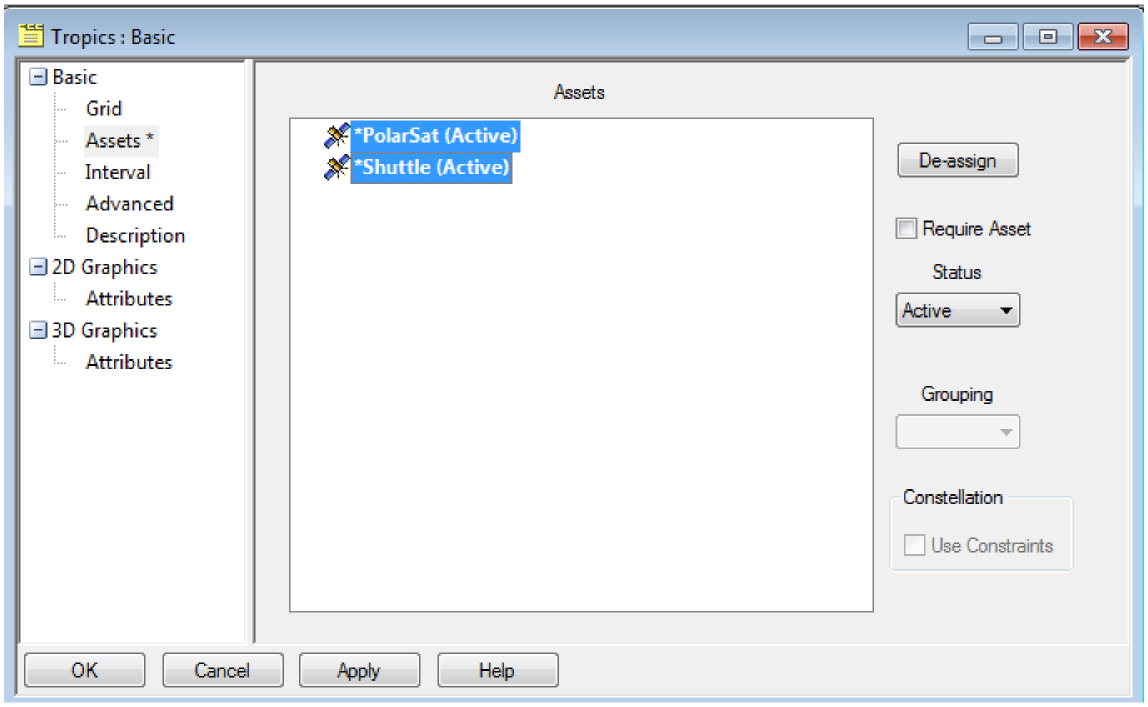
After updating the SelectedIndexChanged() method, build and run the scenario, and select Create Coverage Definition, Set Coverage Bounds and Set Coverage Resolution from the combo box:



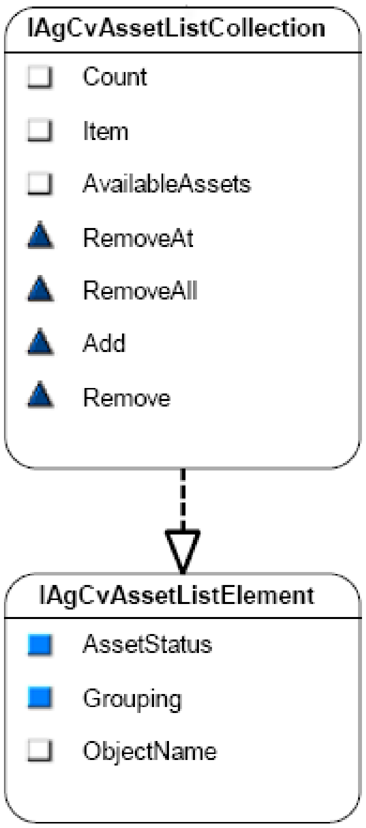
Computing coverage

The ComputeCoverage() method carries out the actual computation of coverage in a single line, but that line is preceded by code to assign the coverage assets and configure graphics properties.

In the STK application GUI, the coverage definition's Basic – Assets page lets you assign the coverage assets (in this case, the two satellites) and set their Status (active or inactive), among other things:

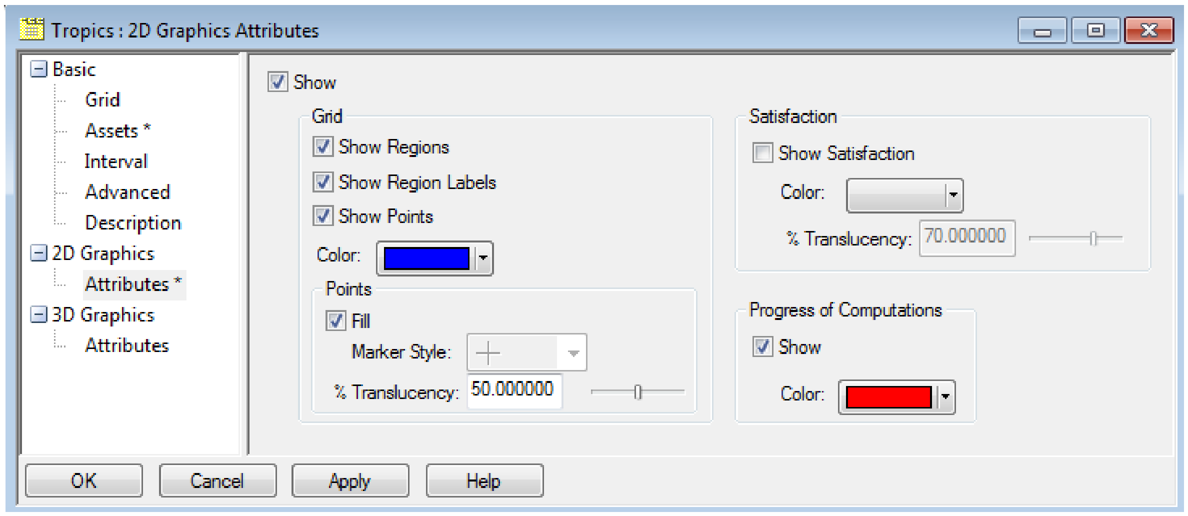


In the Object Model, the above assignment uses the IAgCvAssetListCollection interface, which is retrieved from the coverage definition's AssetList property.



Using the Add method of the IAgCvAssetListCollection interface, the two satellites are added by passing their object paths. The Add method returns an IAgCvAssetListElement interface; in the tutorial we set the AssetStatus to active.

To set 2D graphics properties of the coverage definition in the STK application GUI, use its 2D Graphics – Attributes page:



[✓] Show

Grid
- [✓] Show Regions
- [✓] Show Region Labels
- [✓] Show Points
- Color: 🟦

Points
- [✓] Fill
- Marker Style: +
- % Translucency: 50.000000

Satisfaction
- [ ] Show Satisfaction
- Color:
- % Translucency: 70.000000

Progress of Computations
- [✓] Show
- Color: 🟥

The options selected here:

- Display the boundary of each coverage region in the 2D Graphics window, together with its name.

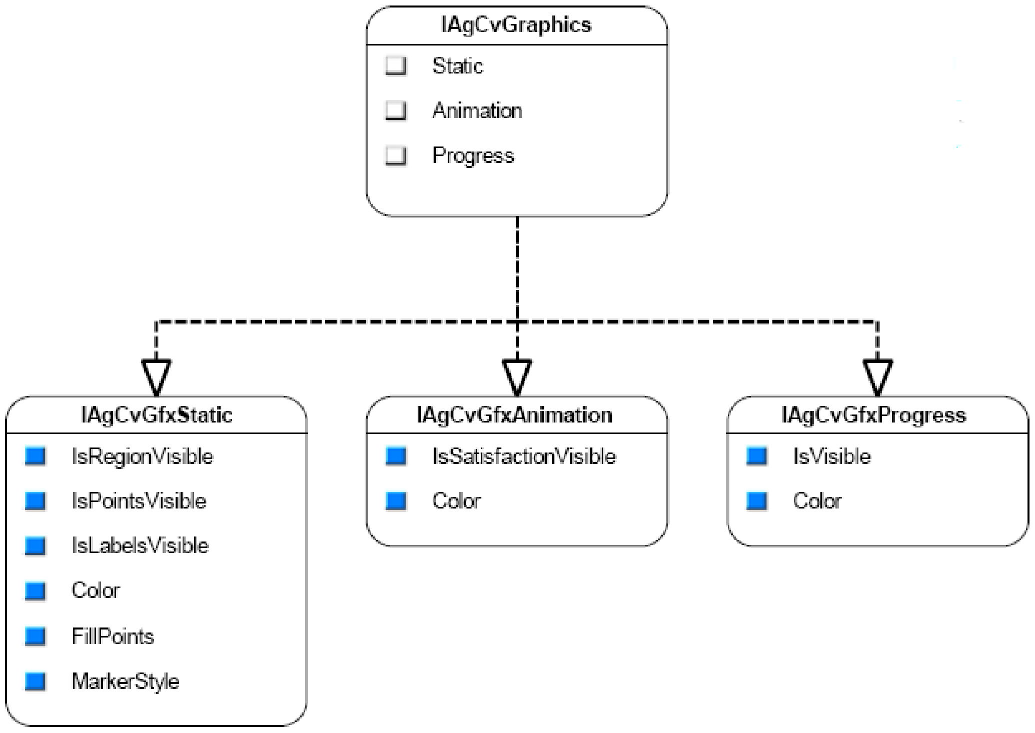
- Show each grid point as coverage computations are completed.

- Display coverage regions and points as filled polygons.

- Highlight grid regions and points as accesses are being computed.

- Disable satisfaction graphics.

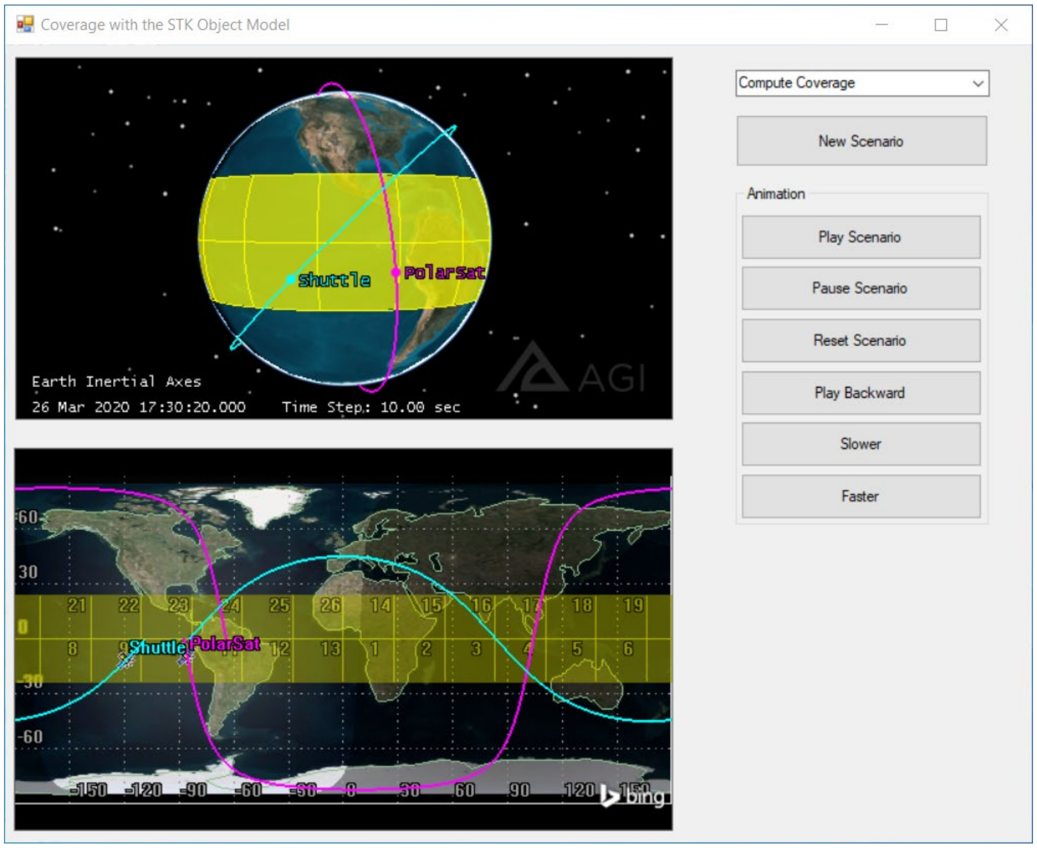
The Object Model provides a hierarchy of interfaces under the coverage definition's Graphics property to let you make the above settings:



- The IAgCvGfxStatic interface lets you set the region, label, point and fill display options.
- The IAgCvGfxProgress interface lets you set the options related to progress of computations.
- The IAgCvGfxAnimation interface lets you configure satisfaction graphics.

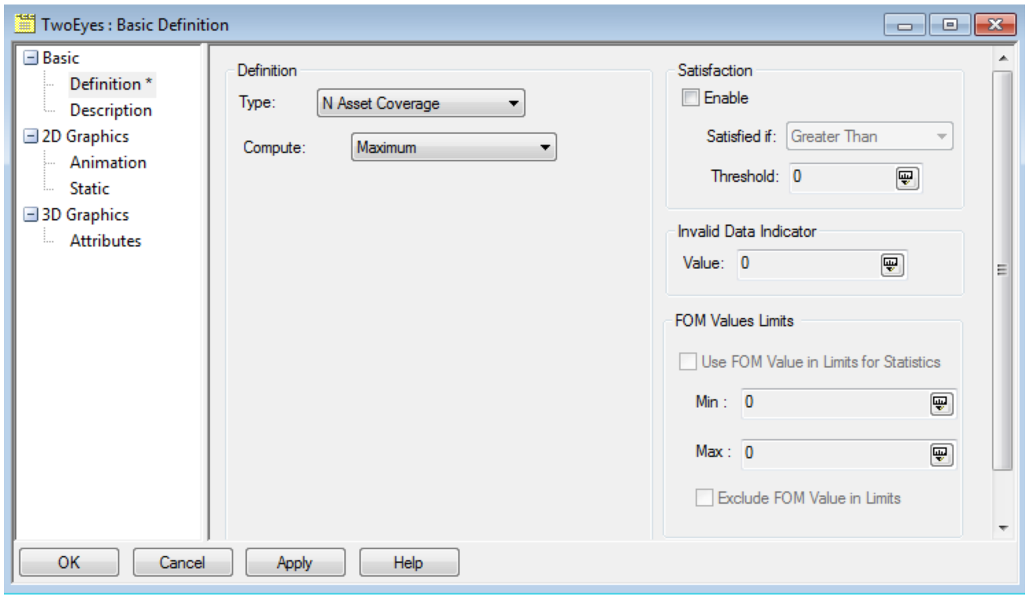
After these settings are made, invoke the coverage definition's ComputeAccesses() method, corresponding to the Compute Accesses option in the coverage definition's tools menu in the GUI.

After updating the SelectedIndexChanged() method, build and run the application, then select Create Coverage Definition, Set Coverage Bounds, Set Coverage Resolution and Compute Coverage from the combo box:



Defining the Figure of Merit

In the STK application GUI, after creating a figure of merit object as a child of the coverage definition object, you can use its Basic – Definition page to select the type of figure of merit you want and to set its Compute option:



Definition

Type: N Asset Coverage

Compute: Maximum

Satisfaction

Enable

Satisfied if: Greater Than

Threshold: 0

Invalid Data Indicator

Value: 0

FOM Values Limits

Use FOM Value in Limits for Statistics

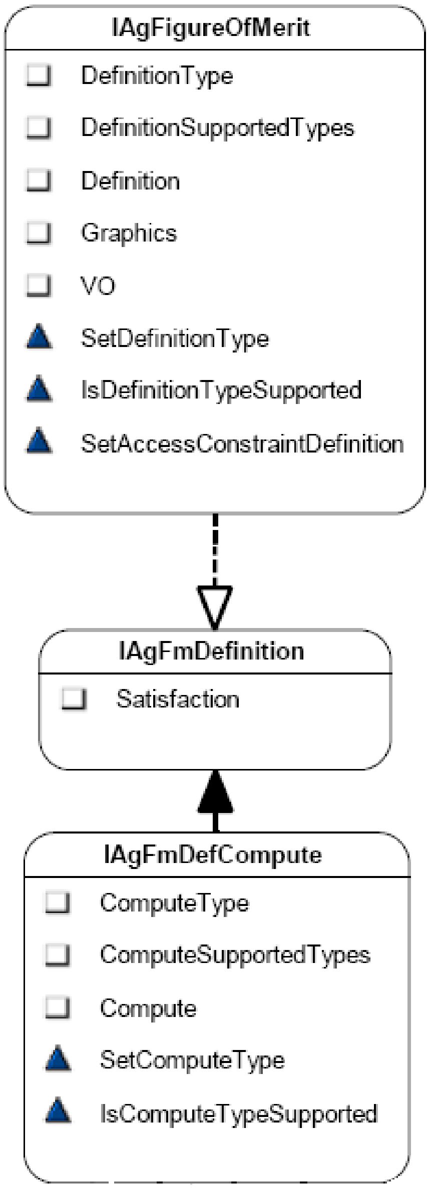
Min : 0

Max : 0

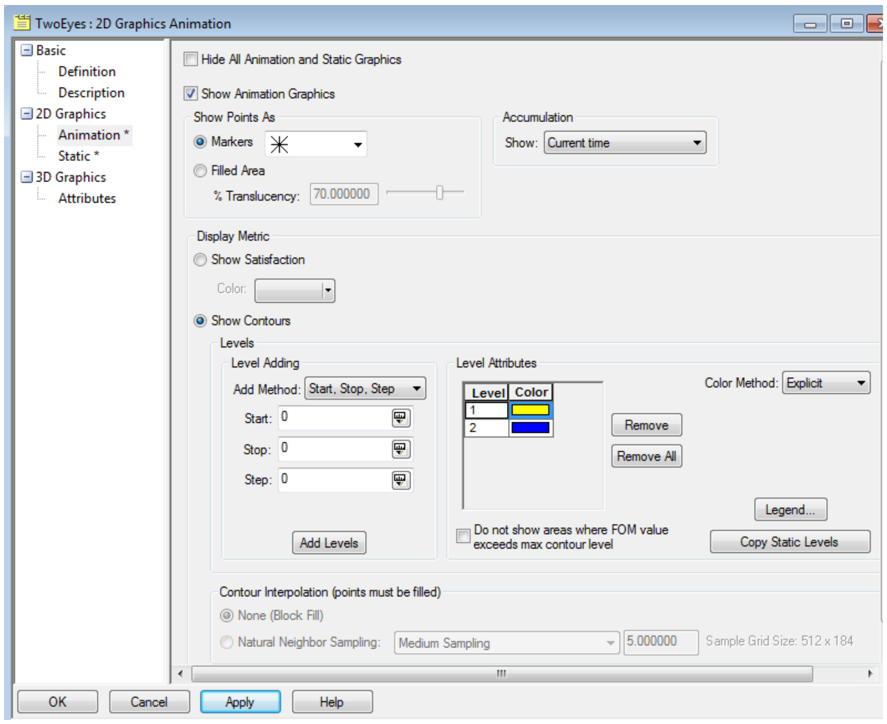
Exclude FOM Value in Limits

Here N Asset Coverage is selected, which measures the number of assets available simultaneously during coverage, with the Maximum Compute option; i.e., the maximum number of assets available over the entire coverage interval.

In the Object model, the figure of merit object provides a SetDefinitionType() method for selecting the type of figure of merit, and an interface available via its Definition property lets you set the compute type:



In the STK application GUI, to configure the display of the figure of merit in the 2D Graphics window, use its 2D Graphics – Animation and Static pages:



TwoEyes : 2D Graphics Animation

[ ] Hide All Animation and Static Graphics

[✓] Show Animation Graphics

Show Points As

[● Markers] ✳

○ Filled Area

% Translucency: 70.000000

Accumulation

Show: Current time

Display Metric

○ Show Satisfaction

Color:

[● Show Contours]

Levels

Level Adding

Add Method: Start, Stop, Step

Start: 0

Stop: 0

Step: 0

Level Attributes

Color Method: Explicit

Level	Color
1	🟨
2	🟦

[ ] Do not show areas where FOM value exceeds max contour level

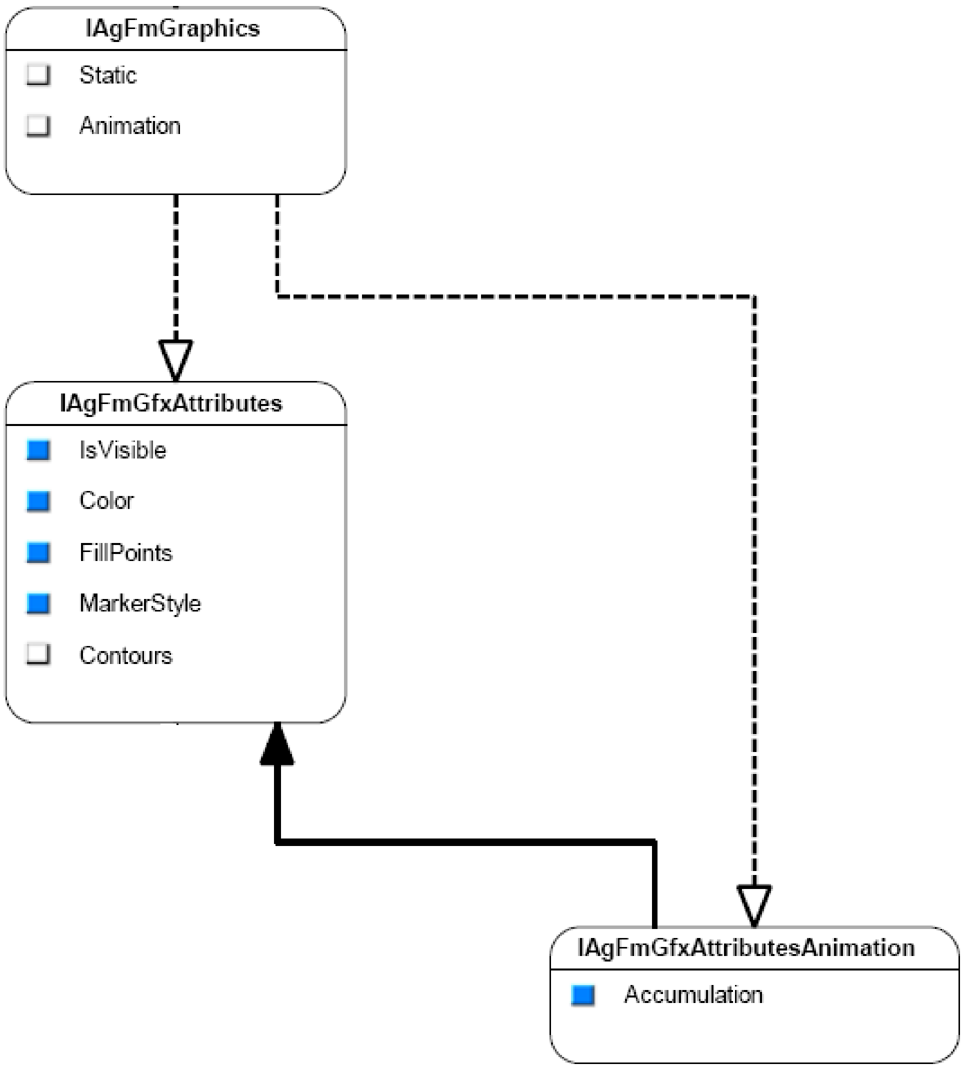
Contour Interpolation (points must be filled)

[● None (Block Fill)]

○ Natural Neighbor Sampling: Medium Sampling 5.000000 Sample Grid Size: 512 x 184

Among other things, options were selected to use markers instead of fill for static and animation graphics, and use Current Time as the Accumulation option; i.e., when animating, only grid points that currently meet the satisfaction criterion are highlighted.

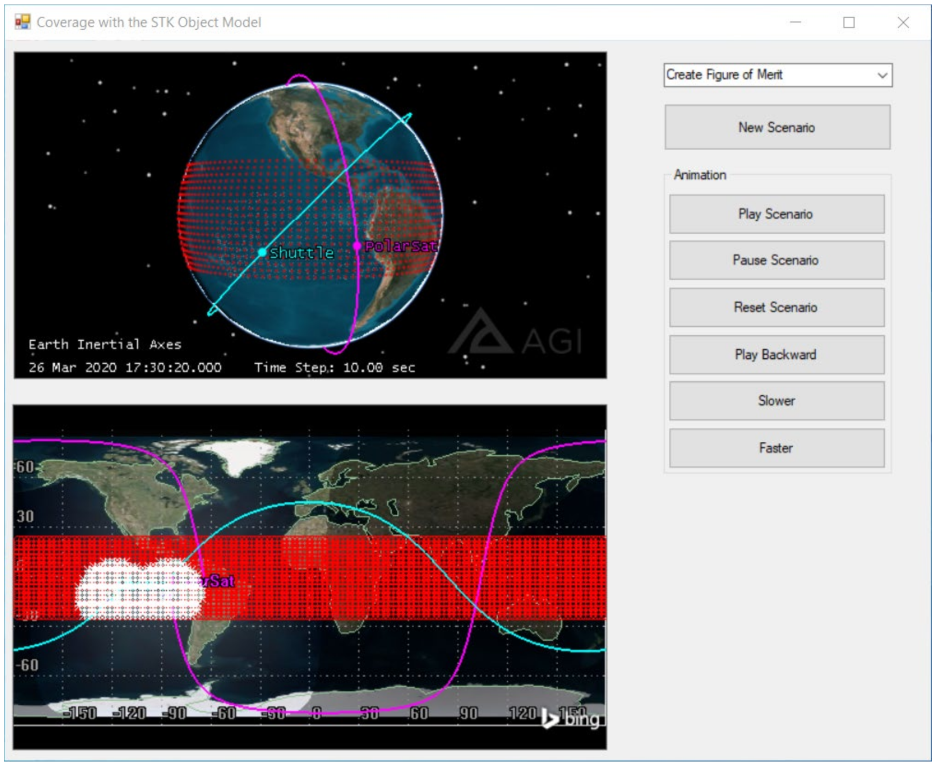
In the Object Model, most of the above settings are made using the IAgFmGfxAttributes interface, which is instantiated first to the Static then to the Animation property of the IAgFmGraphics interface:



A separate interface is provided for setting the Accumulation option.

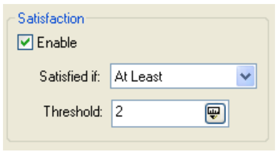
The method you have created to define the figure of merit for this tutorial also includes code to turn off static graphics for the coverage definition.

After updating the SelectedIndexChanged() method, build and run the application, then select Create Coverage Definition, Set Coverage Bounds, Set Coverage Resolution, Compute Coverage and Create Figure of Merit from the combo box:



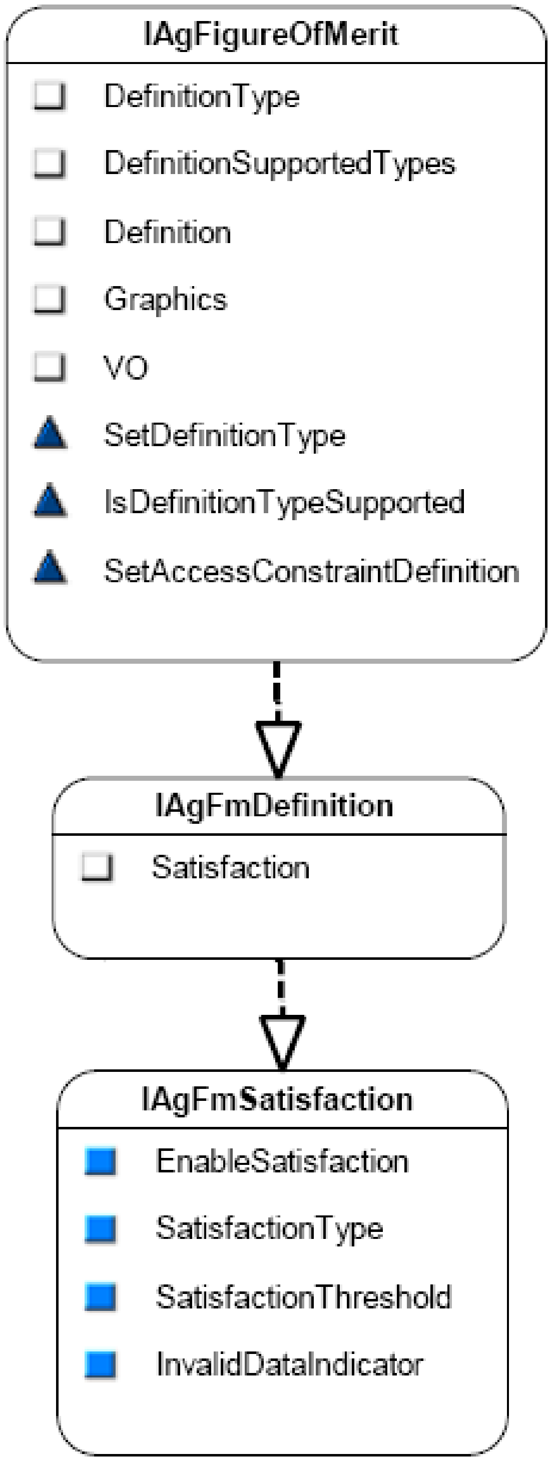
Setting the satisfaction criteria

Defining satisfaction criteria is handled in the STK application GUI using Satisfaction options on the figure of merit's Basic – Definition page:

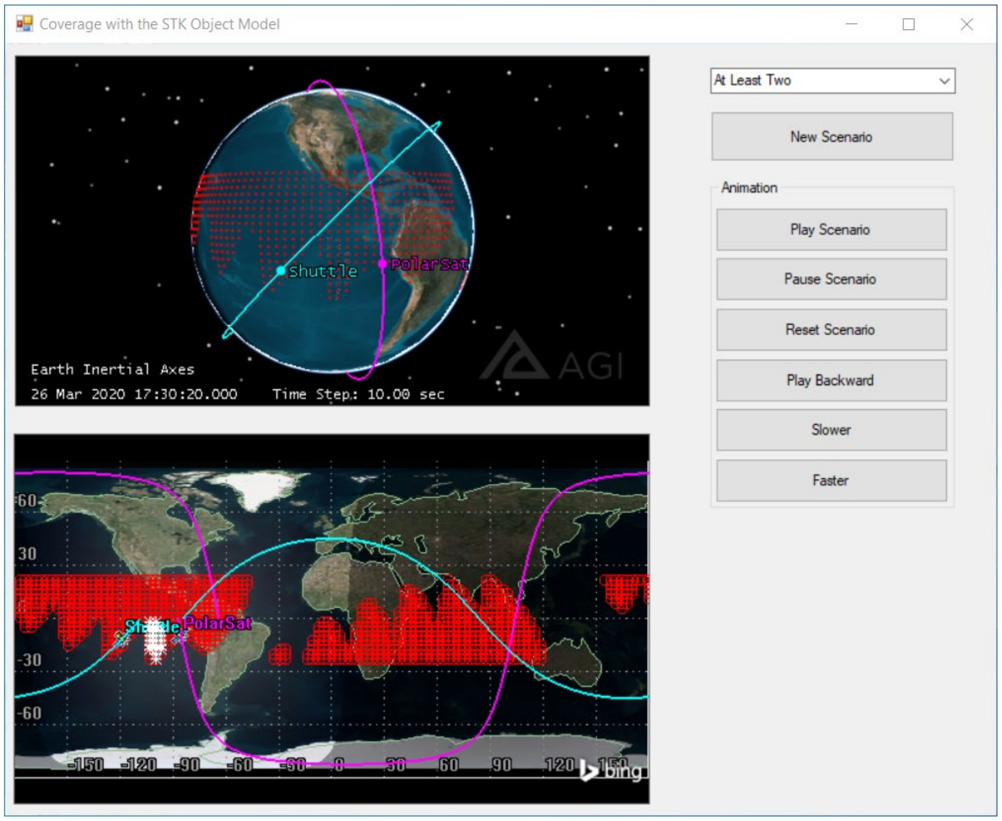

Satisfaction
☑ Enable
Satisfied if: At Least
Threshold: 2

Here we are requiring that at least two assets (satellites) have access to a given grid point.

In the Object Model, satisfaction criteria are set using the IAgFmSatisfaction interface, made available by the figure of merit's Definition property via the IAgFmDefinition interface:

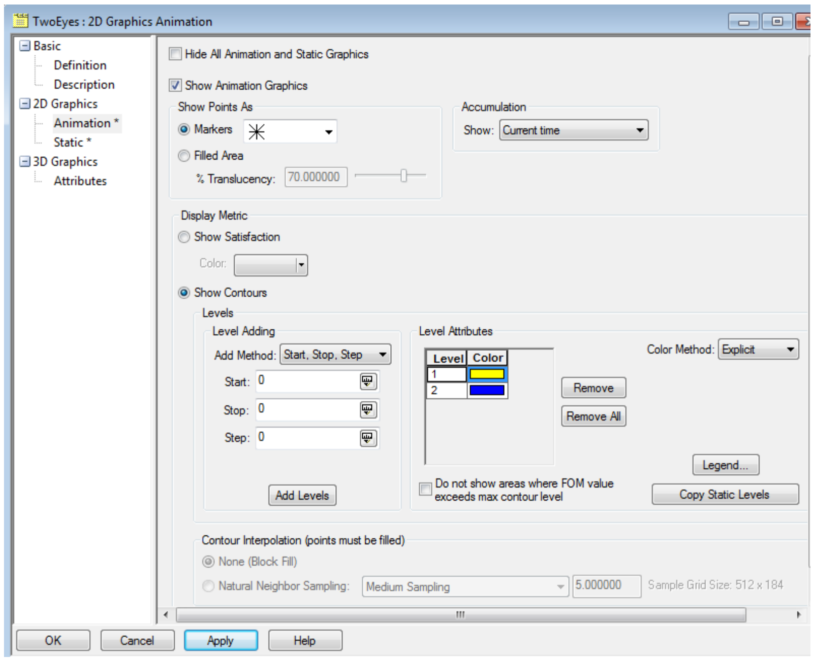


After updating the SelectedIndexChanged() method, build and run the scenario, then select Create Coverage Definition, Set Coverage Bounds, Set Coverage Resolution, Compute Coverage, Create Figure of Merit and At Least Two from the combo box:



Displaying coverage contours

In the STK application GUI, to set up animation contours to show the degree of satisfaction of the figure of merit (by one or both assets) dynamically, use its 2D Graphics – Animation page:


TwoEyes : 2D Graphics Animation

- Basic
  - Definition
  - Description
- 2D Graphics
  - Animation *
  - Static *
- 3D Graphics
  - Attributes

Hide All Animation and Static Graphics: ☐

Show Animation Graphics: ✓

Show Points As: [✓ Markers] Filled Area

% Translucency: 70.000000

Accumulation — Show: Current time

Display Metric: Show Satisfaction [✓ Show Contours]

Color:

Levels

Level Adding — Add Method: Start, Stop, Step

Start: 0

Stop: 0

Step: 0

Add Levels

Level Attributes — Color Method: Explicit

Level	Color
1	🟨
2	🟦

Remove

Remove All

Legend...

Do not show areas where FOM value exceeds max contour level: ☐

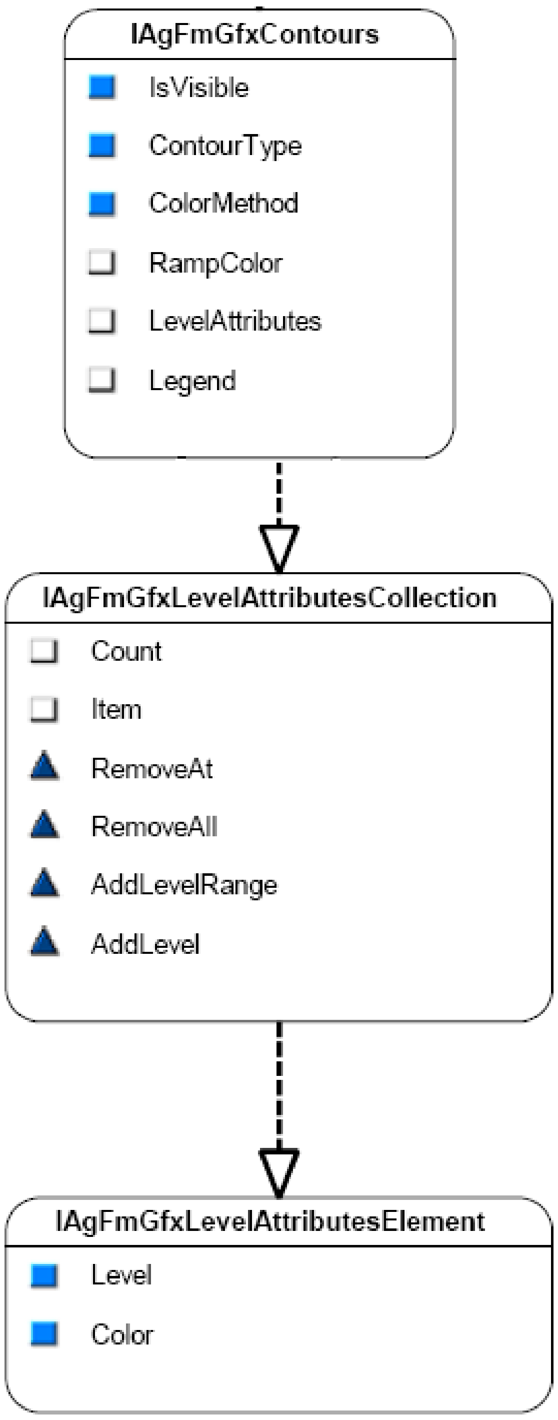
Copy Static Levels

Contour Interpolation (points must be filled): [✓ None (Block Fill)] Natural Neighbor Sampling: Medium Sampling 5.000000 Sample Grid Size: 512 x 184

OK Cancel Apply Help

Here we have opted to show animation contours and have used the Explicit color method to assign a color to each level of satisfaction of the figure of merit (by one or both satellites).

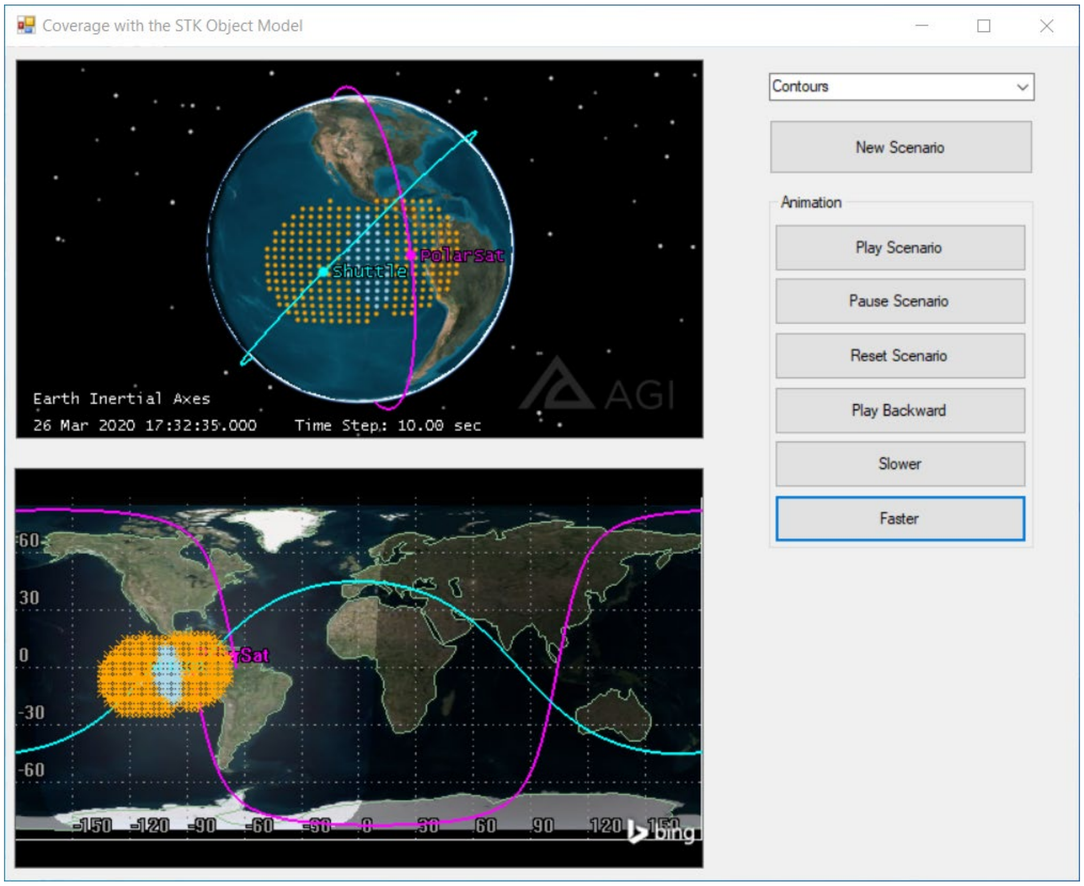
In the Object Model, use the IAgFmGfxContours interface and two interfaces that it makes available to set the above options:



The IAgFmGfxContours interface is available via the Contours property of the IAgFmGfxAttributes interface

The method used in this tutorial to set up animation contours first turns off the figure of merit's static graphics, then leverages the above interfaces to turn on animation contours, add two contour levels and assign a color to each.

After updating the SelectedIndexChanged() method, build and run the scenario, then select Create Coverage Definition, Set Coverage Bounds, Set Coverage Resolution, Compute Coverage, Create Figure of Merit, At Least Two and Contours from the combo box. Then animate the scenario and watch the changing graphics display in the 2D and 3D windows:


Coverage with the STK Object Model
Contours
New Scenario
Animation
Play Scenario
Pause Scenario
Reset Scenario
Play Backward
Slower
Faster
PolarSat
Shuttle
Earth Inertial Axes
26 Mar 2020 17:32:35.000
Time Step: 10.00 sec
AGI
bing