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Performing Synthetic Radar Analysis using a Spacecraft

Note: The results of the tutorial may vary depending on the user settings and data enabled (online operations, terrain server, dynamic Earth data, etc.). It is acceptable to have different results.

Required Product Licenses: STK Professional, Radar
You can obtain the necessary license for the training by visiting http://licensing.agi.com/stk/evaluation or calling AGI support.

Problem Statement

You are conducting an exercise testing a Spotlight Synthetic Aperture Radar (SAR) system over a ground site. An experimental satellite containing a radar package is flying at around 800 km over the ground site. You are also testing whether or not the radar jammer at the ground station can jam the SAR.

Solution

Use the Orbit Wizard to create a specific satellite orbit. Then build a monostatic SAR and create a custom graph to determine if you can image the ground site area. Next, build a radar jamming system at the ground site and use a custom report to determine if the ground radar can jam the SAR.

Create a New Scenario

Create a new scenario with a run time of one (1) hour.

1. Launch STK ( ).
2. Click the Create a Scenario ( ) button.
3. Enter the following in the STK: New Scenario Wizard:

Option	Value
Name:	SAR_Jamming
Start:	Default Start Time
Stop:	Default End Time

4. When you finish, click OK .
5. When the scenario loads, click Save ( ). A folder with the same name as your scenario is created for you.
6. In the Save As window, verify the scenario name and location and click Save .

> **Note:** Save Often!

Disable Terrain

For this scenario, you are not concerned about the impact terrain has on the analysis, so disable the terrain server.

1. Right-click on SAR_Jamming ( ) and select Properties ( ).
2. Select the Basic - Terrain page.
3. Disable the "Use terrain server for analysis" option.
4. Click Apply.

Radar Cross Section

Prior to setting up and constraining a radar system, STK Radar allows you to specify an important property of a potential radar target – the **Radar Cross Section** (RCS).

Since you'll only have one object that uses an RCS, you can set the properties at the scenario level. If you had multiple objects requiring different RCSs, you could insert the RCS at the individual object level.

1. Select the RF - Radar Cross Section page.
2. Take a look at the default RCS properties.
3. Click OK .

RCS values can be expressed in decibels referenced to a square meter (dBsm). STK can use **External Radar Files**, but you don't have an External file for this scenario. You can just use a constant value of zero (0) dBsm.

Target ground site

The target is located in a central location inside the training area. .

1. Insert a Place ( ) object into the scenario using the Define Properties ( ) method.
2. Select the Basic - Position page.
3. Set the following:

Option	Value
Latitude:	33.334 deg
Longitude:	44.3978 deg

4. Click OK .

5. Rename the object Enemy.

Create a SAR satellite

Let's take a moment to build the satellite. You know the inclination is 53 degrees and the altitude is 800 km.

1. Insert a satellite () using the Orbit Wizard () method.

2. Set the following options in the Orbit Wizard:

Option	Value
Type	Circular
Name	SARSat
Inclination	53 deg
Altitude	800 km

3. Click OK .

Servomotor

The radar object's antenna can be boresighted. However, in STK, if you have an antenna that can track another object, use a sensor object as the servomotor.

1. Insert a sensor () object using the Insert Default () method.

2. Select SARSat () as the Attach Object.

3. Click OK .

4. Rename the sensor SARServo.

Define Servomotor

1. Open SARServo's ( ) properties ( ).

2. Select the Basic - Definition page.

3. Set the Sensor Type to Rectangular.

4. Set the Vertical Half Angle to 0.75 deg.

5. Set the Horizontal Half Angle to 7.5 deg.

6. Click Apply.

Target the Ground Site

1. Select the Basic - Pointing page.

2. Set the Pointing Type to Targeted.

3. Move ( ) Enemy ( ) to the Assigned Targets list.

4. Click OK .

Model the Radar

You can use a single beam for this analysis. The radar object is a child object of the servomotor you just built.

1. Insert a Radar ( ) object using the Insert Default ( ) method.
2. Select SARServo ( ) as the Attach Object.
3. Click OK .
4. Rename the radar SAR_Radar.

Define the Radar

1. Open SAR_Radar's ( ) properties ( ).
2. Select the Basic - Definition page.
3. Set the Type to Monostatic.
4. Set the Mode Type to SAR.
5. Click Apply .

Define the Radar Mode

1. Click the Pulse Definition tab.
2. Set the Unambiguous Range to 800 km.
3. Set the Range Resolution to eight (8) meters.
4. Click Apply .

Define the Antenna

1. Click the Antenna tab.
2. Set the Type to Uniform Aperture Rectangular.
3. Set the X dimension to 1.5 meters.
4. Set the Y dimension to 15 meters.
5. Click Apply .

Define the Transmitter

1. Click the Transmitter tab.
2. Enable the Frequency option.
3. Change the Frequency to 5.3 GHz.
4. Click Apply .

Analyze the Radar

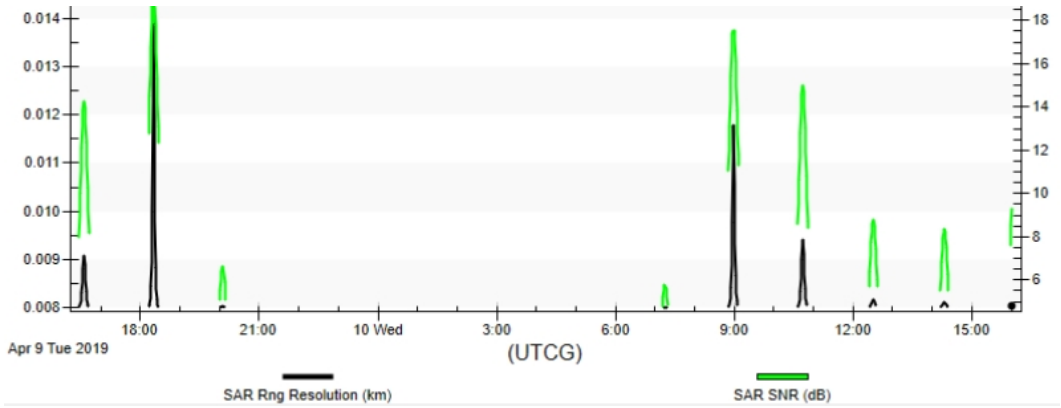
How well does the radar image the ground area?

1. Right-click on SAR_Radar ( ) in the Object Browser.
2. Select Access ( ) to open the Access tool.
3. Select Enemy ( ) in the Associated Objects list.
4. Click Compute .

Create a Custom Graph

For your analysis, you are interested in the contents of two reports, SAR SNR (Signal-to-noise) and Range Resolution. By creating a custom graph that contains these contents, you can quickly determine the effectiveness of the radar.

1. Click the Report & Graph Manager... button.
2. Select the MyStyles directory.
3. Click the Create new graph style ( ) button.
4. Name the graph Range Resolution and SNR.
5. Click Enter on the keyboard to bring the graph properties to the front.
6. Expand (⊞) Radar SAR.
7. Move ( ) SAR Range Resolution to the Y Axis window.
8. Move ( ) SAR SNR to the Y2 axis.
9. Click OK .
10. Generate the graph.



You are looking for an SNR greater than zero. It's a given that as distance increases, your SNR decreases. You can set the animation time by right-clicking on the graph and selecting Set the Animation Time. This option allows you to view a particular period within the 3D Graphics window. The radar is able to image the ground site region. Now it's time to see if you can jam the radar.

11. Close the graph.
12. Close the Report & Graph Manager.
13. Close the Access tool.

Radar Jamming

Now you are ready to simulate the ground site jamming the SAR radar with its own radar.

1. Insert a sensor () object using the Insert Default () method.
2. Select Enemy () as the Attach Object.
3. Click OK .
4. Rename the sensor GroundServo.

Define the Sensor

1. Open GroundServo's () properties ().
2. Select the Basic - Definition page.
3. Set the Sensor Cone Angle to one (1) degree.

Target the Satellite

1. Select the Basic - Pointing page.
2. Set the Pointing Type to Targeted.
3. Move ( ) SARSat ( ) to the Assigned Targets list.
4. Click OK .

Model the Radar

You can use a single beam for this analysis. The radar object is a child object of the servomotor you just built.

1. Insert a Radar ( ) object using the Insert Default ( ) method.
2. Select GroundServo ( ) as the Attach Object.
3. Click OK .
4. Rename the radar Ground_Radar.

Define the Radar

1. Open SAR_Radar's ( ) properties ( ).
2. Select the Basic - Definition page.
3. Set the Type to Monostatic.
4. Click Apply .

Build the Jammer

1. Click the Transmitter tab.
2. Enable the Frequency option.
3. Set the Frequency to 5.3 GHz.
4. Set the Power to 60 dBW.
5. Click Apply.

Jam the Radar

1. Select the Basic - Definition page.
2. Select the Jamming tab.
3. Enable the Use option.
4. Move ()the Ground_Radar () to the Assigned Jammers field.
5. Click OK .

Now you are ready to analyze Jammer's effectiveness against the surveillance radar.

Jam Effectiveness

You are interested in SAR SNR (signal-to-noise ratio) and SAR S/(N+J) (signal-to-noise + Jamming ratio). You can create a custom graph that displays these two together.

1. Right-click on SAR_Radar () in the Object Browser.
2. Select Access () to open the Access tool.

3. Select Enemy ( ) in the Associated Objects list.

4. Click the Report & Graph Manager... button.

5. Select the MyStyles directory.

6. Click the Create new graph style ( ) button.

7. Name the graph SAR Jamming.

8. Click Enter on the keyboard to bring up the graph properties.

Define the Custom SAR Jamming Graph

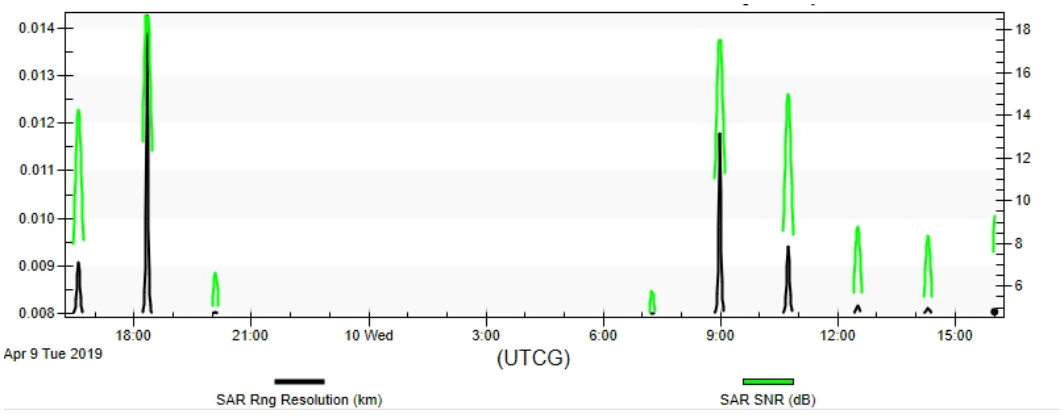
1. Expand (⊞) Radar SAR.

2. Move ( ) SAR SNR to the Y Axis window.

3. Move ( ) SAR S/(N+J) to the Y Axis window.

4. Click OK .

5. Generate the graph.



By placing the SAR SNR and SAR S(N+J) on the same axis, it's easier to read the graph and compare the results. As you can see, the jammer attached to the ground site is effectively jamming the SAR radar.