Ansys 2023 R1

Getting Started with EMIT - Tutorial 4

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Conventions Used in this Guide

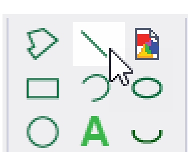
Please take a moment to review how instructions and other useful information are presented in this documentation.

- Procedures are presented as numbered lists. A single bullet indicates that the procedure has only one step.
- Bold type is used for the following:
    - Keyboard entries that should be typed in their entirety exactly as shown. For example, “**copy file1**” means you must type the word **copy**, then type a space, and then type **file1**.
    - On-screen prompts and messages, names of options and text boxes, and menu commands. Menu commands are often separated by greater than signs (>). For example, “click **HFSS** > **Excitations** > **Assign** > **Wave Port**.”
    - Labeled keys on the computer keyboard. For example, “Press **Enter**” means to press the key labeled **Enter**.
- Italic type is used for the following:
    - Emphasis.
    - The titles of publications.
    - Keyboard entries when a name or a variable must be typed in place of the words in italics. For example, “**copy** *filename*” means you must type the word **copy**, then type a space, and then type the name of the file.
- The plus sign (+) is used between keyboard keys to indicate that you should press the keys at the same time. For example, “Press Shift+F1” means to press the **Shift** key and, while holding it down, press the **F1** key also. You should always depress the modifier key or keys first (for example, Shift, Ctrl, Alt, or Ctrl+Shift), continue to hold it/them down, and then press the last key in the instruction.

Accessing Commands: *Ribbons, menu bars,* and *shortcut menus* are three methods that can be used to see what commands are available in the application.

- The *Ribbon* occupies the rectangular area at the top of the application window and contains multiple tabs. Each tab has relevant commands that are organized, grouped, and labeled. An example of a typical user interaction is as follows:

  "Click **Schematic** > **Line**"

This instruction means that you should click the **Line** command on the **Schematic** ribbon tab. An image of the command icon, or a partial view of the ribbon, is often included with the instruction.

- The *menu bar* (located above the ribbon) is a group of the main commands of an application arranged by category such File, Edit, View, Project, etc. An example of a typical user interaction is as follows:

  "On the **File** menu, click the **Open Examples** command" means you can click the **File** menu and then click **Open Examples** to launch the dialog box.

- Another alternative is to use the *shortcut menu* that appears when you click the right-mouse button. An example of a typical user interaction is as follows:

  “Right-click and select **Assign Excitation> Wave Port**” means when you click the right-mouse button with an object face selected, you can execute the excitation commands from the shortcut menu (and the corresponding sub-menus).

Getting Help: Ansys Technical Support

For information about Ansys Technical Support, go to the Ansys corporate Support website, http://www.ansys.com/Support. You can also contact your Ansys account manager in order to obtain this information.

All Ansys software files are ASCII text and can be sent conveniently by e-mail. When reporting difficulties, it is extremely helpful to include very specific information about what steps were taken or what stages the simulation reached, including software files as applicable. This allows more rapid and effective debugging.

Help Menu

To access help from the Help menu, click **Help** and select from the menu:

- **[product name] Help** - opens the contents of the help. This help includes the help for the product and its *Getting Started Guides*.
- **[product name] Scripting Help** - opens the contents of the *Scripting Guide*.
- **[product name] Getting Started Guides** - opens a topic that contains links to Getting Started Guides in the help system.

Context-Sensitive Help

To access help from the user interface, press **F1**. The help specific to the active product (design type) opens.

You can press **F1** while the cursor is pointing at a menu command or while a particular dialog box or dialog box tab is open. In this case, the help page associated with the command or open dialog box is displayed automatically.

Table of Contents

1 - Introduction

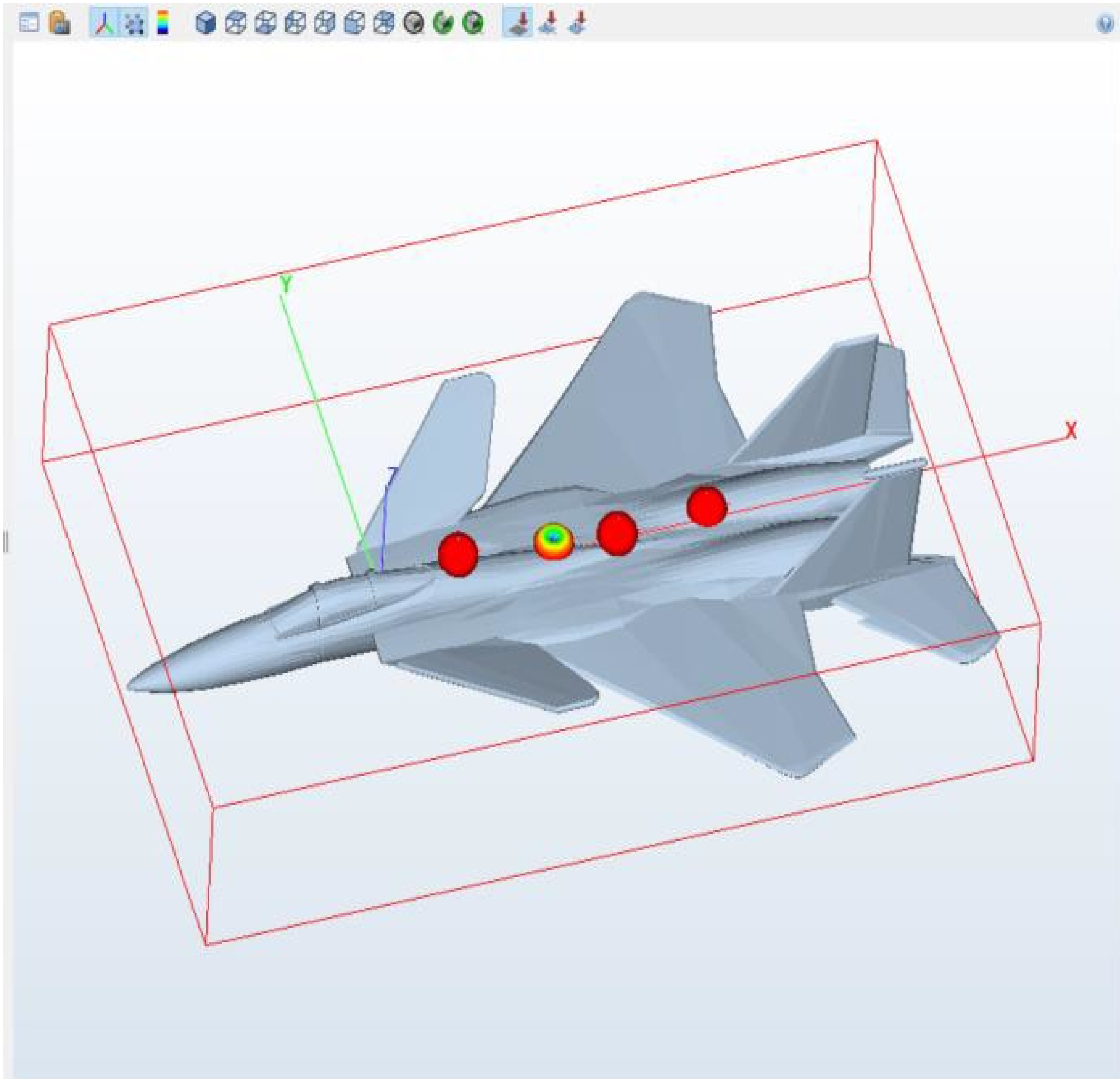
In this tutorial, we will import a geometric model of a platform and add antennas to it. We will also learn about all the antenna-to-antenna coupling models available in EMIT.

Key Concepts

- Importing and using CAD models in EMIT
- Defining antennas in EMIT
- EMIT's antenna-to-antenna (ATA) coupling models
- The Coupling Editor and Antenna Coupling Matrix

Project Configuration

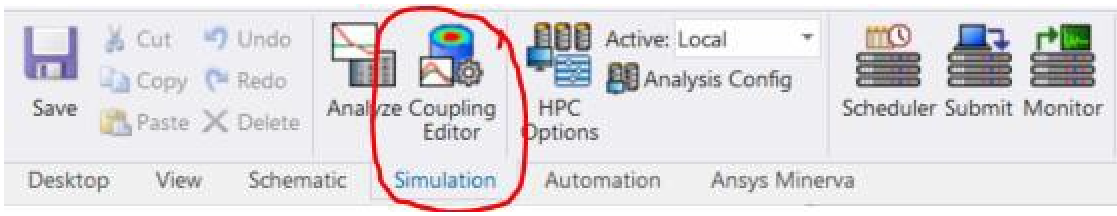
We will create a new project for this example consisting of an aircraft and four antennas and define the coupling models to be used between the antennas.


Y
X

2 - Import a CAD model into EMIT

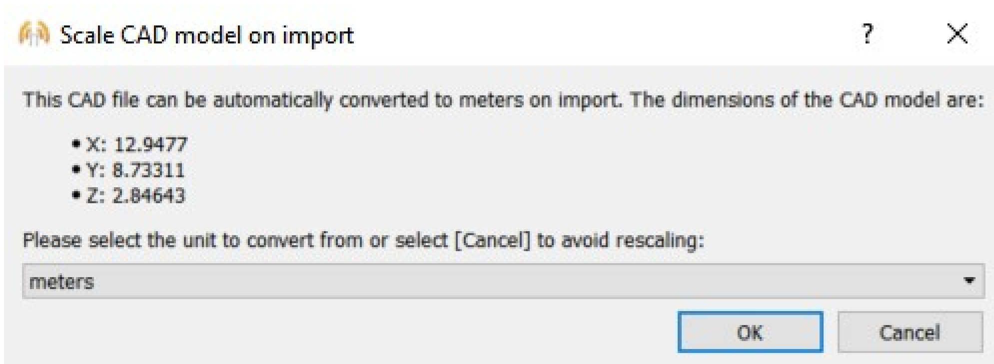
To begin, we will import a geometric representation of our platform into EMIT. EMIT supports several popular CAD File formats (*.obj, *.stl, *.msh). For this example, we will import an *.obj model.

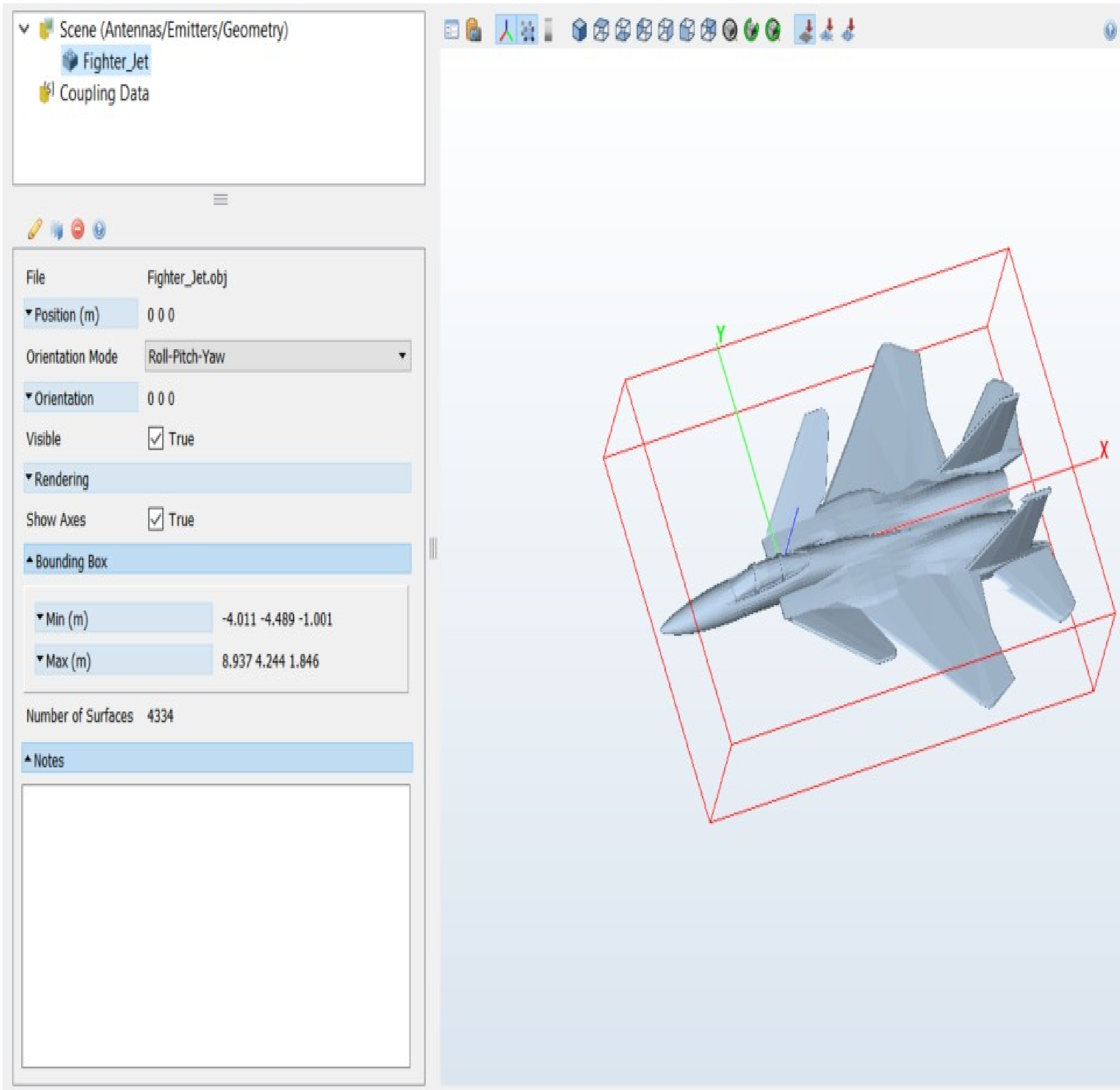
Open Ansys Electronics Desktop (AEDT) and insert an EMIT design. In the Simulation ribbon toolbar, click the **Coupling Editor** icon.



Next, right-click on the Scene (Antennas/Emitters/Geometry) node and select **Add CAD**. A file browser dialog will open. Navigate to the installed examples directory, go to the Tutorial 4 directory, and choose the file named Fighter_Jet.obj. A dialog will appear, prompting you to select the units of the CAD file.

Verify that meters are selected and press **OK**. A new CAD node named Fighter_Jet will appear under the Scene (Antennas/Emitters/Geometry) node in the Coupling Editor's tree and the model will automatically be displayed.

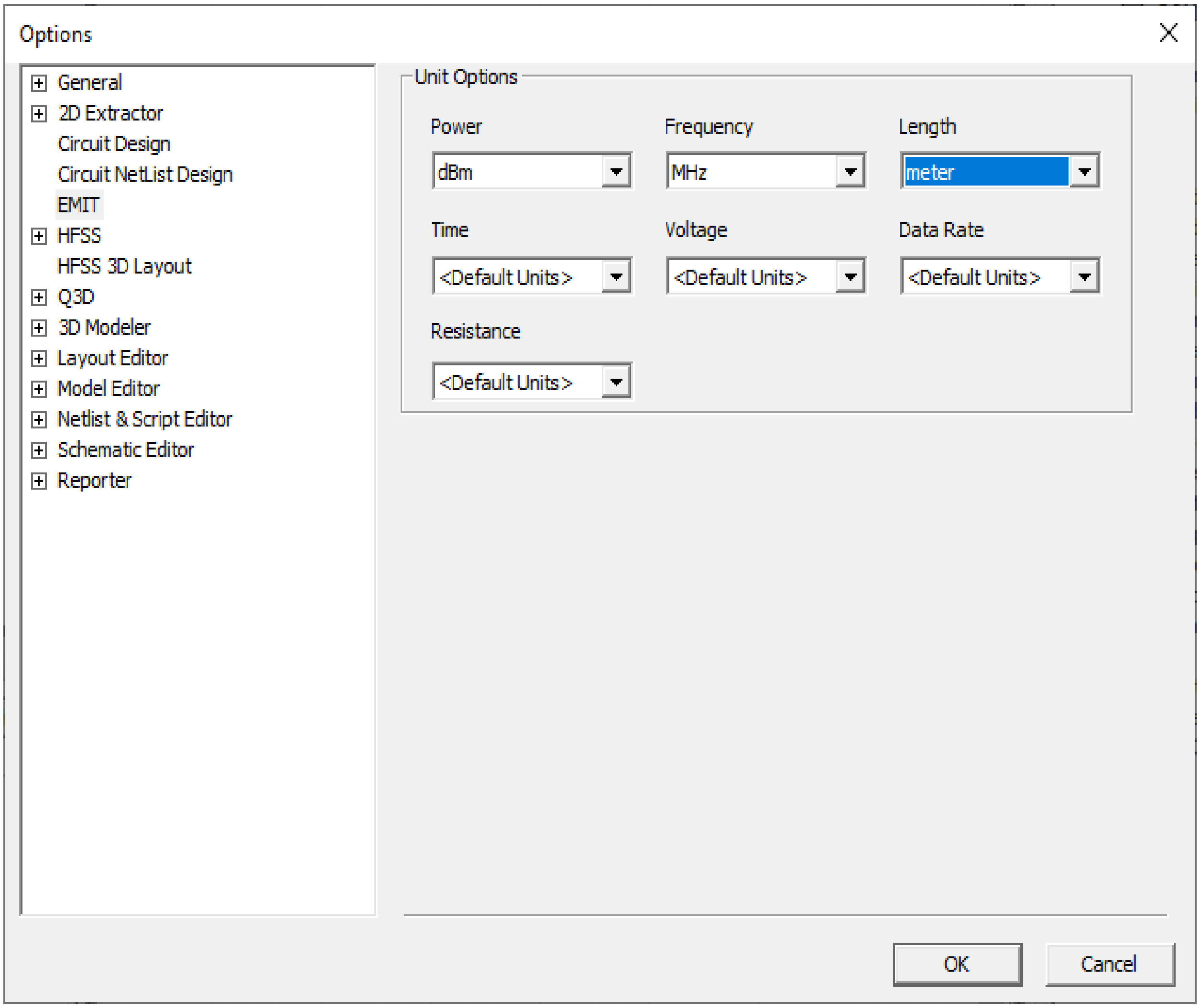




By default, the global axes and a bounding box will be displayed in the 3D window. These can be toggled on/off using the  and  icons in the 3D window toolbar. The mouse can be used for zooming, rotating, and panning within the 3D window. You can access the help for this window by clicking on the  icon in the upper right corner of the window. The help provides detailed information on the options available in the 3D window.

Press **OK** to close the Coupling Editor and then save the project as *Tutorial 4*.

Since we imported the CAD file using meters for the length units, we should also set the length units of the project to meters. In the Desktop tab of the ribbon menu, click **General Options** to open the Options dialog. Select the EMIT section, and ensure the Length units are set to meter, as shown below.

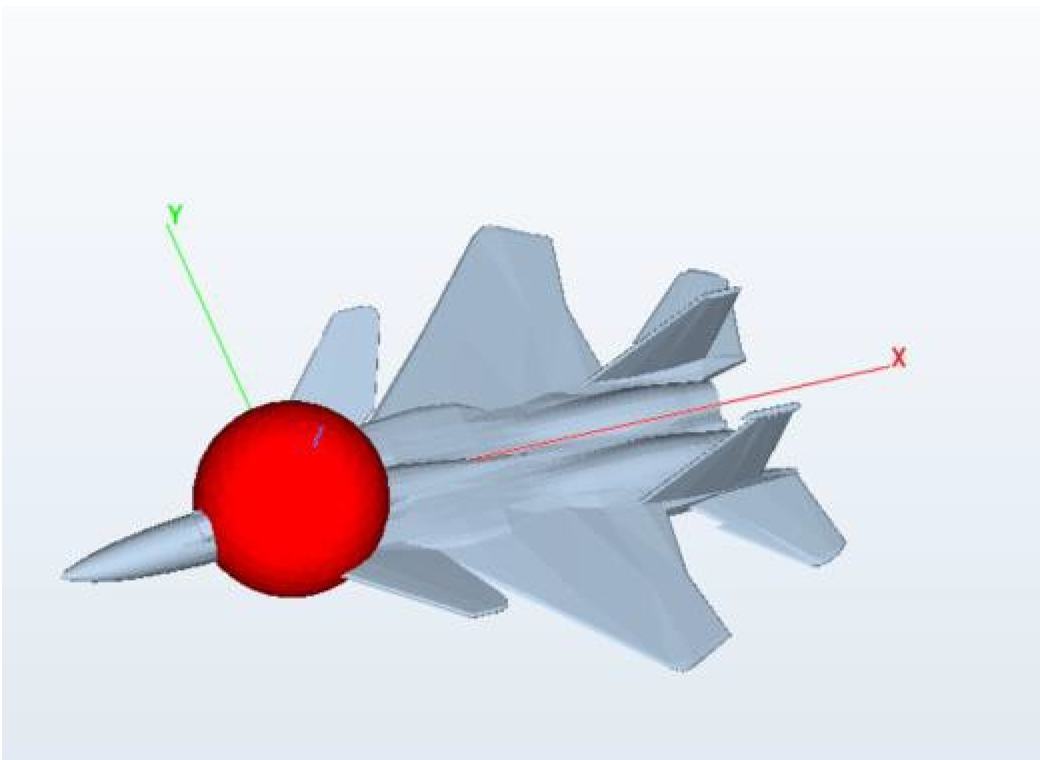


Before proceeding with antenna placement, it is appropriate to briefly discuss the role of CAD models in EMIT scenarios. CAD models are used in EMIT mainly for visualization purposes and to aid in properly positioning the antennas. As we'll see shortly, antenna patterns and scattering matrices provided to EMIT (or created using its parametric antenna models) can be used to compute the ATA coupling between antennas on a platform. However, EMIT does not implicitly consider the presence of the platform and its impact on the antenna coupling. It is assumed that the data provided to EMIT (antenna patterns and scattering matrices) have already considered the installed effects of the antenna on the platform. So, when providing antenna patterns to EMIT for example, these patterns should be for the antenna installed on the platform. The same holds for scattering matrices. While EMIT has several ATA coupling models available, EMIT is not a computational electromagnetics tool that computes installed antenna interactions. It is intended to work hand-in-hand with the data produced by the CEM tools (or measurements) available to the user. With this in mind, we will now proceed with adding antennas and defining the ATA coupling.

3 - Add Antennas to the Scenario

We will add four antennas to the scenario. If it is not open, then open the Coupling Editor by right- clicking on the design in the Project Tree and selecting **Coupling Editor**”. To add the first one, right- click on the Scene (Antennas/Emitters/Geometry) node in the Coupling Editor tree and select Add Antenna. A new antenna node will appear in the tree, but you will not see the antenna appear in the 3D window with the CAD model. This is because, by default, the antenna we create is positionless. In the antenna’s property panel, set Position Defined = true. You will now see both the aircraft and the antenna that we just added at its default location. In the picture below, the bounding box is toggled off, but the axes are being displayed.

The red, spherical object you see for the antenna is its radiation pattern. By default, all new antennas in EMIT are Isotropic radiators with a peak gain of 0 dBi. You can control the size and color of the sphere by expanding the antenna node and selecting its child Pattern node. The Size slider can then be used to grow/shrink the sphere’s size.

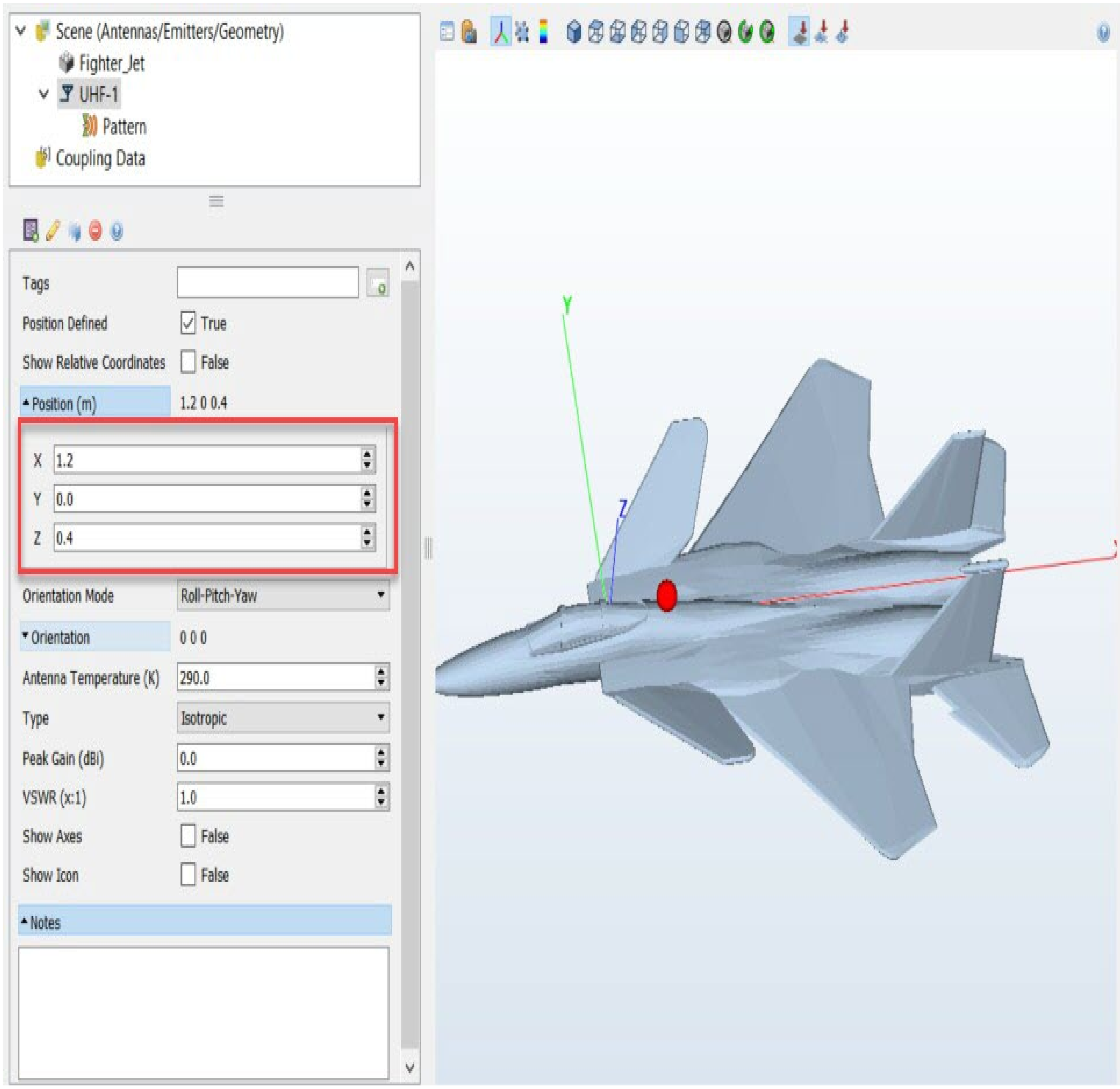


Rename the antenna from Antenna 1 to UHF-1. Antennas can be placed on the platform using EMIT’s interactive antenna placement feature. Select the node named UHF-1 in the Coupling Editor tree so that it is highlighted. Then in the 3D window, press Ctrl+left-click anywhere on the CAD model and EMIT will automatically re-locate the UHF-1 antenna to the point selected. The following icons control how the antenna will be placed:

- Place object at selected point
- Place object at selected point with its z-axis perpendicular (tangent) to the surface
- Place object at selected point with its z-axis pointing toward you

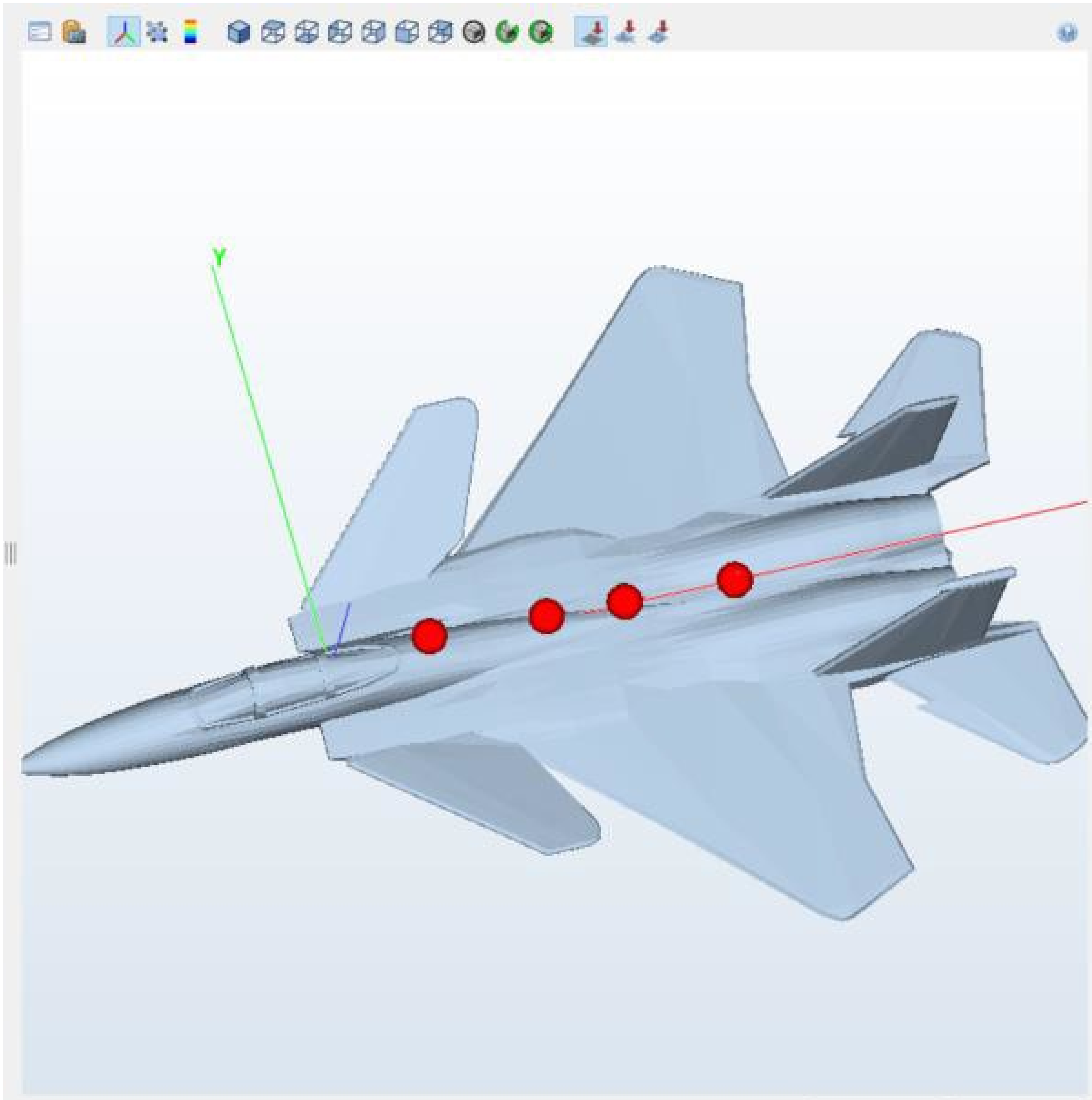
Feel free to play around with the interactive antenna placement feature some more to better explore how it works.

For this example, however, we want to place the UHF-1 in a specific location so we will manually enter the coordinates rather than placing it via the interactive antenna placement feature. To place the antenna in the desired location on the aircraft, select the UHF-1 node, and ensure **Show Relative Coordinates** is disabled. In the UHF-1 node's property panel, expand the Position folder and enter the coordinates for the antenna as shown below. When you are finished, the antenna will appear at a position on top of the aircraft's fuselage as shown.

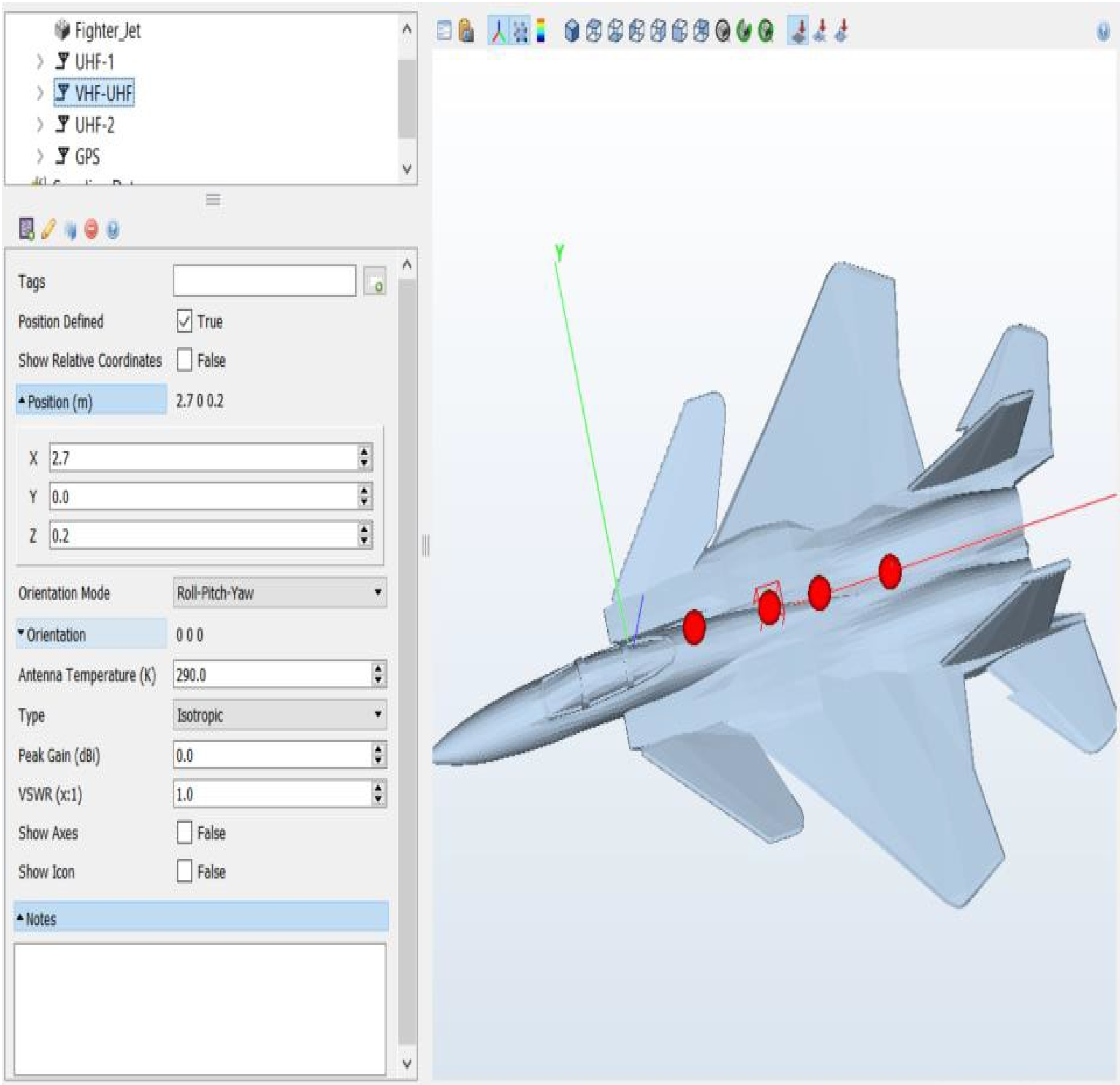


Follow the same procedure to add three more antennas to the scene, named and positioned as shown in the table below. In the Pattern node for each antenna, feel free to adjust the size and color of the antenna marker to something visually pleasing to you. In the figure below, the bounding box display has been toggled off.

Antenna Name	Location (x,y,z) in meters
VHF-UHF	(2.7, 0.0, 0.2)
UHF-2	(3.7, 0.0, 0.2)
GPS	(5.1, 0.0, 0.2)



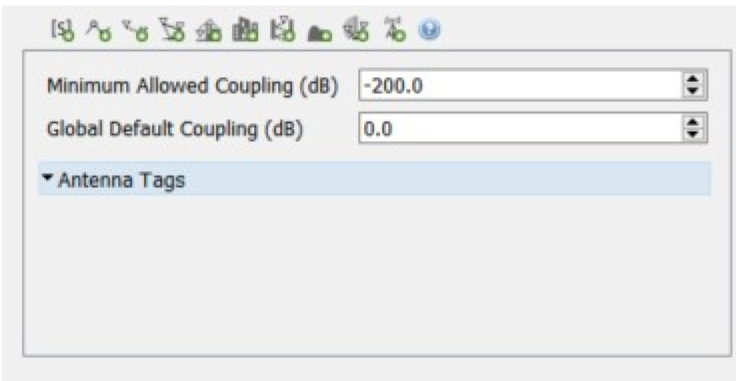
Notice that if you have the bounding box display toggled on in the 3D window, when you select an antenna in the Coupling Editor tree, a bounding box is displayed for that antenna in the 3D window as shown here with the VHF-UHF antenna (second from from) selected:



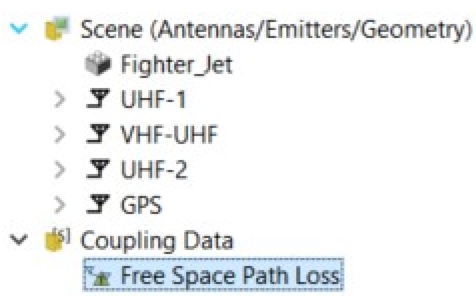
At this point we have added four antennas to our scenario, but other than their locations, we have not defined any other properties for these antennas. Before doing that we will review some of the ATA coupling models available in EMIT.

4 - Antenna-to-Antenna (ATA) Coupling Models in EMIT

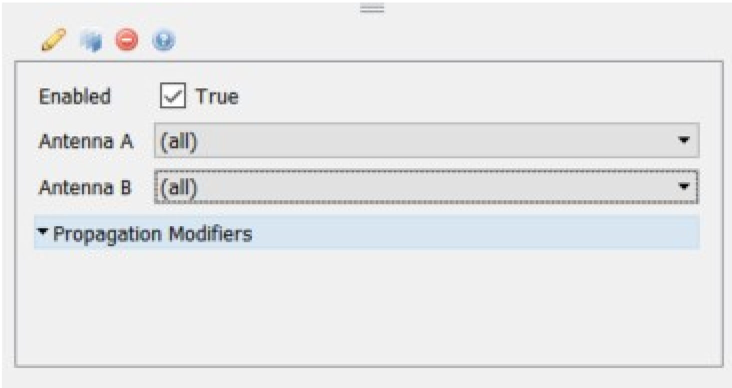
The Coupling Data node in the Coupling Editor tree manages the different types of ATA coupling models available in an EMIT project. There are ten coupling models available in EMIT. If no coupling models are added to a project, then EMIT will use the value defined by the Coupling Data node's Global Default Coupling.



By default, there are no coupling models defined and so the Global Default Coupling value will be used as the coupling between all antenna pairs. To add a coupling model, right-click on the Coupling Data node in the tree and select Add Path Loss Coupling. This will add a node below the Coupling Data node.



Note that the Coupling Model nodes will all have warnings when initially added. This is because antennas must first be assigned to the nodes. To assign antennas to the Free Space Path Loss coupling model that we just added, select that node and in the property panel select **(all)** for both Antenna A and Antenna B as shown below. This tells EMIT to use this coupling model to compute the coupling between all antenna pairs. Notice that the warning symbol on the Free Space Path Loss node in the Coupling Editor tree goes away.



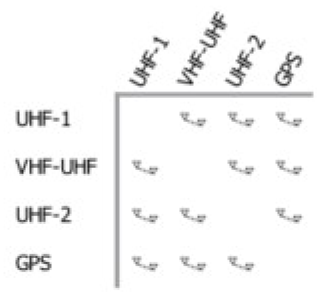
Before proceeding, take a few minutes to review the EMIT help sections on each of the coupling models available. You can find that information in EMIT's online help.

The type of coupling model that is applicable depends on the particular scenario being analyzed. Given the information provided, EMIT will choose the highest priority coupling model to use for any given pair of antennas at each frequency analyzed. The priority of the coupling models is determined by the position of each Coupling Model node in the Coupling Editor tree with the models increasing in priority as you go further down the tree. If an antenna pair's parameter definitions do not meet the requirements of a Coupling Model, a warning will be displayed for the Coupling Model node and that model will be excluded from the simulation (e.g. some models require that the antenna is placed a minimum distance above the ground plane). The checkbox beside each coupling node permits the user to control which coupling models EMIT will use. Unchecking the box means that the coupling model is disabled and EMIT will not use it for the analysis. Finally, note that each Coupling Model type can be added any number of times. This allows the specific parameters of the model (e.g. Hata) to vary between the different Hata nodes (for examole, Large City vs Rural environment).

5 - The Antenna Coupling Matrix

EMIT's Antenna Coupling Matrix provides a high-level summary of the coupling models that will be used by EMIT in the simulation for all antenna pairs. It is presented in matrix form and the icon in the matrix entries indicates the highest priority model for the antenna pair. If an antenna pair has multiple coupling models assigned to it, then the icon will appear "stacked."

To view the Antenna Coupling Matrix, select the Coupling Data node or any of the Coupling Model nodes below it. The Antenna Coupling Matrix for our current project should appear as shown below. Since the only information EMIT has about the antennas at this point are their locations, it can only compute Path Loss coupling based on the distance between the antennas. This is not necessarily a good model for the antennas mounted on this platform but it is the only one that EMIT can compute given the information provided. If EMIT does not have enough information to use a coupling model, a warning will appear on the node.



6 - Specify Additional Antenna Information and Explore Other ATA Coupling Models

Normally, if S-matrix data is available for two or more antennas, then it should be included in a project with the highest priority (i.e. positioned at the bottom of the tree under the Coupling Data node). Then, EMIT will use that data to compute the ATA coupling over the applicable frequency range and the next highest priority model for other frequency ranges. Note that if there are frequency ranges for which no Coupling Models are applicable, then EMIT will use the Global Default Coupling value for those frequencies.

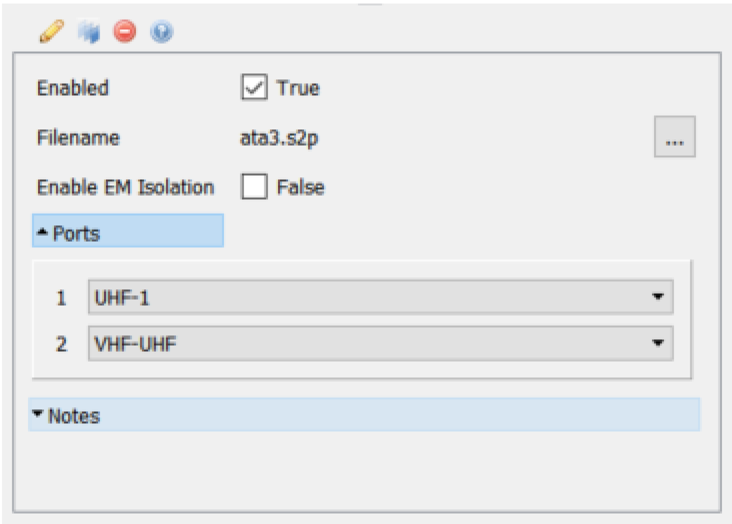
In this part of the tutorial, we will provide additional information to EMIT about the antennas to enable EMIT to utilize the various ATA coupling models available.

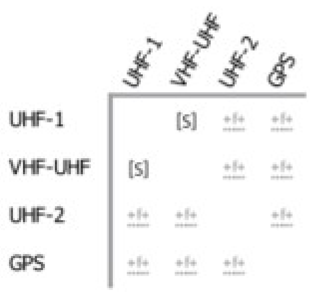
Note: in the following, all needed data files are supplied with your EMIT installation in the Examples/EMIT/Tutorials directory of the installation.

To begin, suppose that we have measured data for the ATA coupling between the UHF-1 and VHF-UHF antennas in the form of a 2-port scattering matrix. EMIT can import this data directly provided it is in the common Touchstone file format (in this example we are using a 2-port S-matrix, but EMIT places no limits on the number of ports). Right-click on the Coupling Data node in the Coupling Editor tree and select Add S-Matrix File. In the resulting file browser window, navigate to the location of the files provided for this example and select the file named ata3.s2p.

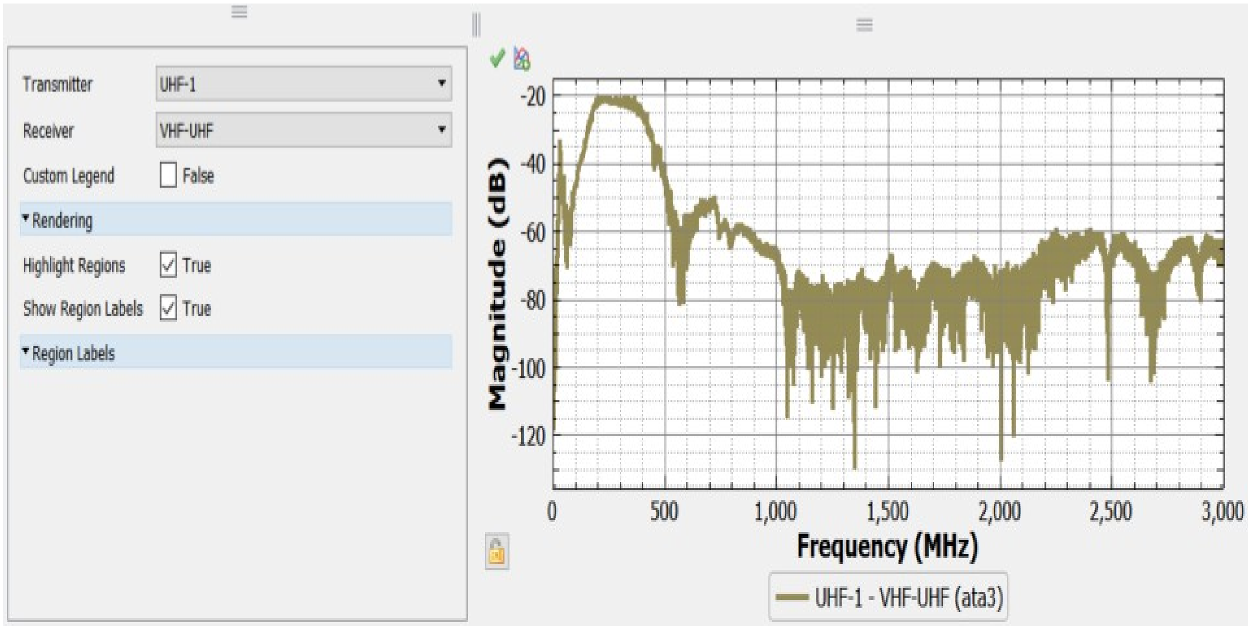
EMIT will read the Touchstone file and ask you if you wish to create antennas for each of the ports. When prompted, select No as we have already created the antennas for our scenario. If you choose Yes, EMIT will create an antenna for each port in the Touchstone file automatically. A new node will appear under Coupling Data corresponding to the imported S-parameter data.

We now need to specify which antennas are associated with this 2-port S-matrix file. Select the ata3 node and in the property panel specify UHF-1 for port 1 and VHF-UHF for port 2. We also wish to disable the Free Space Path Loss model for now, so uncheck the box to the right of that node in the project tree. Note the changes in the Antenna Coupling Matrix when you are done.



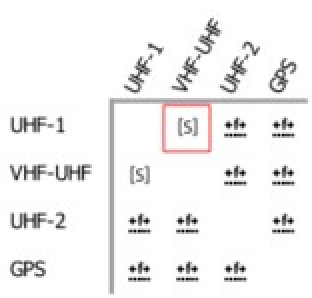


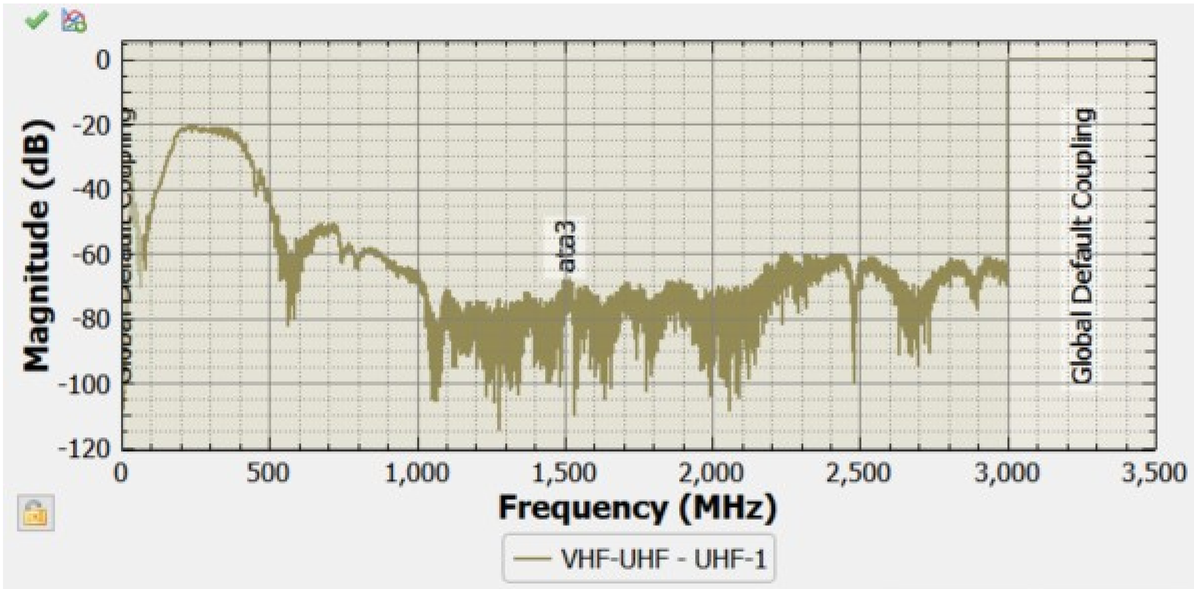
With the S-matrix ports now defined, we can plot the coupling data by selecting the ata3 node in the Coupling Editor tree. You can change which entry in the S-matrix is being plotted using the Transmitter and Receiver fields in the plot trace node (select the UHF 1 – VHF-UHF legend entry to display the plot trace node property panel). Below, we see the S-parameters corresponding to coupling from the UHF-1 antenna to the VHF-UHF antenna. As you can see, our data file contains coupling data for these antennas up to 3 GHz.



When we display the plot from the ata3 node as above, the raw S-matrix data is plotted over the frequency range that it spans. In this case, from 300 kHz to 3 GHz. It is often the case that coupling data will be available over a frequency range that is less than that desired for the complete analysis. It is also possible that coupling data may be available over multiple segments of a band. EMIT allows such partial coupling data to be used in its analysis. EMIT will automatically choose the best coupling data/model available over the analysis bandwidth for the scenario.

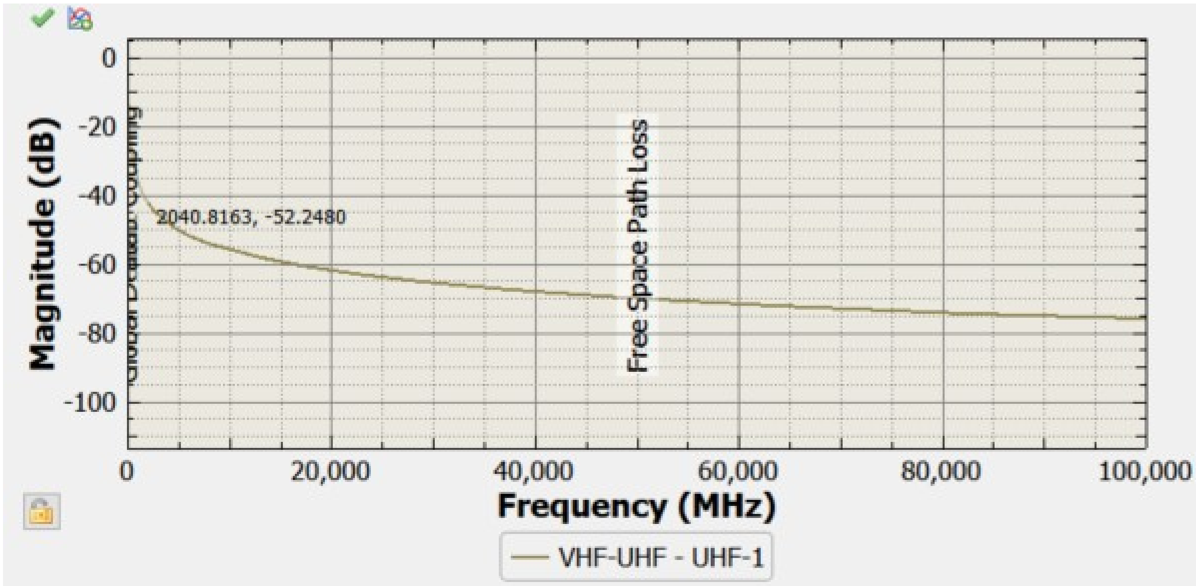
To see this in action, we can plot the coupling that EMIT will use in the analysis between the UHF-1 and VHF-UHF antennas by selecting the corresponding antenna pair in the Antenna Coupling Matrix. As we see in the plot below, the coupling that EMIT uses is the measured data that we imported up to 3 GHz and above that it uses the Global Default Coupling model since we disabled the Free Space Path Loss coupling.



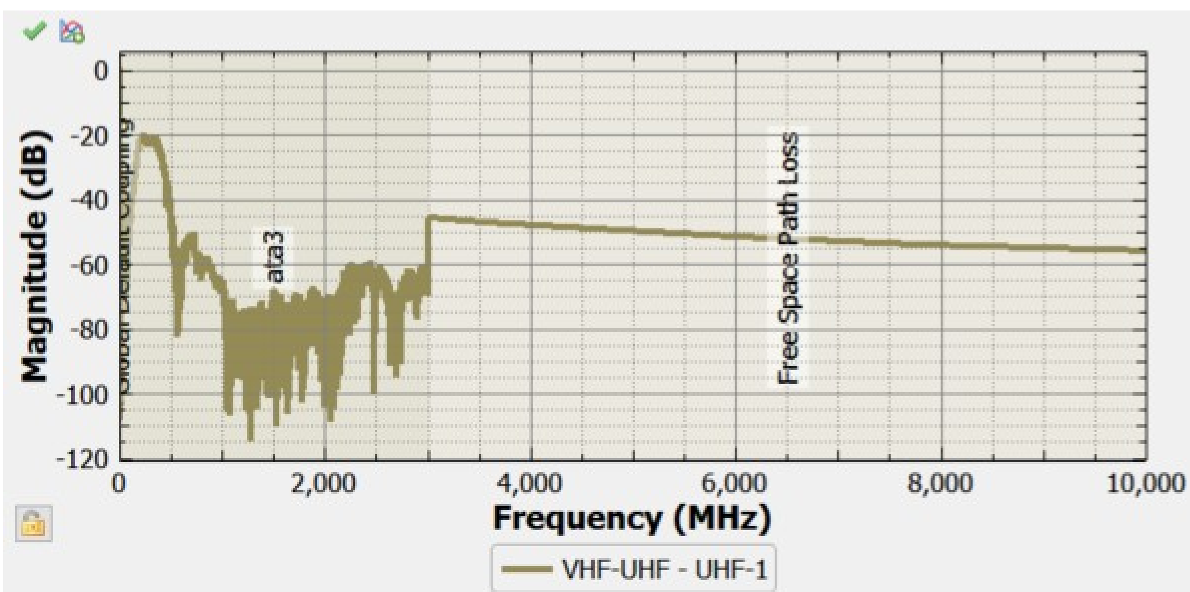


To see the impact of EMIT's priority rankings, re-enable the Free Space Path Loss coupling node. Next, drag that node to a position below the ata3 coupling node in the Coupling Editor tree.

The Free Space Path Loss node should appear below the S-Parameter (ata3) node in the tree and thus it has a higher priority. This tells EMIT to use the path loss coupling model for all antenna pairs since all antenna pairs (in this case) have the necessary information defined (i.e. antenna patterns and positions). Note that the Free Space Path Loss coupling model will also include the directional antenna gains. The VHF-UHF to UHF-1 coupling plot should automatically refresh and appear as below.



Note that the coupling model used for all frequencies (above the far field frequency) is the Free Space Path Loss model. This is because the Free Space Path Loss model is valid over all frequencies greater than the far field frequency and is defined as the highest priority coupling model in the project. Since we have measured S-Parameter data though, we want that to be the highest priority model, so select the Free Space Path Loss node in the project tree and drag it back above the ata3 node. Now, the (zoomed in) coupling plot should appear as:



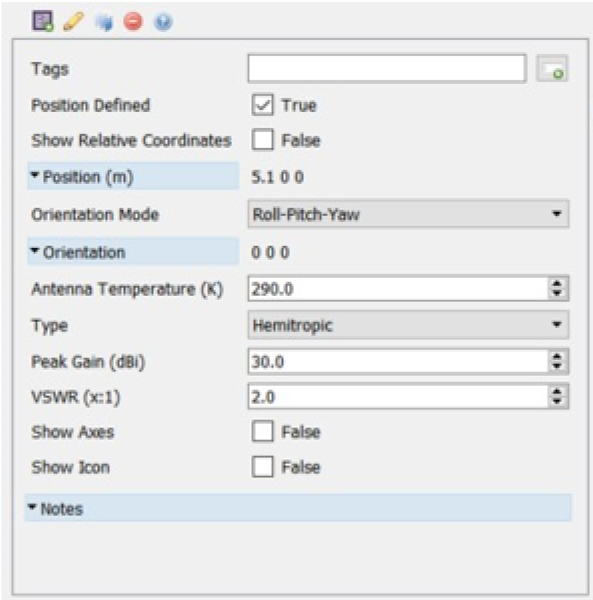
Multiple scattering matrix files covering different frequency ranges can be used to define the coupling between an antenna pair and EMIT will use them all over the appropriate frequency ranges. In cases where data may overlap, EMIT will choose the data from the highest priority coupling model at the overlapping frequency points.

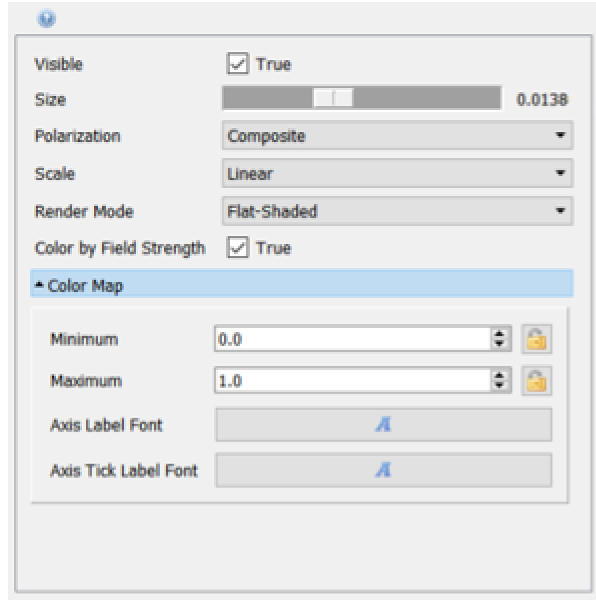
Now we will add an antenna pattern to the GPS antenna. Suppose that we have the following information regarding the GPS antenna:

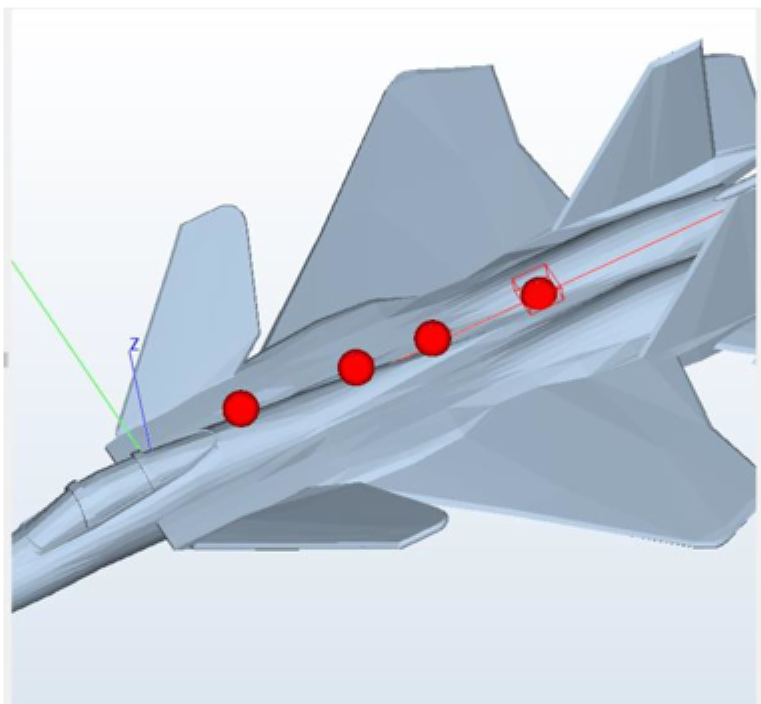
- Gain = 30 dB (note that this is an active Rx antenna with a built-in LNA)
- Max. In-band VSWR = 2
- Dual Band Operation at L1 (1575.5 MHz) and L2 (1227.6 MHz)
- Bandwidth 20 MHz centered about L1 and L2 with 30 dB out-of-band rejection

We will use EMIT's built-in parametric antenna models and antenna passband capability to create an antenna corresponding to these specifications. We'll assume an antenna gain pattern that is radiating hemispherically upward. Select the GPS antenna node and in its property panel change the Type = Hemitropic. We will get a reasonable approximation to the actual antenna pattern using this model. One thing to note is that EMIT's hemitropic parametric antenna model is scalar in nature. That is, it does not correspond to a particular polarization.

When you select the antenna type, you will see two things happen. First, the property panel will change to show the parameters associated with the hemitropic antenna model. And second, the antenna pattern will be displayed in the 3D window. Enter the parameters shown below for the antenna. There are several options available for displaying the pattern under the Pattern node's property panel. You can experiment with these to observe the effect on the display.

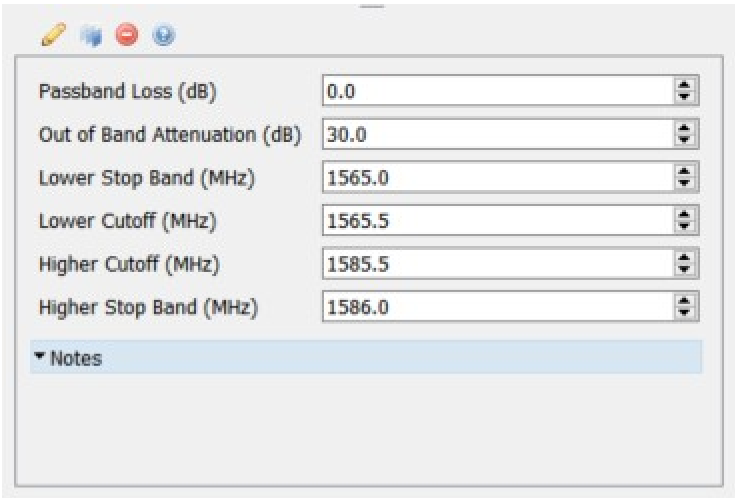


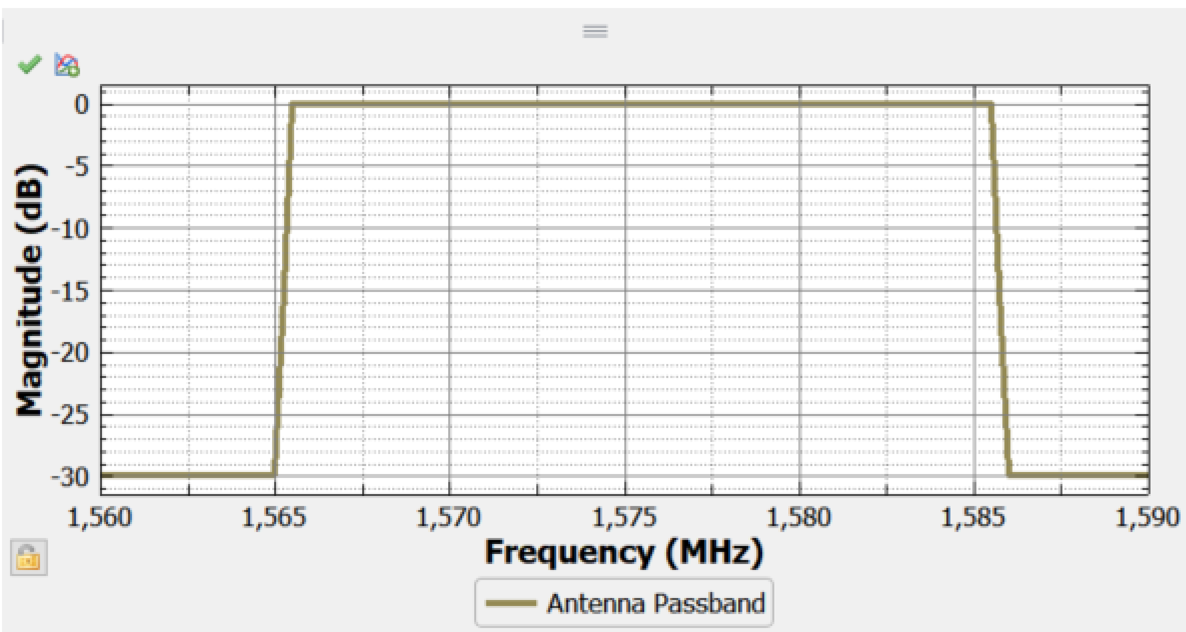




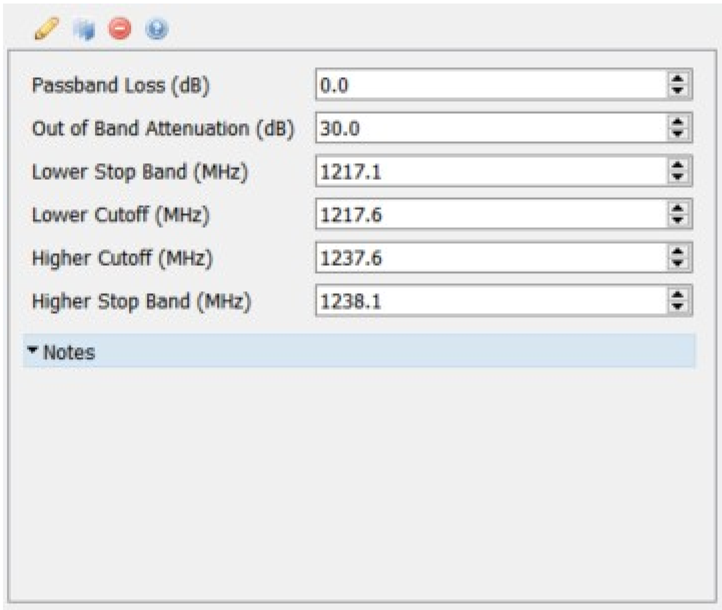
With the exception of the Wire Dipole and Wire Monopole, EMIT's parametric antenna models are frequency independent. In order to accommodate the out-of-band rejection specified for this antenna, we will use EMIT's Antenna Passband feature. Right-click on the GPS antenna node and select Add Antenna Passband. An Antenna Passband node will appear as a child of the GPS antenna in the Coupling Editor tree. Repeat to add a second Antenna Passband node to the GPS antenna.

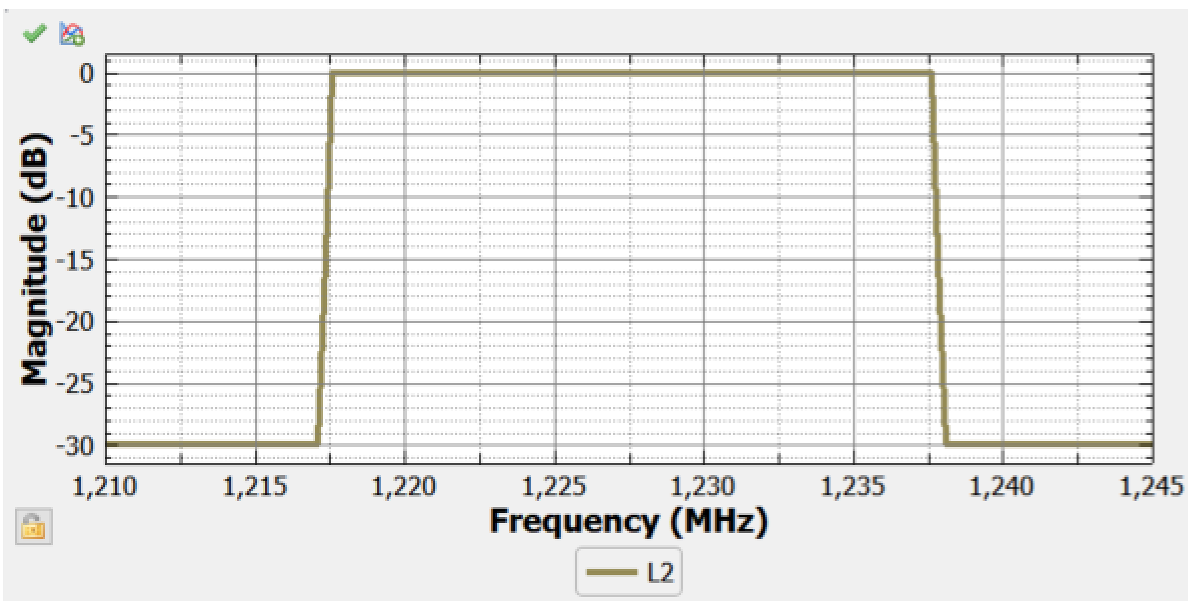
An Antenna Passband defines the bandpass characteristics for an antenna. Since our GPS antenna is a dual-band antenna, we will use two Antenna Passbands to define each operating band of the antenna. Select the first Antenna Passband node and define the passband characteristics for the L1 operating frequency as shown below, where we assume 0 dB passband loss and a reasonable roll-off for the response. The passband will automatically be plotted as the parameters are changed.



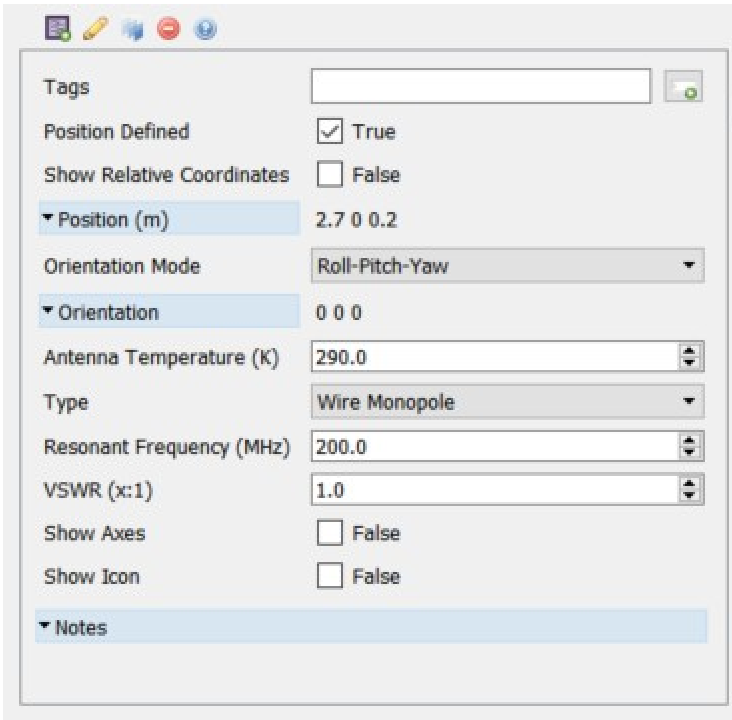


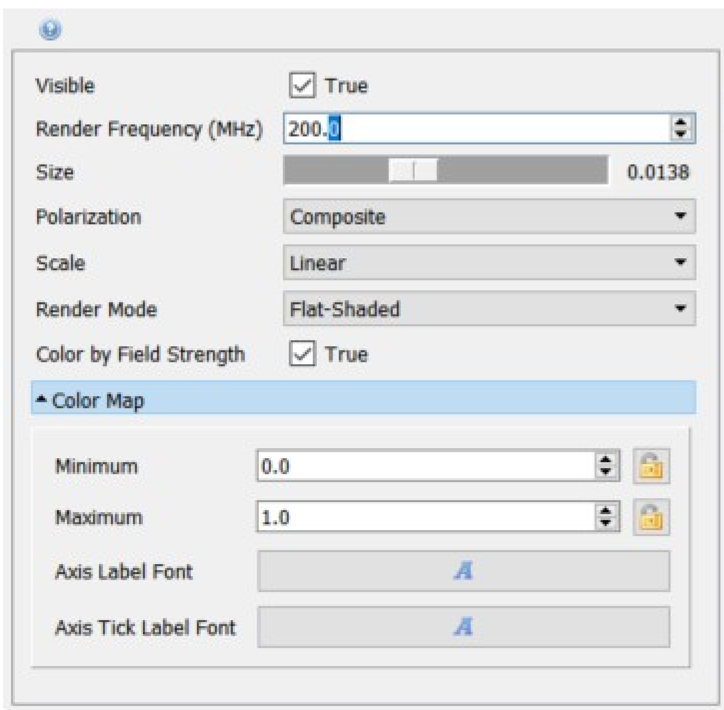
In a similar fashion, define the second passband as shown below:

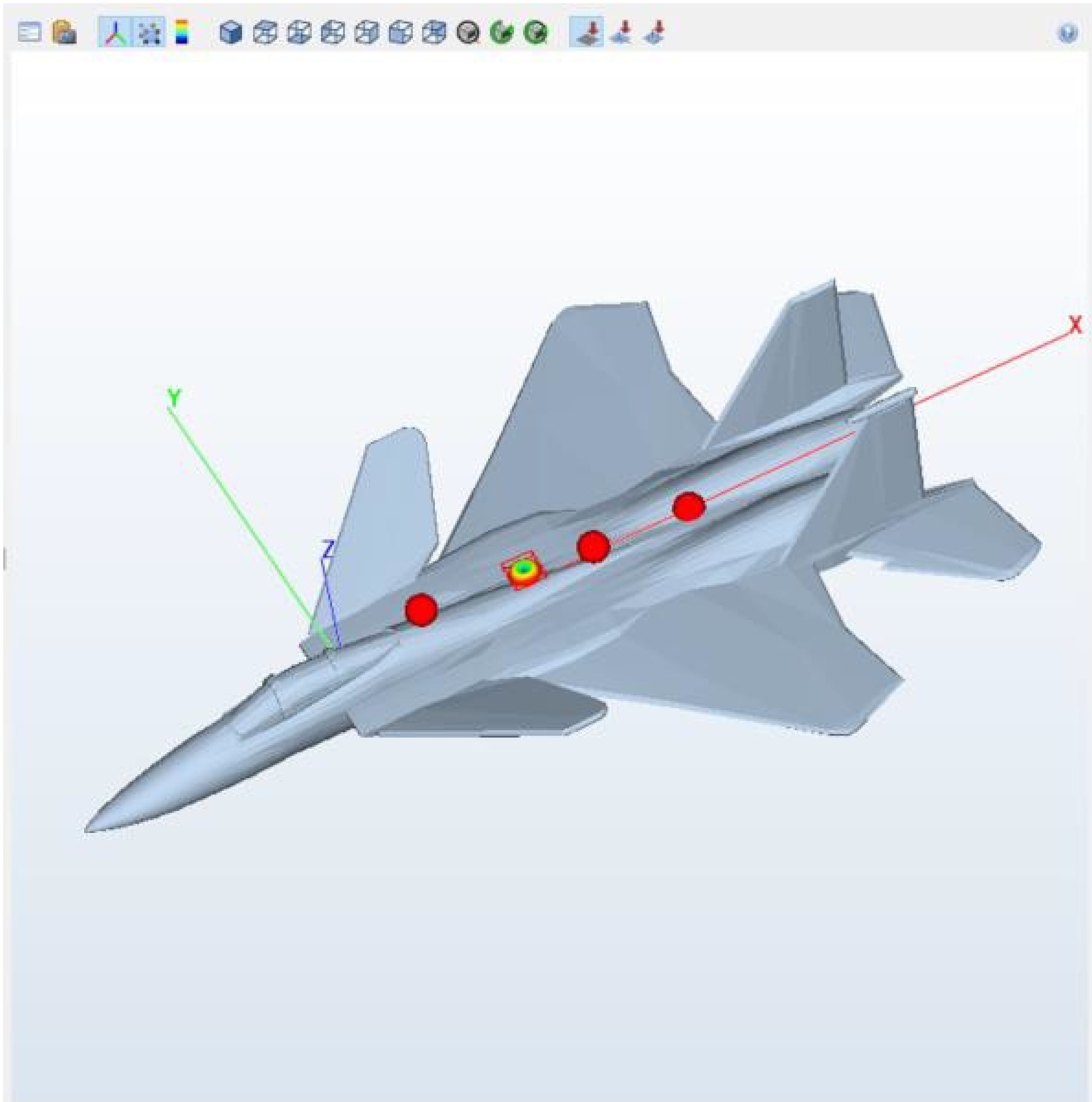




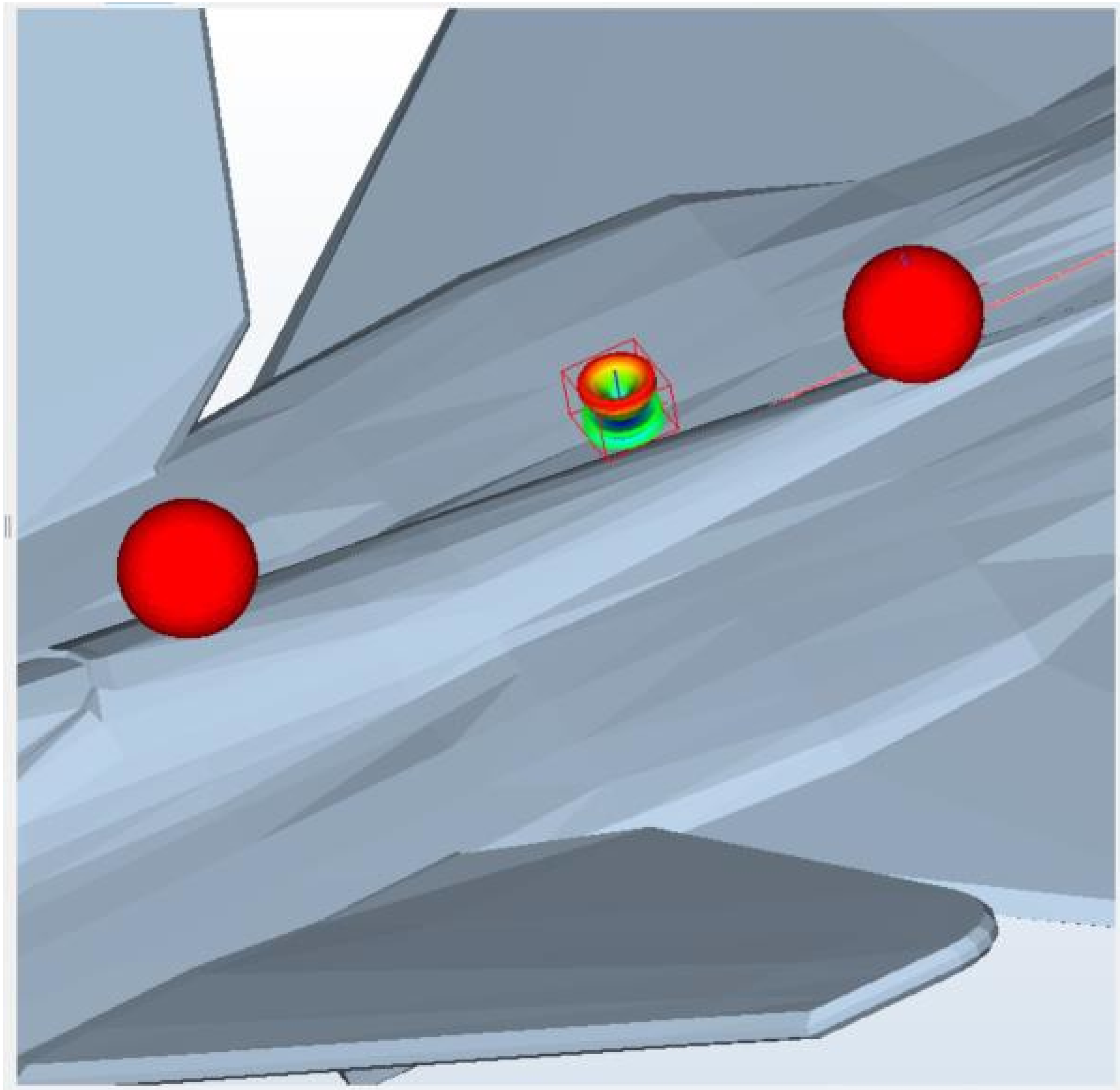
Suppose that the VHF-UHF antenna is a monopole antenna resonant at 200 MHz. We can define a parametric antenna by selecting the VHF-UHF antenna node and choosing Wire Monopole for the antenna type with the parameters defined as shown below. The antenna pattern will automatically update in the 3D window.


Tags
Position Defined
True
Show Relative Coordinates
False
Position (m)
2.7 0 0.2
Orientation Mode
Roll-Pitch-Yaw
Orientation
0 0 0
Antenna Temperature (K)
290.0
Type
Wire Monopole
Resonant Frequency (MHz)
200.0
VSWR (x:1)
1.0
Show Axes
False
Show Icon
False
Notes

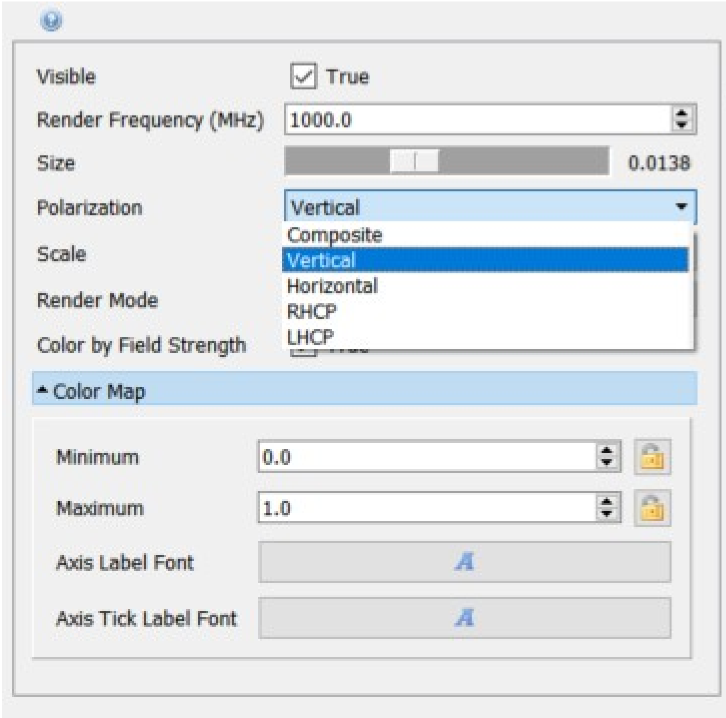

Visible
True
Render Frequency (MHz)
200.0
Size
0.0138
Polarization
Composite
Scale
Linear
Render Mode
Flat-Shaded
Color by Field Strength
True
Color Map
Minimum
0.0
Maximum
1.0
Axis Label Font
Axis Tick Label Font



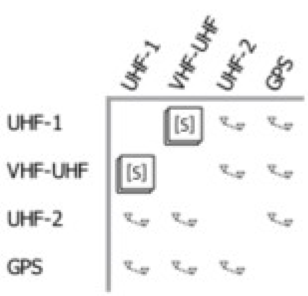
For this antenna type, the parametric model is frequency dependent and the frequency that the pattern is displayed at is controlled by the Render Frequency setting in the antenna pattern's property panel. In the figure above, we see the pattern displayed at 200 MHz where the antenna is a quarter-wavelength long (since 200 MHz was defined to be it's Resonant Frequency). Below, we see the pattern with Resonant Frequency = 1000 MHz.

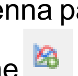


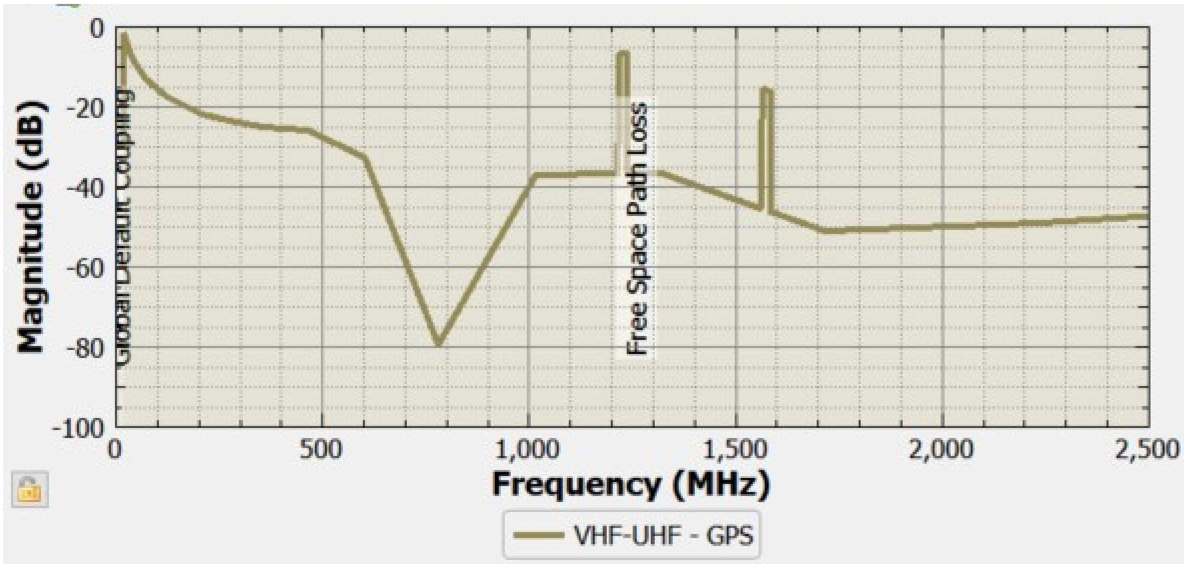
This type of antenna also displays polarization characteristics; specifically, the monopole is vertically polarized. You can change the polarization displayed via the antenna pattern's property panel as shown below.



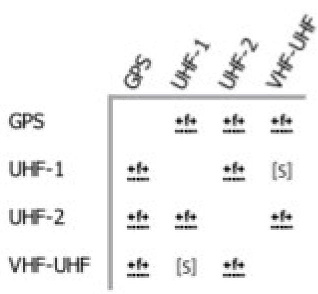
You may have noticed that we have both an antenna pattern and a S-matrix associated with this antenna. EMIT will use whatever information is available for a particular antenna and use the highest priority model that it can for computing coupling to the other antennas in the scenario. In this case, for the VHF-UHF to UHF-1 coupling, EMIT will use the S-matrix coupling over the frequencies defined in the imported data (0.3-3000 MHz) and Path Loss Coupling (including antenna gains) over the other frequencies. For coupling from the VHF-UHF antenna to any other antenna, EMIT will simply use the Path Loss Coupling model. Note that the matrix squares corresponding to the VHF-UHF to UHF-1 coupling now appear “stacked.” That is because there are two coupling models (S-Parameter and Path Loss Coupling) that are associated with that antenna pair.



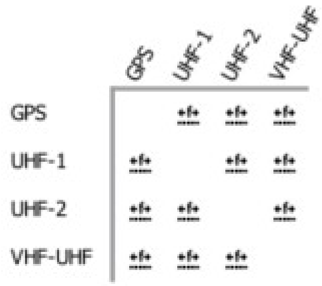
Select the entry in the Antenna Coupling Matrix for the GPS and VHF-UHF antennas to see the coupling between these two antennas computed by EMIT using the Path Loss coupling model and zoom in as shown below to see the effect of the antenna passband characteristics that we defined for the GPS antenna. Note that you can select the  icon to view the property panel for the plot and manually enter the x and y axis extents.



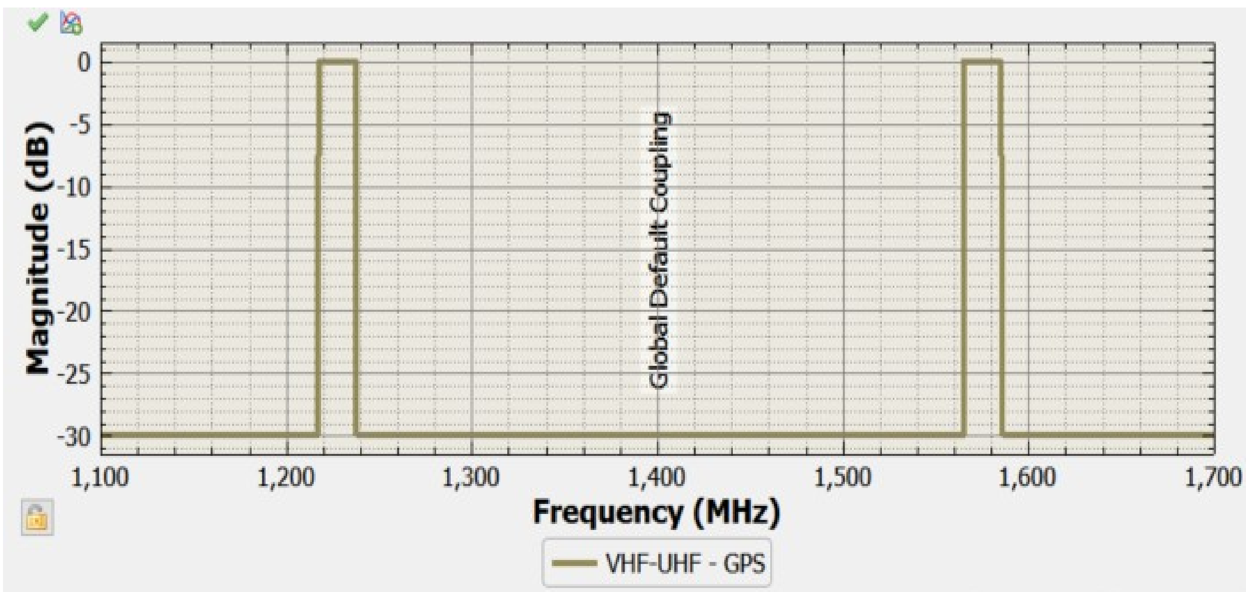
To reiterate an important point, the Antenna Coupling Matrix shows the highest priority coupling model that EMIT will use in the simulation if those antennas are connected to radios. The user has the ability to control which coupling models EMIT will consider when deciding on the best approach by disabling individual coupling nodes in the Coupling Editor tree. For example, disable the Free Space Path Loss node by unchecking the box beside it in the Coupling Editor tree. EMIT will ignore this coupling model when deciding which is the best coupling to use in the simulation and the Antenna Coupling Matrix will reflect this.



If you wish to use the Global Default Coupling value for the simulation, you can disable all other coupling types as shown below. Also, EMIT will use the Global Default Coupling value for interactions between radios (or emitters) with positionless antennas connected to it and no S-Parameter coupling defined.



With all coupling models disabled (that is, Global Default Coupling value used), select the GPS vs VHF-UHF matrix entry in the Antenna Coupling Matrix. Notice that even if Global Default Coupling is the only coupling model defined, EMIT includes the effects of any Antenna Passbands that are defined. This is a very useful way to create user-defined frequency-dependent antenna coupling characteristics.



So, why might you want to use Global Default Coupling instead of the other EMIT coupling models seen in this example? The use of the Path Loss coupling model computes the coupling based only on the free- space path loss between the antennas and the directional antenna gains. In a complex cosite environment, important near-field and platform interaction effects are completely ignored and use of the Path Loss model may represent a gross simplification of the coupling mechanisms. In such a case, it may be better to use a conservative (worst-case) Global Default Coupling model instead of a potentially inaccurate model that can be computed with the available data. However, the decision as to whether that model is 'good enough' for the particular scenario under consideration is ultimately a decision that must be made by the analyst.

Another important consideration is blockage by the platform. EMIT makes no attempt to compute antenna blockage and so if antennas' line-of-sight is blocked, then the coupling models that make use of the free-space path loss between those antennas are not appropriate and should not be used. Suppose we had an antenna located on the bottom of our aircraft's fuselage in this example. In this case there is no line-of-sight coupling path between the antennas and the use of the Path Loss Coupling model, which incorporates the antenna gain, would grossly overpredict the coupling between the antennas.

Enable all coupling types before proceeding and save your project.