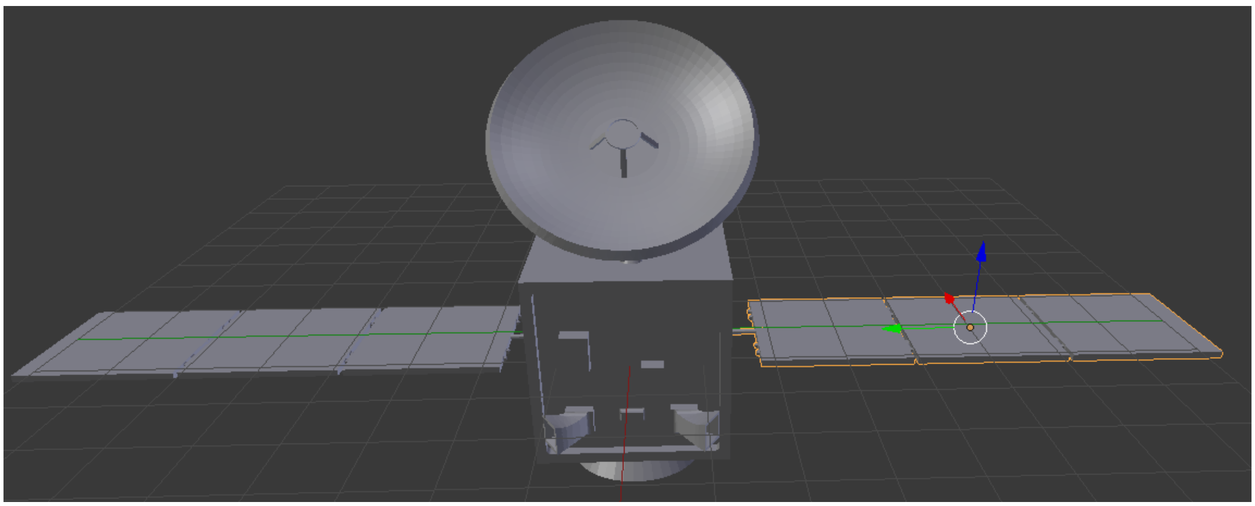
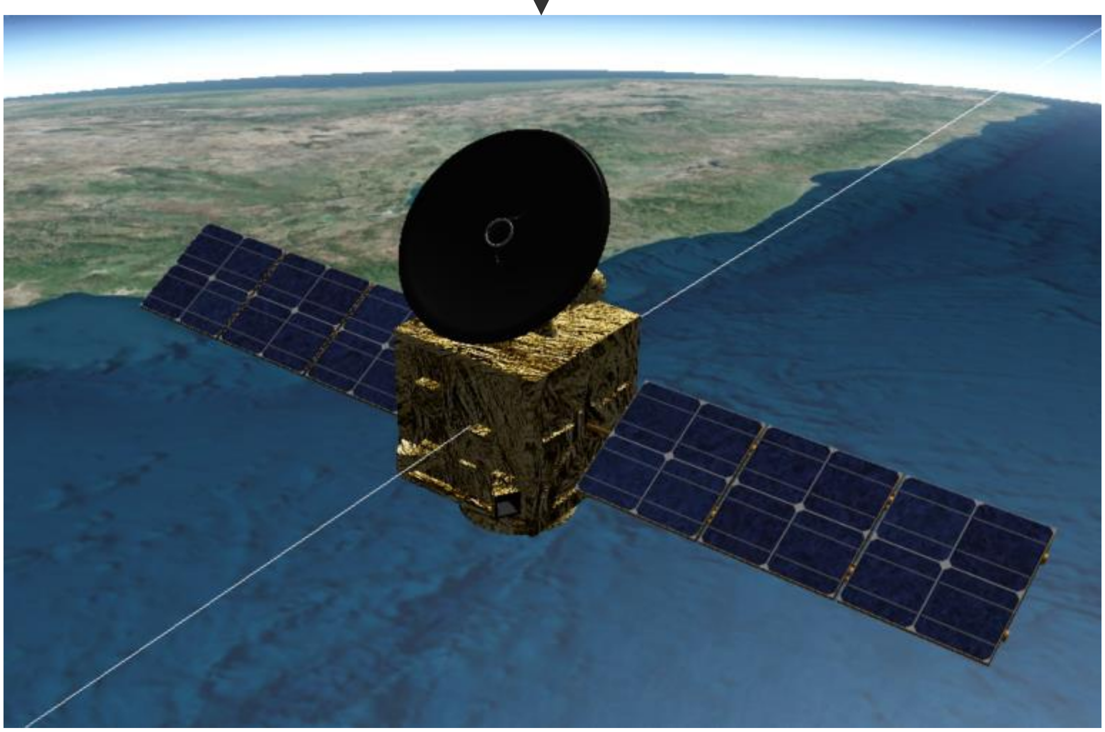
BLENDER MODELLING AND ARTICULATIONS FOR STK USERS





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BLENDER FUNDAMENTALS

Blender is a free software that is well known for its vast modelling and animation capabilities. If you do not already have Blender installed, it can be downloaded here: https://www.blender.org/download/

This tutorial is not meant to serve as a full Blender tutorial, rather it is meant to provide the basics required for understanding Blender's functionality and how it can be used with STK. While not necessary, a general working knowledge of 3D modelling will be helpful for working through this tutorial. For additional tutorials about Blender please consider utilizing the following resources.

Blender Support: https://www.blender.org/support/

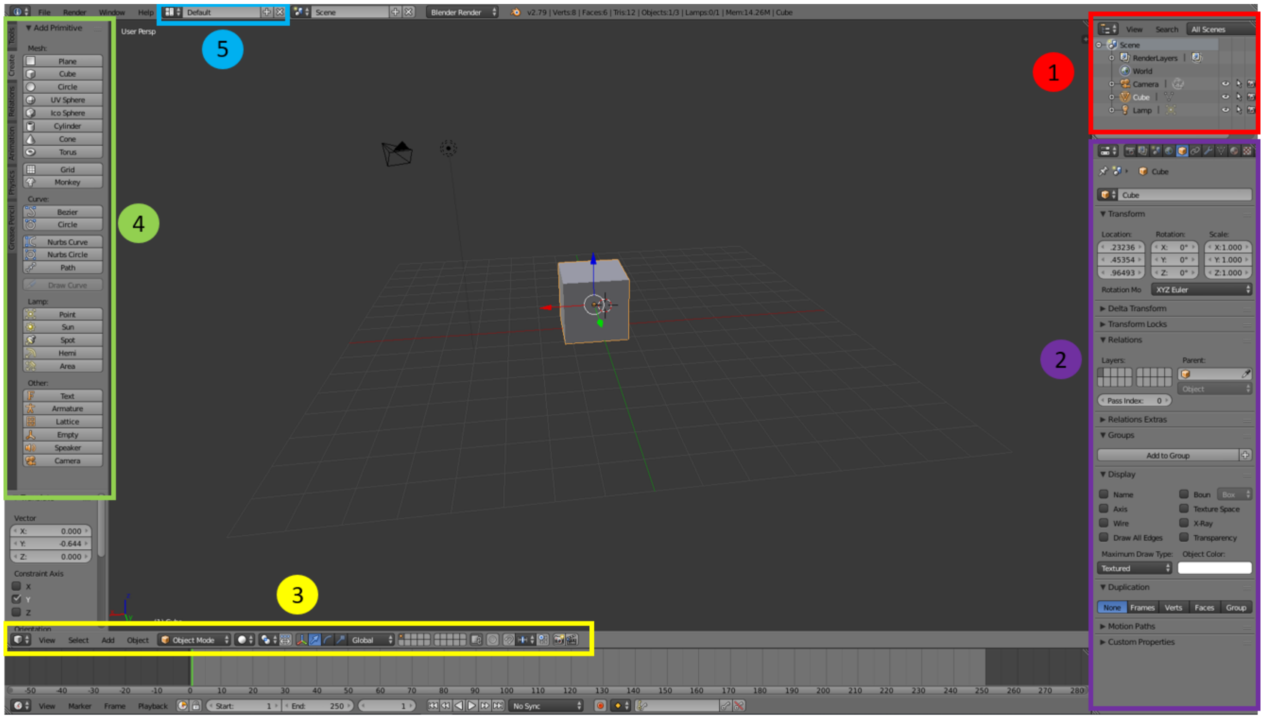
Blender Guru: https://www.blenderguru.com/

CGCOOKIE: https://cgcookie.com/learn-blender

Additionally there are some great courses available one Lynda.com if you have a subscription.

RECOMMENDED SETTINGS AND BASIC CONTROLS

Upon opening Blender you will see the default setup as seen in the image below. There are several sections of the window that have been marked to show important control locations and the accompanying table describes the purpose of each of these sections. If you do not see the primitives menu, click on the create tab on the left hand side.

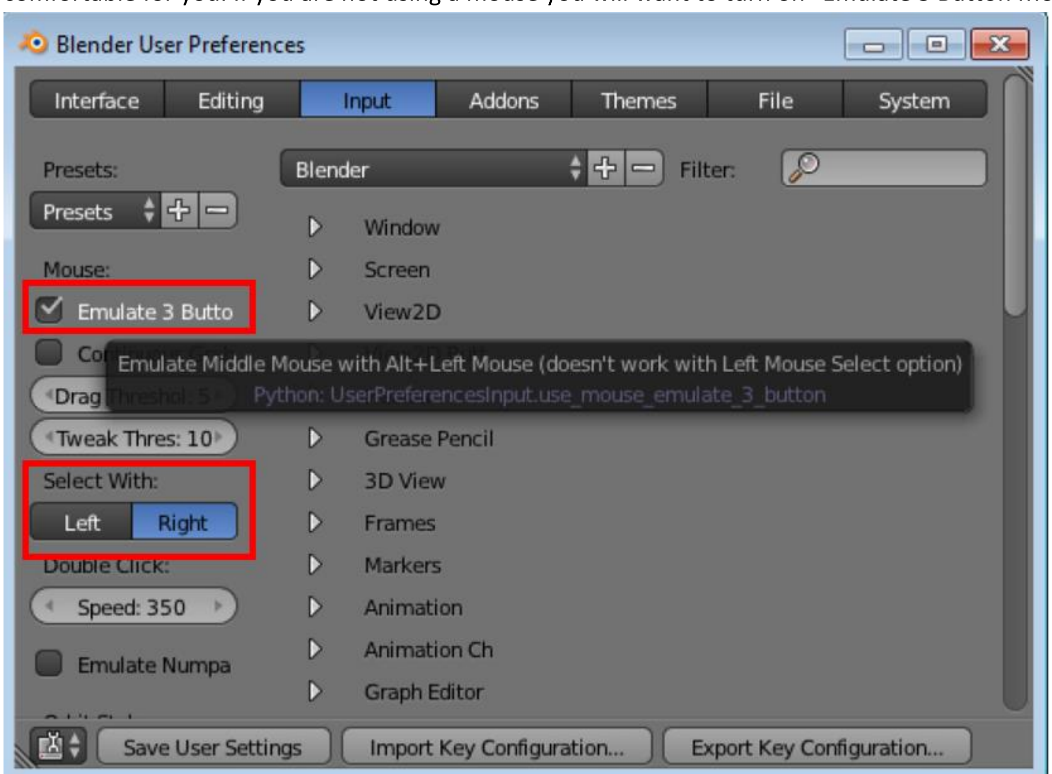


Reference Number	Name	Description
1	Outliner	Lists all objects in the scene and the hierarchy for object parenting
2	Properties Menu	Options able to change scene and object properties, add object modifiers, and add materials/textures
3	Design Tools	Options for changing the edit mode, displaying active layers, and enabling movement constraints
4	Primitives	The quickest way to add basic objects, lights, and other scene objects. Primitives are located under the "Create" Tab.
5	Window Layout	Allows the user to change between commonly used window layouts

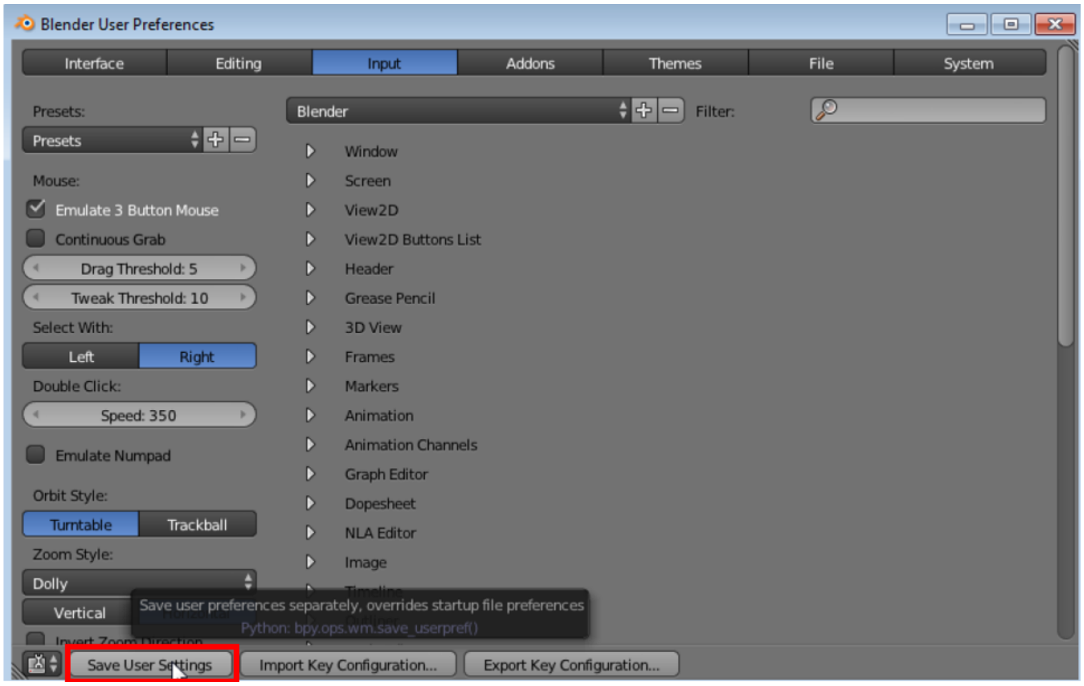
By default Blender expects the user to be using a 3-Button mouse. The right mouse button is used to select objects, the left mouse button is used to change the location of the 3D curser, and the center scroll wheel is used to rotate and zoom into the scene. Additionally you can pan by clicking Shift and the center mouse button at the same time. This control scheme can be counter intuitive for some users because the select functionality is on the right mouse button. This can easily be changed in the user preferences.

1. User preferences can be found under the main file menu at the top of the screen

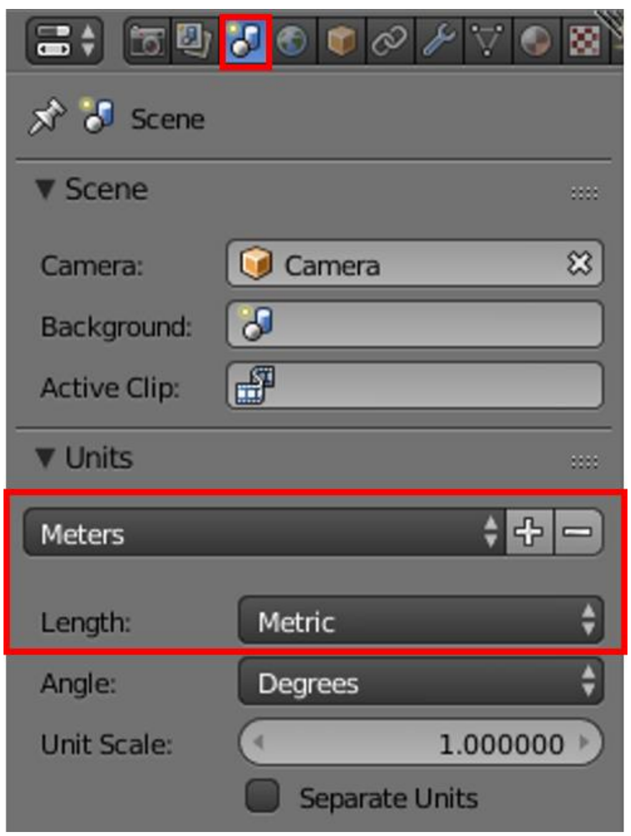
2. Mouse options are found under the Input tab. Change the "Select With" to Left if that is more comfortable for you. If you are not using a mouse you will want to turn on "Emulate 3 Button Mouse"



3. Under the "Add-ons" tab ensure that "Import-Export: STL Format" is enabled
4. Make sure you save your user settings. Once the settings have been saved, they will remain the same every time you open Blender



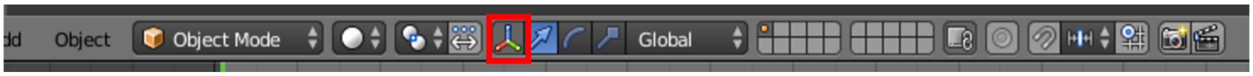
5. STK uses default units of meters so Blender needs to consider any imported models in meters. In the properties panel, click on the "scene" tab and change the Unit Preset to "Meters" and Length to " Metric"



WORKING WITH PRIMITIVES

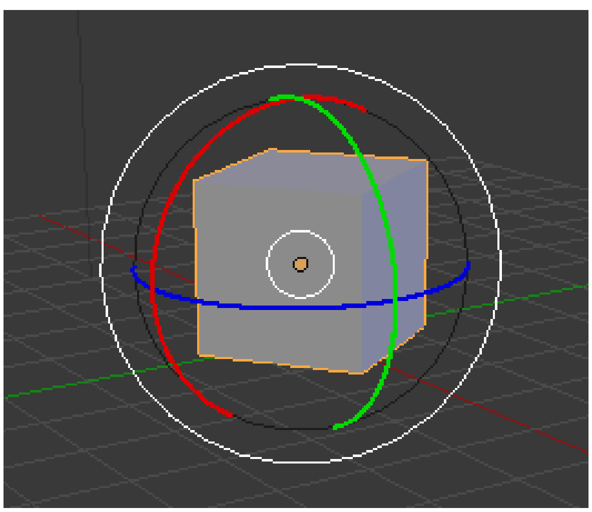
Primitives are the building blocks for all designs in blender. When Blender is first opened there is always the default cube primitive in the center of the scene. Additional primitives can be added from the primitives menu, under the create tab on the left panel. This section will serve to demonstrate basic manipulation of primitives to make working with full imported models easier.

When selected every primitive displays its body axes. If you do not see the axes then enable the 3D manipulator Widget in the Design Tools

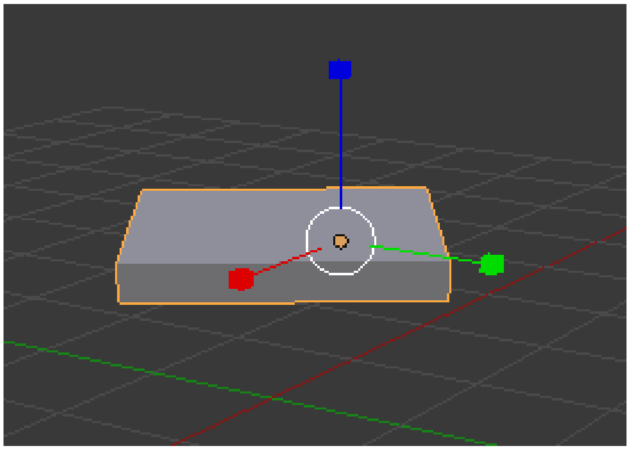


When the 3D manipulator is selected there will be three buttons directly to the right that control freeform translation, rotation, and scaling respectively.

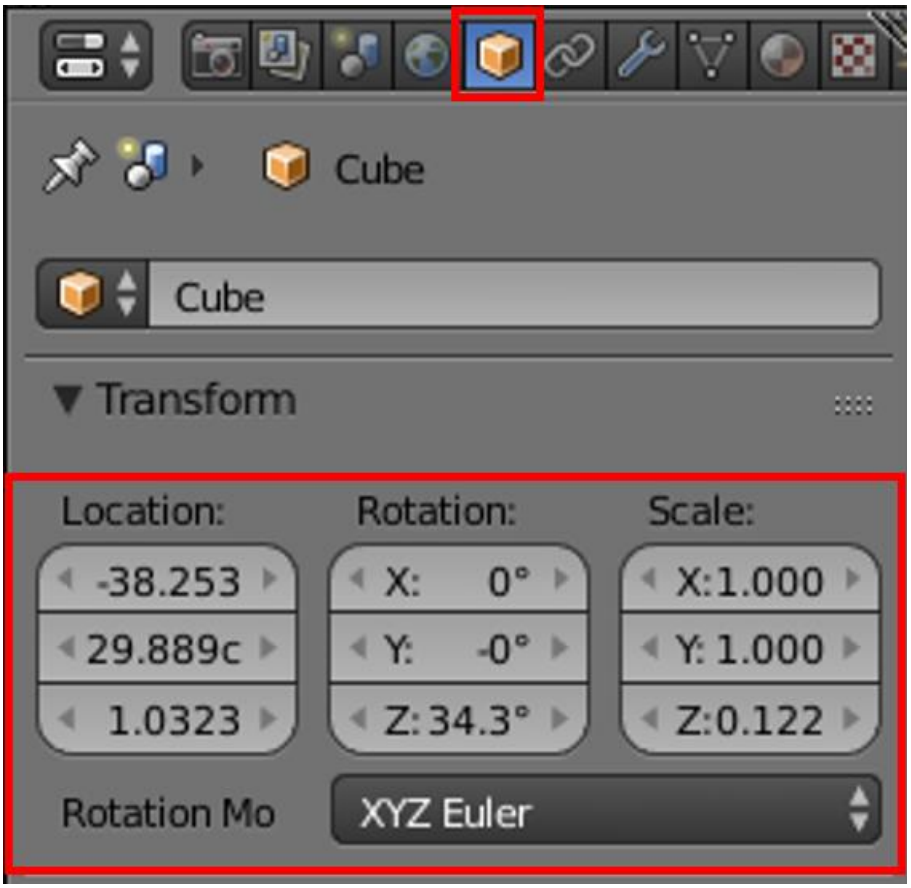
1. Ensure that the cube is selected and you can see the body axes
2. Ensure that translation 3D manipulator is selected. Clicking anywhere on the object and dragging will result in the object following the curser. If you click on one of the displayed axes and then drag the object, the object will only be able to move on that axis. Try moving the cube in different directions to get a feel for the mechanics. The hotkey for translational movement is G(“Grab”). After pressing G you can press X, Y, or Z to constrain the motion along that axis
3. Click on the rotation 3D manipulator. This will bring up the rotation arcs about the three primary axes. Clicking on dragging will result in the rotation of the object about that axis. The hotkey for rotation is R. After pressing R you can press X, Y, or Z to constrain the rotation about that axis.



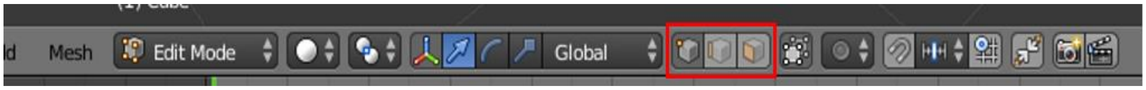
4. Click on the scaling 3D manipulator. The axes will look very similar to the translation axes but the ends will be cubes. Clicking and dragging on one of these axes will result in the size of the object changing along that axis. The following image shows the cube scaled down along the z-axis. The hotkey for rotation is S. After pressing S you can press X, Y, or Z to constrain the scaling to that axis. When using the hotkeys, if you do not specify the axis of scaling then the model will be uniformly scaled about all three axes.



5. Translation, rotation, and scaling values can also be accessed under the object tab in properties panel



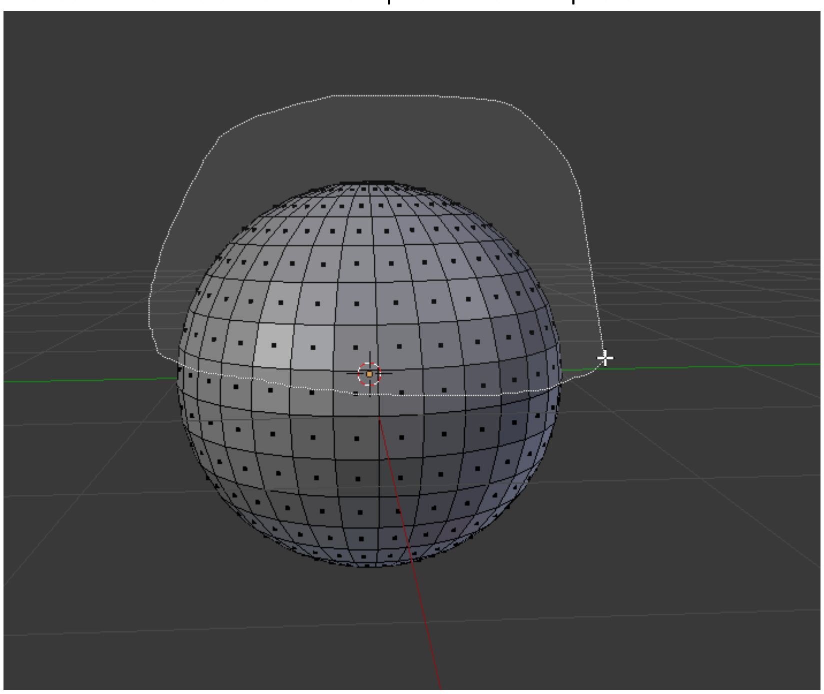
6. There will be several instances where you will need to edit an object later in the tutorial. To enter edit mode select an object and hit Tab. You can also enter edit mode by changing the mode from "Object Mode" to "Edit Mode" in the design tools at the bottom. When you switch modes the design tools will change and should look the same as the image below. The most important of these new controls are highlighted in red and are the controls for selecting different aspects of the objects. You have option to only select vertexes, edges, or entire faces.



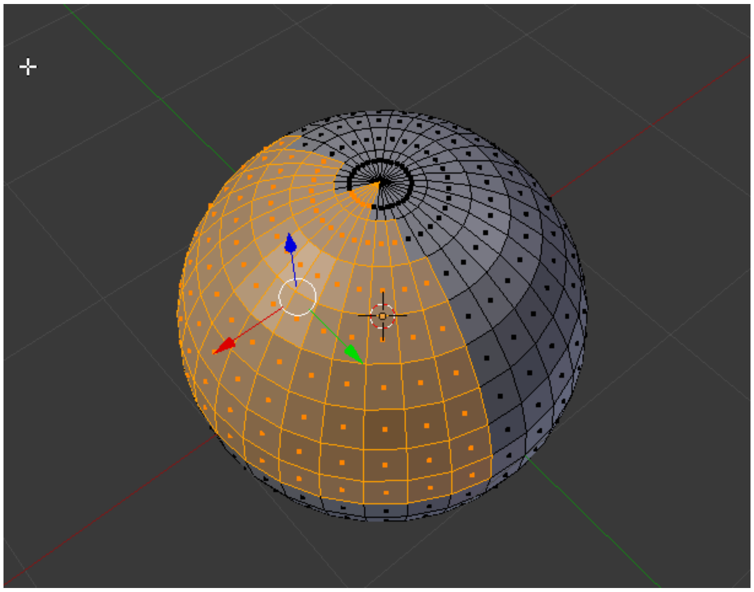
7. Switch to face select mode. You can also switch between modes by hitting Ctrl+Tab. Grab any face and move it around. You will notice that instead of the whole object moving, now only that face moves and the object shape changes to complete the geometry. You will notice similar behavior when in edge and vertex select mode as well. The following image shows a modified sphere after only two scaling operations in edit mode.

8. Some additional techniques can be better demonstrated with a sphere instead of a cube. Delete the cube and insert a sphere from the primitives menu.

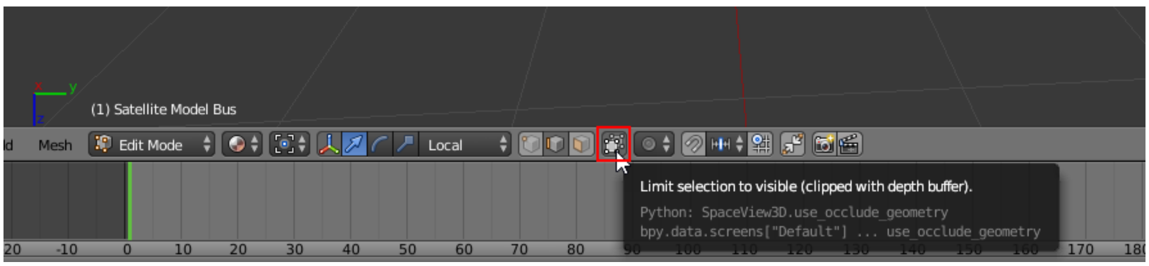
9. Enter edit mode by hitting Tab. Make sure that the face select option is chosen. Now hit Ctrl+RMB (Right mouse button) to active the lasso select tool. You must continue holding down the mouse button to keep the tool active. Lasso around the top section of the sphere



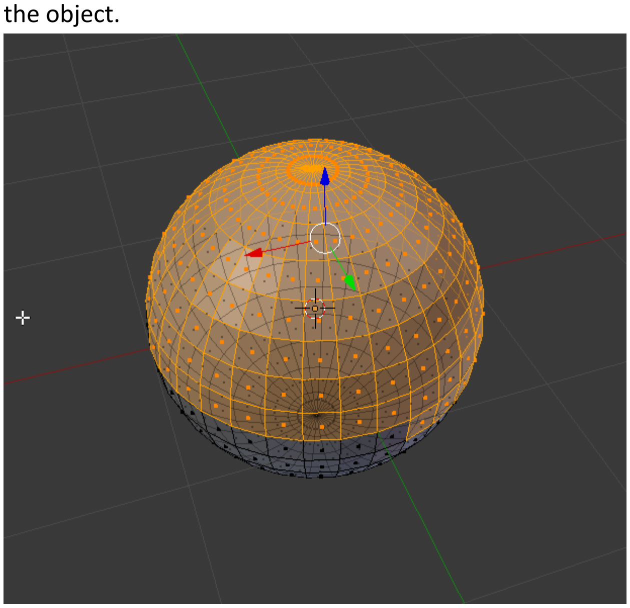
10. Notice how it selects all faces within the lasso that you can see. This is an easy way to manipulate a large amount of faces and will be used for texturing later in the tutorial. Deselect all the faces by hitting A.



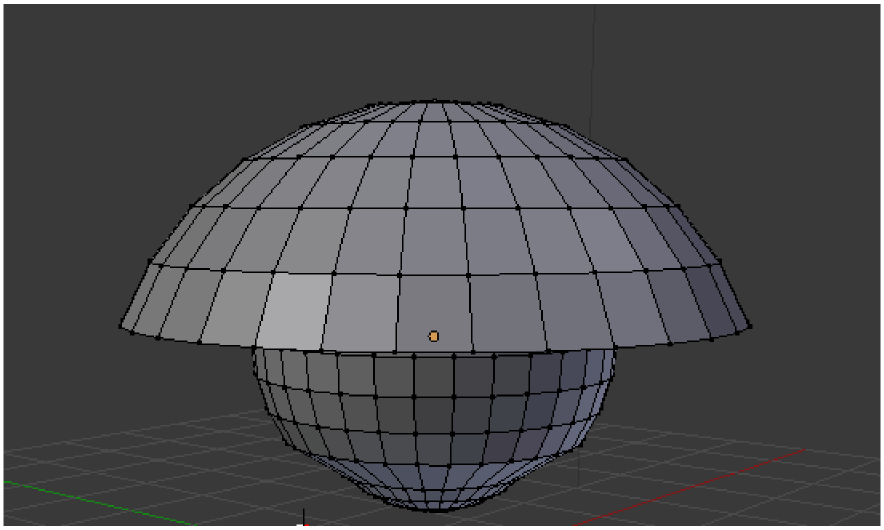
11. Now Turn on XRay mode from the design tools.



12. Now you can see all faces on the other side of the object as well. Use the lasso select to select the top half of the sphere again. Notice now it selected all faces within the lasso, even the ones on the other side of the object.



13. You can then scale (or any other operation) to all selected faces. The following image shows the sphere with two scaling operations; one increased scaling on the top, and one decreasing scaling on the bottom.



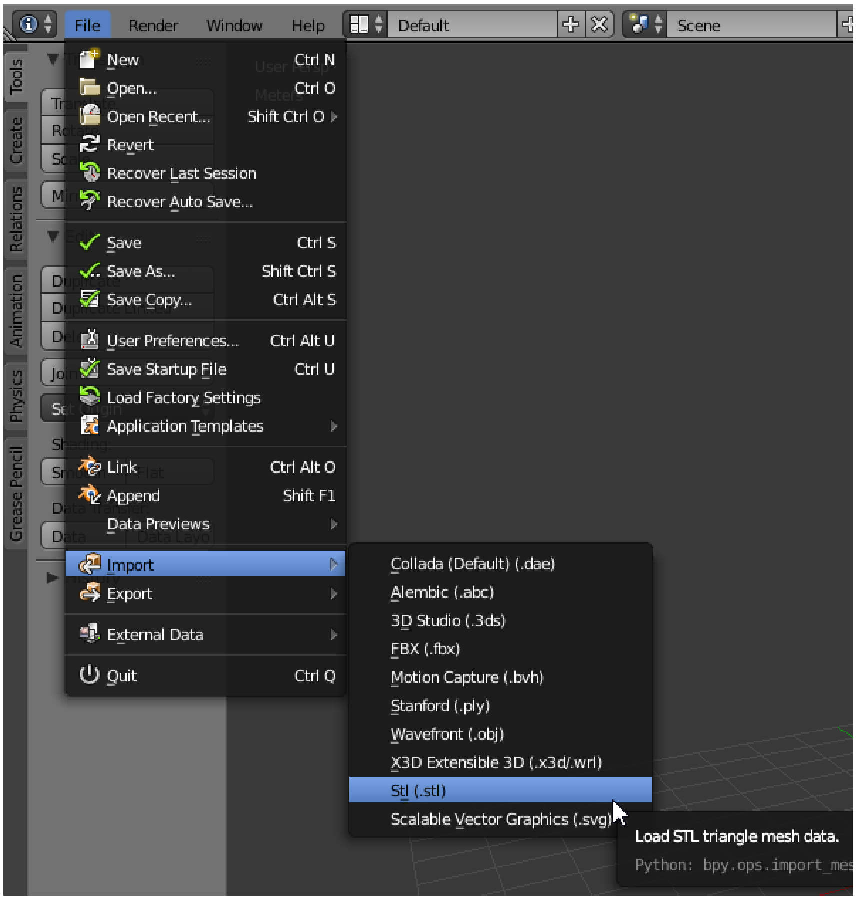
With the steps shown in the section, you should have enough knowledge for basic model manipulation and editing. For more information and help on modelling please visit one of the resources given at the start of the tutorial. Any additional controls needed for later steps in this tutorial will be explained in detail.

IMPORTING MODEL FILES

Most CAD files are cumbersome in OpenGL because of small parts like bolts, bolt holes, screws, nuts, and washers that heavily increase the polygon count. These and other internal components like circuit boards and gyroscopes should be removed in the host CAD application, unless absolutely required, before exporting the assembly as a STL. **Any part that needs to articulate should be exported as a separate STL files**. If the exported STL file is larger than 10MB, or roughly 90,000 polygons, then it should be broken up into at least a couple of assemblies, depending on its complexity, or it will not load into STK. The reason for this is that the XML reading library libXML, which is used by the Collada DOM, has a limit of 10 million characters within any xml tag. This does not mean that you cannot have any file larger than 10MB, only that each component/assembly/node within the Collada file cannot be larger than 10MB. You can have as many components/assemblies/nodes as are needed.

From this point forward the tutorial will use the STL files provided with the tutorial. They should be located in the same folder as this document.

1. Open a new document in blender and delete the cube primitive.
2. Go to File->Import->STL



3. Select all files that you wish to import. You should import the satellite bus, HGA, and solar panel array files. Do not worry if you cannot see the imported objects or if it looks wrong, this will be addressed.
4. After you import these three components import one more instance of the solar panel array for the other side of the spacecraft
5. At this point when you look at the 3D display the models will seem very large. This is because the scaling is off and must be changed. This is common for imported files that were designed in units other than meters. The solution for this will be addressed in the next section.

MODIFYING AND PREPARING MODELS FOR USE IN STK

The rest of this tutorial will walk you through all the steps required to modify a pre-existing model for use in STK and how to make all moving components work properly.

Notes on the Model: The model used for this tutorial is roughly based on the Emirates Mars Mission (EMM), which is set to launch in 2020 to study the atmosphere of Mars. The model was designed using Solidworks 2017.

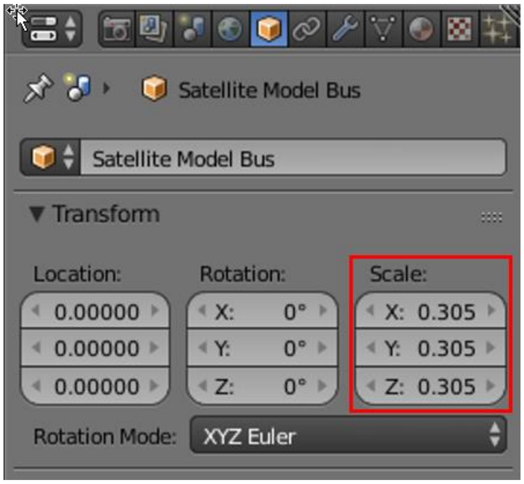
COMPONENT SCALING

STK default unit preference is meters. Because of this STK believes that all models will also use meters as its default distance measurement; however, depending on how your model was designed it is likely that the default unit were not meters. Luckily there is an easy scaling function in Blender that will uniformly scale the full model to the correct size. The quickest way to access the scaling option is through the object menu in the properties panel which was shown in the previous section.

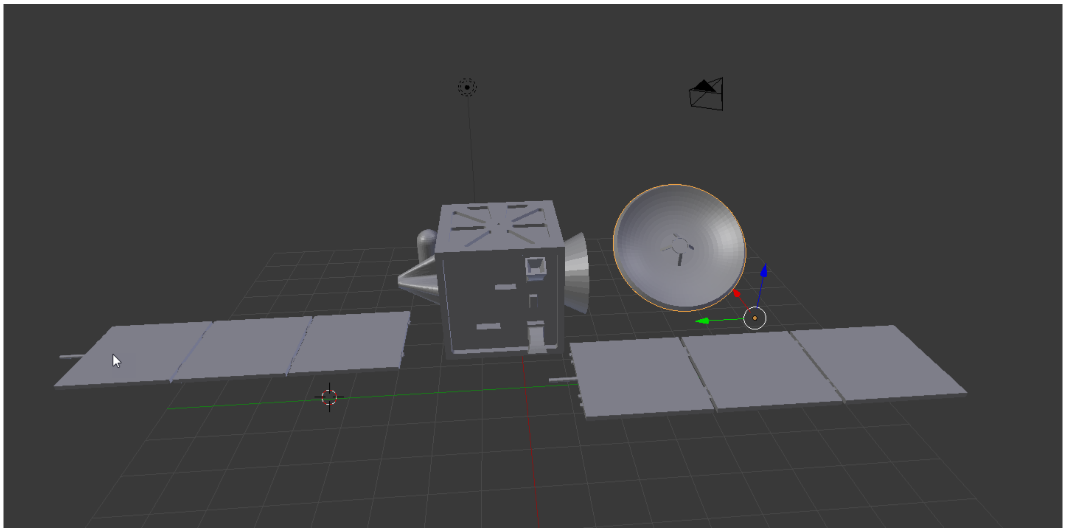
Depending on how your model was designed use the following conversions on all three axes to convert to meters. This process must be done for every STL assembly that was imported.

Converting From	**Scaling Factor**
Millimeters	0.001
Centimeters	0.01
Decimeters	0.1
Inches	0.0254
Feet	0.3048

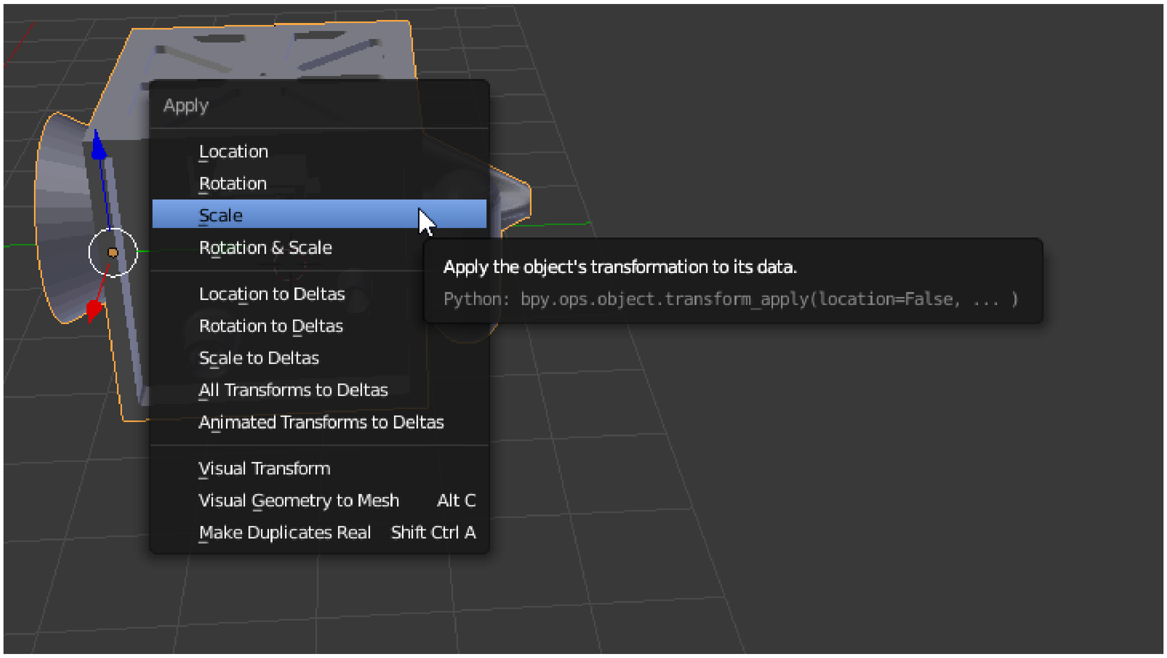
1. Select the satellite bus in the outliner or by clicking it in the 3D window. Navigate to that object's properties and scale each axis by 0.3048.



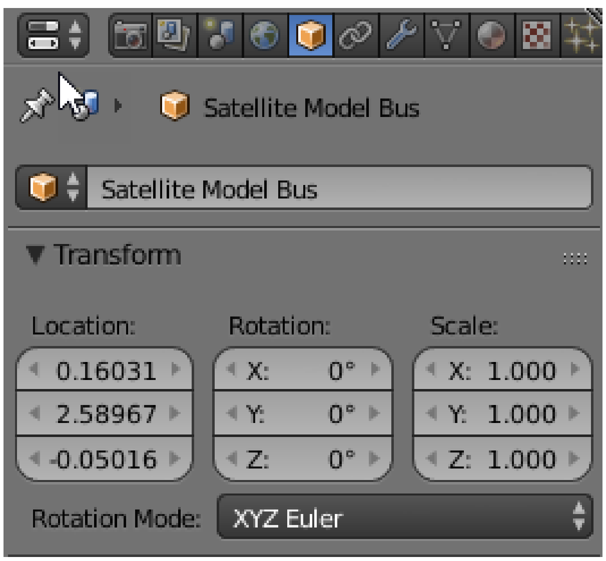
2. Scale each additional component by the same value. Zoom in so you can see all of the components. You may need to move one of the solar arrays so you can see the other.



3. Select the satellite bus and hit Ctrl+A to bring up the "Apply" menu. Select scaling from the menu



4. Selecting scaling will reset the scaling value back to 1 based on the scaling that you have already completed. If you now look at the object properties for the bus you will see that the scaling has been reset to 1 but the model is still the correct size.



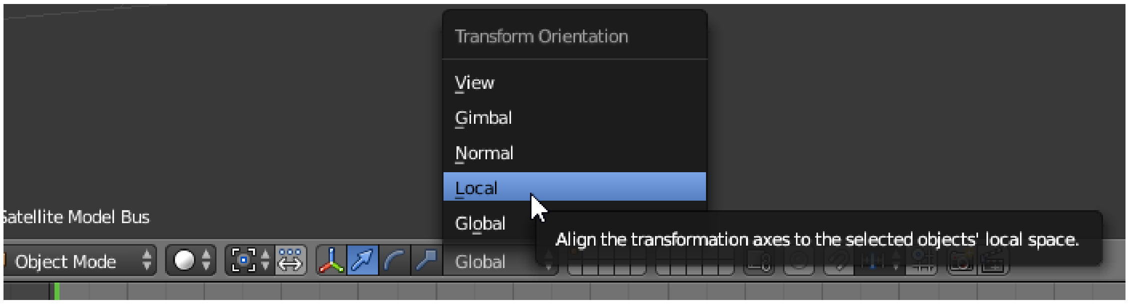
5. Rescale the other three components. Now that all of the components are the proper size, their coordinate systems must be properly aligned and then fitted together.

AXES ALIGNMENT

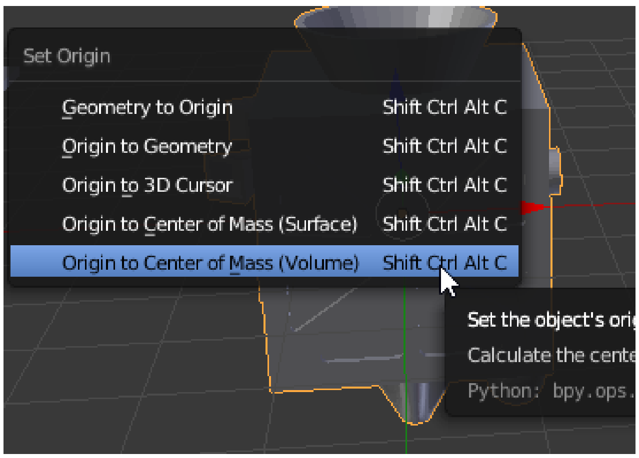
If you look at any of the objects in the scene, you will realize that the origin of each object is not in the center of the object. This is a common issue that would result in wrong articulations. Each object's local origin must be modified to mitigate this issue.

Note: While the local origin of an object can be moved, the primary axis directions cannot be changed. Because of this it is critical that the imported STL file has the correct coordinate system.

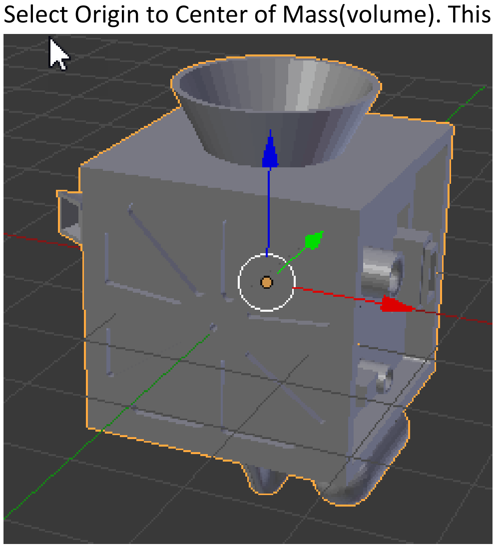
1. Change the visible coordinate system to the local system to make sure you are editing the correct system



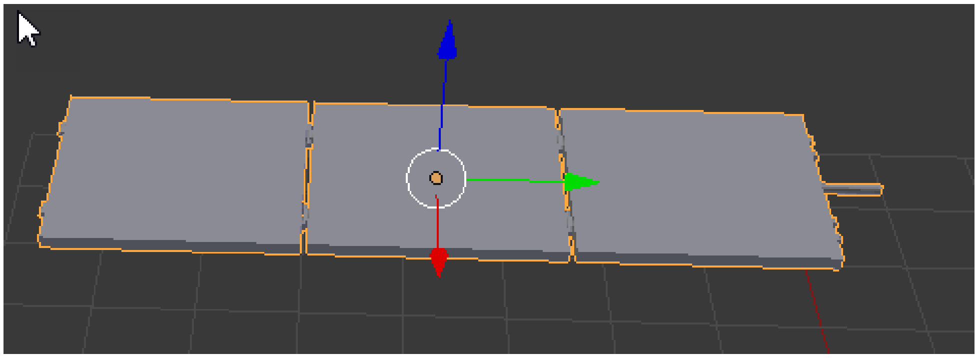
2. Select the satellite bus and hit Ctrl+Alt+Shift+C to bring up the origin options



3. Select Origin to Center of Mass(volume). This will reset the coordinate system to the center of the object.

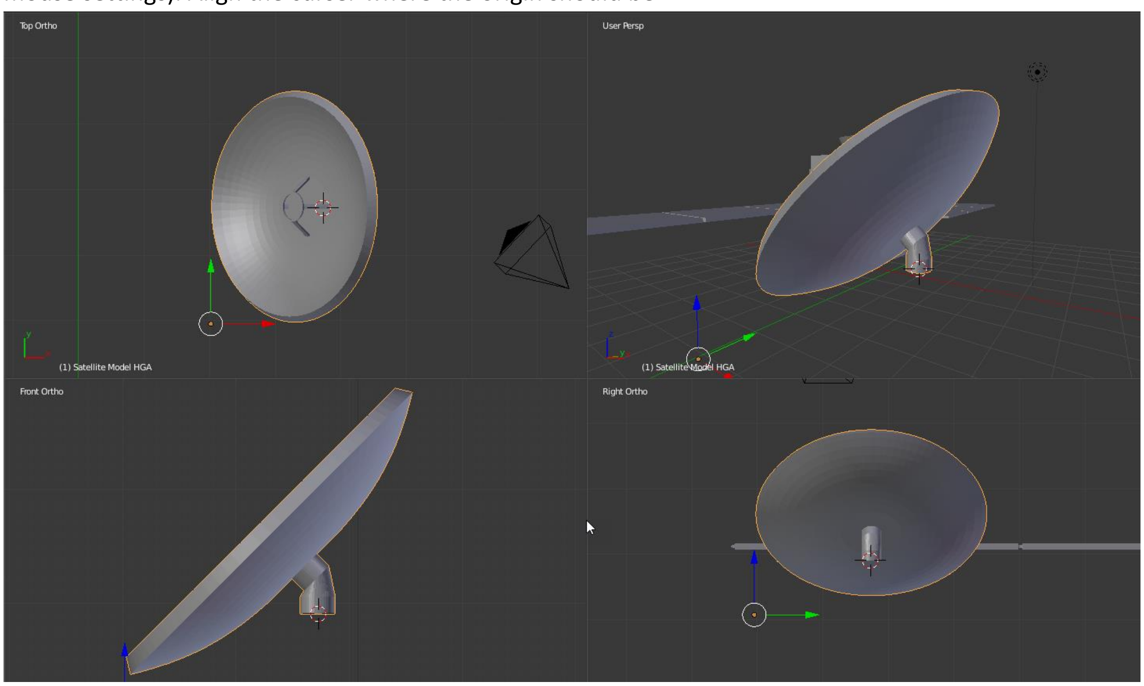


4. Move the origin in the same manner for both solar arrays

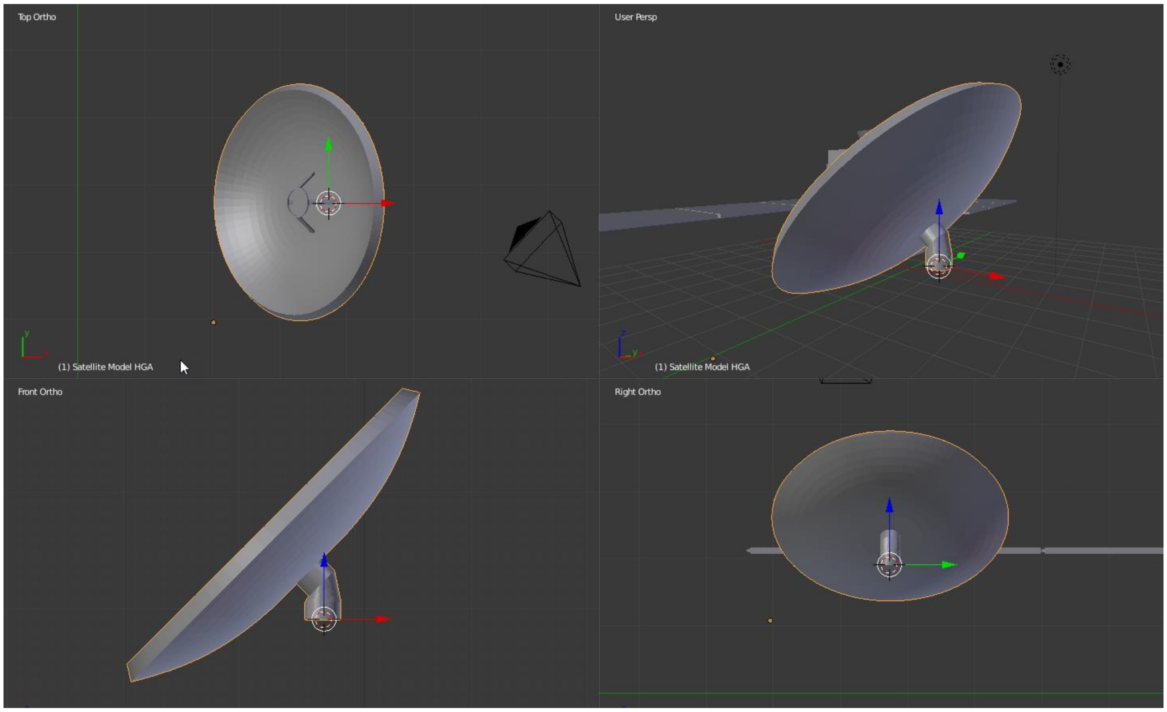


5. For the HGA, moving the origin to the center of mass is not an option since it should rotate about the arm on the back side of the dish. To properly place the origin it will need to be done manually. Press Ctrl+Alt+Q to Enter Quad view. This will make it easier to align the origin. Move the views (shift+CMB to pan) so you can see the HGA in all views

6. Move the 3D curser by clicking the right mouse button (or left mouse button if you never changed your mouse settings). Align the curser where the origin should be



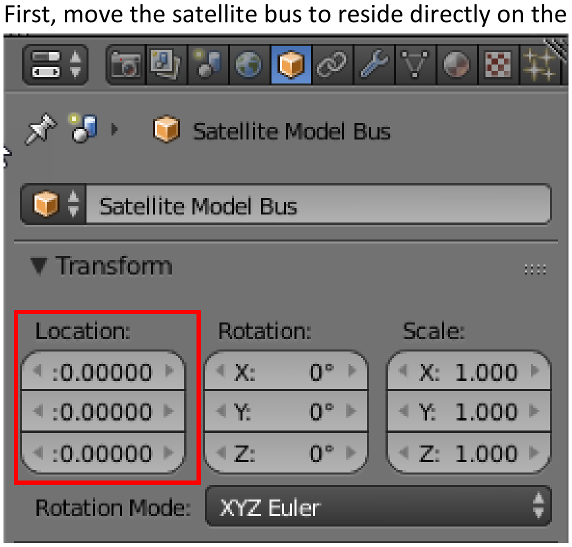
7. Hit Ctrl+Alt+Shift+C to set the origin. Select Origin to 3D Curser. You will see the origin align to the location of the curser.



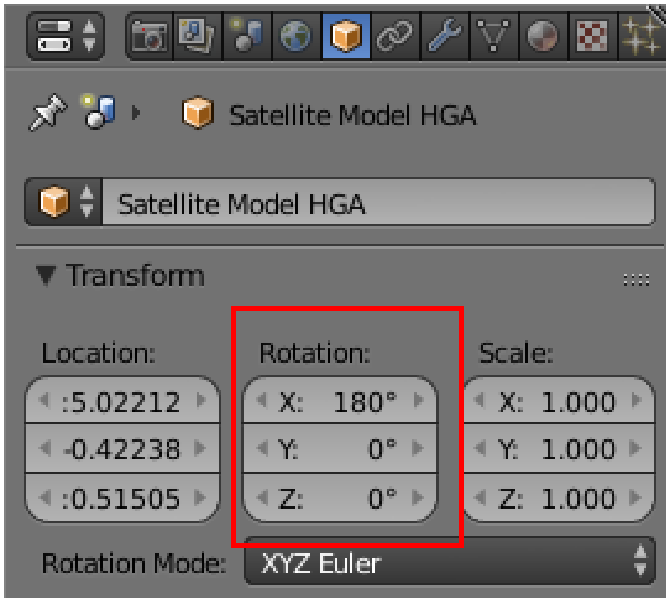
COMPONENT ALIGNMENT

Now that all of the components have the proper axes, they must now be aligned with each other to resemble a spacecraft.

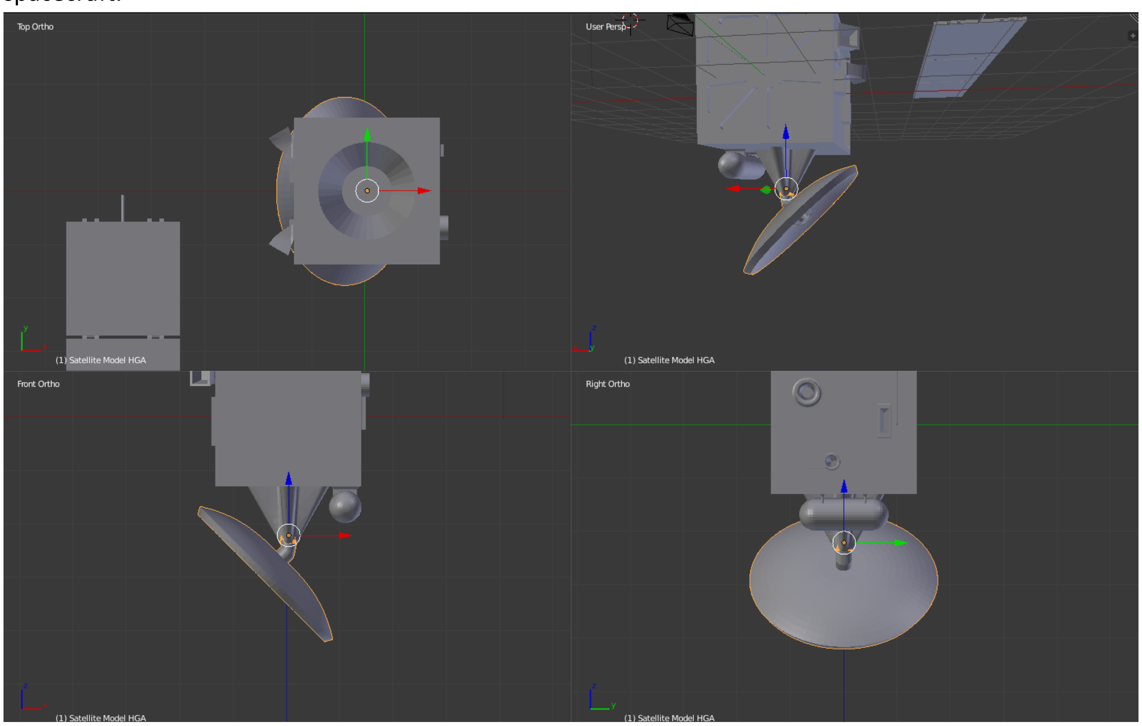
1. First, move the satellite bus to reside directly on the origin. This can be done in object properties.



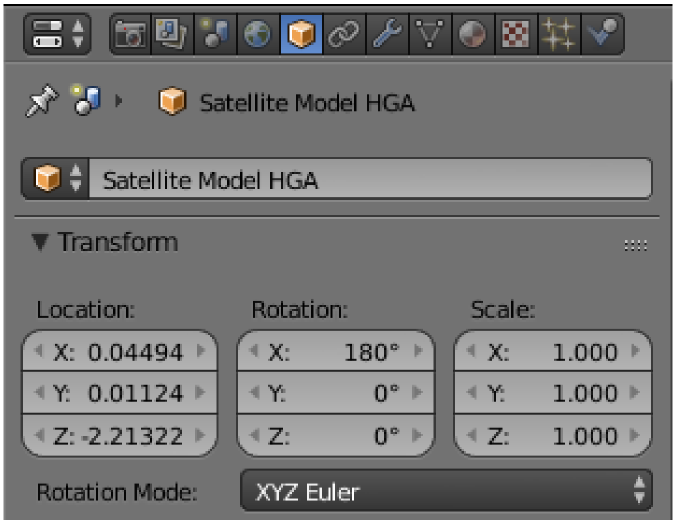
2. Rotate the HGA 180 degrees about the x-axis to properly align it with the mount on the bus



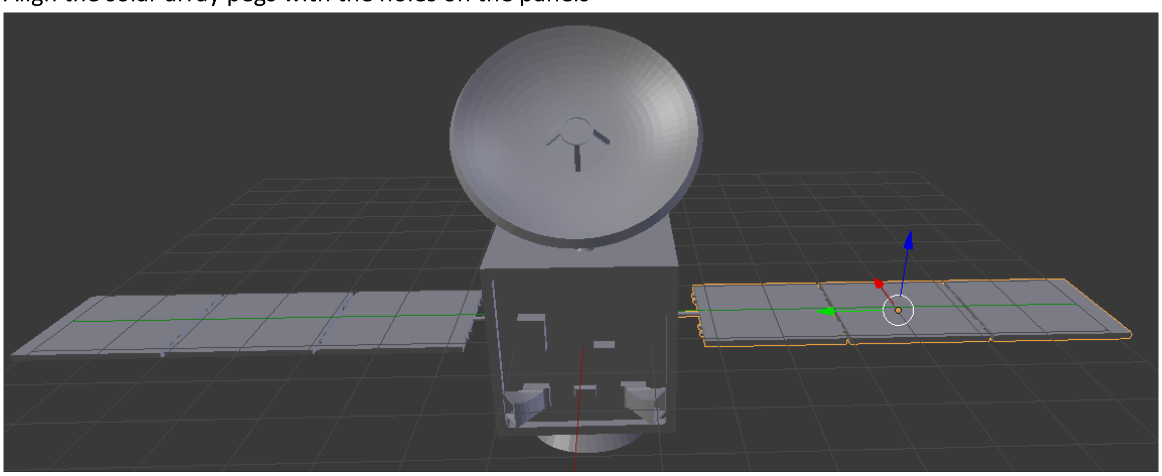
3. Enter Quad view by hitting Ctrl+Alt+Q. Move the HGA so it is properly aligned with the mount on the spacecraft.



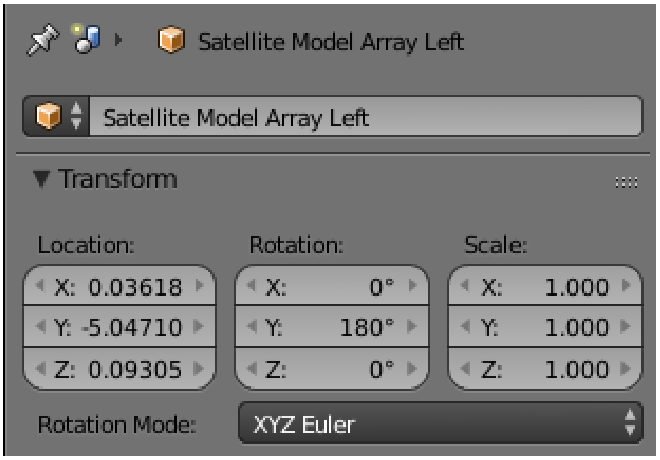
If the bus is positioned correctly, you can use the following setting to achieve the same result:

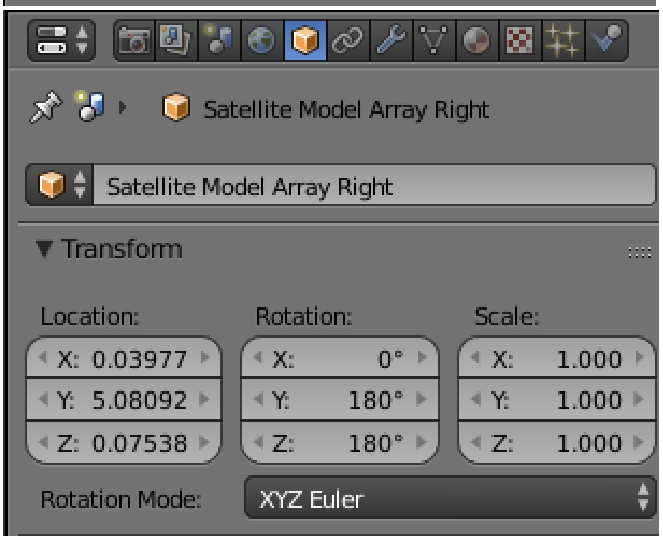


4. For the solar arrays, the goal is to have the rod come directly out of the central hole on the plus and minus Y decks of the bus structure. Upon inspection you will notice that one solar array is pointing the wrong way. Rotate this array by 180 degrees about the z-axis.
5. Rotate each array by 180 degrees around the y-axis. This will be important for solar panel groups later on.
6. Align the solar array pegs with the holes on the panels



If the bus is positioned correctly, you can use the following setting to achieve the same result:

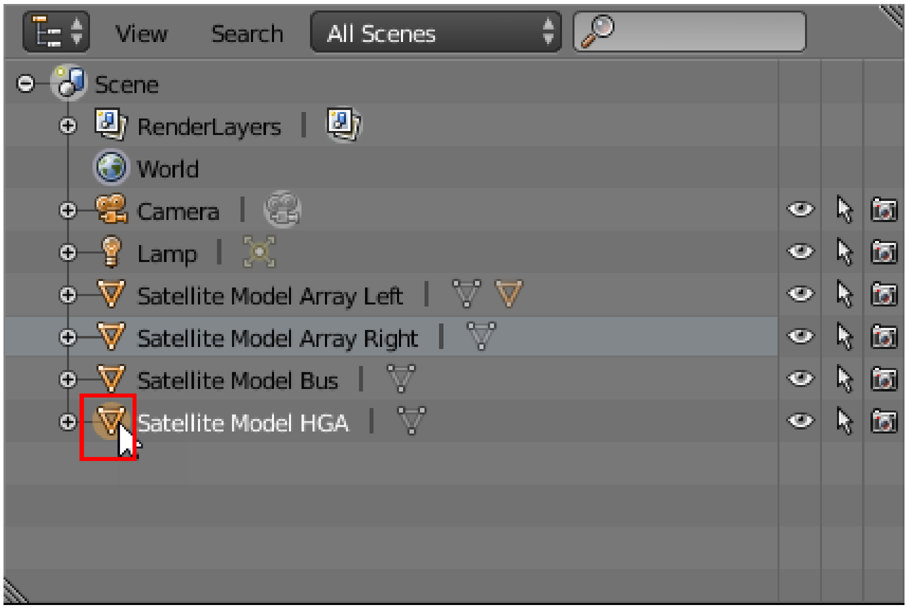


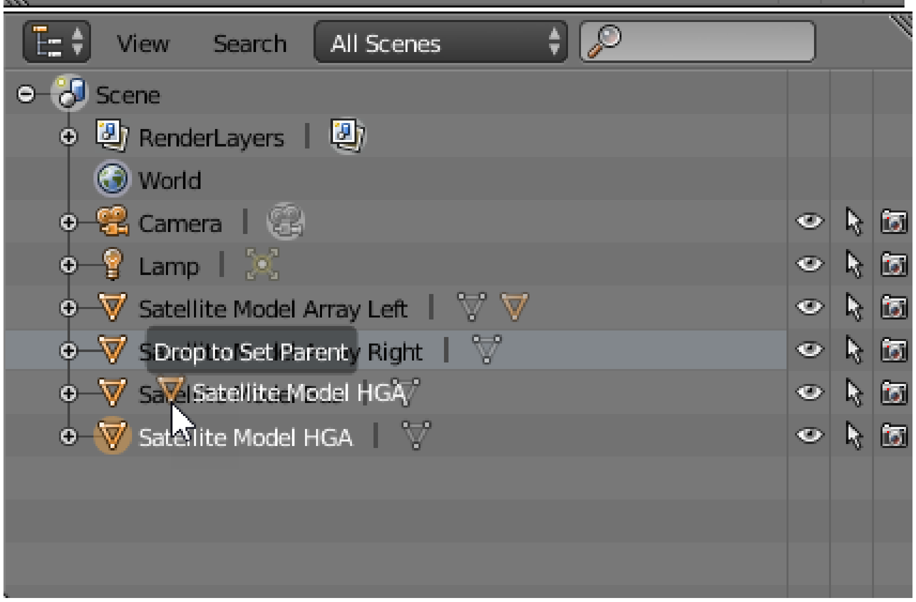


COMPONENT PARENTING

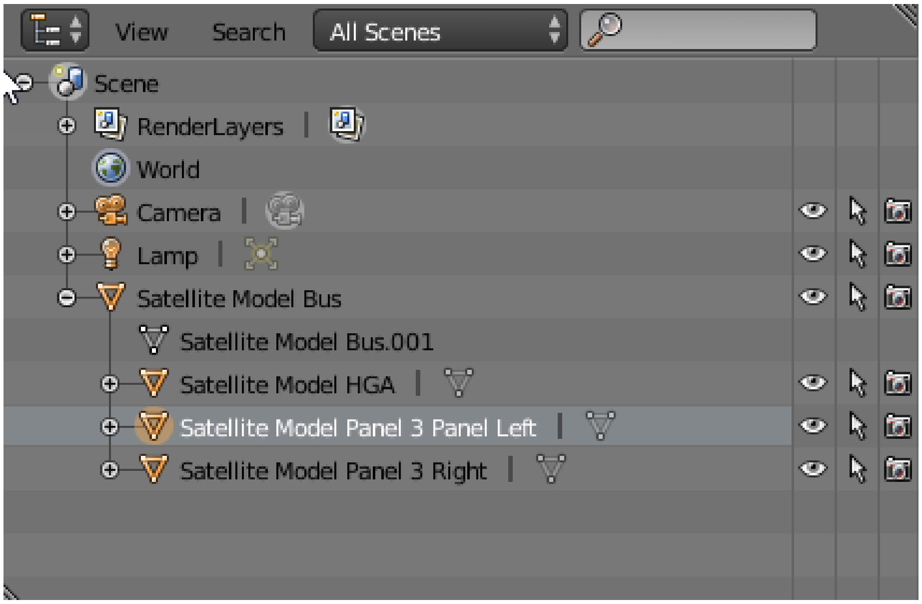
Proper component parenting is crucial for correct articulations attitude adjustments. For example, if a solar array is not parented to the main body of a satellite and the main body rotates (i.e. any attitude adjustment in STK) then the arrays will not rotate with the rest of the spacecraft. For this particular assembly the high gain antenna and both solar arrays must be parented to the main spacecraft bus.

1. In the outliner select the HGA object. Drag the orange triangle (next to the HGA name) and drop it on top of the orange triangle that corresponds to the satellite bus.





2. Follow the same process for both solar panel arrays. Additionally you should rename your array objects so you can differentiate between them. This can be done by right clicking on the object in the outliner and choosing rename.
3. When all three components are parented to the main bus your outliner structure should look like the following image.



4. Now that everything is parented try moving the bus structure and you will see the rest of the structure move with it

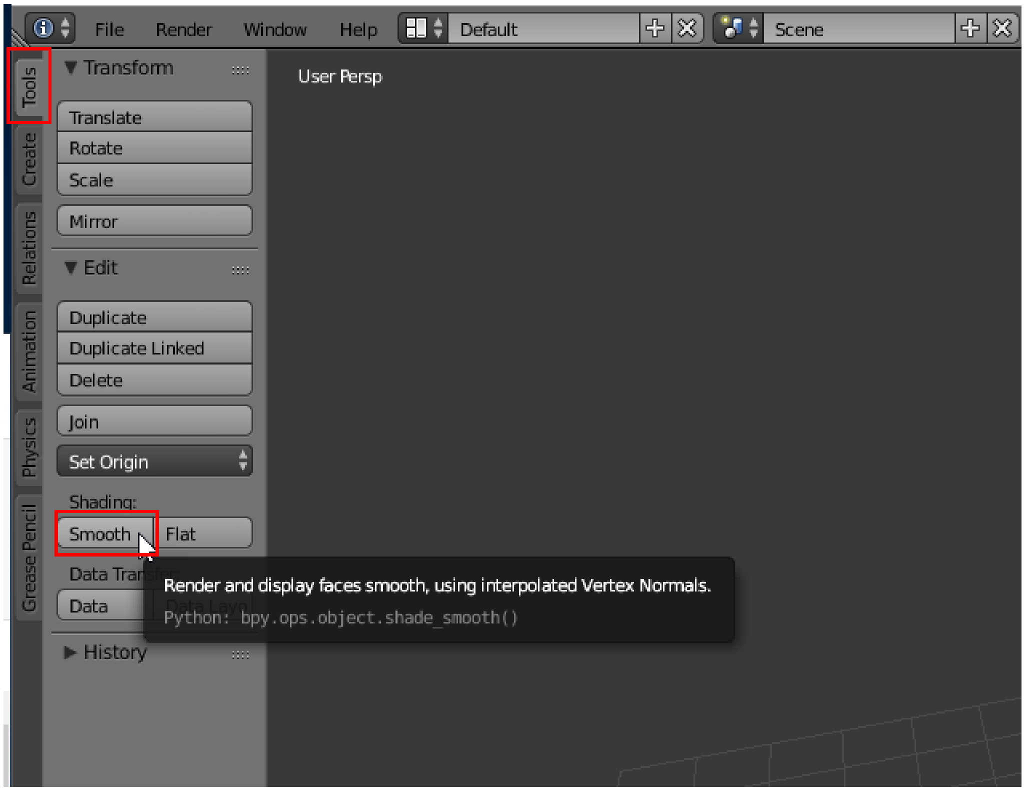
Note: The child components are not locked in place. Even though they will move according to the parent object, there is nothing stopping them from moving if you only move the child component. Remember that you can always use Ctrl+Z to revert back a step if you accidently move a component.

SHADING

Shading is not a requirement for importing models, but it can easily increase the quality of your models and how they are rendered in the final version. There are many complex shading methods that will not be discussed in this tutorial and only the most basic method will be covered here. For more information on different method please utilize the references given at the beginning of this tutorial.

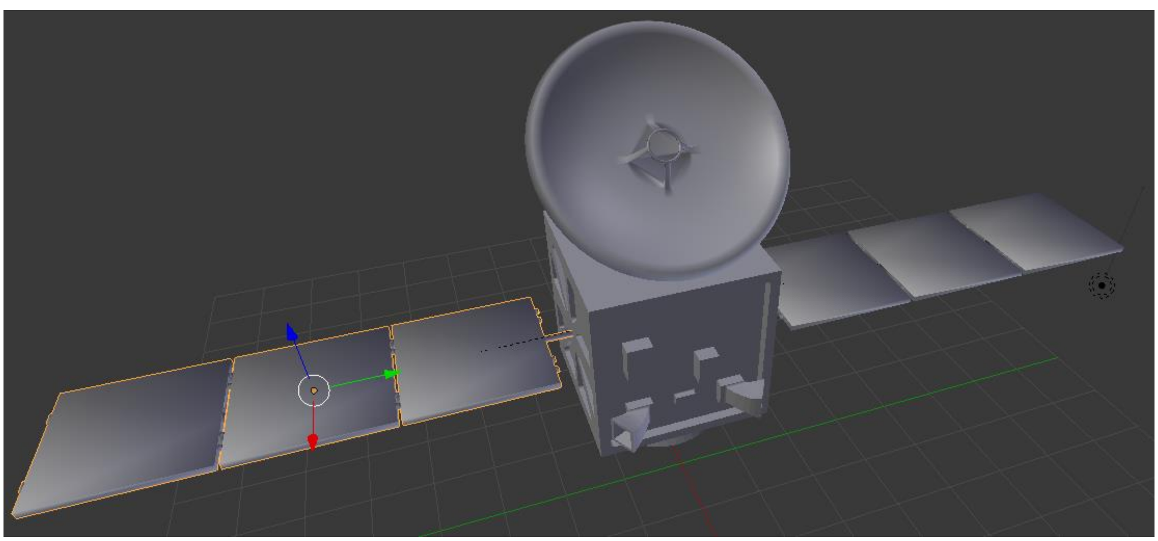
The main purpose of shading is to minimize edges on curved surfaces. If you look closely at the HGA you will notice clear lines on the disk which indicate the edge of individual polygons that make up the disk. The goal is to shade the entire component to eliminate these lines and smooth out the surface.

1. Select the HGA and navigate to the tools tab of the left hand panel



2. Select smooth shading from the shading options. By default every component is set to flat shading unless changed

3. Notice that the HGA now has a much smoother finish. Complete the same process for both solar arrays. The end result will look this:

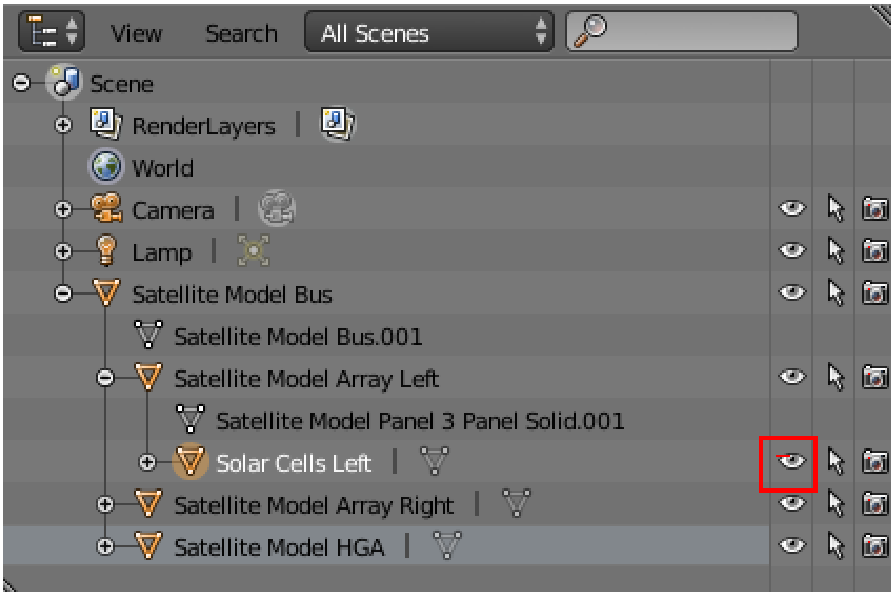


4. **DO NOT** enable smooth shading on the bus component. Components that have complex geometry do not smooth well. If you do select smooth shading by accident, it can be reverted by switching back to flat shading.

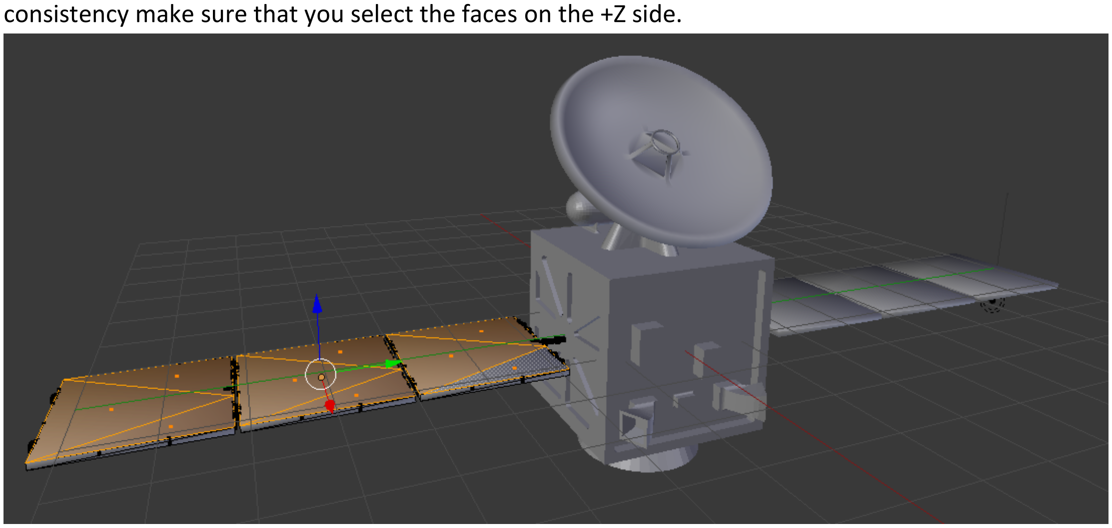
SOLAR PANEL GROUPS

Creating solar panel groups is a requirement for the STK Solar Panel Tool to work correctly. With the current setup the solar panel tool would consider all outward facing polygons on each solar panel, including the back and side faces. To fix this an object must be created to represent just the solar cells.

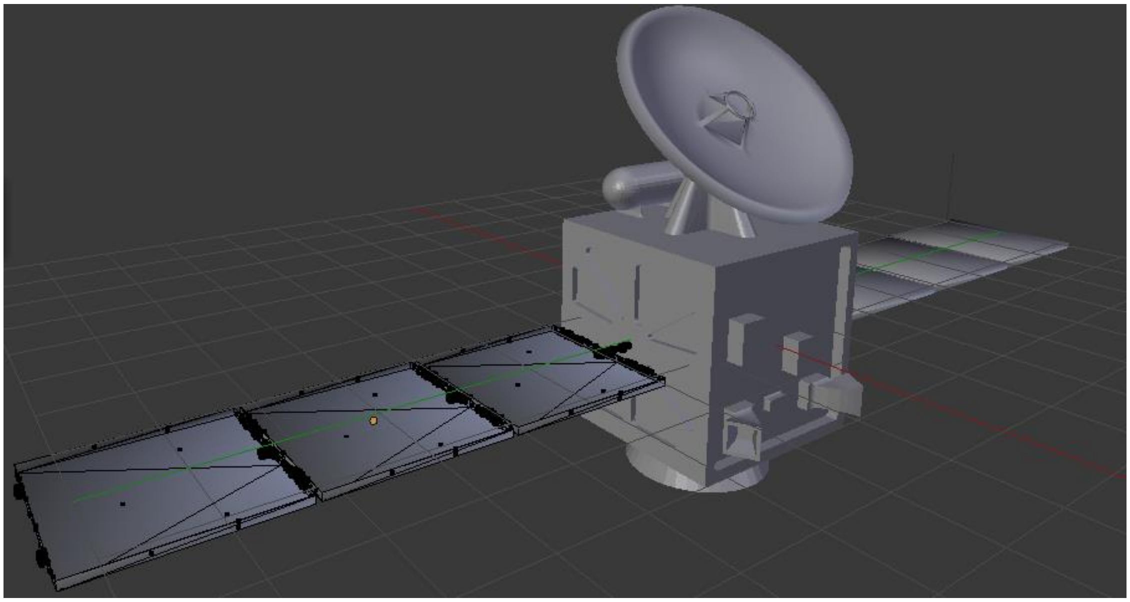
1. Select the left solar array. While having the curser in the 3D window hit Ctrl+C and then Ctrl+V to copy and paste the array on top of itself. If the copied array appears away from the original array, make sure your bus location is set to (0,0,0).
2. In the outliner rename the copy "Solar Cells Left". Parent the solar cells to the left array



3. Hide the solar cells by clicking the eye icon in the outliner
4. Select the original array and enter edit mode (Tab). Shift Select all faces that represent solar cells. For consistency make sure that you select the faces on the +Z side.



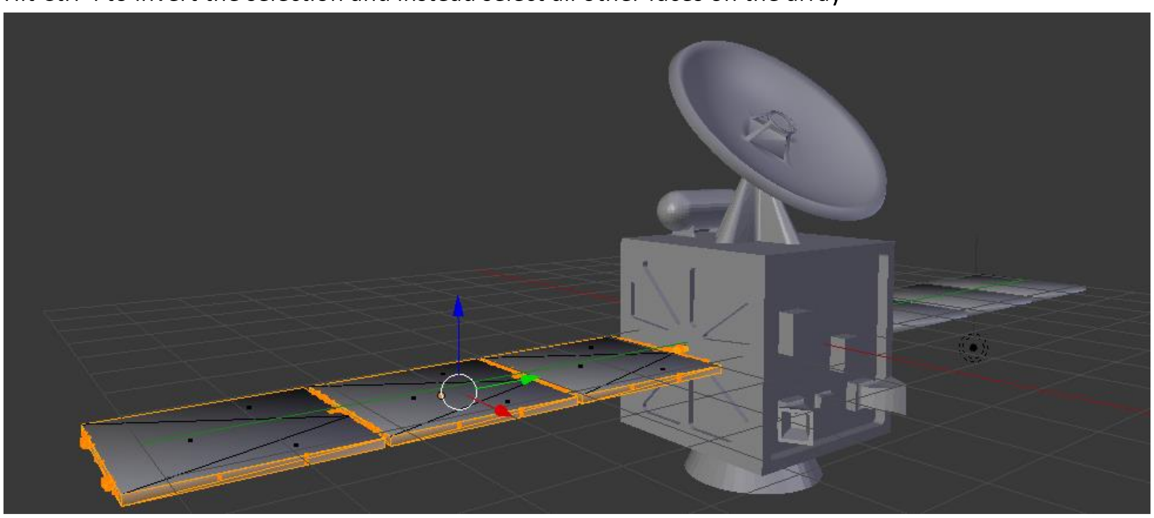
5. When all faces are selected, delete only the faces with the Delete key.



6. Exit Edit mode by hitting Tab. In the outliner hide the array and unhide the solar cells

7. Select the solar cells and enter edit mode (Tab). Once again select all faces that represent solar cells.

8. Hit Ctrl+I to invert the selection and instead select all other faces on the array



9. Delete these selected faces. The only faces left will be the solar cells.

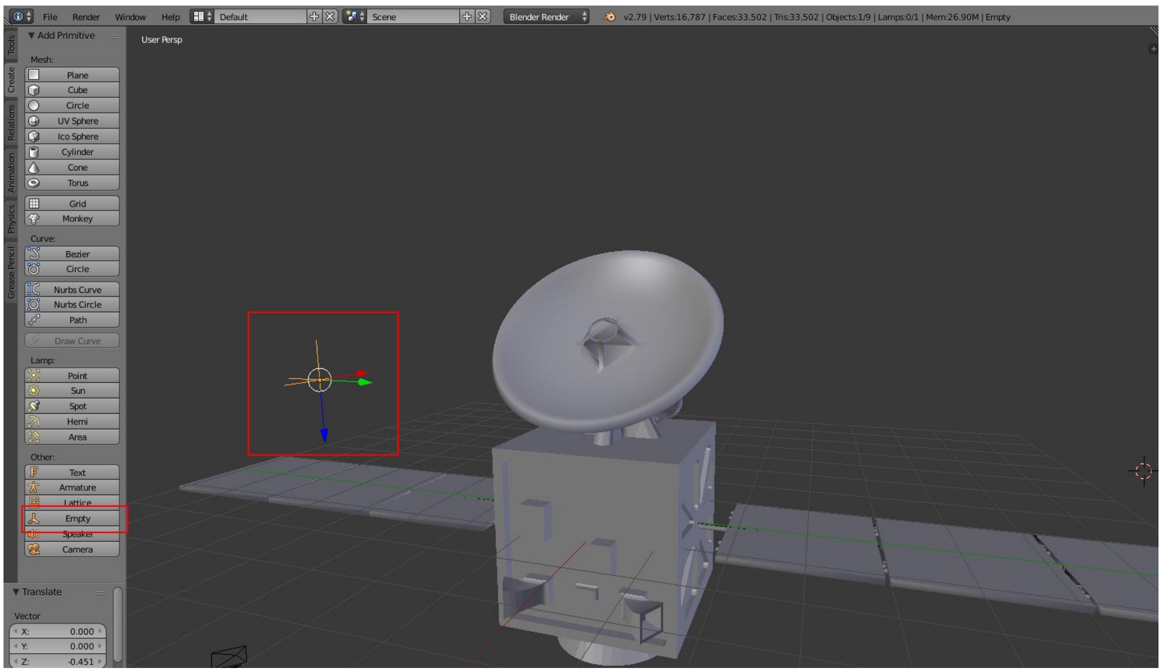
10. Now if you unhide the array object you will see the full array and the Solar Panel Tool will work correctly with the newly created cells.

11. Complete the same steps for the other array.

SENSOR ATTACH POINTS

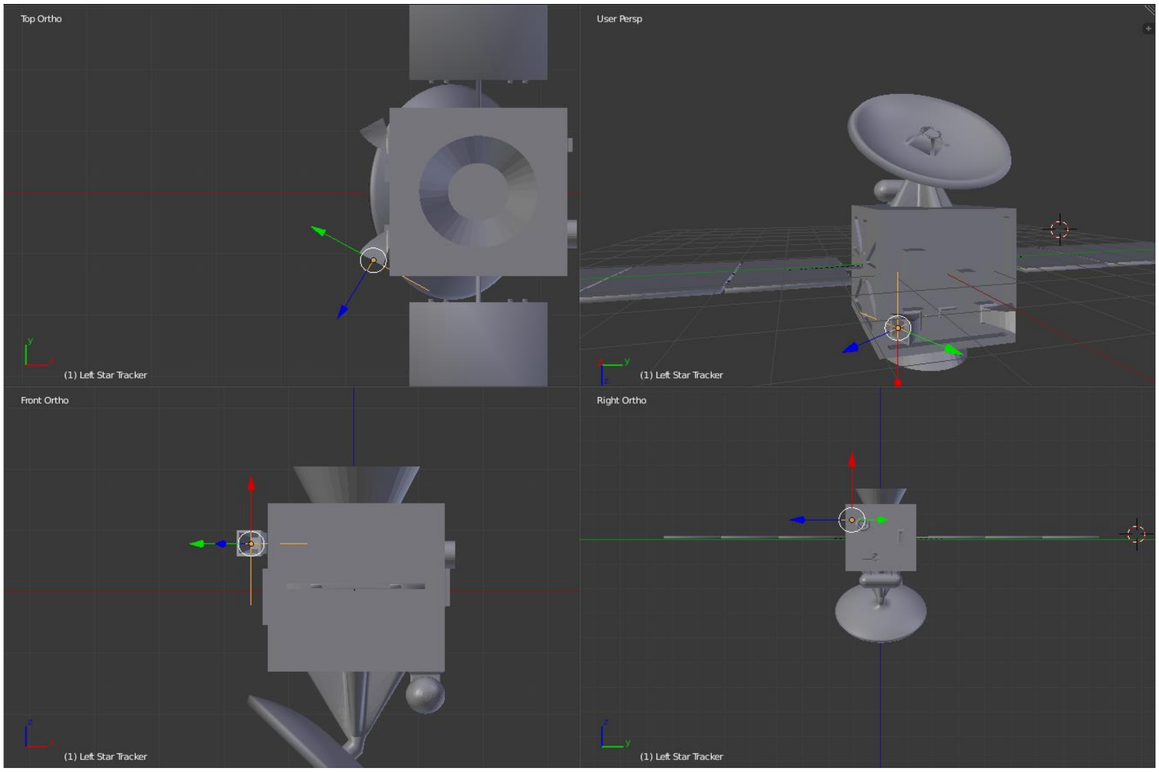
To achieve the most accurate modelling of you your mission it is crucial to orient your sensors in the proper position. STK offers a great feature that allows the user to specify custom points on a model to attach sensors. For this feature to work properly, the sensor attach points must be pre-defined in Blender. This model was designed to have six sensor attach points; one for the HGA sensor, two for the star trackers, and three for the main instruments.

1. A sensor attach point in tied to an "empty" object (better known as a "null" if you are familiar with other graphics design software). Insert an empty from the primitives menu.

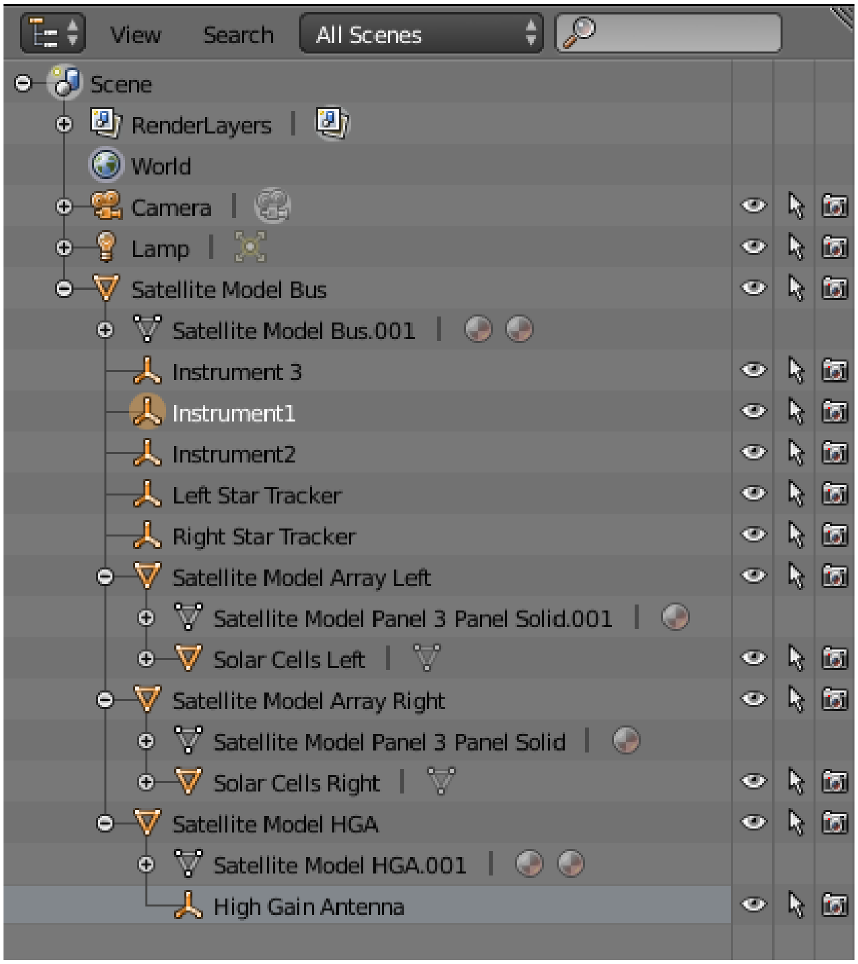


2. Enter quad view by hitting Ctrl+Alt+Q. This will make it easier to align the empty.

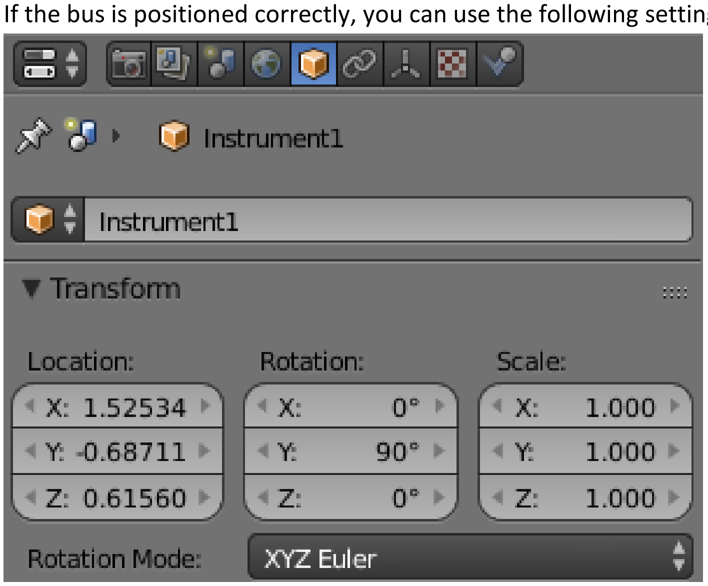
3. Align the empty with one of the star trackers. Rotate the empty so that the z-axis is pointing outwards from the plane of the star tracker. Blender does not think that an empty as an origin point. Because of this, you will be unable to snap the empty to the 3D curser if you try and it must be moved manually. If you have trouble aligning the empty, check the end of this section which documents the exact location and orientation of each empty in the assembly.

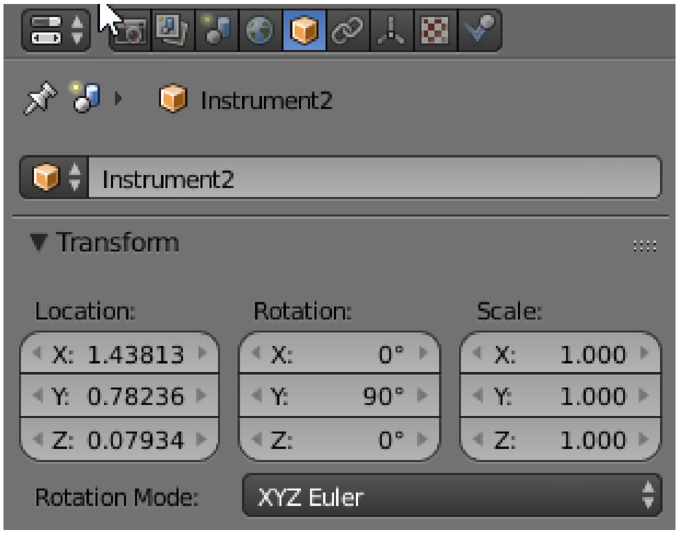


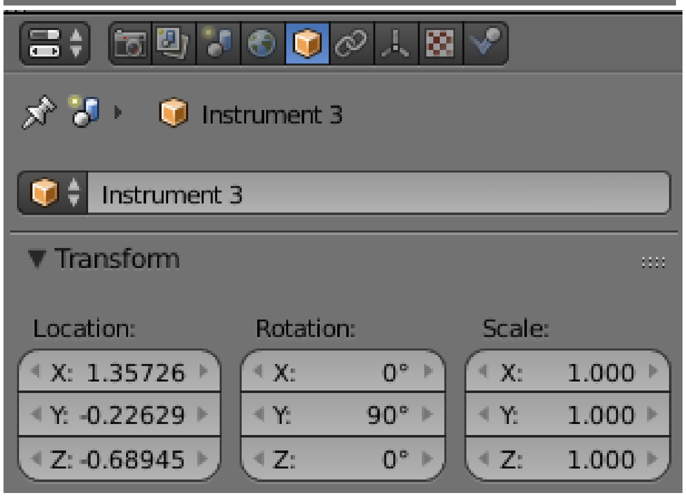
4. Complete this process for the other star tracker, the HGA sensor, and the three instruments on the opposite face. Make sure each empty is parented with the satellite bus. Now that all of the empties have been added, the model assembly is complete. Your outliner should resemble something like the following.

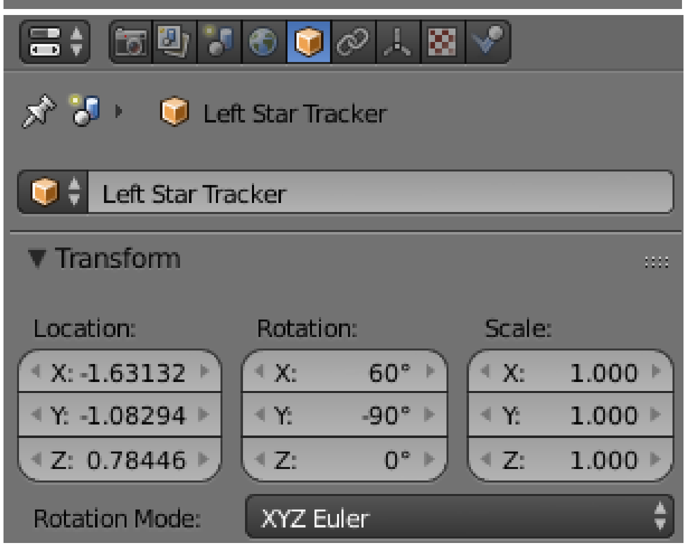


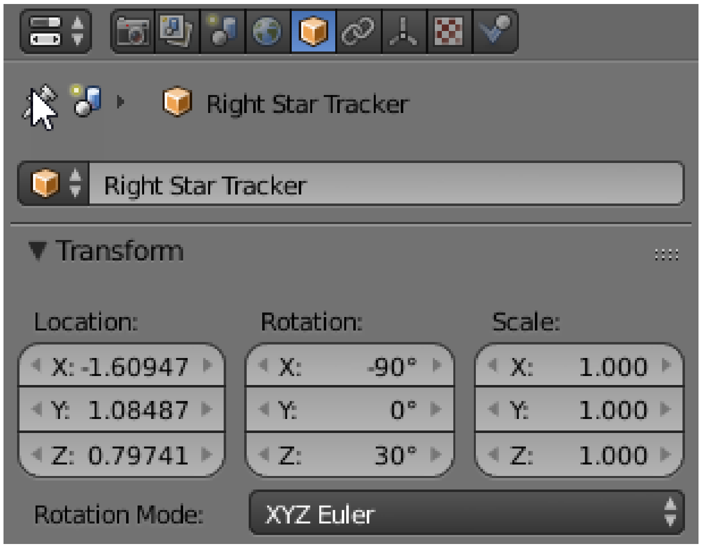
If the bus is positioned correctly, you can use the following setting to achieve the same result:

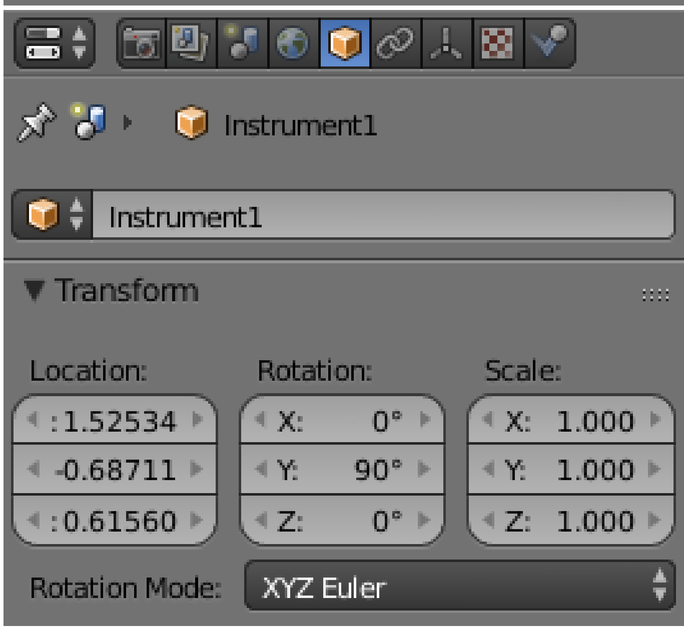



Instrument2
Instrument2
Transform
Location:
Rotation:
Scale:
X: 1.43813
Y: 0.78236
Z: 0.07934
X: 0°
Y: 90°
Z: 0°
X: 1.000
Y: 1.000
Z: 1.000
Rotation Mode:
XYZ Euler


Instrument 3
Instrument 3
Transform
Location:
Rotation:
Scale:
X: 1.35726
Y: -0.22629
Z: -0.68945
X: 0°
Y: 90°
Z: 0°
X: 1.000
Y: 1.000
Z: 1.000


Left Star Tracker
Left Star Tracker
Transform
Location:
Rotation:
Scale:
X: -1.63132
Y: -1.08294
Z: 0.78446
X: 60°
Y: -90°
Z: 0°
X: 1.000
Y: 1.000
Z: 1.000
Rotation Mode:
XYZ Euler





Now that the model is complete the next step is to create materials and textures for the model to make it look realistic.

Save Point

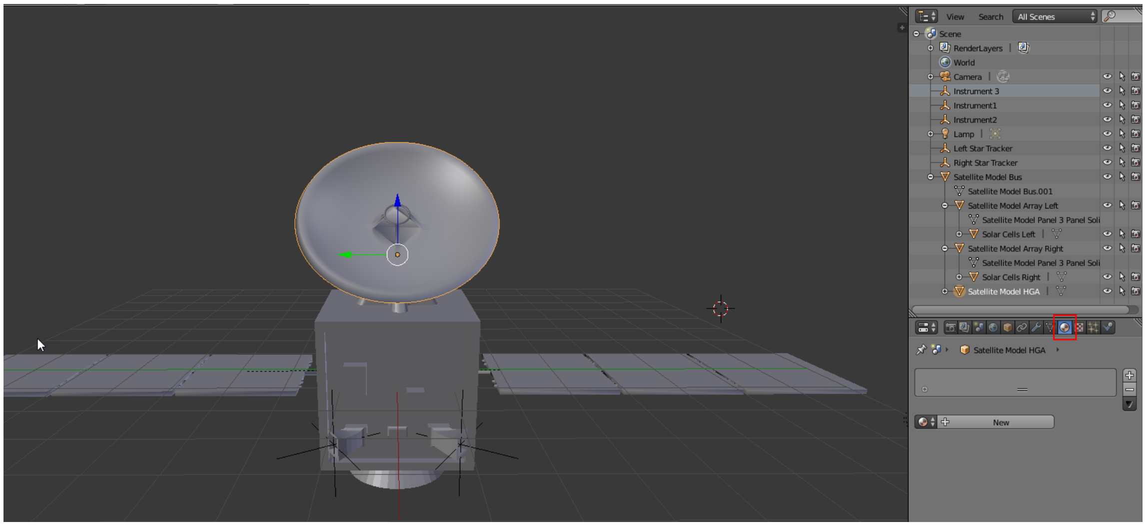
MATERIALS AND TEXTURES

Creating materials and textures is the most time consuming aspect of model development because it can take several iterations to get everything looking correct. This portion of the tutorial will cover some basic material creation and texture mapping for all components in the assembly. If you are planning on creating models frequently, it is highly recommended that you learn all of the different mapping techniques from the reference material.

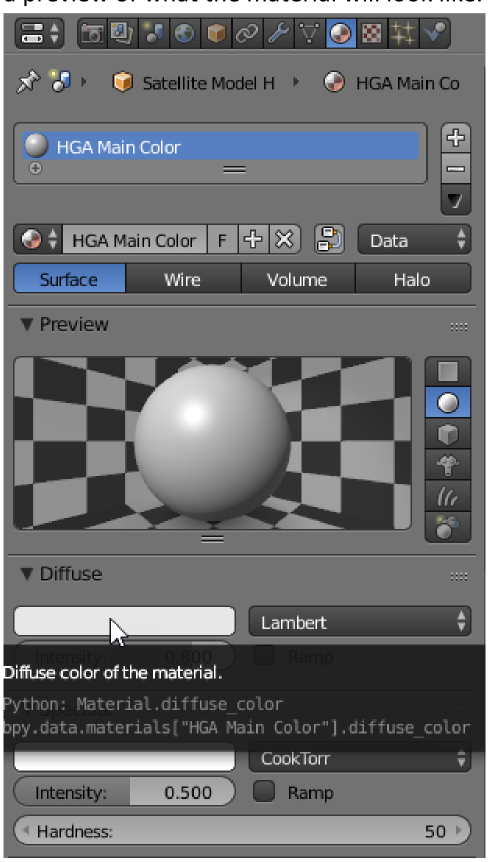
ADDING MATERIALS AND COLOR

Material and color are essentially analogous in blender. This is important to remember for this part of the tutorial. A true “material look” will likely come from a texturing pattern which will be covered in the next section. Regardless, the presence of a material is required for any texturing or coloring. For this assembly materials will be applied to all components but textures will only be applied to the solar cells and the satellite bus.

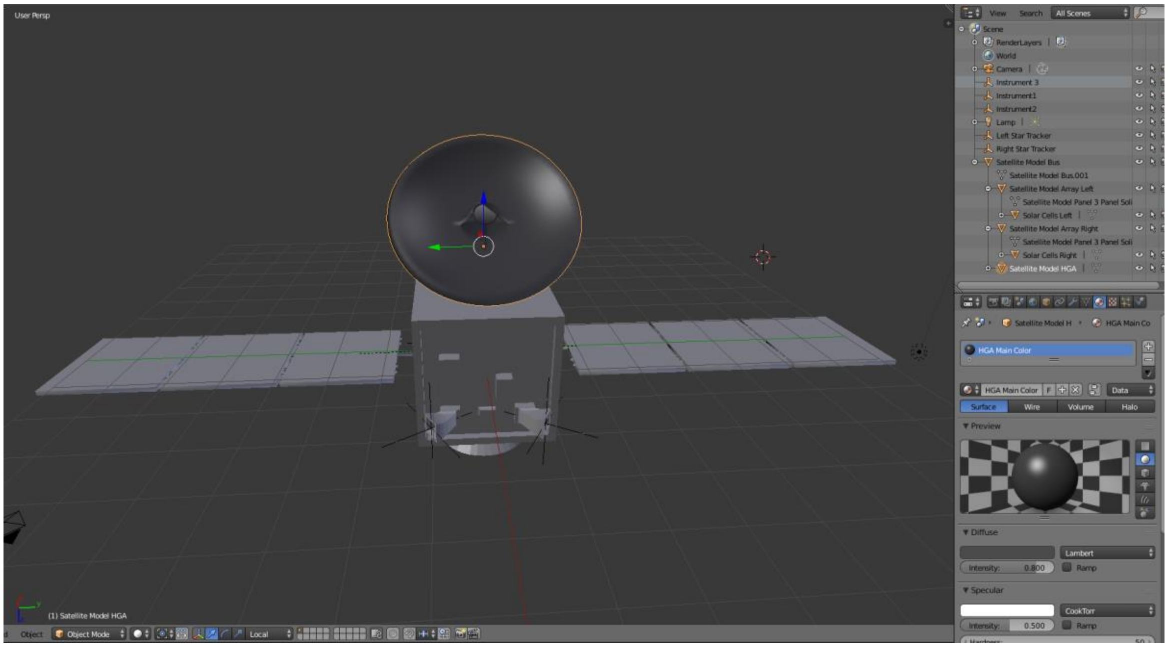
1. Select the HGA and navigate to the materials section of the properties panel



2. Select “New” to create a new material. This will pull up all of the possible options for a material along with a preview of what the material will look like.

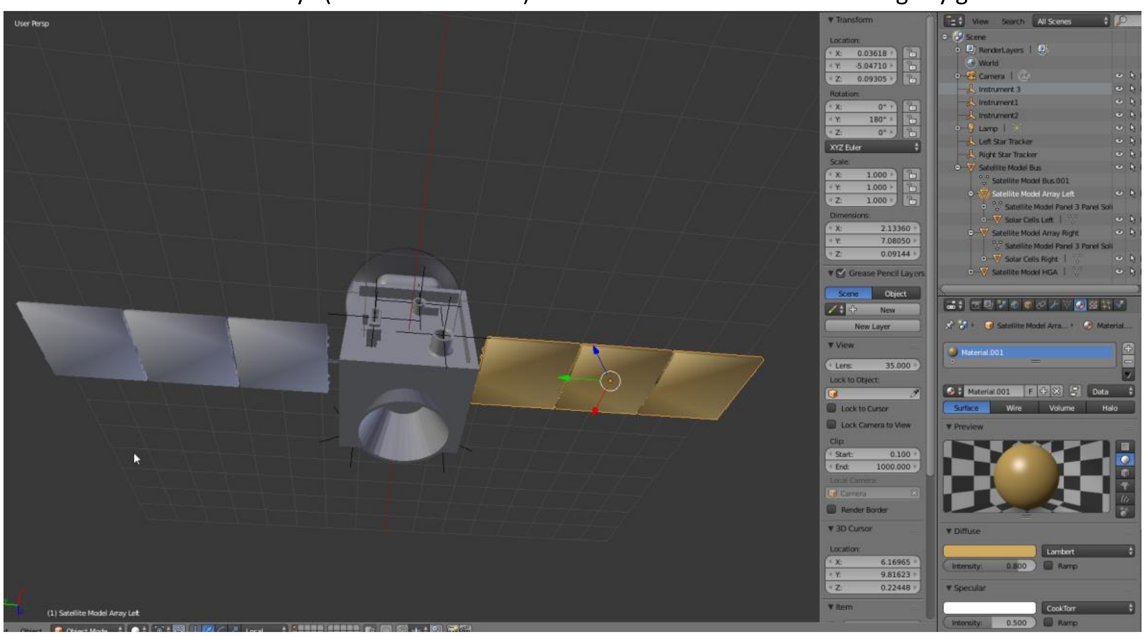


3. Click on the Diffuse color bar to pull up the color wheel. For the HGA a dark gray was chosen, but the color chosen is personal preference.



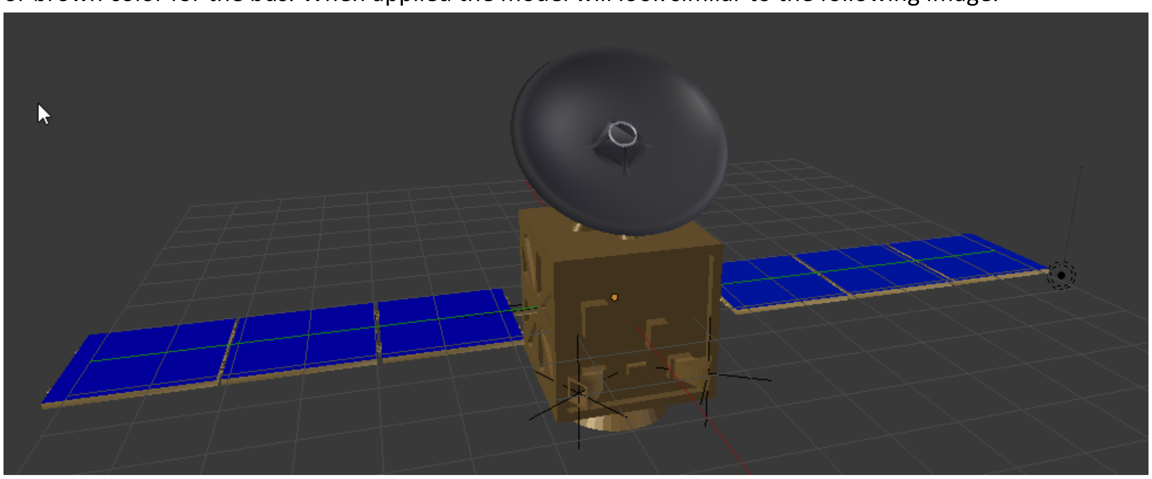
4. Notice that if you are in object mode and you assign a color, all faces of that object will change color. To only assign a material to a particular face, you must be in edit mode and assign the material to specific faces. This will be covered in more detail when the bus is textured.

5. Select one of the solar arrays (not the solar cells). Add a new material that has a slightly gold color



6. Select the other array and apply the same coloring. If you do not know the exact color, then you can use the eyedropper tool to match the exact color with a surface in the model.

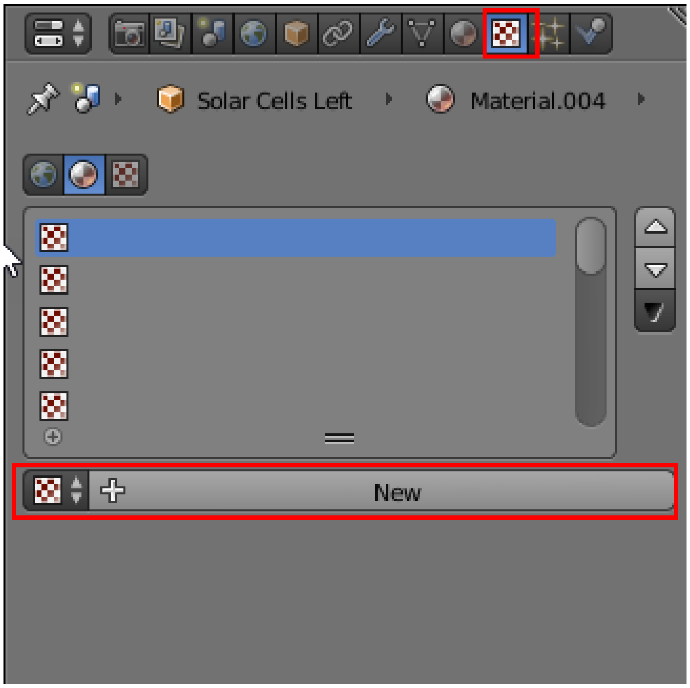
7. Even though the final look of the solar cells and the bus structure will be based off image textures, a base material is required to add the texture. Add a blue color as the material for the solar cells and a dark gold or brown color for the bus. When applied the model will look similar to the following image.



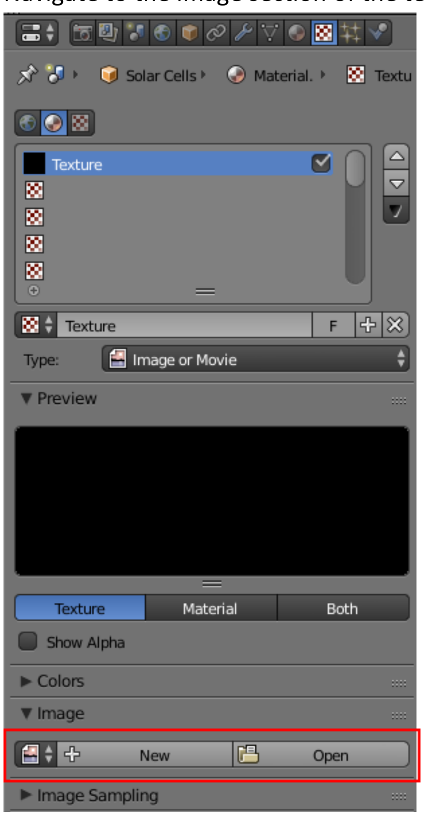
ADDING TEXTURES WITH UV MAPPING

There are many way to add textures to a model but the method that will be used here is image mapping. In the documents provided for this tutorial you will find a solar cell texture and a seemless gold foil texture. These textures will be mapped to the surface to create a more realistic model

1. Select the left solar cells and navigate to the textures tab of the object properties. Select New texture. Notice that the material that this texture is associated with is listed at the top of the panel next to the object name.

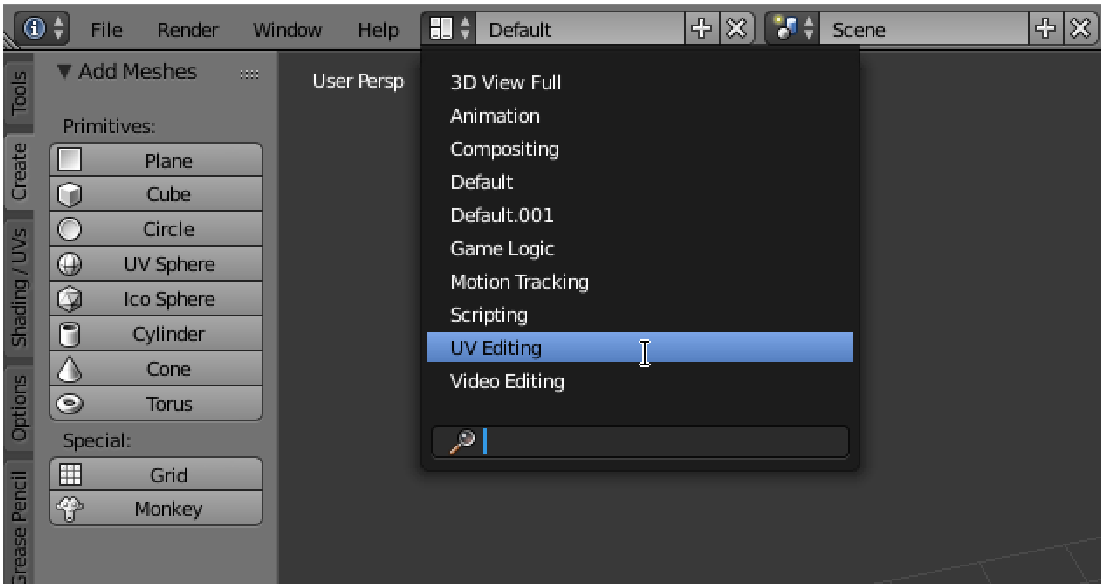


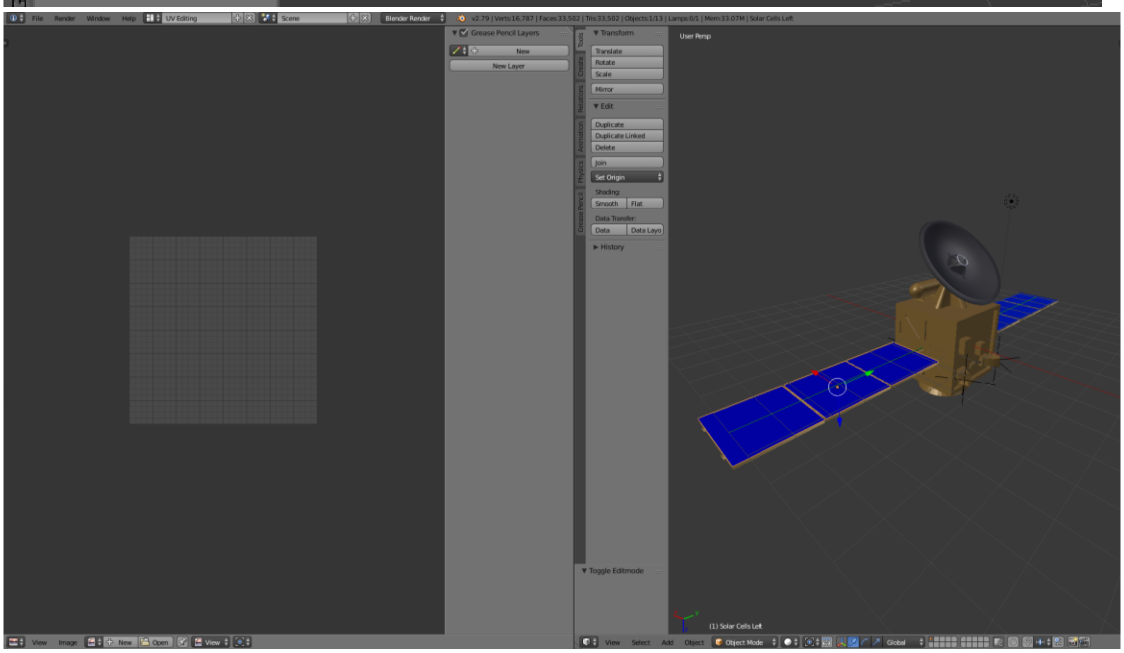
2. Navigate to the Image section of the texture menu and select Open.



3. Select the solar cell texture from the tutorial folder. This will import the image as a texture but still will not show up on the object because it needs to be mapped to a surface

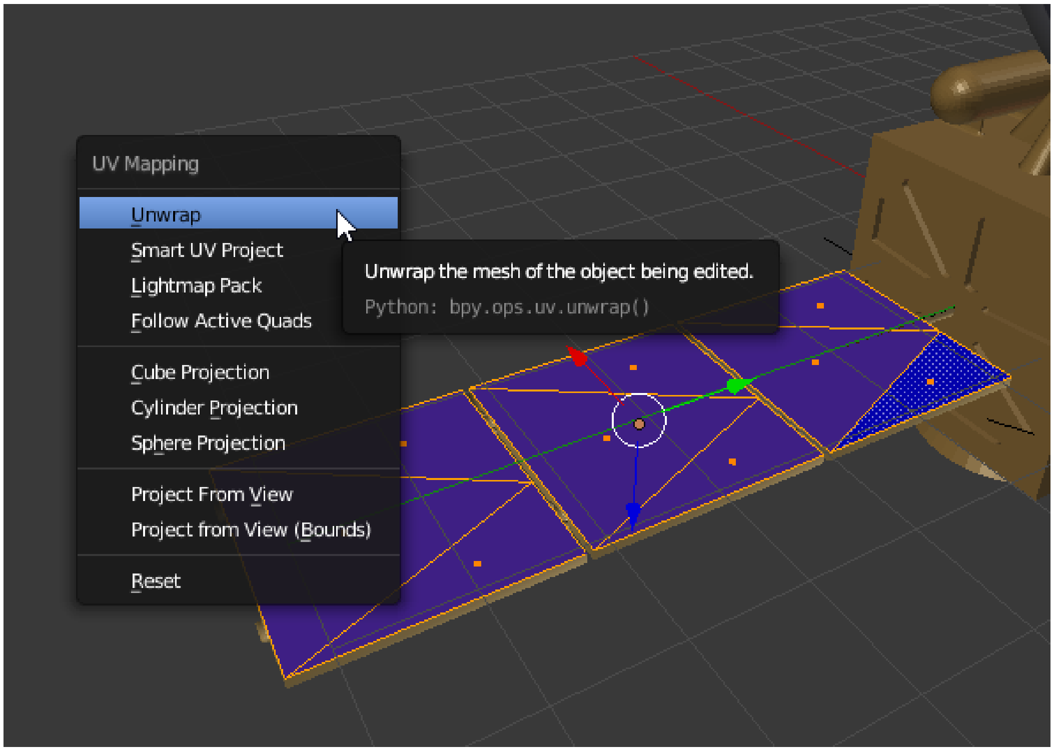
4. Switch to the UV editing view by changing the current window setup. After selecting your Blender window will look like the image below.



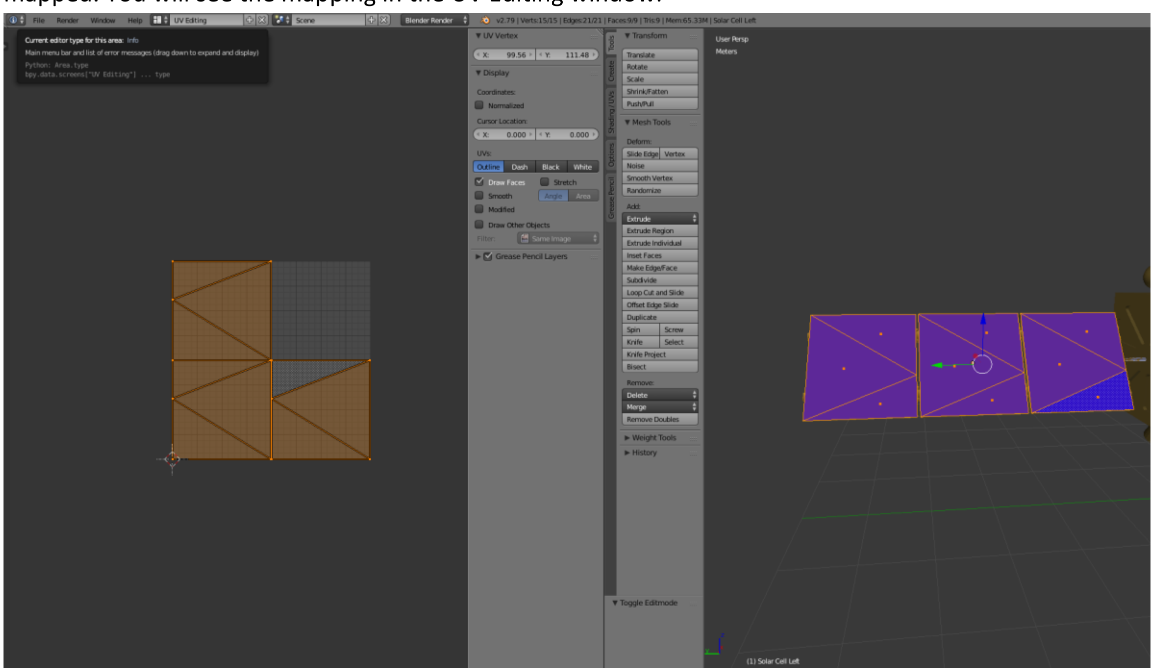


5. In the 3D display window enter edit mode on the left solar cella and select all outward faces.

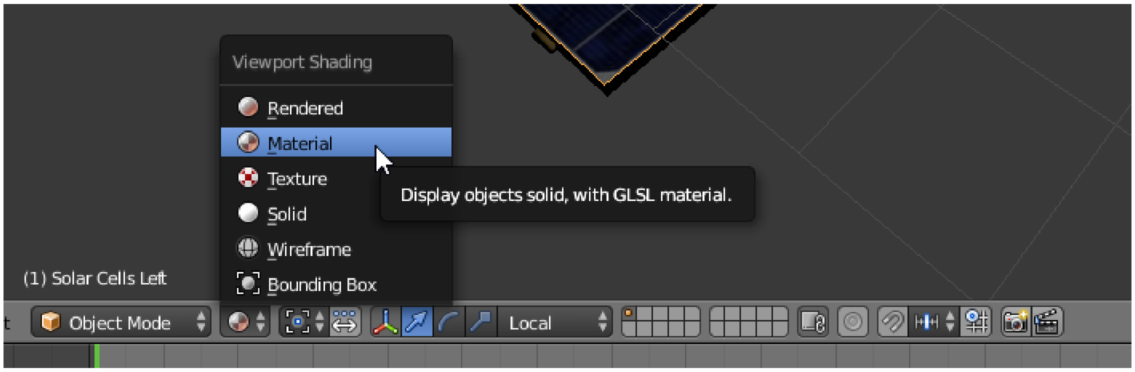
6. Hit U to pull up the UV mapping Menu.

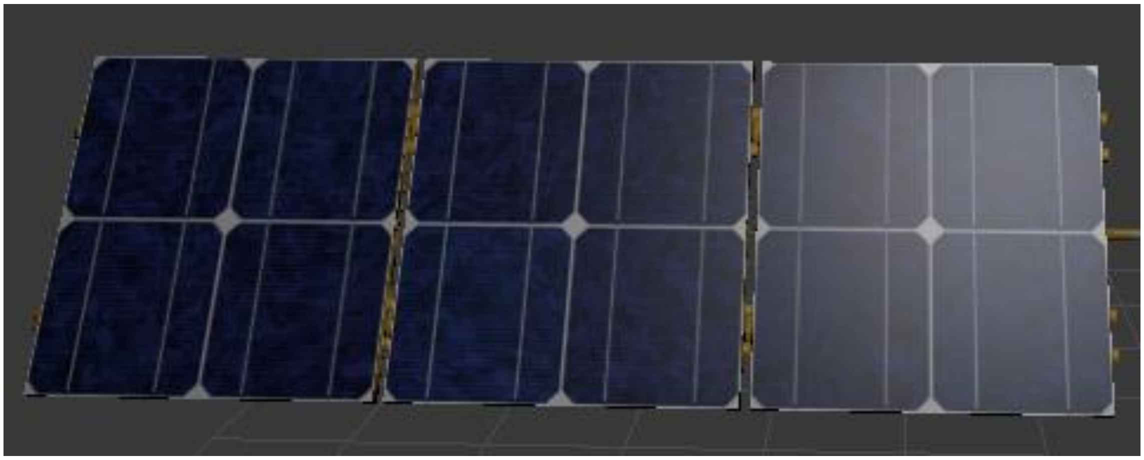


7. Click Unwrap to map the surfaces. The unwrap command works best for flat suraces that are easily mapped. You will see the mapping in the UV Editing window.



8. Exit out of edit mode and you will see the mapping disappear (That is okay). If you look at the solar panel you will see no difference. This is because the current display is set to solid and must be changed to Material. This can be changed from the design tools at the bottom of the 3D display window. Once switched to Material mode you will be able to see the textured solar panel.



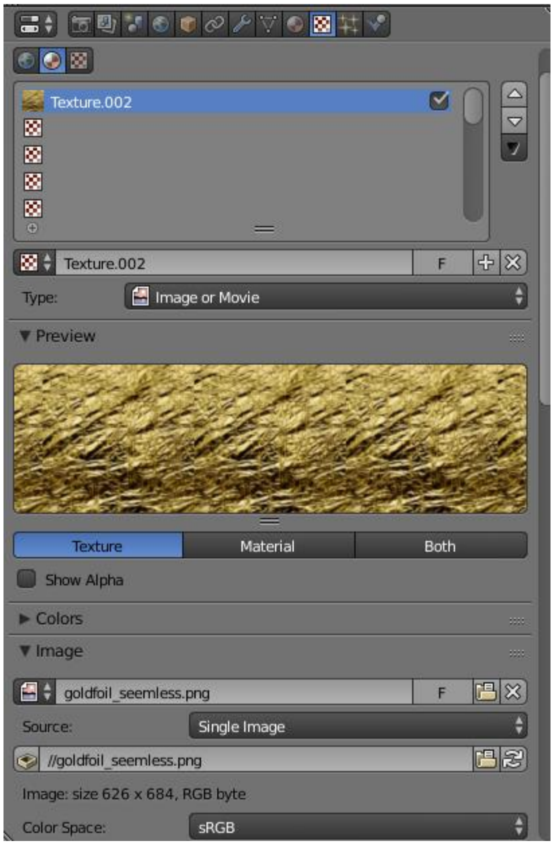


Notes on lighting: If your model appears black or partially black it is likely because your lighting is wrong. By default there should be a lamp present in the scenario. You can move the lamp, similar to any other object, to light different parts of the assembly. Additionally you can insert a new light from the primitives menu. It was found that a hemi-lamp works well to illuminate a large part of the assembly.

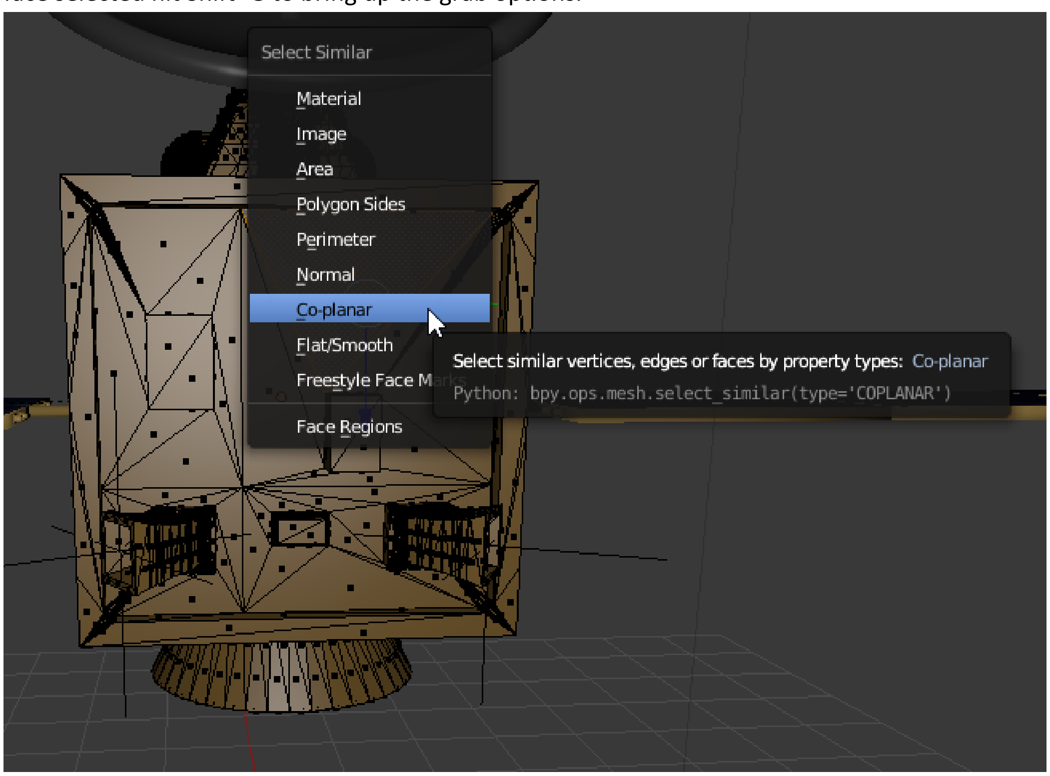
9. Complete the same process for the other solar cells. There should be no difference between the two sides

Because of the complex geometry, only a few sections of the bus will be mapped out in the tutorial; however, the final version found in the tutorial files is fully mapped. If you would like to map the entire spacecraft for practice follow the same set of steps but feel free to experiment with some of the other UV mapping techniques to become familiar with more options. Luckily, the gold foil texture is meant to look very similar regardless of how you map the image.

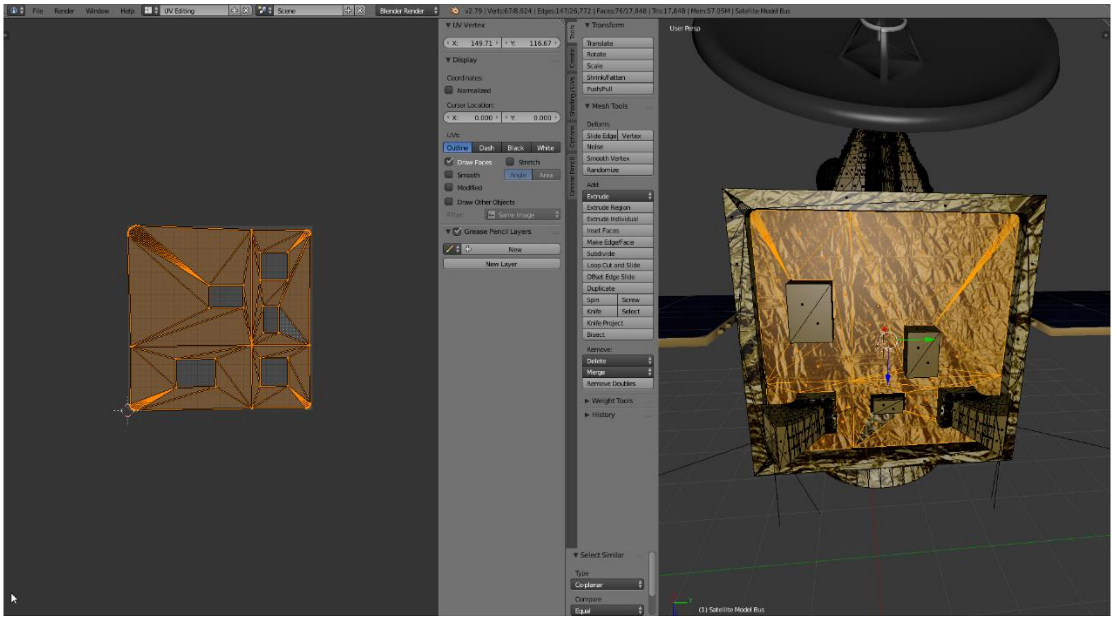
10. Select the satellite bus and load the gold foil image into a new texture.



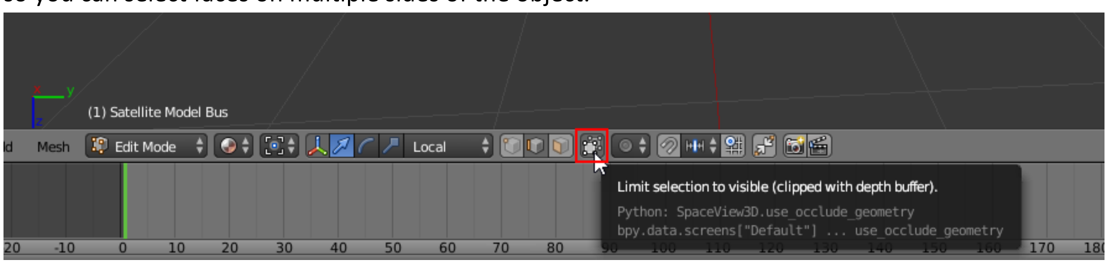
11. Reorient to a front view, and enter edit mode. Select any of the flat faces behind the star tracker. With a face selected hit Shift+G to bring up the grab options.



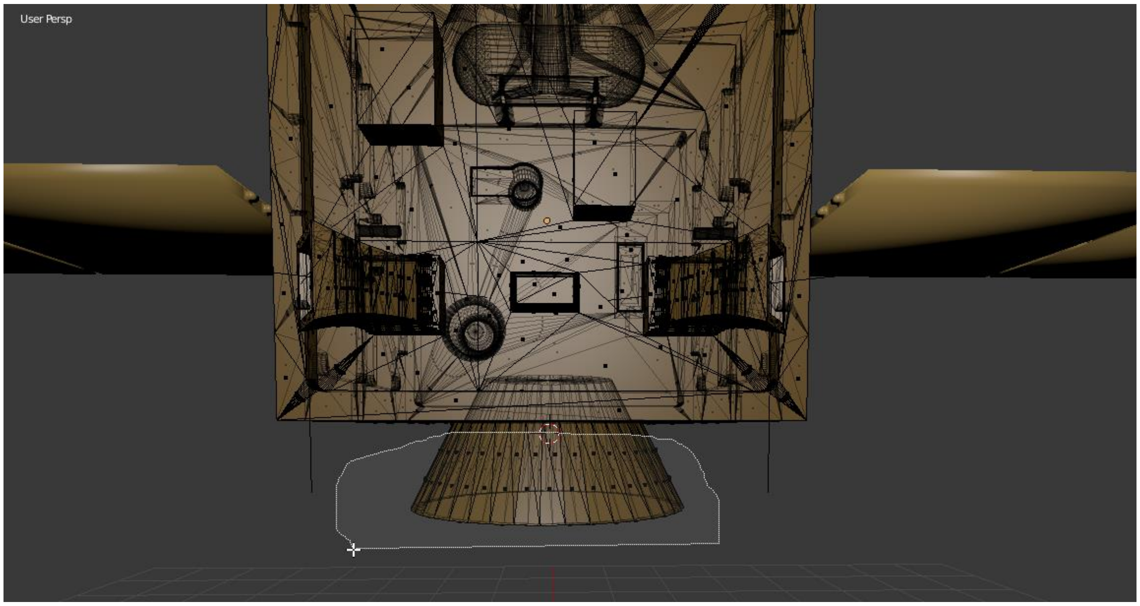
12. Select Co-Planar surfaces to select all faces that are on the same plane. Press U to bring up the UV mapping options. Chose unwrap to create the UV map. If you change to the UV editor view it should look something like the following



13. If you still have faces selected from the last mapping hit A to deselect the selected faces (Hitting A again will select all faces on the object). Focus on the motor casing at the bottom of the model. Edit XRay mode so you can select faces on multiple sides of the object.

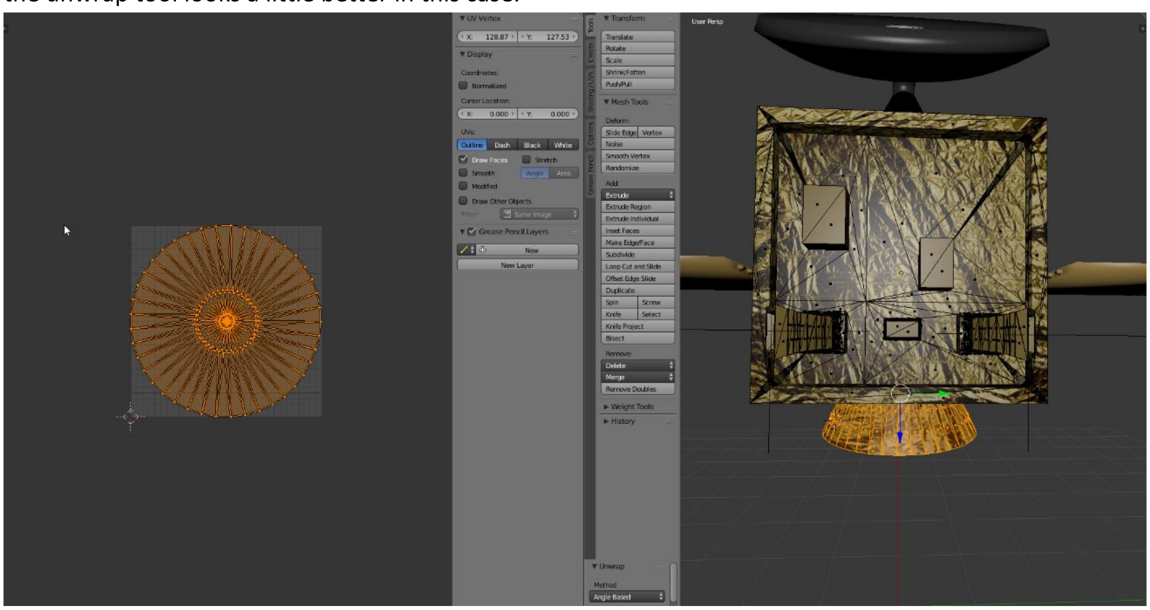


14. Lasso select (Ctrl+RMB) and select all faces on the casing.

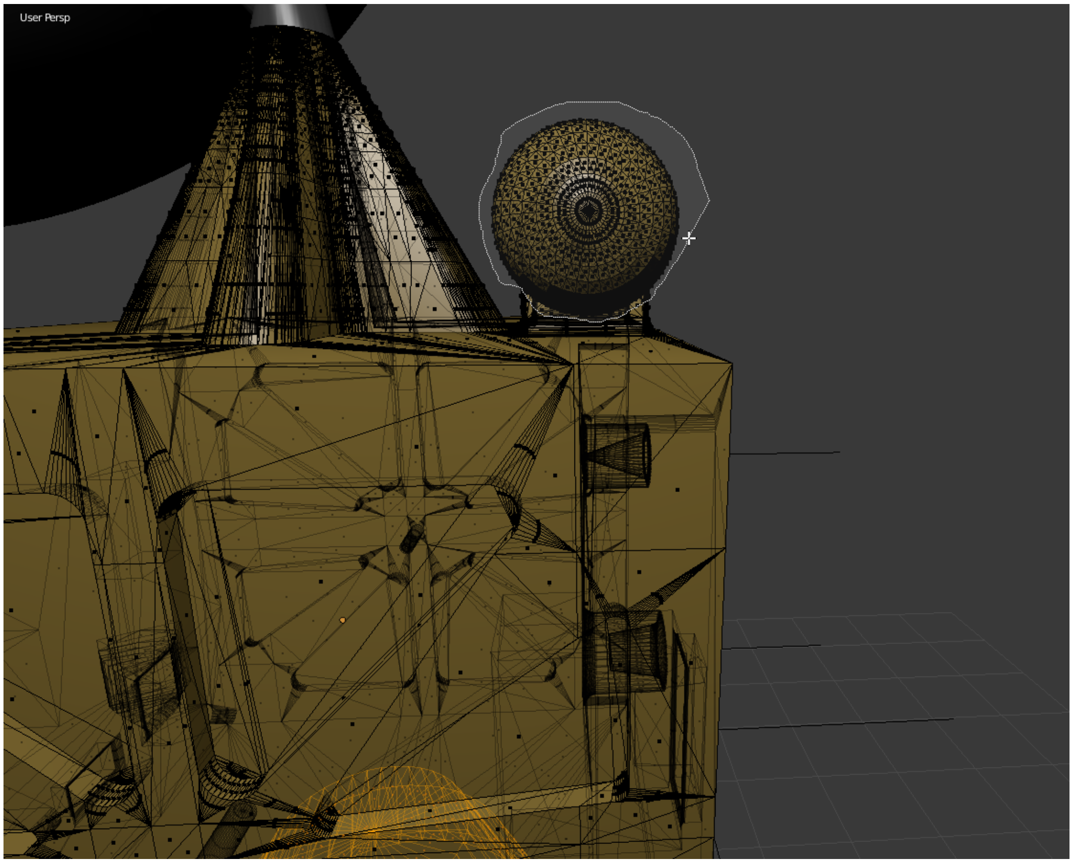


15. If you accidently miss a few faces you can turn off XRay mode and select individual faces. When all the faces are selected hit U for the UV options and unwrap the faces.

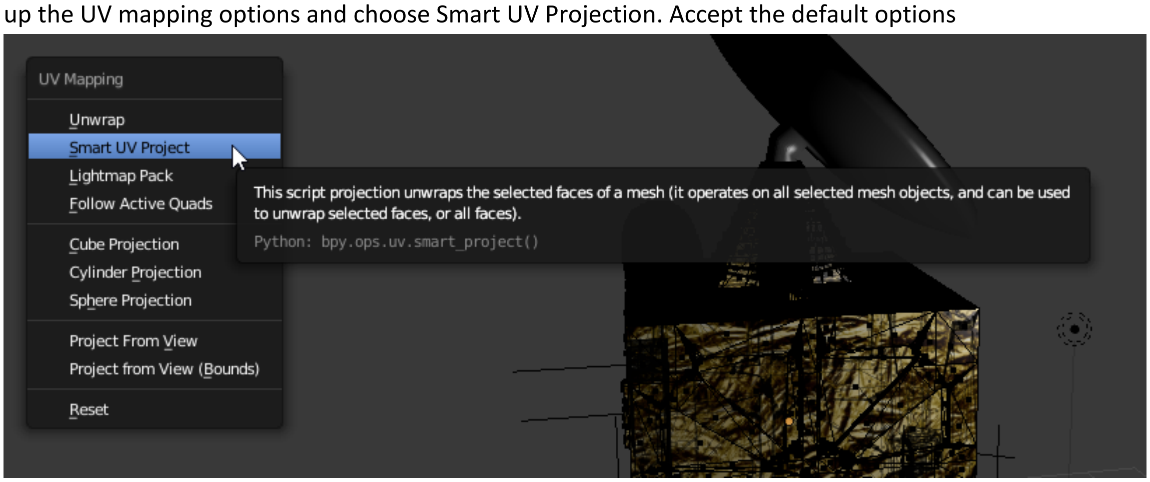
    Tip: Cylinder Projection is another great method for rounded shapes like this, but it just so happens that the unwrap tool looks a little better in this case.

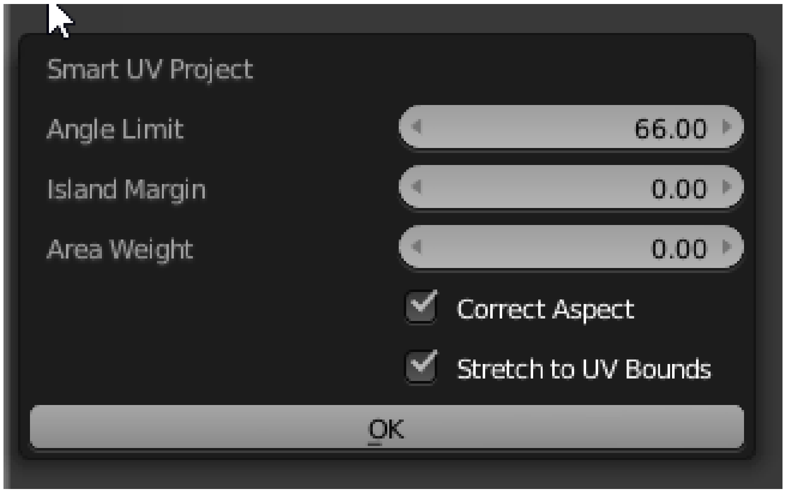


16. Next, rotate your view by 90 degrees. The goal is to texture the pressurant tank that is located behind the HGA. Go into XRay mode and lasso select the entire tank.

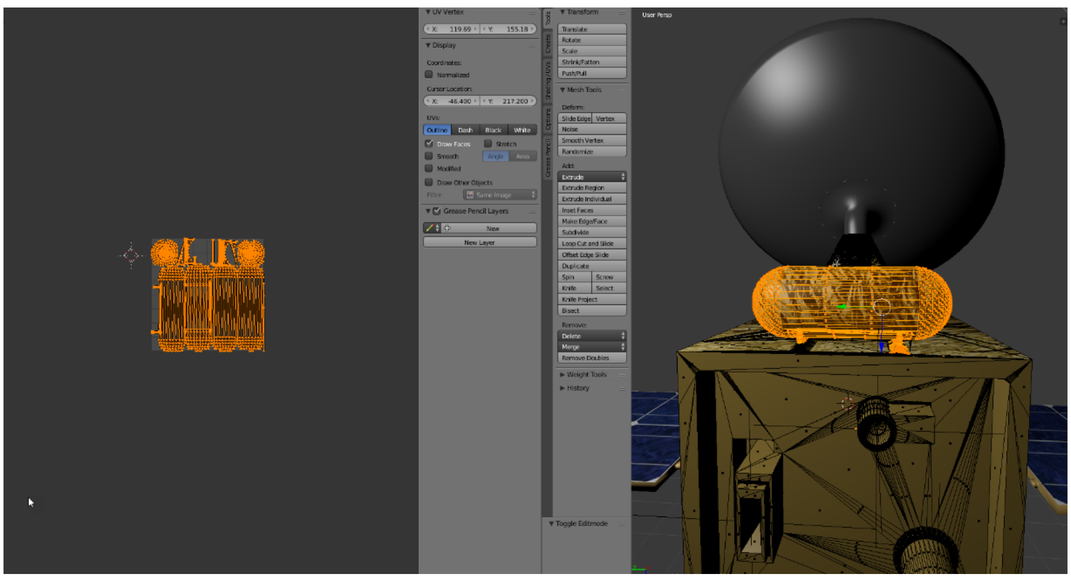


17. The tank is not a normal shape, which can make it difficult to map. The cylinder project does not work because of the tank ends and normal unwrapping does not work because it stretchs the image. Luckily Blender has the "Smart UV Projection" Option which works very well for complex geometry. Hit U to pull up the UV mapping options and choose Smart UV Projection. Accept the default options

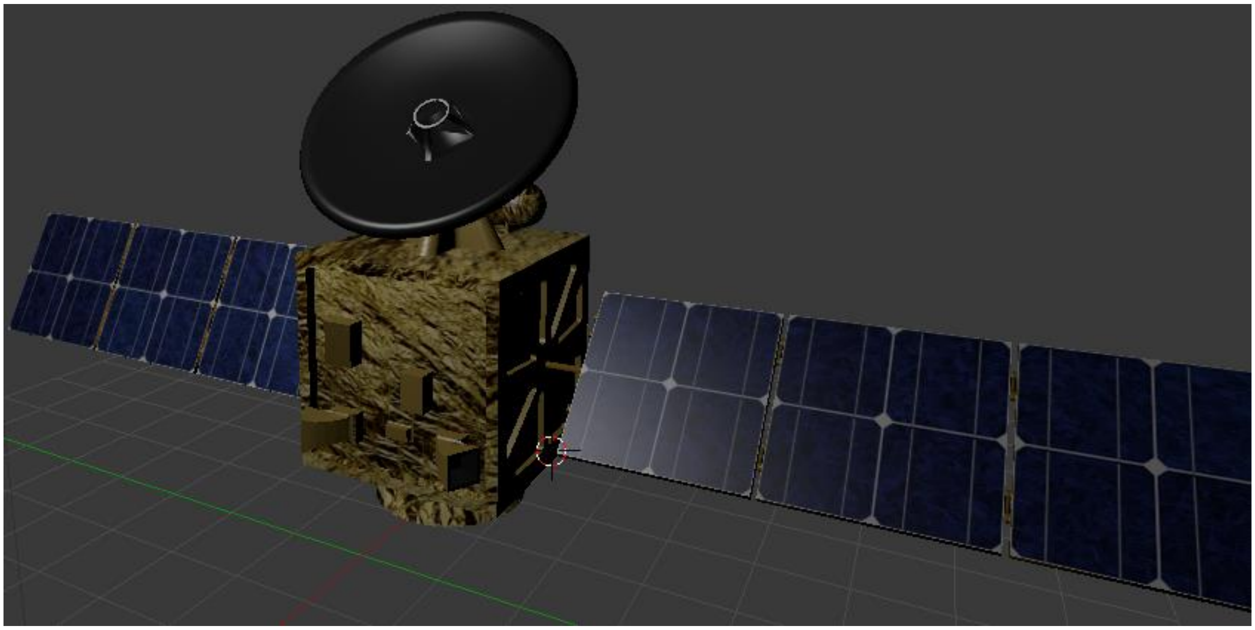




18. When created the UV map will look similar to the following image. Smart UV projection was able to map the image without severily stretching it. This is one of the most useful tools for UV mapping. If you are mapping a component with this tool and experience stretching, try remapping the component and turn off the "Stretch to UV Bounds" option.



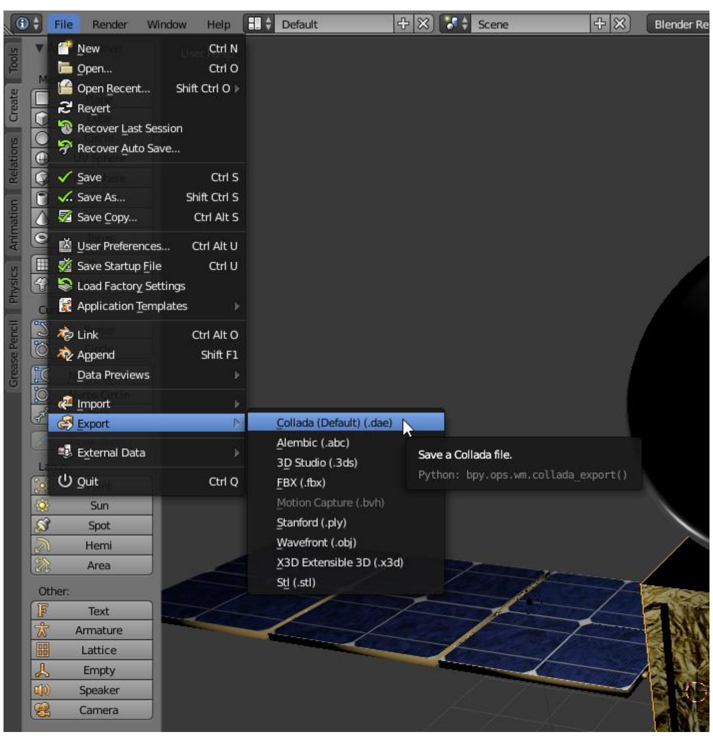
19. After a few more mappings, all of which use unwrap, smart UV projection, or cube projection, the model will be completely finished. Feel free to map out the rest of the bus on your own or load in the final version to see the full mapping. The satellite will look similar to the following image.



EXPORTING AND ARTICULATION FILE CREATION

EXPORTING COLLADA FILE

Now that the model is completed the only thing left to do in Blender is export the model as a collada file (.dae). Go to file->Export->Collada. Accept the default options and change the name if you desire. Hit the export button and you can close blender.



CREATING ANCILLARY FILES

The Collada file (.dae) defines the model geometry and node names, while the ancillary file (.anc) is the driving code behind all articulations, sensor attach points, and solar panels in STK. For the ancillary file to work correctly it must be in the same directory as the Collada file. Unfortunately the ancillary file must be written by hand but luckily the format is always the same and a basic template can be used as a guide. A master ancillary file has been provided with the tutorial files for exactly this propose. The master file documents the syntax for all possible sections and the table below gives a description for each section.

Section	**Description**
Articulations	Components (i.e. arrays, landing gear, doors, propellers) that move in either rotational or translational motion
Pointable Elements	Components (i.e. radio dishes, cameras, sun tracking panels) that can automatically point to and target other objects
Solar Panel Groups	Elements defined specifically as solar cells and are assigned an efficiency value
Effect Attach Points	Points that are used for attaching vapor trails to the 3D model
Sensor Attach Points	Points used for attaching STK sensors to the 3D model
Non-Obscuring Materials	Components (i.e. secondary mirrors or radar domes) that are invisible to sensors. Can be used with the STK sensor Obscuration tool

For the model in this tutorial there are articulations, sensor attach points, and solar panel groups. This section of the tutorial shows how to set up the ancillary file with the sections specifically for this model. If you are creating a model with additional attributes that are not covered, simply follow the format given in the master ancillary file.

To complete this part of the tutorial you will need a text editor. Notepad++ is the recommended editor, and will be used in this section, because of its ability to format the text to specific programming languages.

1. In Notepad++ open the Satellite_Model_Final.dae and Satellite_Model_Final.anc files that have been provided. In the collada file suppress all sections except the Visual Scenes.

```
1    <?xml version="1.0" encoding="utf-8"?>
2    <COLLADA xmlns="http://www.collada.org/2005/11/COLLADASchema" version="1.4.1" xmlns:xsi
3      <asset>
13     <library_cameras>
34     <library_lights>
104    <library_images>
112    <library_effects>
352    <library_materials>
378    <library_geometries>
613    <library_controllers/>
614    <library_visual_scenes>
615      <visual_scene id="Scene" name="Scene">
616        <node id="Camera" name="Camera" type="NODE">
617          <matrix sid="transform">0.6859207 -0.3240135 0.6515582 5.667644 0.7276763 0.305
618          <instance_camera url="#Camera-camera"/>
619        </node>
620        <node id="Lamp" name="Lamp" type="NODE">
621          <matrix sid="transform">-0.2908646 -0.7711008 0.5663932 -1.807593 0.9551712 -0.
622          <instance_light url="#Lamp-light"/>
623        </node>
624        <node id="Satellite_Model_Bus" name="Satellite_Model_Bus" type="NODE">
```

2. The Visual Scenes section documents all objects in the assembly and how they are related to each other. What really matters in this section is the node name for each component, since the nodes will be the only part being referenced by the ancillary file. If you look at line 624 of the collada file, you will see the node information for the satellite bus.

```
614    <library_visual_scenes>
615      <visual_scene id="Scene" name="Scene">
616        <node id="Camera" name="Camera" type="NODE">
617          <matrix sid="transform">0.6859207 -0.3240135 0.6515582 5.667644 0.7276763 0.30!
618          <instance_camera url="#Camera-camera"/>
619        </node>
620        <node id="Lamp" name="Lamp" type="NODE">
621          <matrix sid="transform">-0.2908646 -0.7711008 0.5663932 -1.807593 0.9551712 -0.
622          <instance_light url="#Lamp-light"/>
623        </node>
624        <node id="Satellite_Model_Bus" name="Satellite_Model_Bus" type="NODE">
625          <matrix sid="transform">1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1</matrix>
626          <instance_geometry url="#Satellite_Model_Bus_001-mesh" name="Satellite_Model_Bu
627            <bind_material>
628              <technique_common>
629                <instance_material symbol="Material_006-material" target="#Material_006-r
630                <instance_material symbol="Material_007-material" target="#Material_007-r
631              </technique_common>
632            </bind_material>
633          </instance_geometry>
634          <node id="Satellite_Model_Array_Left" name="Satellite_Model_Array_Left" type="N
635            <matrix sid="transform">-1 0 -8.74228e-8 0.03618345 0 1 0 -5.047102 8.74228e-
636            <instance_geometry url="#Satellite_Model_Panel_3_Panel_Solid_001-mesh" name='
637              <bind_material>
638                <technique_common>
639                  <instance_material symbol="Material_001-material" target="#Material_001
640                </technique_common>
641              </bind_material>
642            </instance_geometry>
```

The node name will be exactly the same as the name given in Blender. If you put spaces in your names they will be replaced with underscores.

3. Now that you have seen where the node names come from, move over to the ancillary file. If you look at the first articulation section you will see that it is called MainBus_Articulation and it is tied to the "Satellite_Model_Bus" node. The node name is exactly the same as the node name in the collada file. It is important to note that the articulation name is not the same as the node name. **Your articulation will not**

work if the articulation name is the same as the node name.

```
<articulations>
  <articulation name = "MainBus_Articulation" type = "transform">
      <stage init = "1" max = "1" min = "0" name = "Size" type = "uniformScale" />
      <stage init = "0" max = "360" min = "-360" name = "Roll" type = "xRotate" />
      <stage init = "0" max = "360" min = "-360" name = "Pitch" type = "yRotate" />
      <stage init = "0" max = "360" min = "-360" name = "Yaw" type = "zRotate" />
      <stage init = "0" max = "1000" min = "-1000" name = "MoveX" type = "xTranslate" />
      <stage init = "0" max = "1000" min = "-1000" name = "MoveY" type = "yTranslate" />
      <stage init = "0" max = "1000" min = "-1000" name = "MoveZ" type = "zTranslate" />
      <assigned_nodes>
          Satellite_Model_Bus
      </assigned_nodes>
  </articulation>
```

The primary parent of the assembly will almost always have a full set of articulations to allow the user to move and rotate the entire assembly anywhere that they need. These articulation types are documented in the seven lines below the articulation name. Every articulation will have an initialization value, max value, min value, name, and the type of articulation. For the angular articulations the units are degrees and meters for the translational articulations.

4. Staying on the same section, notice the tags that mark the start and end of each section. These tags are required for every section and the name will vary based on the purpose of the section

```
<articulations>
  <articulation name = "MainBus_Articulation" type = "transform">
      <stage init = "1" max = "1" min = "0" name = "Size" type = "uniformScale" />
      <stage init = "0" max = "360" min = "-360" name = "Roll" type = "xRotate" />
      <stage init = "0" max = "360" min = "-360" name = "Pitch" type = "yRotate" />
      <stage init = "0" max = "360" min = "-360" name = "Yaw" type = "zRotate" />
      <stage init = "0" max = "1000" min = "-1000" name = "MoveX" type = "xTranslate" />
      <stage init = "0" max = "1000" min = "-1000" name = "MoveY" type = "yTranslate" />
      <stage init = "0" max = "1000" min = "-1000" name = "MoveZ" type = "zTranslate" />
      <assigned_nodes>
          Satellite_Model_Bus
      </assigned_nodes>
  </articulation>
```

Notice the **<articulations>** tag at the top of the above image. This tag is for the entire articulations section, not just the bus articulation. The ending tag for this is given after the solar panels and HGA articulations have been defined.

5. Now move down to the first solar panel articulation. Notice that the format is exactly the same but the node name and articulation name has been changed. Additionally there is only a yRotate articulation since it should only rotate about the y-axis. If you wanted the solar panels to fold out this is where the additional articulation information would go.

```
<articulation name = "Plus_Y_Panels" type = "transform">
    <stage init = "0" max = "360" min = "-360" name = "Rotate" type = "yRotate" />
    <assigned_nodes>
        Satellite_Model_Array_Right
    </assigned_nodes>
</articulation>
```

6. Now move on to the solar panel groups section. Notice how the section tag changed to indicate a solar panel group. Also notice that in the starting line of each new solar panel group an efficiency is defined for the group. This is always a number from 0 to 100. Lastly, notice that how you assign the nodes for solar

panel groups is exactly the same as articulations.

```
<solar_panel_groups>
    <solar_panel_group efficiency = "28" name = "Plus_Y_Solar_Cells">
        <assigned_nodes>
            Solar_Cells_Right
        </assigned_nodes>
    </solar_panel_group>

    <solar_panel_group efficiency = "28" name = "Minus_Y_Solar_Cells">
        <assigned_nodes>
            Solar_Cells_Left
        </assigned_nodes>
    </solar_panel_group>
</solar_panel_groups>
```

7. Finally, move down to the sensor attach points section. Notice that once again the starting and ending tags have changed to denote a different section. This section is the easiest to configure because all you need is a list of node names that represent the sensor attach points. These will be the names of the empties you created in Blender

```
<sensor_origins>
    Left_Star_Tracker
    Right_Star_Tracker
    Instrument1
    Instrument2
    Instrument_3
    High_Gain_Antenna
</sensor_origins>
```

8. The last thing to note is the first two lines and the last line of the files. These lines are required for the file to run and should not omitted or changed.

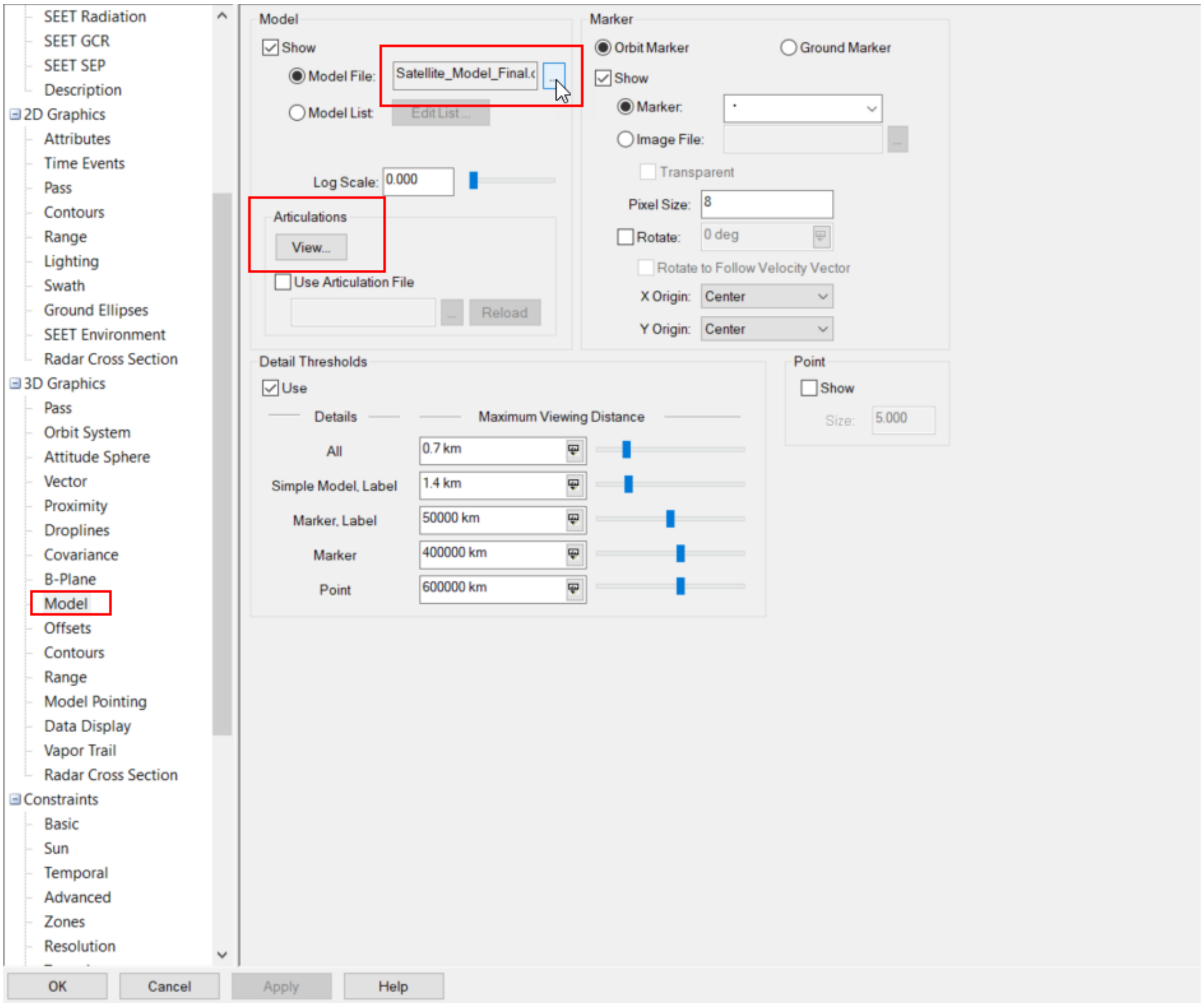
With the collada and ancillary files completed, the model can be successfully imported into STK and visualized.

IMPLEMENTATION IN STK

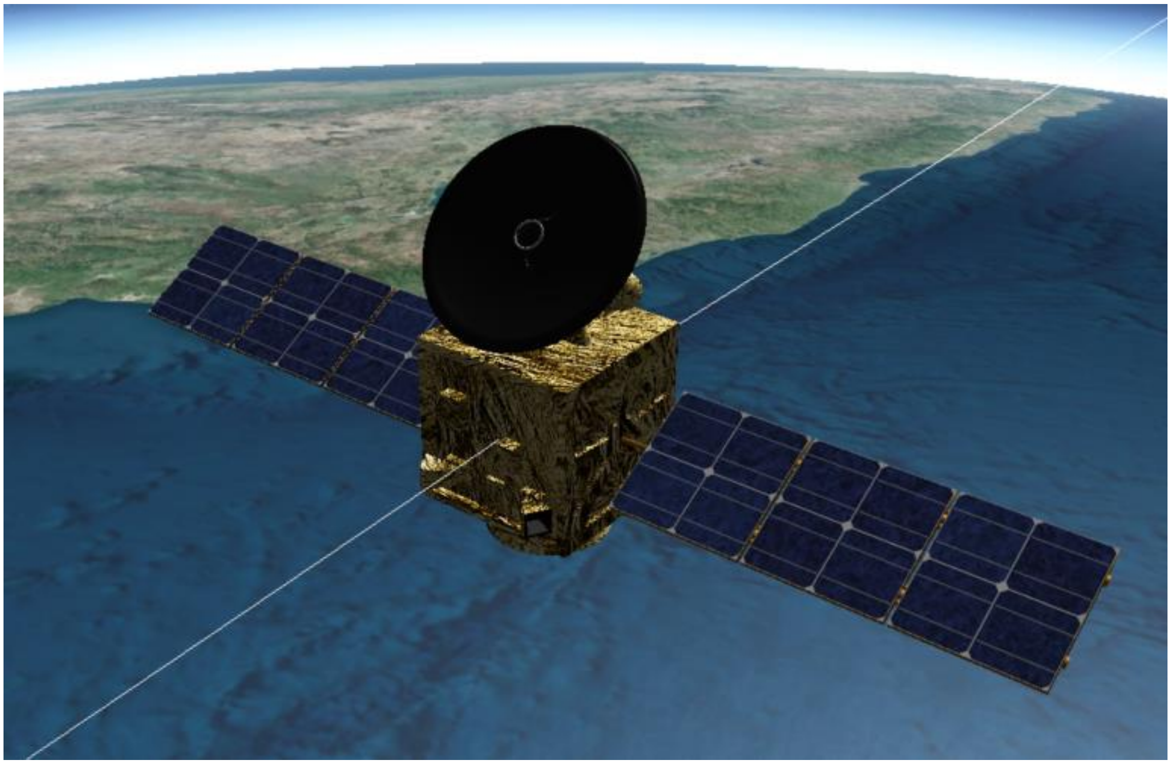
For the model to look and work properly in STK the collada, ancillary, and all texture images must be in the same directory. The purpose of this section is solely to demonstrate how to use the features created in Blender. For additional information on STK tutorials please visit agi.com/training.

1. Open a new scenario in STK and create a new satellite. In the satellite properties, navigate to the 3D graphics->Model page. Under model click the ellipsis to browse for the model file and open the collada file from the tutorial folder. You do not need to load the ancillary file. It will automatically be loaded as

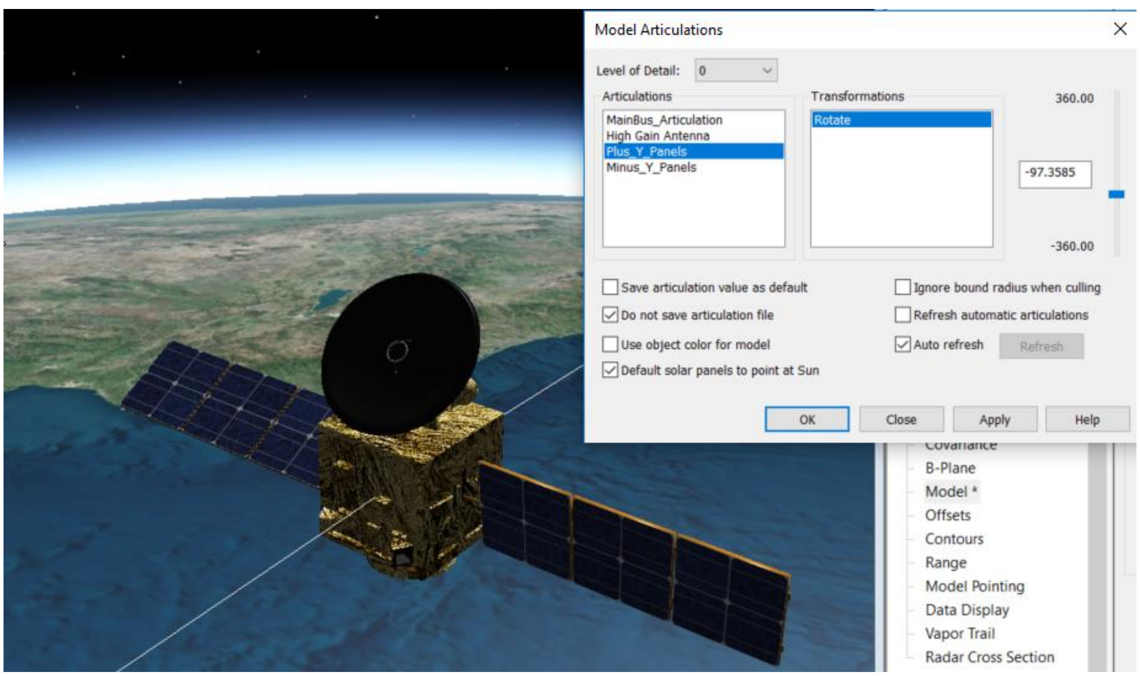
long as the file name is the same as the collada file and in the same directory.



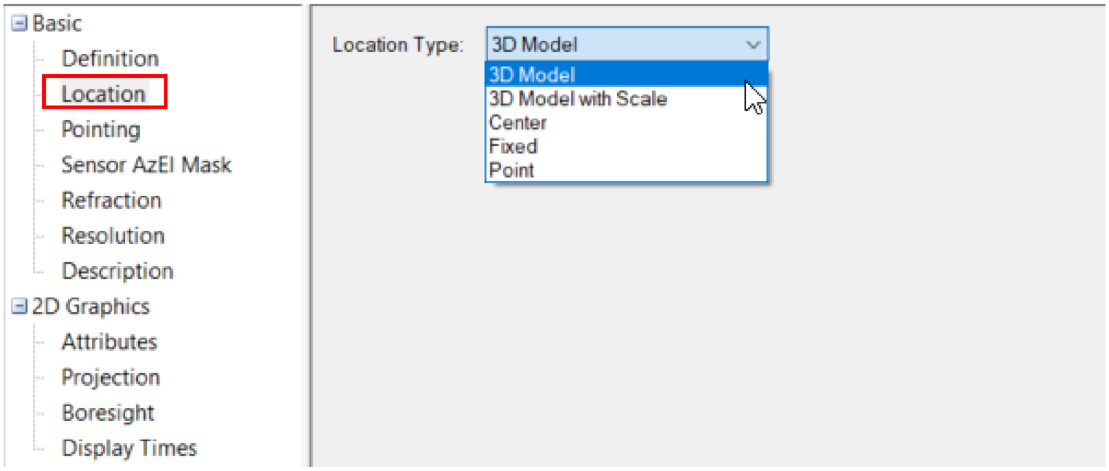
2. Once you load in the model and click apply you will see the model appear in the 3D graphics window with full textures



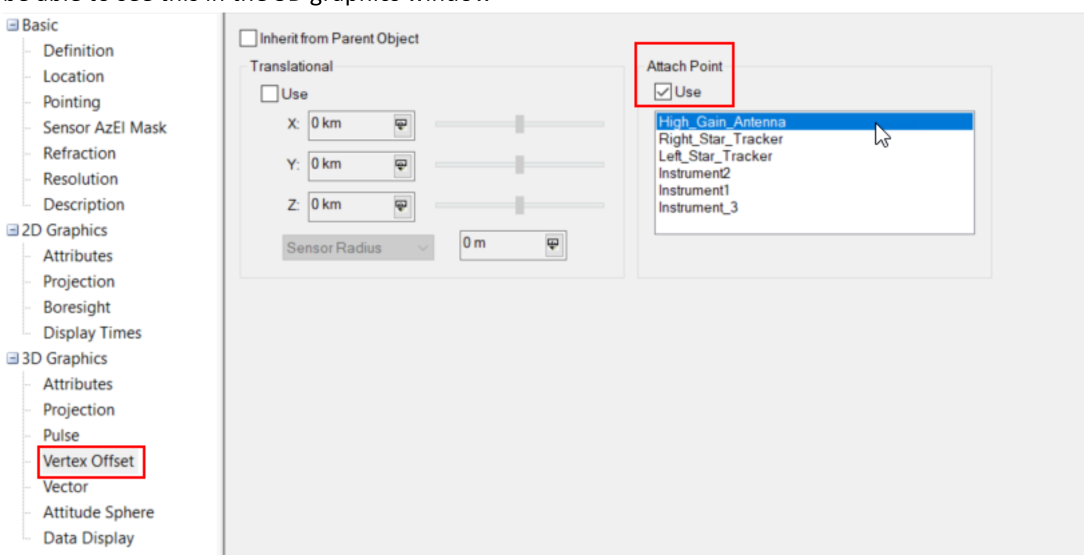
3. Still on the model page, click on the view articulations button. This will pull up a popup with all the possible articulations for the model. If you change the value then the object will move in the 3D Graphics window



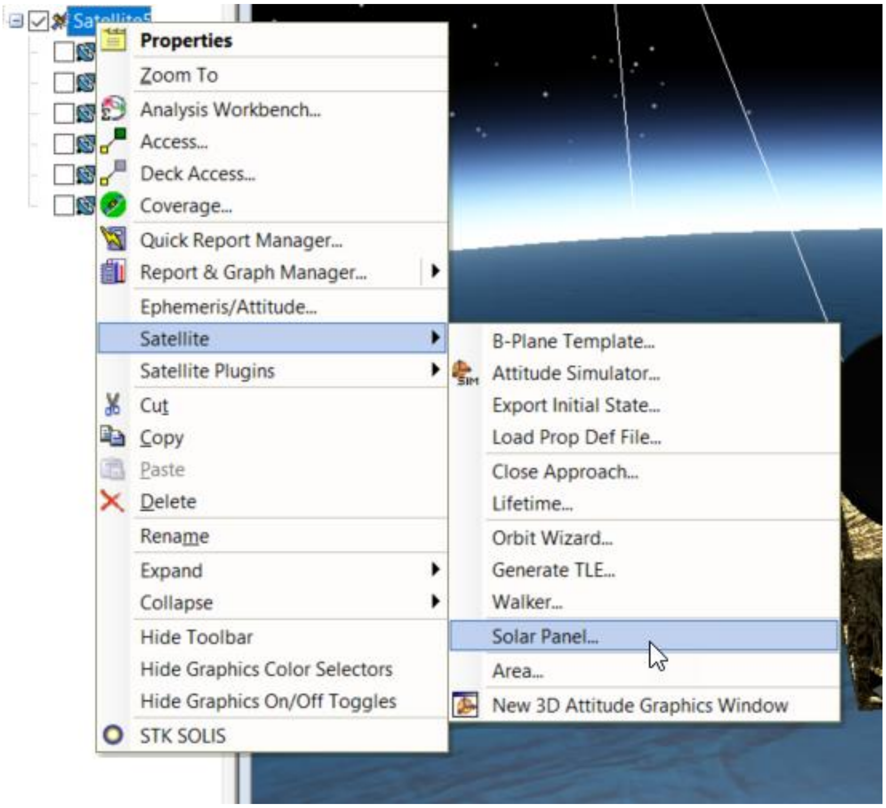
4. Insert a new sensor and attach it to the satellite. Open the sensor properties and navigate to the Location page. Change the location to 3D model



5. Still in the sensor properties navigate to the 3D Graphics->Vertex Offset page. Enable the use attach point option and select the High Gain Antenna. Now the sensor will be at the attach point specified and you will be able to see this in the 3D graphics window



6. Open up the solar panel tool from the satellite menu



7. You can see that the solar cells that were created in Blender are now available in the solar panel tool for calculations.