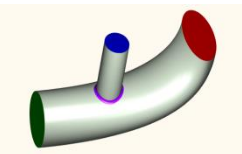
Basic Preprocessing

This introductory tutorial shows how to create closed ("watertight") volumes from a given surface model. In this example an airplane wing will be prepared to be simulated in a wind tunnel. For learning purposes, the model geometry is rather simplified. The closed geometry can be exported as colored STL data and readily meshed by various meshing and simulation packages without any further preprocessing. Boundaries such as inlet, outlet, symmetry plane etc. can be directly specified with individual colors. Note that only half of the model is involved due to the model symmetry.

The steps described in this tutorial are generally used whenever the external simulation software (e.g. CFD or grid generator) requires the model geometry input in the form of STL data. In all other cases you can directly export the surface model using the various export formats available in CAESES.

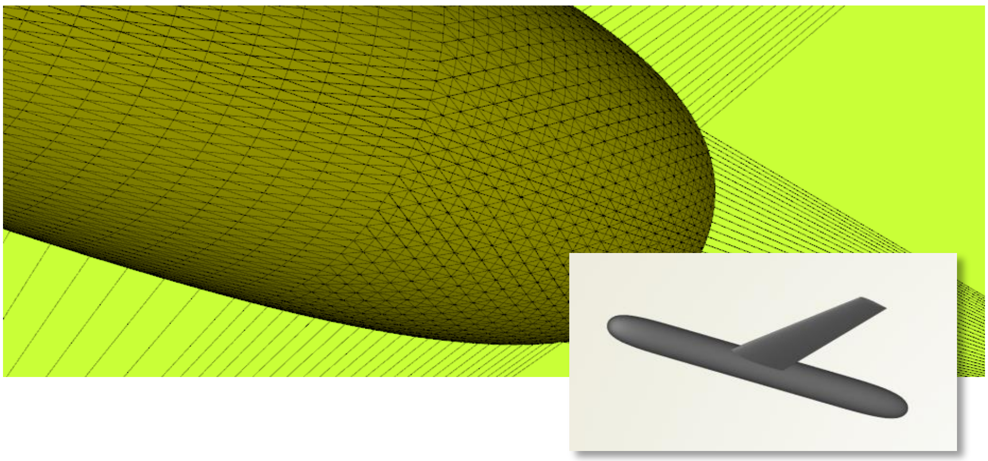
The preprocessing steps as shown in this tutorial only need to be done once for a model. In design studies or optimizations, such a preprocessing setup can be applied to all manually/automatically created variants (assuming the variants have the same topology).



Please note that there is a new complementary functionality (type *FBRep*) that has been introduced with version 3.1. See the brep tutorials and samples in the documentation browser for boolean/trim operations and convenient fillet creation along edges.

CAESES Project

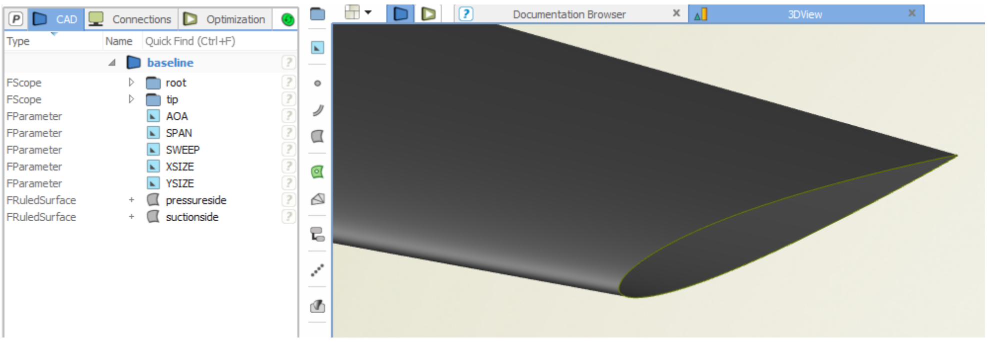
The resulting model of this tutorial can be found in the section *samples > tutorials* of the documentation browser.



1 Initial Geometry

This tutorial is based on the tutorial *first modeling steps* for which a resulting project file is available. Alternatively, you can use your own resulting file from the previous tutorial, *geometry variation*.

- Choose *file > open sample*.
- Open the project *tutorials > 01_First_Modeling_Steps.fdb.*
- Save a copy of this project via *file > save project as* so that we do not modify the original tutorial file.

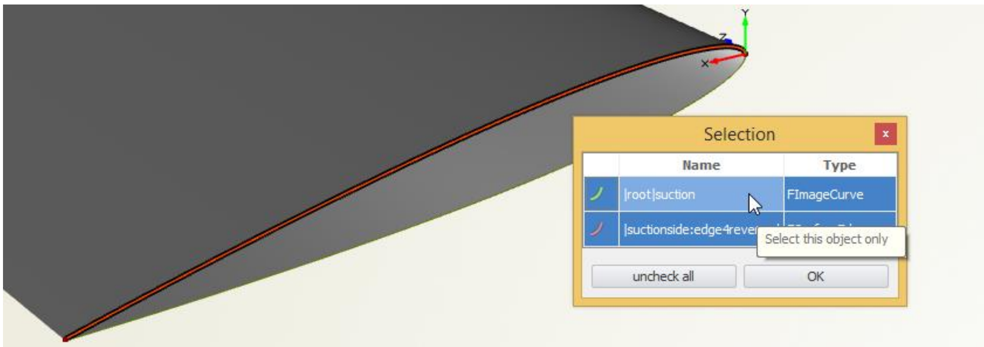


2

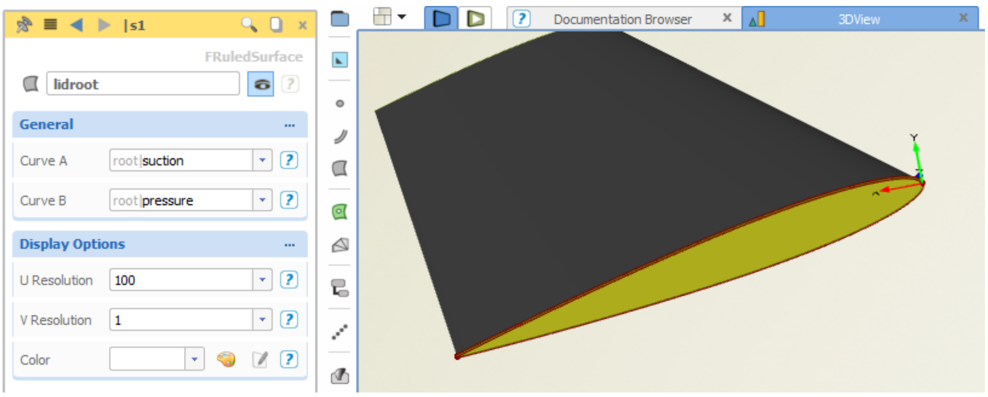
Root and Tip Lids

The wing geometry needs to be a closed geometry (i.e. watertight). First, the lids for the wing are created:

- Select the suction side curve of the root profile.



- Press CTRL and select the pressure side curve of the root profile so that both curves are selected.
- Choose *CAD > surfaces > ruled surface* in order to create a lid for the root contour.
- Set the name to “lidroot”.



- Repeat this procedure for the tip profile and call the resulting ruled surface “lidtip”.

✓ You can also use the *last action* which in this case has been the creation of a ruled surface. While the two tip curves are selected, press either *F12* or use the last button in the vertical toolbar.

✓ In a later stage, check out the new brep type (menu > cad > breps). It provides the possibility to directly close lids within operations (close planar holes etc).

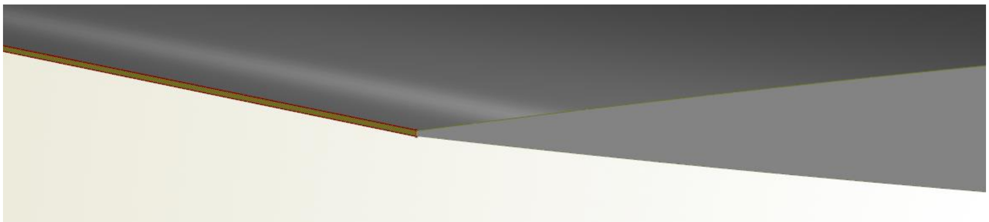
3

Trailing Edge

In this step, the missing trailing edge surface is added so that the geometry can be made watertight:

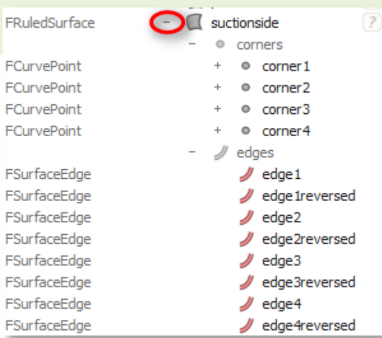
- In the 3D view, select the surface curve “edge1” of the suction side surface.

- Press CTRL and select “edge1” of the pressure side surface.
- Choose *CAD* > *surfaces* > *ruled surface* and name the resulting surface “trailingedge”.



✓ Each surface in CAESES has 4 corner points and a set of default surface edges such as “edge1”. Depending on whether you move the mouse to the beginning or the end of the surface edge, it offers you e.g. “edge1” or “edge1reversed”, respectively. The orientation is based on the surface orientation. These additional points and curves can also be found in the object tree.

Remember: Orientations of curves and surfaces are important in CAESES and can cause surfaces to be twisted.

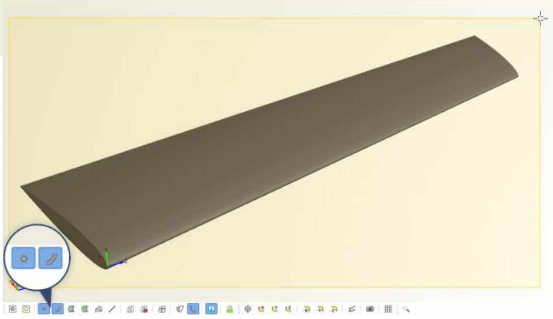


4 Surface Discretization by using a Trimesh

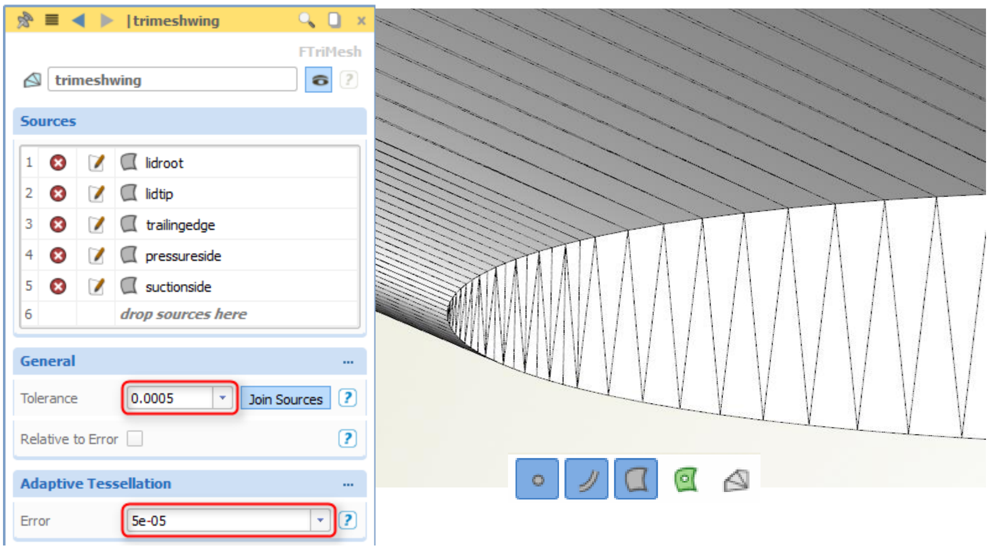
Now, the wing has all of the required surfaces. In this step, we will create a *trimesh* using all these surfaces as input. The trimesh will discretize and close the geometry. Trimeshes (and *solids*, see below) control the STL output.

- Select all five surfaces of the wing.

✓ Remember: Selection can be done via the tree or interactively. For instance, switch off points and curves in the 3D view and pull a rectangle from the lower right to the upper left with the left mouse button: all “touched” surfaces will be selected. Don’t forget to disable the filters afterwards again.



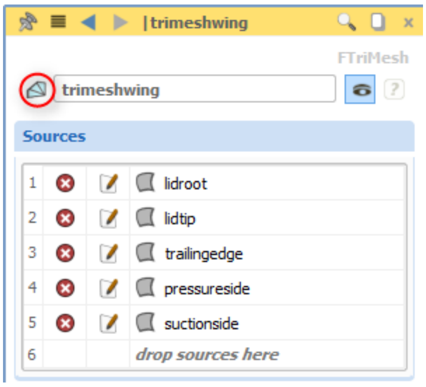
- Choose *CAD > meshes and solids > trimesh* and set the name of the new object to “trimeshwing”.
- Since trimesh and surfaces are coincident, use the 3D view filters to only show the trimesh.
- Set the value of the attribute *tolerance* to “0.0005”.
- Set the value of the attribute *error* to “5.e-5”.



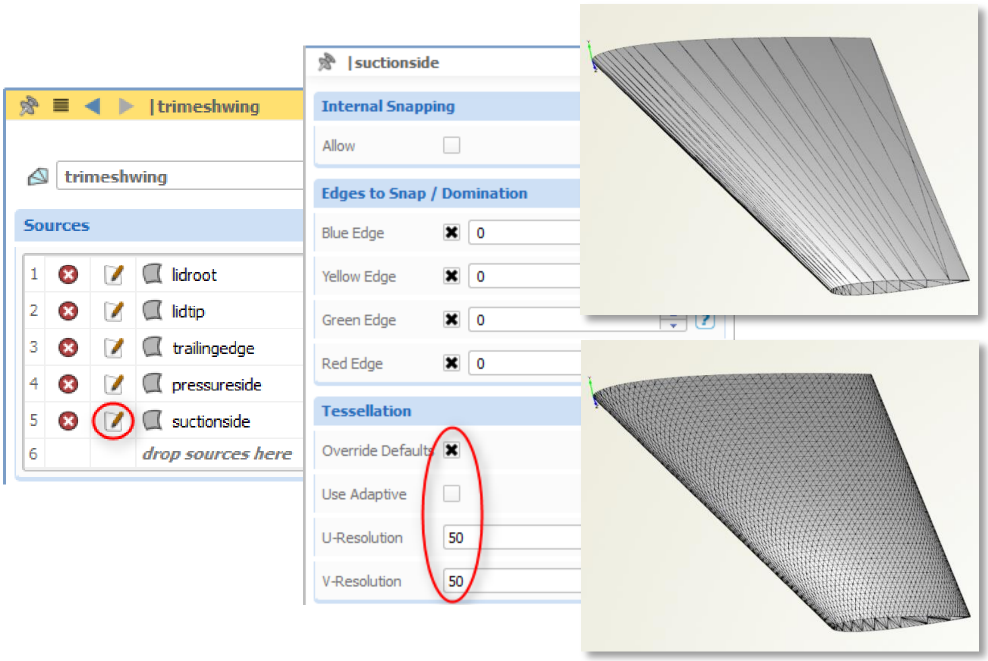
5 Additional Trimesh Information

The trimesh comes with various options that allow finetuning the surface discretization further. Things you have to know:

- Note that the icon of the trimesh in the object tree has turned from grey to blue which indicates closed geometry (test it by deactivating the button “Join Sources” of the trimesh).
- In the documentation browser, there is comprehensive documentation available for trimeshes. Just click on the type icon of a trimesh (see screenshot) or alternatively press f1 while the object is selected. For trimeshes, this documentation also covers the attributes *error* (“discretization error”) and *tolerance* (“tolerance for joining two tessellations”) from the previous step 4.

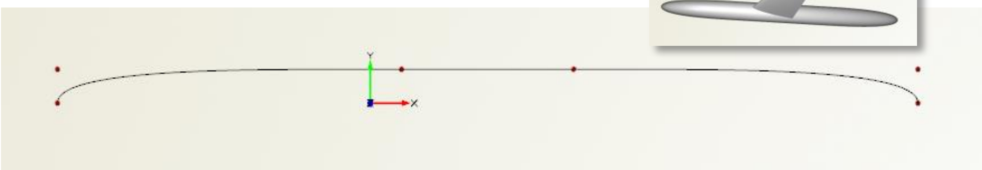


✓ Example: If you want to customize the discretization of a surface in a trimesh, edit the corresponding surface (click on the icon in the sources list). For instance, activate *override defaults* and enter user-defined values for the u- and v-resolution of the surface.

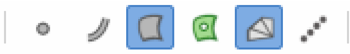


6 Fuselage Contour – Part 1

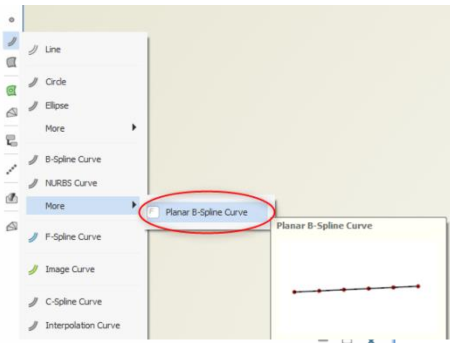
The wing still needs to be connected to a simplified fuselage, whose contour is modeled in this step:

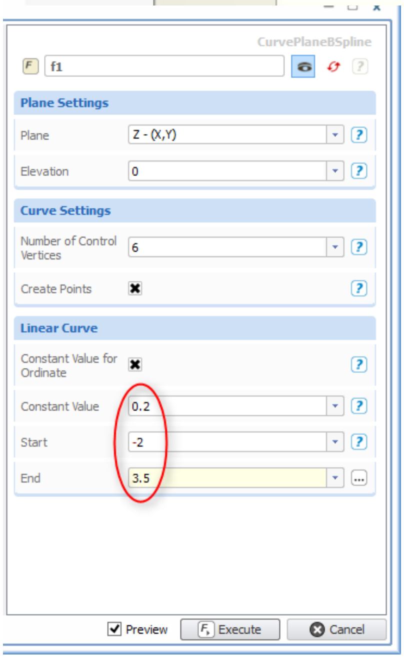


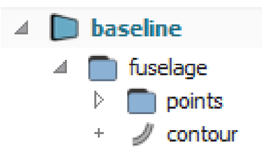
Make sure that the 3D view filters are deactivated, or switch on the surface and trimesh filter to be able to focus better on the upcoming contour curve. Optionally, since surfaces and trimeshes are coincident, make the 5 wing surfaces invisible by clicking on their object tree icons.



- Choose *CAD > curves > more > planar b-spline curve* in the *B-Spline/NURBS* curve menu.
- In the curve creation dialog, set a constant value of “0.2”, a start abscissa of “-2” and end abscissa of “3.5” (note that there is a preview in the 3D view).
- Confirm with the *execute* button which creates a new scope “f1”. It contains a *b-spline* curve with its control vertices (points).
- Rename “f1” to “fuselage”.
- Rename the curve named “curve” in the “fuselage” scope to “contour”.
- Rename the scope “auxiliary” in “fuselage” to “points”.



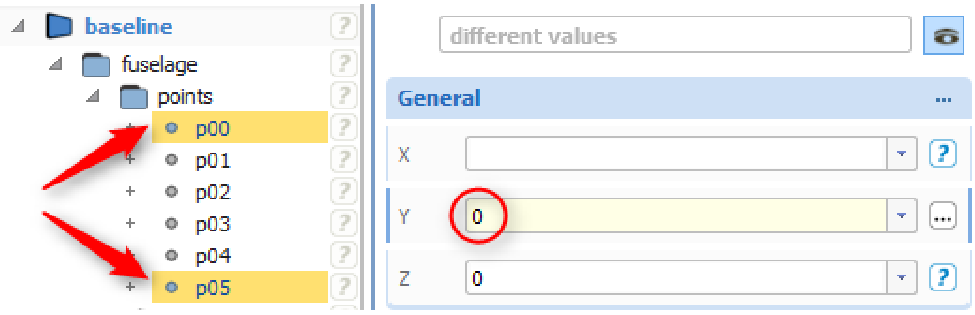




7

Fuselage Contour – Part 2

Let's manipulate the single points in order to create a simple fuselage shape:

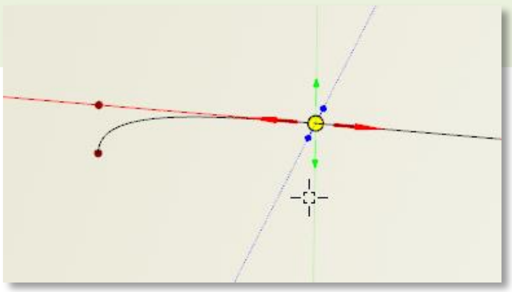


- Select the first and the last point, "p00" and "p05", using CTRL and set the y-value to "0".
- Select the second point "p01" and set the x-value to "-2".
- Select the second last point "p04" and set the x-value to "3.5".

✓ You can select multiple objects and set the common attributes at once. For instance, we selected both "p00" and "p05" and then set their y-coordinates to "0".

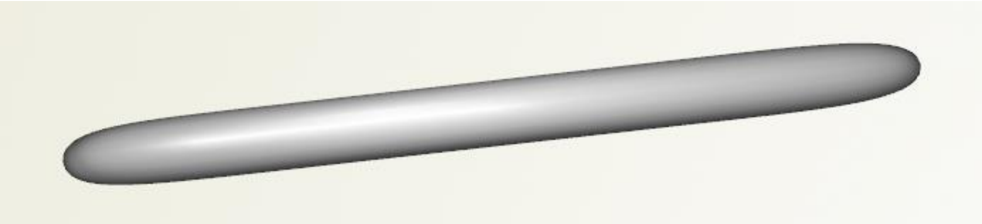
- As an option, select "p02" or "p03" and move them individually in the x-direction.

✓ A selected point shows colored handles for moving it in the global x-, y- and z-direction. Just click on one of these arrows, keep the mouse button pressed and drag the point.

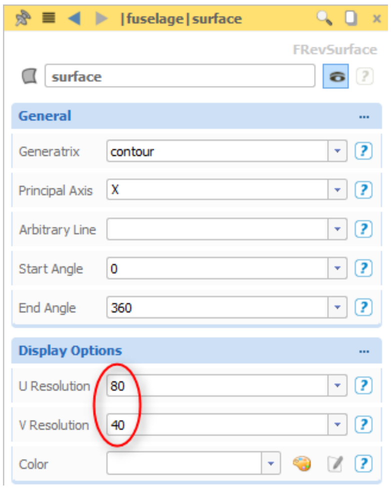


8 Fuselage Surface and Trimesh

Based on the fuselage contour, a *surface of revolution* and a *trimesh* are created:

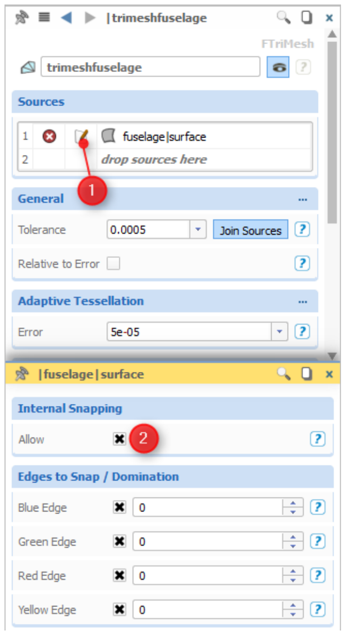


- Select CAD > surfaces > surface of revolution and set the name to “surface”.
- Choose the contour curve to be the *generatrix* input for the surface.
- Set the end angle to “360”.
- Set the u- and v-resolution to 80 x 40 for a smoother visualization.
- Drag and drop “surface” into the scope “fuselage”.

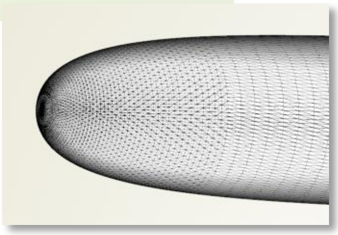


Now, let’s create the trimesh:

- Keep the fuselage surface selected and choose *CAD > meshes and solids > trimesh*.
- Set the *tolerance* to “0.0005” and initial *error* to “5e-5” again.
- For “fuselage|surface”, activate internal snapping (see screenshot, step 1+2).
- Set the name to “trimeshfuselage”.

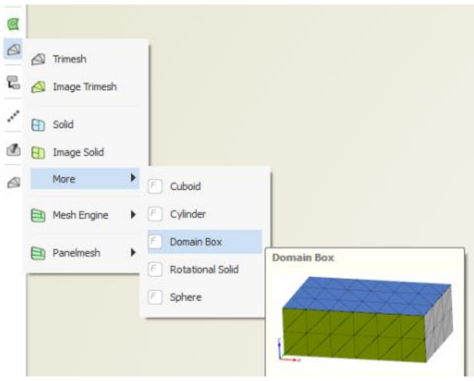


✓ Note that the icon of the trimesh is blue now, which again indicates a closed geometry.

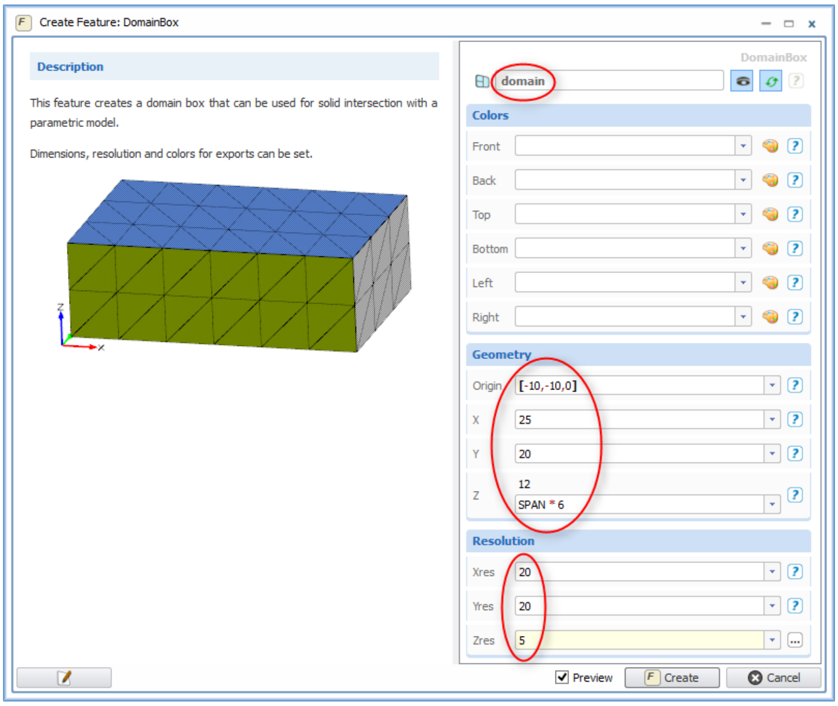


9 Domain Box

In this step, a domain box is created in preparation for a wind tunnel simulation.



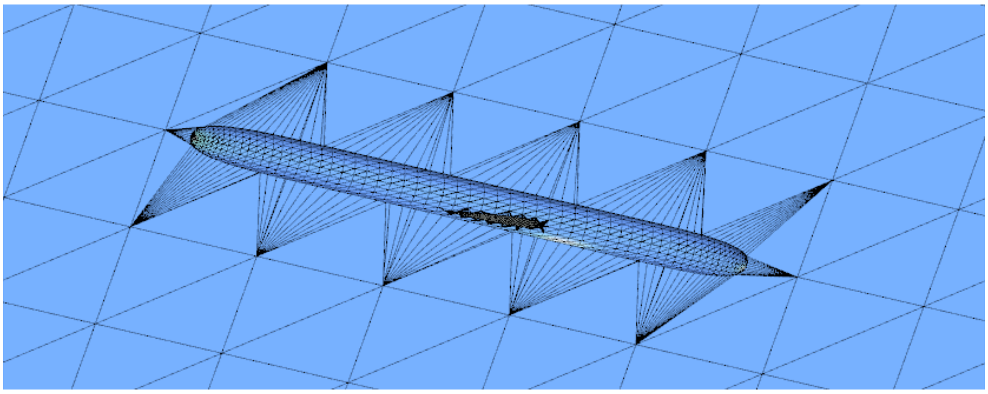
- Choose *CAD > meshes and solids > more > domain box.*
- In the creation dialog, set the name to "domain".
- Set the resolution to 20 x 20 x 5.
- Set the origin to "[-10,-10, 0]".
- Set the x-length to "25".
- Set the y-length to "20".
- Set the z-length to "SPAN*6" i.e. make the z-length dependent on the span parameter of the model: You can either type it in or drag & drop "SPAN" from the object tree into the editor.
- Press *create* in the dialog to add the new object into the object tree.



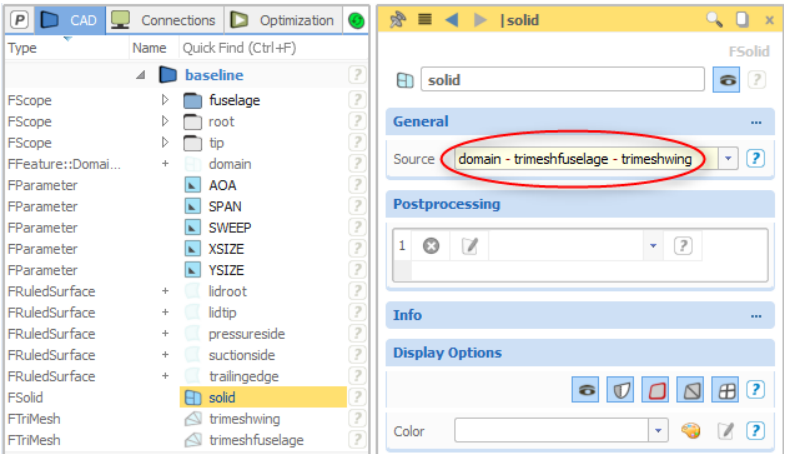
10

Single Closed Volume

Finally, the fuselage and the wing will be subtracted (“difference”) from the domain using Boolean Operations.



- Choose *CAD > meshes and solids > solid*.
- Enter the boolean operation using the character “-“ in order to subtract the two trimeshes (fuselage & wing) from the domain (See screenshot below).



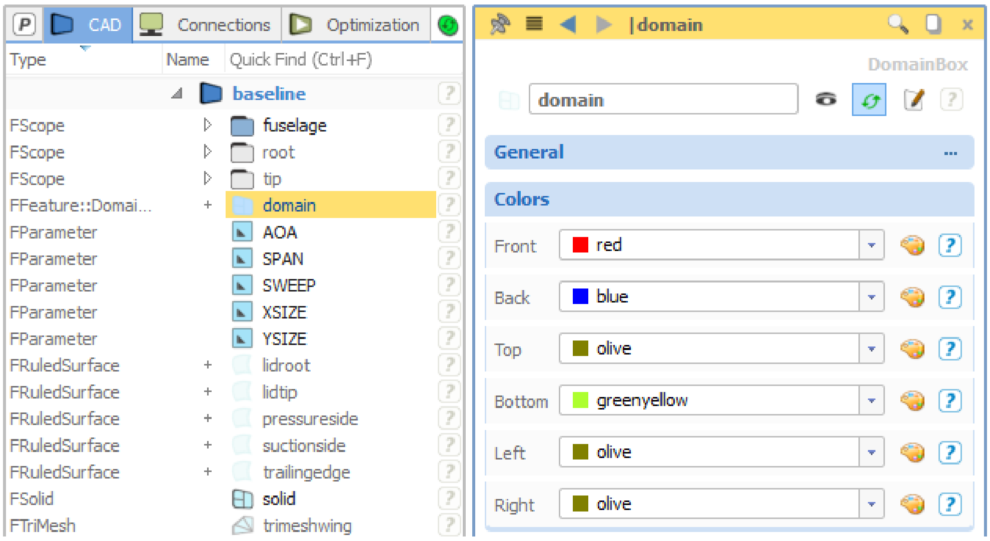
Again, the trimeshes and solids are coincident and get displayed at the same location. Make the trimeshes and the domain box invisible so that only the resulting Boolean Operation is visible. You can also use the wireframe mode or clipping planes of the 3D view in order to have a better insight into the solid geometry. Check the GUI introduction tutorial for more information.

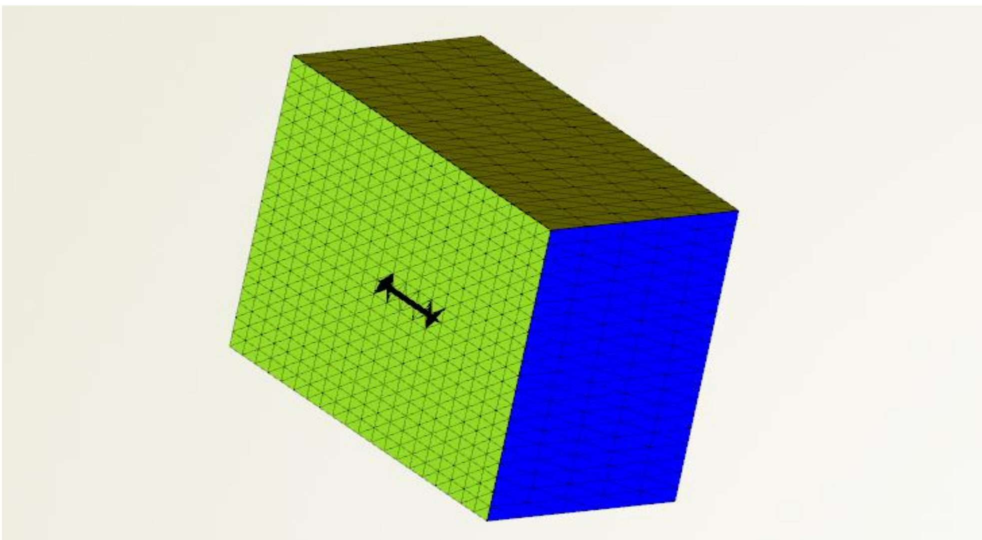
11

Colored STL Export: Domain Box

The geometry is now ready to be exported in a common STL format. Additionally, we want to utilize colors for the faces in order to assign inlet, outlet as well as different colors for distinguishing further wall types.

- Select “domain” from step 9 and set the colors in the editor window: We choose a different color for inlet and outlet (“blue” and “red”), a color for the symmetry plane (“greenyellow”) as well as a color for the walls (“olive”).

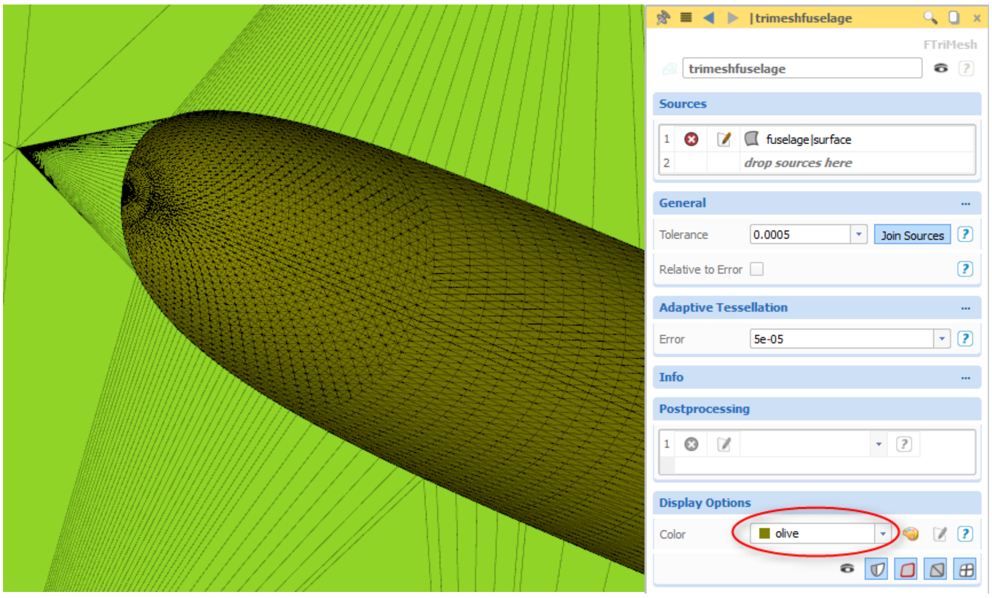




12 Colored STL Export: Fuselage and Wing

The fuselage and wing trimesh can be considered as common walls so they get the same color like the walls of the domain box.

- ▶ Select “trimeshfuselage” and assign the color “olive” to the trimesh. Note again that the color information is directly transferred to the object “solid” (even if “trimeshfuselage” is not visible itself).

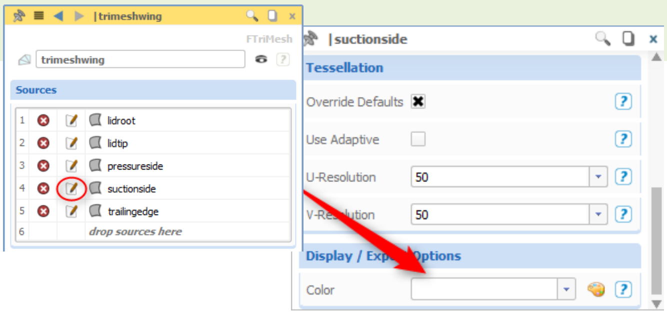


- ▶ Select “trimeshwing” and assign the color “olive” to the trimesh.

We can now export the closed geometry along with its color information:

- ▶ Select the solid and choose e.g. *file > export > STL (Color).*

✓ The wing is made of 5 surfaces. If you like to color them differently just edit the source surface of the trimesh and assign a color to it.



13 Conclusion

As a result of this tutorial, a closed geometry is created and exported. The model parameters can be changed and the updated model is automatically regenerated. For instance, angle of attack (parameter “AOA”) can be set from “-10” to “-5” and the geometry still is closed without additional work. Try changing the profile parameters such as camber, thickness etc. This is beneficial for automated processes such as design studies or optimizations.

Typically, one would split up the wing surface further and have a separate surface for the leading edge. This can easily be done by using image surfaces (*CAD > surfaces > image surface*) where the image domains are restricted for creation of sub surfaces. In the same way you can split up the fuselage so that the merged solid avoids sharp triangles with tiny angles. The resulting project of this tutorial (in the section *samples > tutorials* of the documentation browser) is slightly modified to avoid such sharp triangles. Image surfaces are utilized and customized settings are entered for some of the trimeshes (see also the tip on page 6, “override defaults”).

The next tutorial will show you how to connect simulation tools such as CFD to CAESES.

As mentioned in the beginning of this tutorial, check out the brep type which is a powerful alternative to the trimeshes (*FTrimesh*) and solids (*FSolid*). Breps keep the mathematical description and topology of all input sources and applied operations. They can be exchanged with other CAD systems using STEP or IGES, and are particularly powerful if you have more complex trimming and fillet operations.