



# **3D PRINTING EXERCISE - 1**

## **Part Analysis, Supports & Preparation for Printing**

3DXpert 16

Tutorial\_V12 – 3DXpert 16 Beta release



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## Introduction

Welcome to 3DXpert. This exercise will guide you through the 3DPrinting environment of 3DXpert.

It focuses on 3DXpert's 3D printing functionality. Although the various steps to follow are detailed, it is recommended to have a basic knowledge in running the general software tools.

In this exercise, we will create a new project, add the part and analyze it.

One of the advantages of 3DXpert is that it does not work only on Mesh objects. In this exercise we will work on a B-rep\* CAD model.

\* "B-rep" is the short term of 'Boundary Representation'. In CAD, this is a method for representing shapes using their limits. For example, a solid object is represented as a collection of connected surface elements; a face is represented by a surface with boundary limits.

## Part 1 – Creating the 3D Printing project and loading the part

While it is possible to add several parts and arrange them on the tray, in this exercise we will work with a single part.

Another way to position several parts on the tray is through the 3D Operator environment (this is not discussed in this exercise).

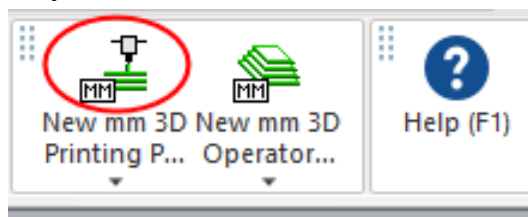


Note:

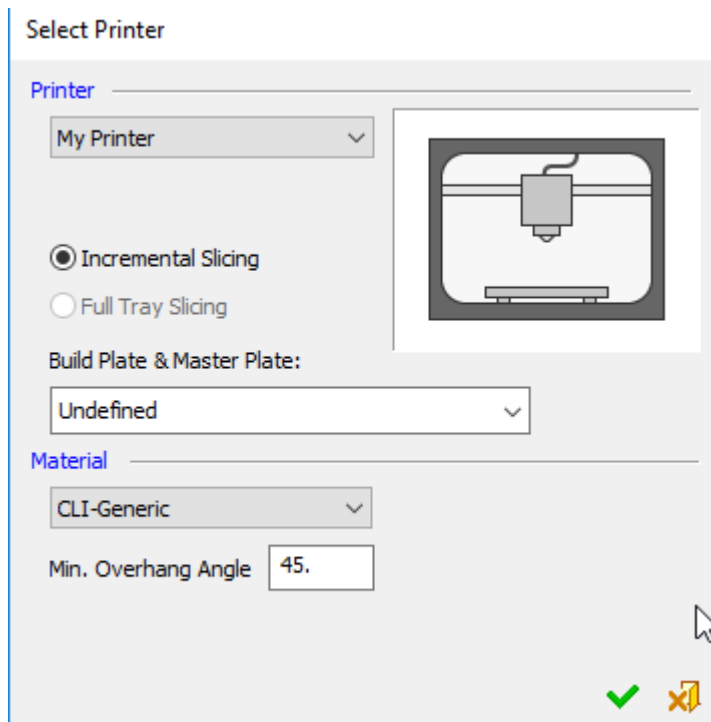
In this exercise, for training purposes, we will use a 'training' printer and material database. This printer is not suitable for actual printing.

Installation of the 'Training' Printer:

1. Extract the file '**ProX DMP Training.zip**' to the folder:  
**C:\ProgramData\3D Systems\3Dxpert\16.0\Data\3D\_Printing\Technology\_Folder**  
The result is a new folder called 'ProX DMP Training'.
2. Let's open a new 3DPrinting project. From the tool bar, click the 'New 3DPrinting Project' button.



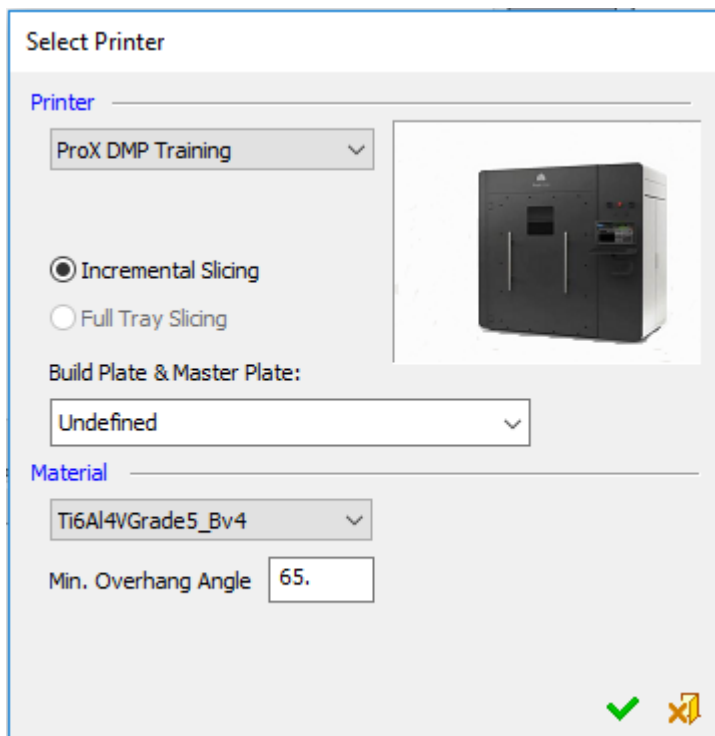
After the installation, creating the very first project, the system uses a default Printer called '**My Printer**'. This is a generic printer.



In this exercise, we will switch to the 'training' printer.

The system remembers that last used printer, so when you switch to a different printer, it will be used also in the subsequent project(s) that you create.

From the Tool Bar on the top of the 3DXpert window, click '**Select Printer**' and define the printer you are going to work with. From the list of available printers, select '**ProX DMP Training**'.



3. Select a **Build Plate** (for the purpose of this exercise, this can be any plate scheme). The plates that are available are the standard plates which can be obtained through the printer's vendor. For example, select the plate **250x250\_Ti** from the list.
4. Define a Material. The list shows only the materials that are relevant for the selected printer. For this exercise, select the material **Ti6Al4VGrade5\_Bv4**.

The definition of material is essential, as without a material it is not possible to load/set a matching Build Style. 'Undefined' material means that Technologies will not be available later on, so if you do not define a material, the system will prompt when pressing the OK button.



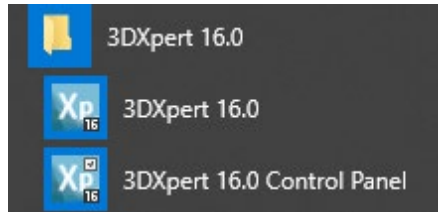
**3DXpert Printer/Material Updates**

[Download the latest materials configuration files for your printer](#)

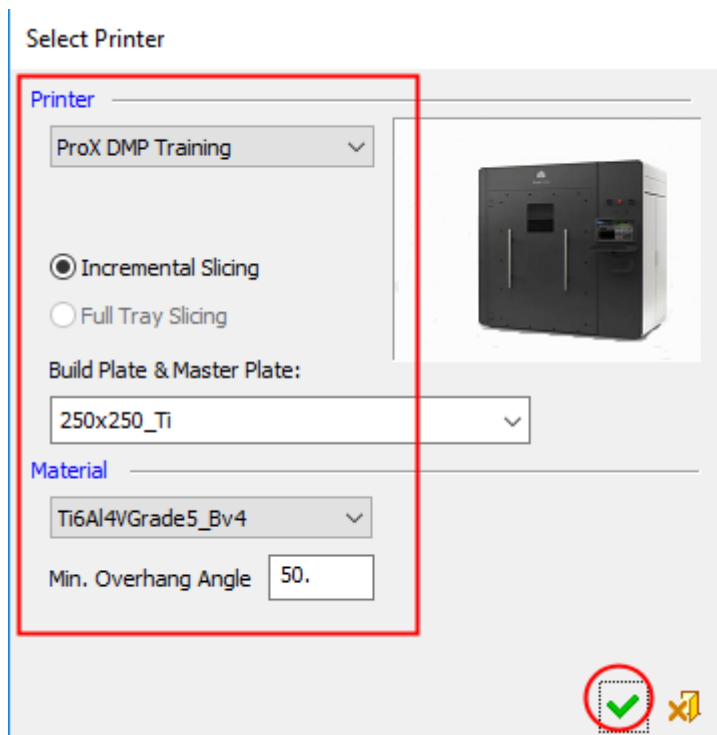
Note on Material configuration files: With the installation of 3DXpert, 3D Systems printers' configuration files are supplied.

Best practice printers and materials configuration files are available to users for download. These are called 'Standard' materials.

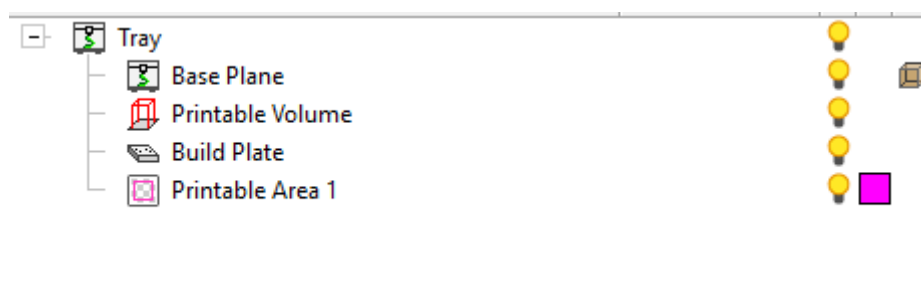
To download the material configuration files for your printer or check if you have the latest files for your printer, launch the 3DXpert Control Panel, and run 3DXpert Printer/Material Updates.



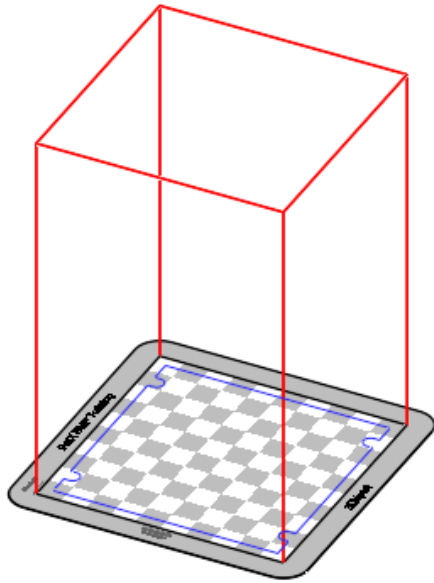
- Back in the Select Printer dialog, set the **Min. Overhang Angle as 50**. We will see later on how this parameter is used. Press **OK** to finish the project's setup step.



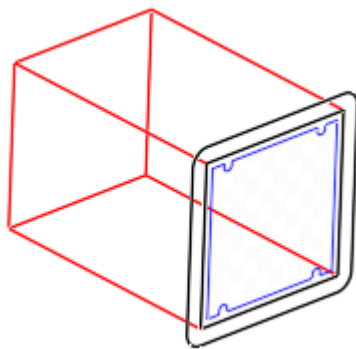
Note: For a clear view of the part, you can always hide and show the tray by pressing the bulb alongside the Tray part in the project's tree.







Also note that if you rotate the tray and look at it from the bottom, it becomes transparent, in order to clearly see the part.

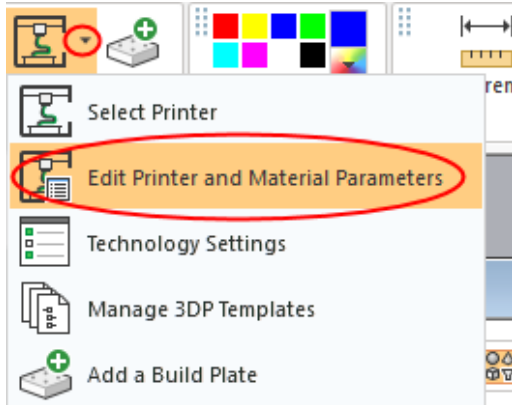


The tray from the bottom.

The text on the tray describes the printer type, the Recoater/Roller direction and the Gas Flow direction, as set in the printer parameters (as we shall soon see).

In addition to the Printer, Build Plate, Material and Angle, there may be various other parameters you would like to control.

6. Click **Edit Printer Parameters** from the 3D Printing Toolbar to enter another dialog.



This dialog contains various parameters of the specific printer you are using. Most of them are dictated by the printer and should not be changed.

Notice among others the XY& Z tray sizes, the direction in which the roller or recoater moves and the gas flow direction. The gas flow ensures that the smoke emitted during the printing operation will not create a mask that interferes with the laser beam.

These parameters will be used later on by the Slicer, as the data is prepared for printing.

#### Edit Printers and Materials

Printer: ProX DMP Training

Restore Defaults
Delete Printer
Copy as new

Printer Type: ProX DMP Training

Comment:

Chose Picture:

Technology: None

Default Printable Area: Undefined

☐ Multi Head Printer Multi Head Definition

Influential Gas Flow: Directional

☒ Continous Power Change

☐ For Dental

Default Slicing Mode:

☒ Incremental Slicing
☐ Full Tray Slicing

Material: Ti6Al4VGrade5\_Bv4

Restore Defaults
Delete Material
Copy as new

Material Name: Ti6Al4VGrade5\_Bv4

Angles for Design (does not affect slicing)

Default Min. Overhang Angle: 65.

Down-Facing Angle: 90.

Up-Facing Angle: 45.

Staircase Effect Angle: 10.

Save Material

Technology Settings

Template Manager

Save Printer

Default Project Parameters

Default Layer Thickness (µm): 30.

Minimal Distance Between Objects: 1.

Minimal Distance Above Tray: 0.

Tray Settings

Tray X Size: 275.

Tray Y Size: 275.

Tray Z Size: 420.

☐ Use Heated Build Platform

Tray Origin Point

☒ Center of Tray
☐ Manually Define  
(Distance from origin to bottom left corner)

X Origin: -137.5

Y Origin: -137.5

Tray Markings

Printer Text on Tray: ProX DMP Training

☒ Mark Recoater \ Roller \ Printheads Direction on Tray

☒ Recoater
☐ Roller
☐ Printheads

Recoater \ Roller \ Printheads Direction:

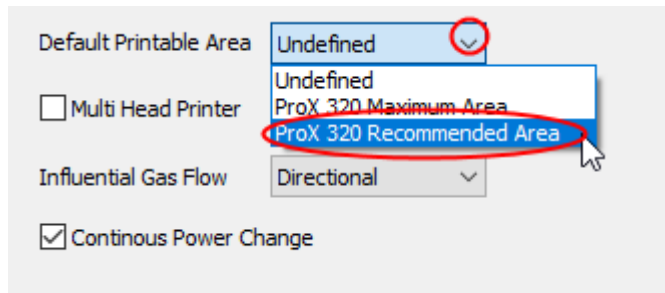
☒ X
☐ Y

☒ Mark Gas Flow Direction on Tray

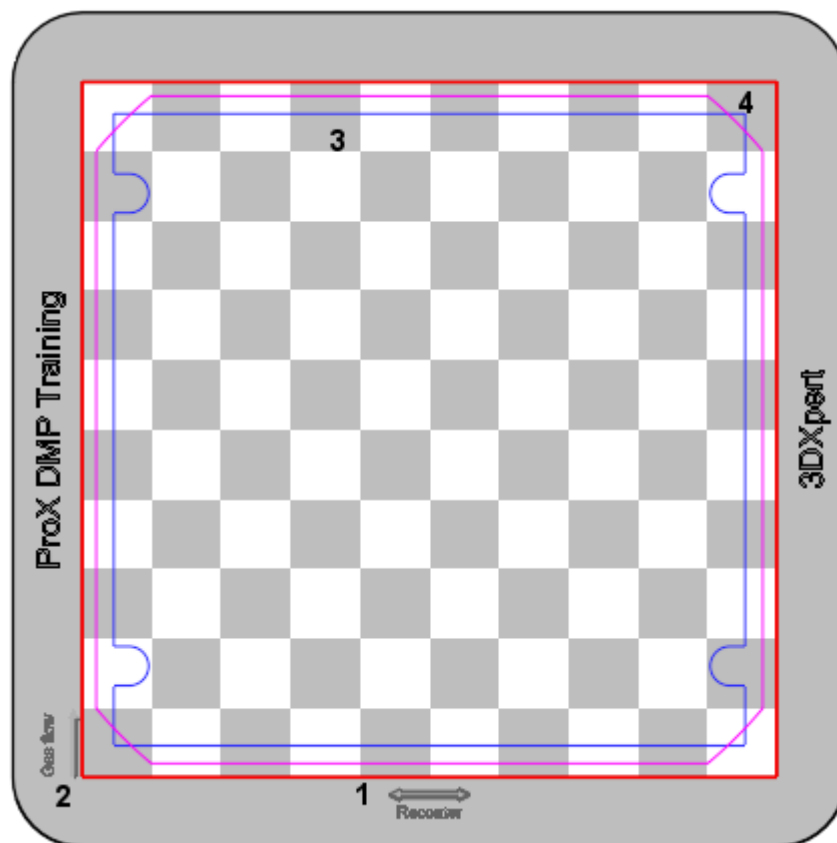
Gas Flow Direction:

☐ X
☒ Y
☐ -X
☐ -Y

- Set the **Printable Area** (the area on the tray where the laser beam is in optimized working conditions) as Recommended Area:

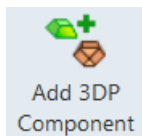


- Press the **Save Printer** button and then Close to exit the dialog. Press **OK** to confirm and exit the Edit Printer dialog. Look at data presented on the tray:
  - 1-Roller/Recoater direction
  - 2-Gas Flow direction
  - 3-Build Plate scheme (blue)
  - 4-Printable Area scheme (purple)



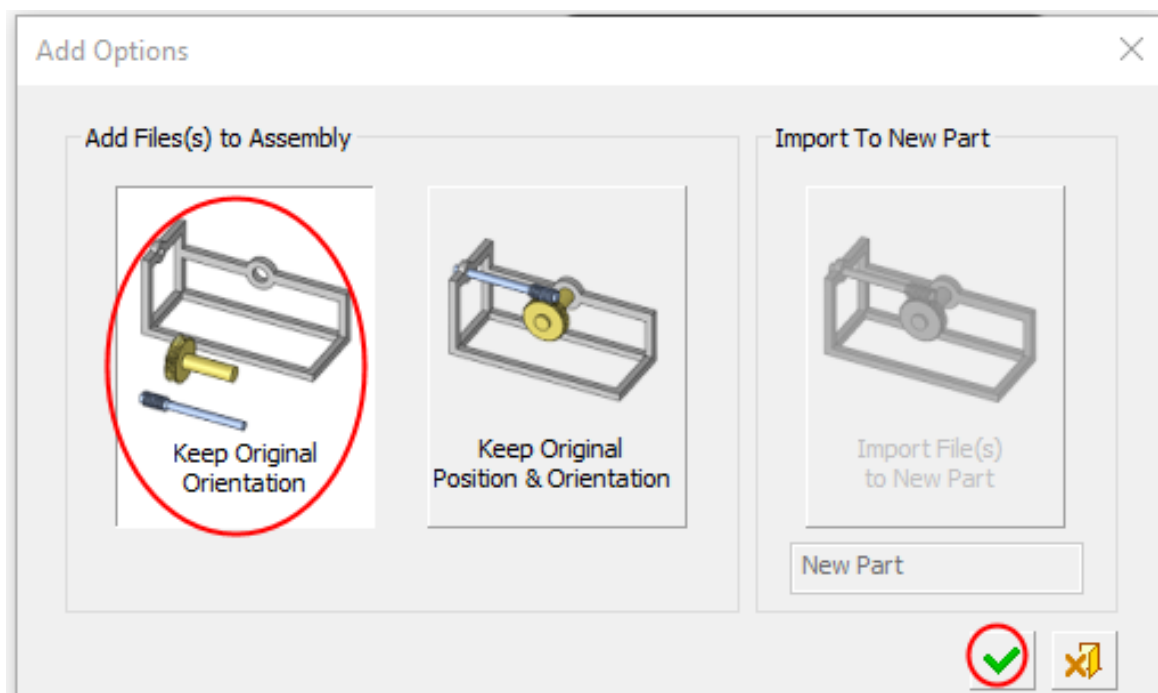
The Build Plate and Printable Area are taken into account in the printability checks (see later).

9. Let's add the part we are going to print. Press the **Add 3DP Component**



As the 3DXpert Explorer opens up, browse and select the file **Manifold\_05.elt**. Press 'Select' or double click the file. A dialog shows up.

10. In this Add Options dialog, you can set how multiple parts will be added to the 3DXpert assemblies. Or, alternatively, you may also add them to a new part.



Let us review the options:

- 1) **Keep Original Orientation** - This option enables to bring each part as originally positioned. However, the parts are automatically nested on the tray and not placed in the center of the tray.
- 2) **Keep Original Position & Orientation** - This option is suitable for loading an existing assembly, as this keeps the parts in the same position as originally located, with respect to the assembly. Note, that the system does not load the parent assembly itself. Only the parts are added, and even if the assembly contains sub-assemblies, only the parts from the assembly are added, each as a separate file. NOTE: In order to keep the parts' relative position, make sure to select all of them when using the Position Body tool (see later).
- 3) **Import Files to a New Part** - This option is enabled only when adding several parts. In many cases, you do not want to keep the existing assembly with

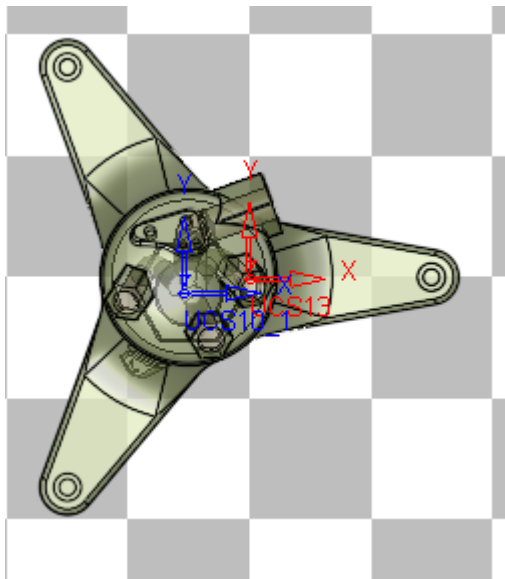
multiple parts (as original saved), but rather to combine several designed parts to a single part.

This mode enables to import all the components from the assembly or multiple parts to a single part, so that this part includes all the relevant objects.

If only a single file is selected (as in this exercise) and it is a part (not an assembly), this option is disabled.

11. Select '**Keep Original Orientation**' and press **OK**.

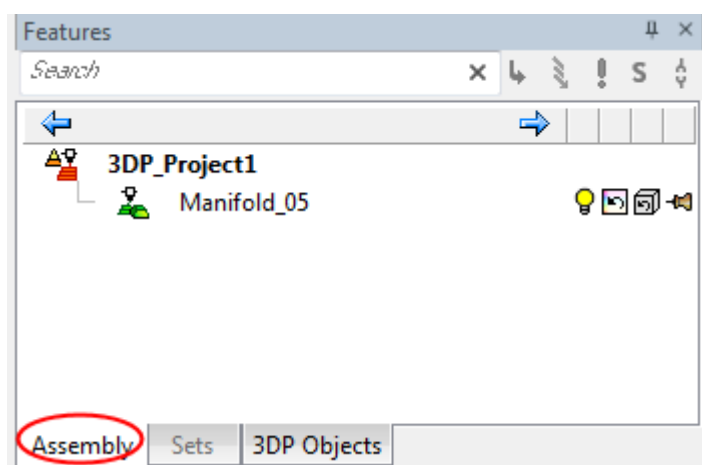
The part has now been added to the project.



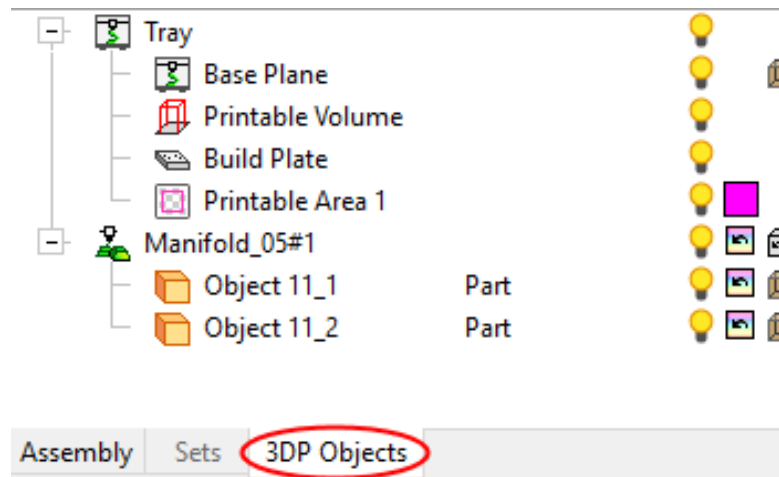
The project data tree is organized in two CAD modes - a CAD standard Assembly Tree and a dedicated 3D Printing Objects Tree.

12. To switch between these modes click the relevant Tab (as shown by a red circle).

The Assembly Tree



## The 3DP Objects Tree



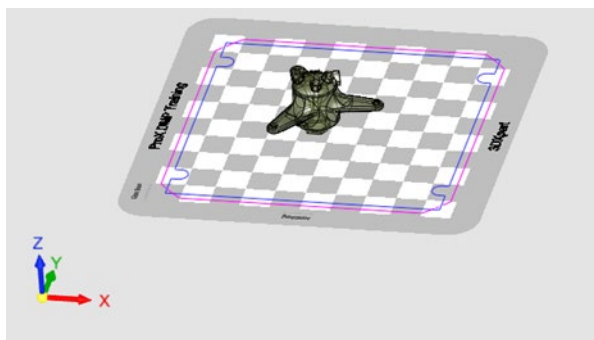
Although we have added the build plate and a single part, there are two objects visible in the 3DP Objects tree (Object 11\_1 & Object 11\_2).

The reason for this is that the added part (whose name is shown in the assembly Tree) is composed internally of two objects (we will come back to the handling of these objects later on in this exercise.)

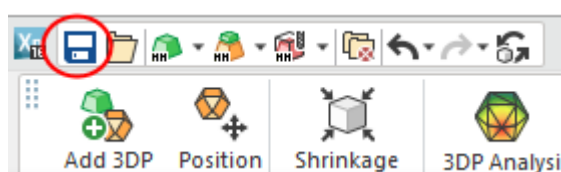
The default names of the objects are assigned by the system and can be renamed by the user.

The Objects Tree also includes additional Technology data that we will discuss later on.

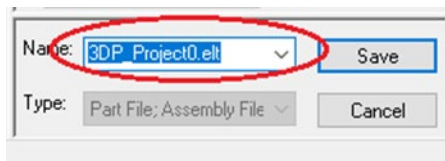
The part is now placed inside the tray area:



13. At this point, before we continue, let's save the project. Click **Save**.



14. The Browser opens up. Keep the default name and press **Save**.



## Part 2 – Position Body

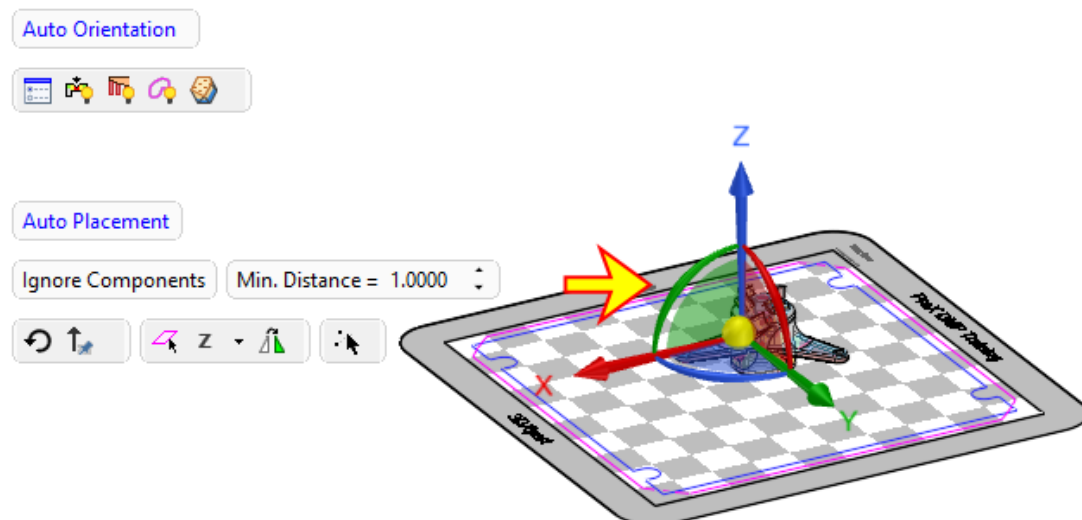
When positioning the body, the system takes into account the following:

- The [valid printing areas on the tray](#); the **Build Plates** (blue contour) and the **Printable Area** (the purple contour). These boundaries are displayed and the body cannot be positioned beyond them.
- Whether the build plate has holes for screws.
- The default settings in the [Best Fit Positioning Preferences](#).

15. The current placement of the model is temporary. To properly position the part inside the tray, press '**Position Body**' from the Menu Bar.



16. Notice the 'Triad' aside the part.

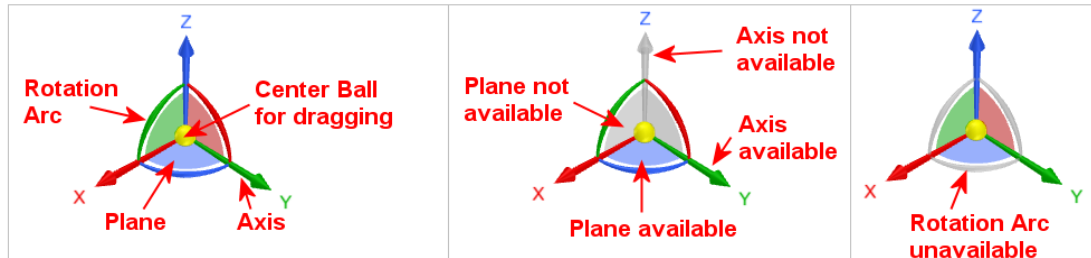


The Triad figure allows dynamic moving and rotating of parts and bodies on the screen.



The Triad allows dragging in the X,Y and Z directions or on the XY, XZ and YZ planes (as well as free dragging). It also allows rotation around each one of the axes. Tooltips are displayed when dragging or rotating objects, providing real time delta movement information.

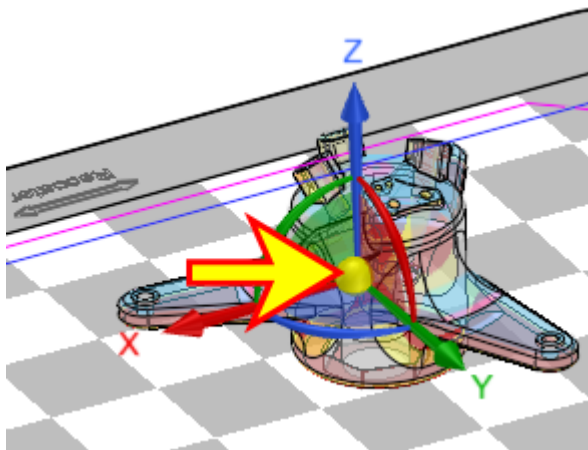
The Triad symbol appears in numerous functions when dragging on screen.



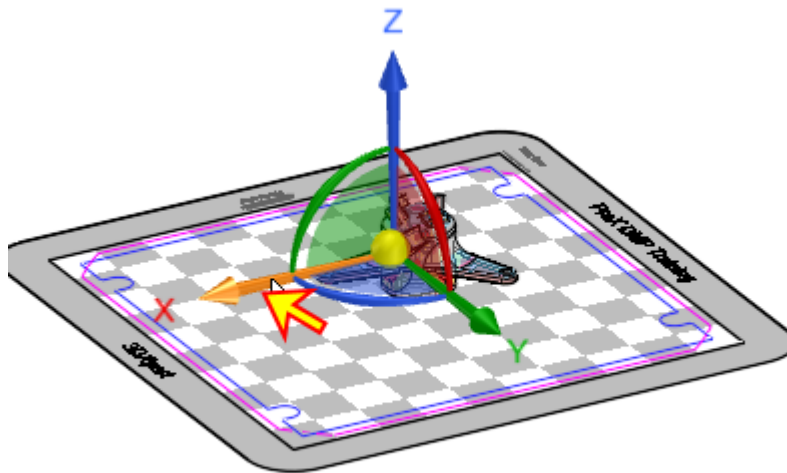
Planes and axes that are available for the current operation are displayed in color. When there is no rotation, the rotation arcs are grayed out (disabled). When planes are not available, they are grayed out (disabled). When there is only rotation, the axis arrows are grayed out (disabled), and the planes are not displayed. The center ball of the triad can be used to move it.

Colored planes may be used for function operations; select the required plane. Grayed out planes and axes cannot be selected.

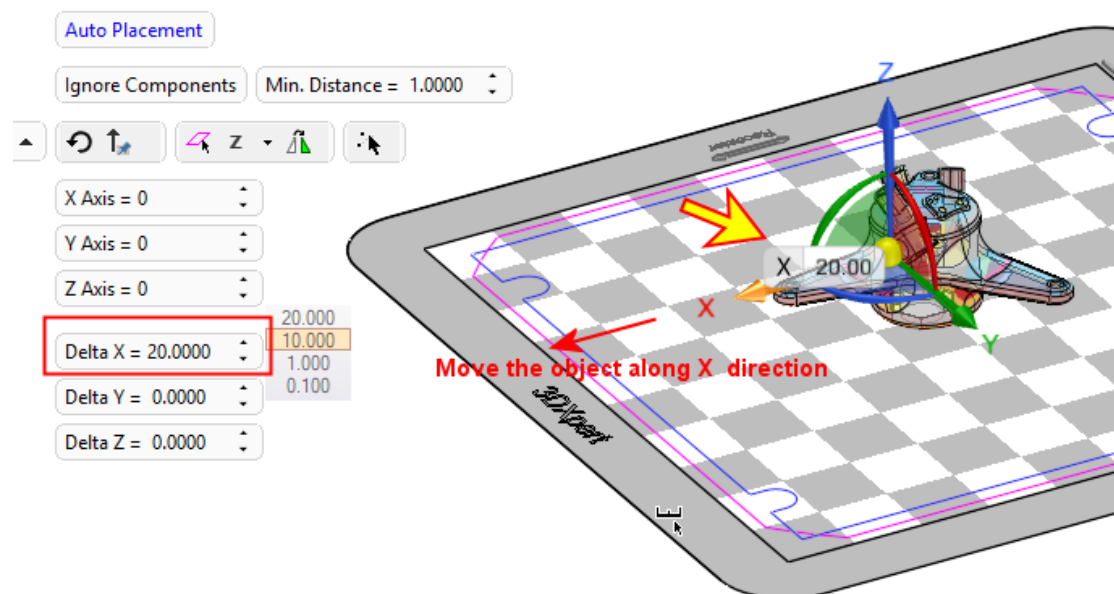
17. You can drag it around freely by picking the center ball and moving the mouse



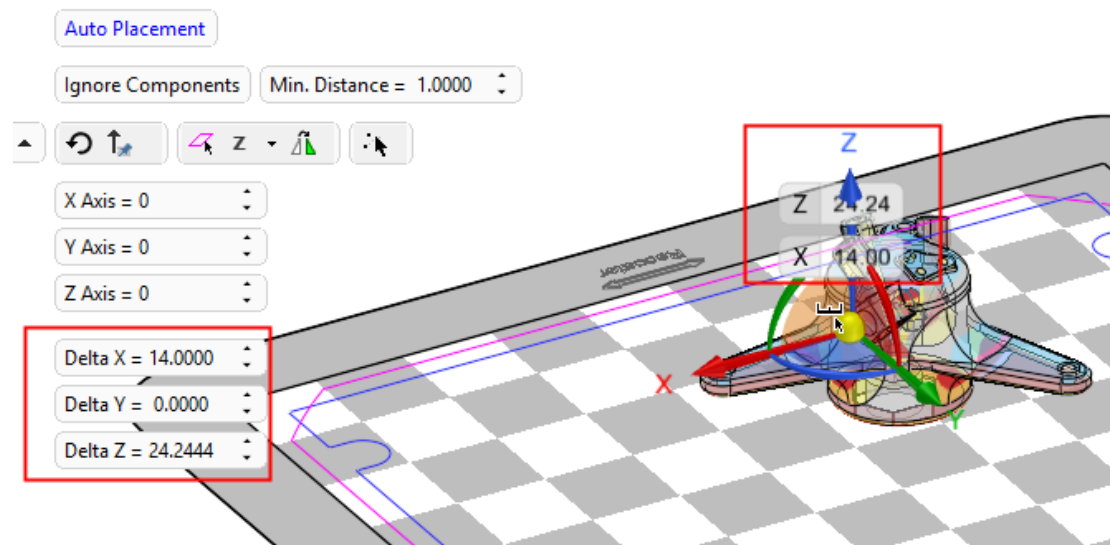
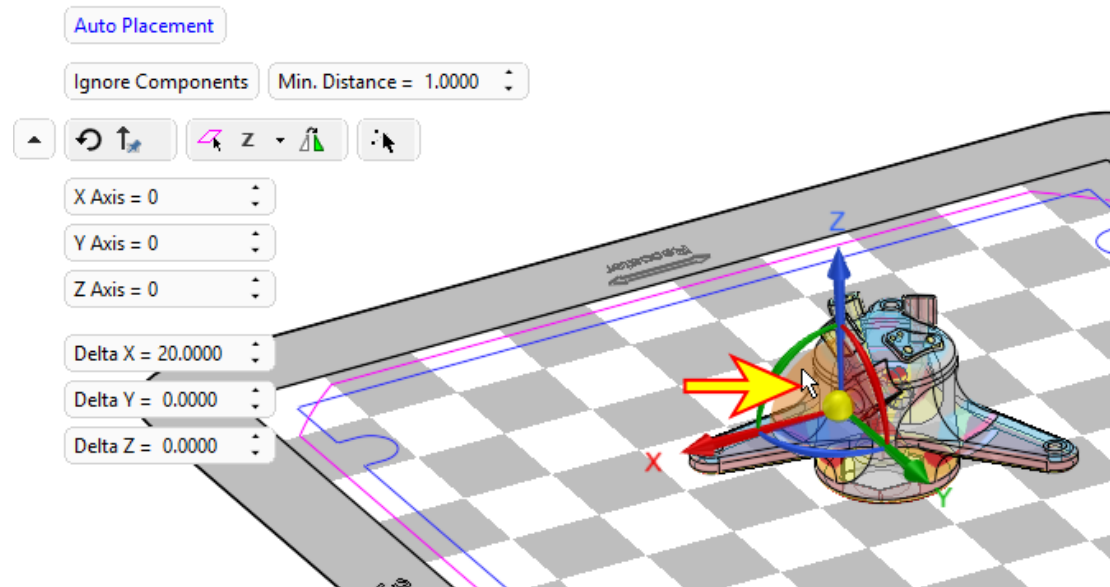
18. Drag the X axis.



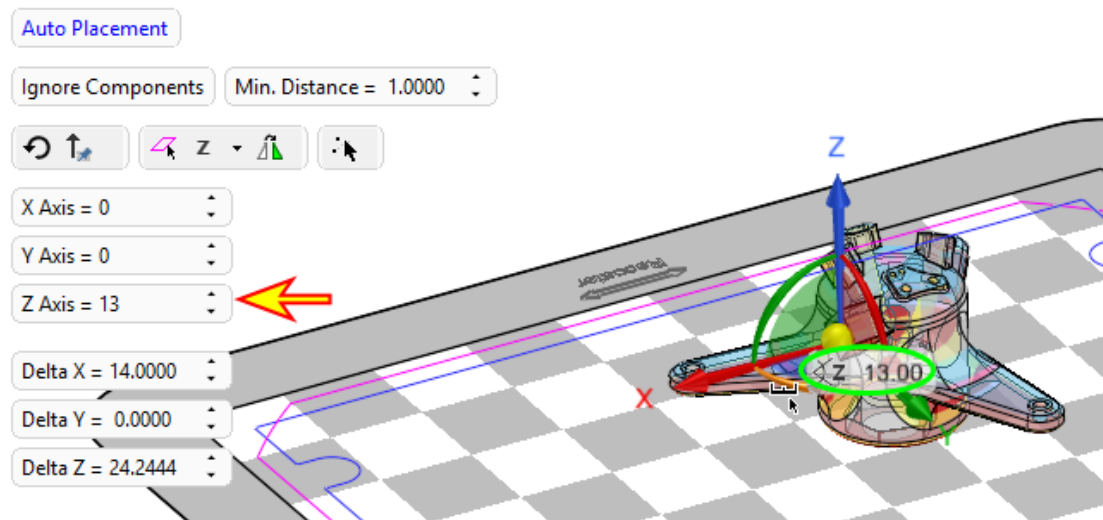
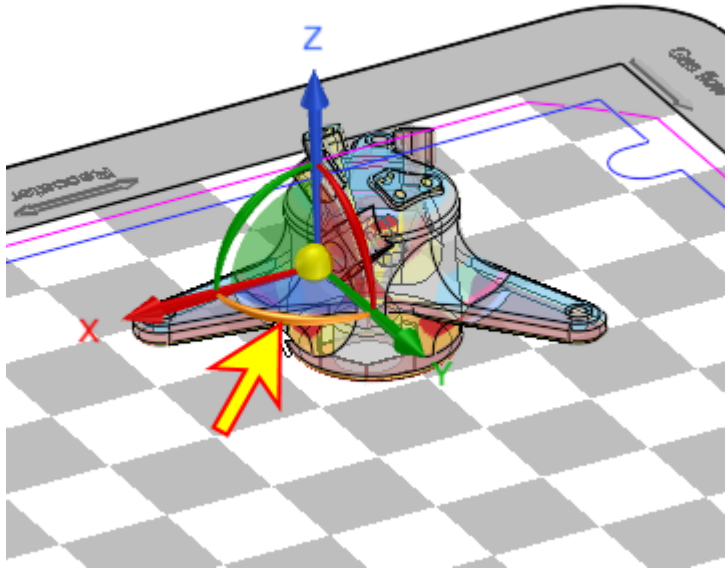
Delta distance value displayed when dragging an axis.



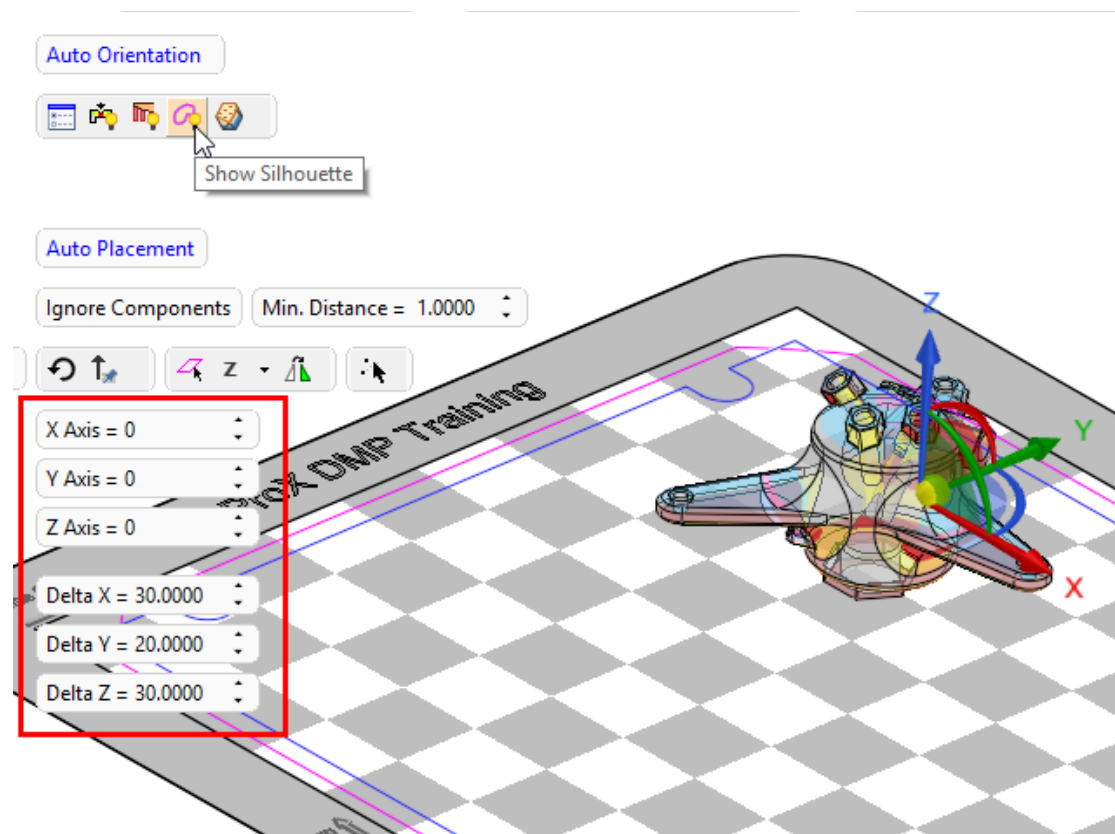
19. Select the XZ plane as indicated by the arrow below and drag it. X and Z values are displayed and change accordingly.



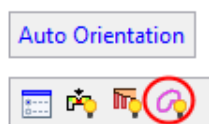
20. To rotate the part. Pick one of the rotation arc. Move the mouse around the relevant axis.

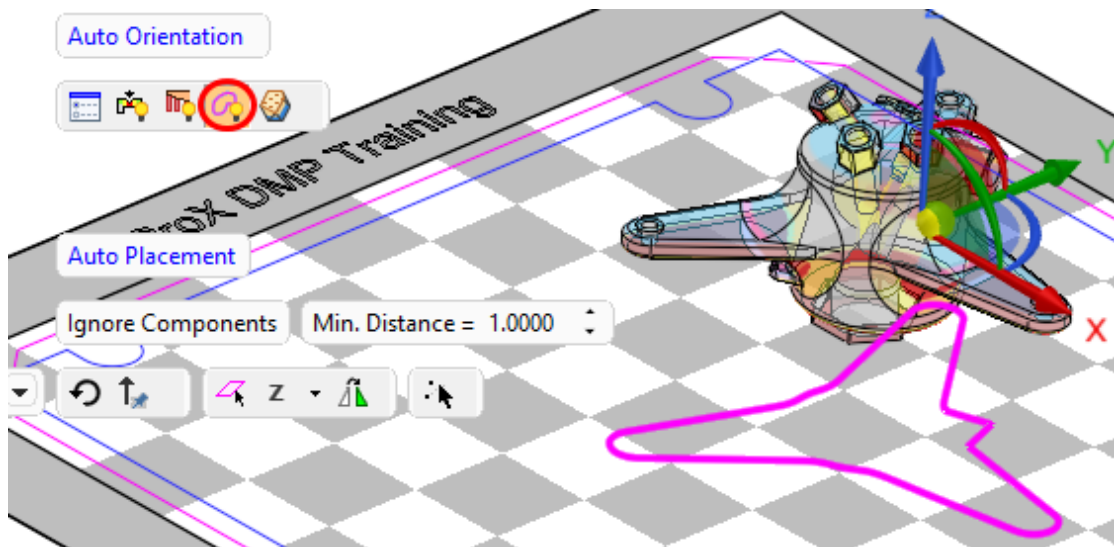


21. Planes and axes that are available for the current operation are displayed in color.  
When there is no rotation, the rotation arcs are grayed out (disabled).  
When planes are not available, they are grayed out (disabled).  
When there is only rotation, the axis arrows are grayed out (disabled), and the planes are not displayed.
22. See that the part cannot escape the boundaries of the tray. If, during its rotation, the part protrudes below the tray, once the mouse is released, the part will jump to position inside the tray. The part can escape the boundary of the tray (but not below it) if selecting ignore component.
23. Finally set the parameters as follows:



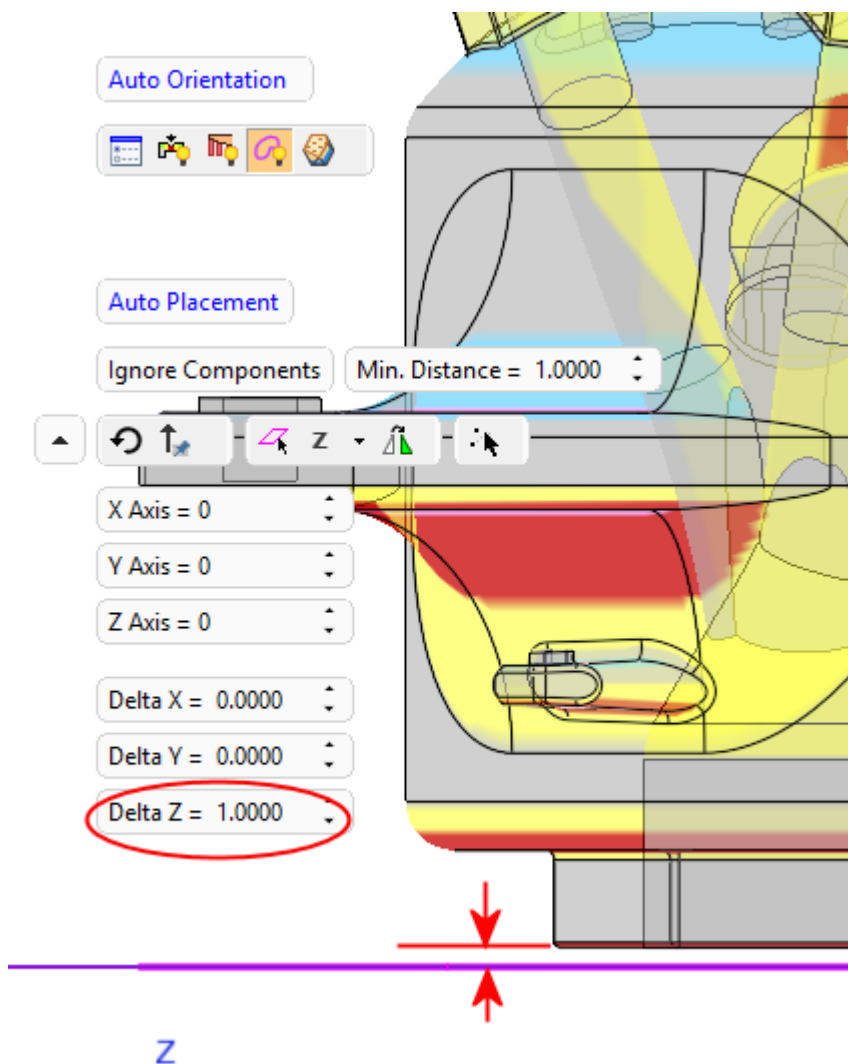
24. Press the “Show Silhouette” button.





There are several tools to position the part according to the best practice. We will now go through various positioning functionality.

25. The position of the part above the tray is dictated by the Delta Z parameter.

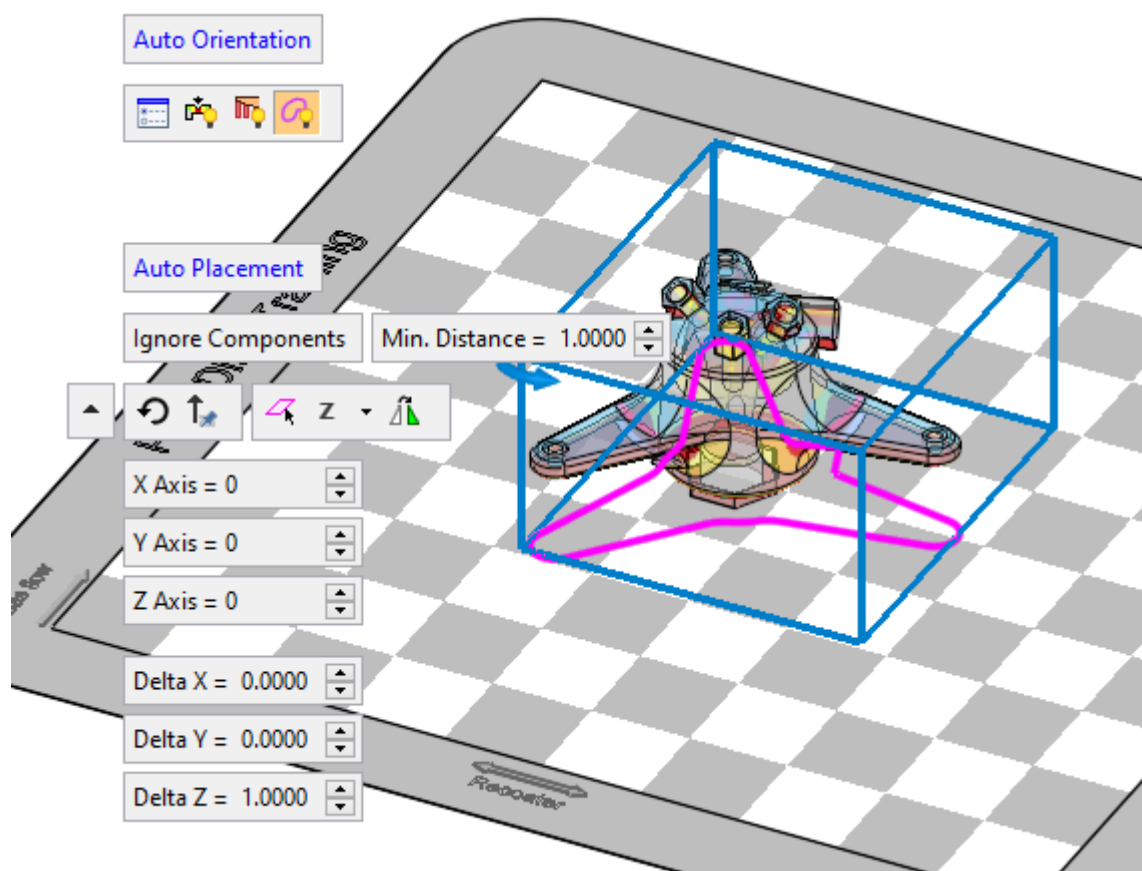


26. Change the value to see it moving up and down.
27. During positioning of the part, the system runs a down facing analysis.

The down facing analysis is a visual analysis tool, based on the defined Overhang Angle.

See that some the part's faces are colored in yellow or in red. These are the down facing areas (or, in other words. faces that 'see' powder below).

The value of the angle is taken from the printer parameters dialog, and can be changed here. As the value is modified, the system updates the analysis results accordingly.

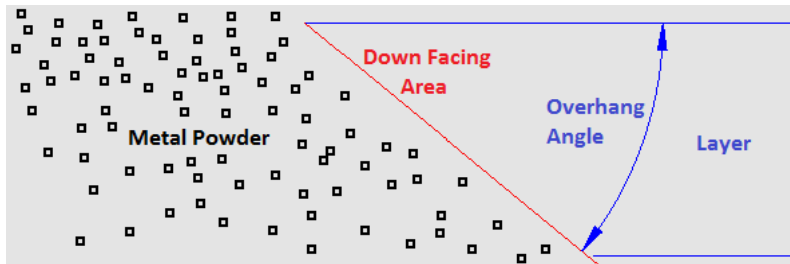


The part areas colored in red are those which require a support (again, according to the min. angle). The down facing areas colored in yellow will meet the powder but do not need a support.



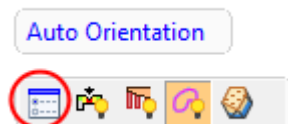
More on the Overhang Angle:

The overhang angle (previously defined in the Edit Printer dialog) is measured from the horizon.



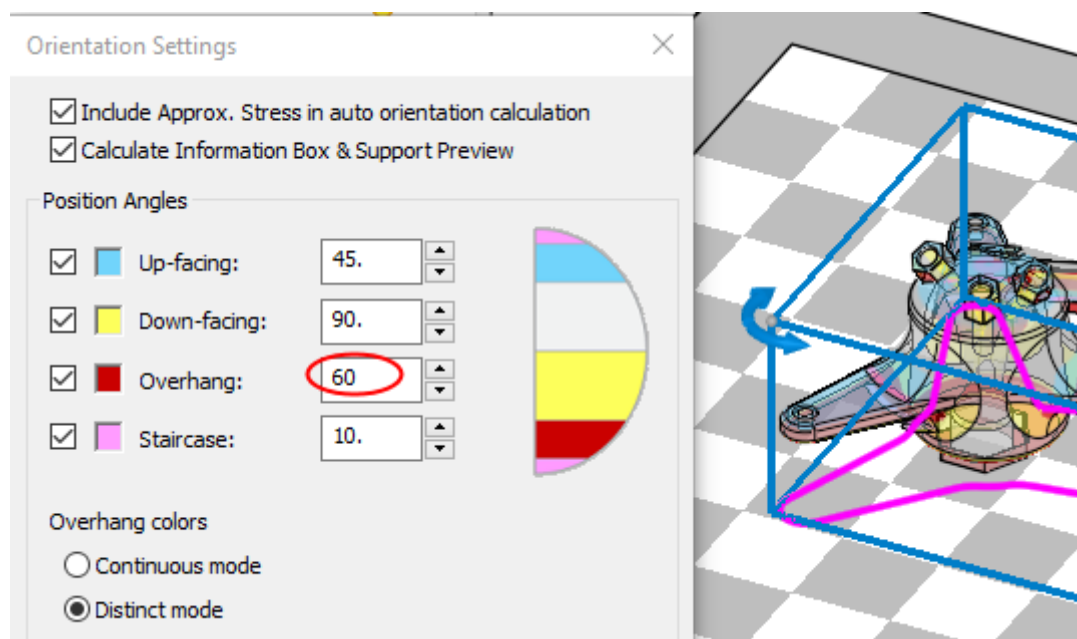
The 'Overhang Angle' parameters as well as some other parameters can be changed through the Orientation Setting Dialog, which be explained later on.

28. Press the **Orientation Settings** icon.

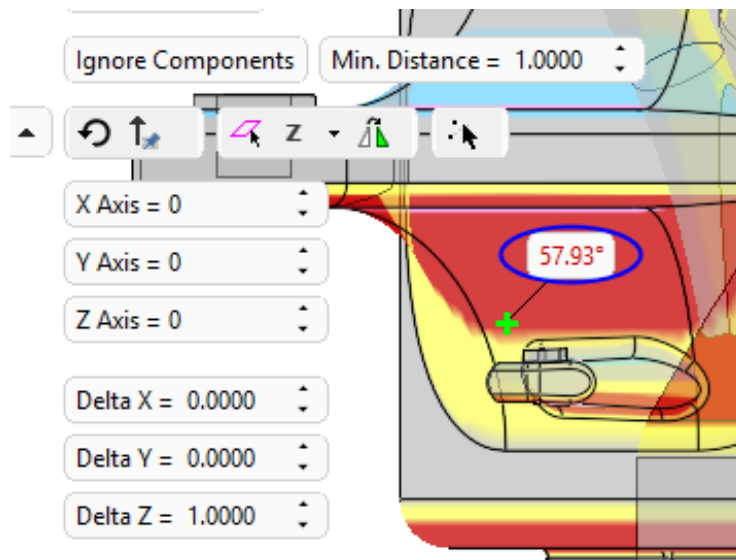


Here the 'Overhang Angle' parameter shows 50, as we have defined before.

29. Change the Overhang Angle from 50 to 60 and see that additional areas will be colored in red.

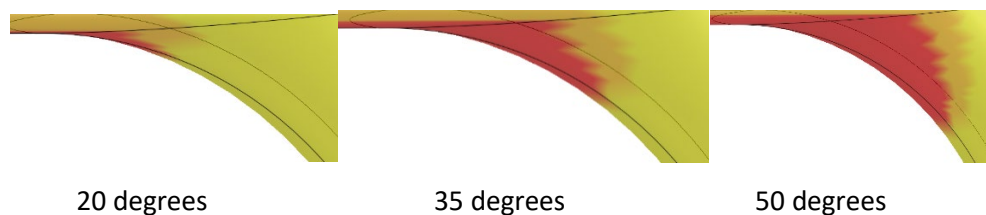






30. To better see why, look at the following images.

As the angle increases, additional areas will require supports to sustain printing, as shown in the following example:



31. Rotate the part. The analysis will rerun and update the colors according to the 'new' down facing areas.
32. Rotate the part by entering values to the X,Y & Z Axes boxes. Note that when entering values to the X,Y & Z Axes parameters, the rotation is performed around the main tray axes.

In addition, when entering Position Body or using Auto Orientation / Select Plane, all the angle values are reset to zero. This way it is easy to fine tune the position and set a delta from the current position. These changes also lead to the new Reset Orientation button.

33. The Reset Orientation button restores the part to the zero position (i.e., as placed originally). Press the **Reset Orientation** icon.

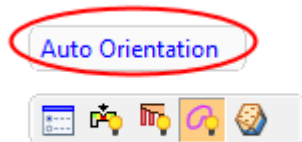


The '**Auto Placement**' button puts the part in the center of the screen at the lowest point, keeping the current orientation. (Note that the Delta X,Y & Z values will get a value of zero).

So far, we have discussed the manual position tools.

Let's see now the **Automatic Orientation tool**. This tool appears at the top.

34. Press the **Auto Orientation** button.

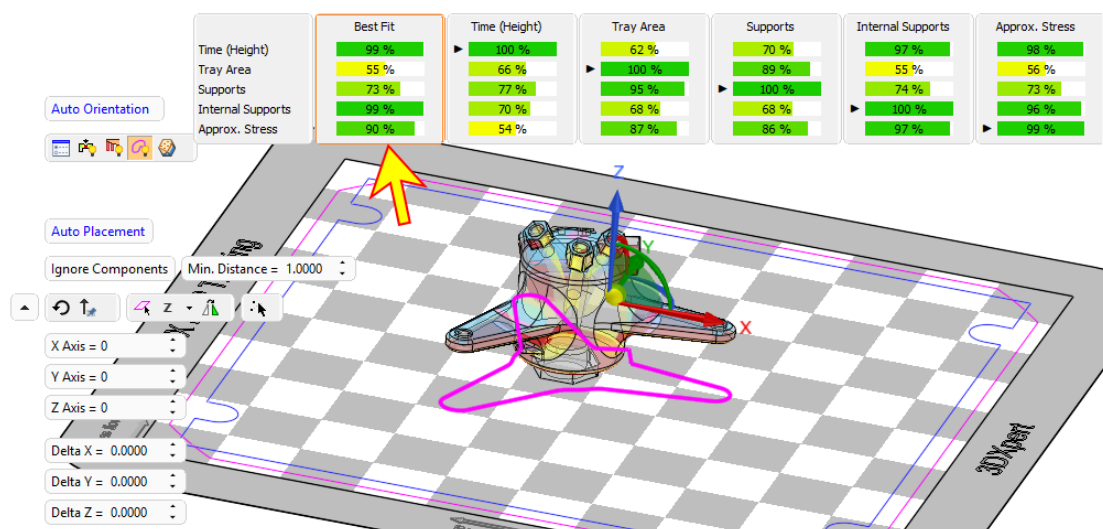


The system analyzes and automatically orientates the part on the tray, based on the following analysis criteria: Time, Tray Area, Supports, Internal Supports and Approximated Stress. The results are displayed in a panel showing the optimum orientation for each analysis criteria.

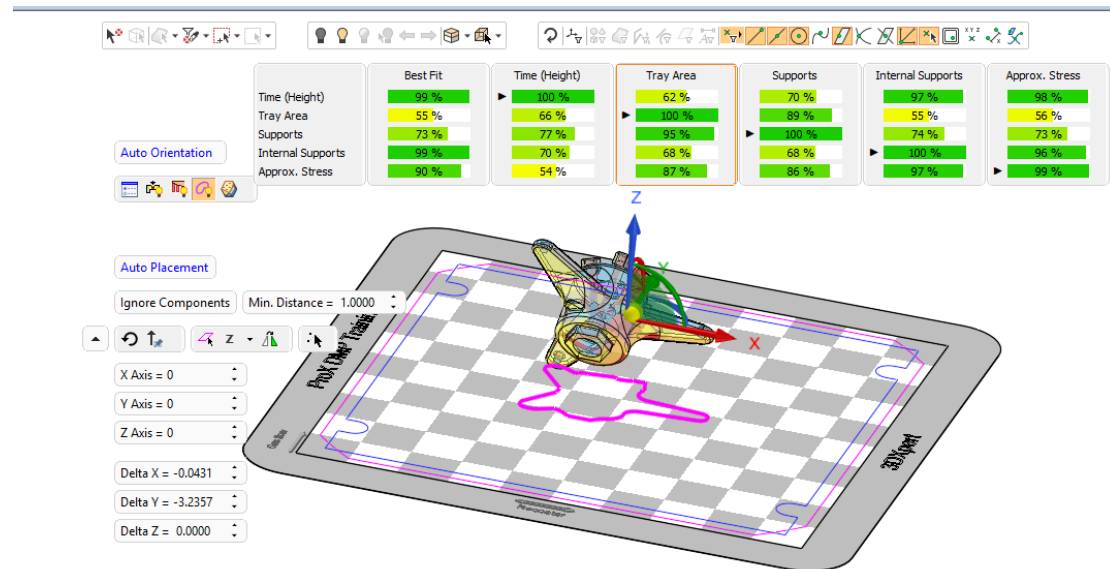
By default, the system displays an optimized orientation that **Best Fits** all the analysis criteria, based on the weight importance given to each of criteria in the Orientation Settings dialog, or the default weight values defined in the Best Fit Positioning Preferences. Any defined orientation restrictions are also taken into account.

Within each calculated analysis criteria in the panel, the best possible fit for a specific parameter is indicated by an arrow and a color coded marking, where the darkest green indicates the best fit.

When an analysis criteria in the panel is selected, it is highlighted and the graphics window displays the resultant part position on the tray. In the image below, the **Best Fit** group is marked as selected.

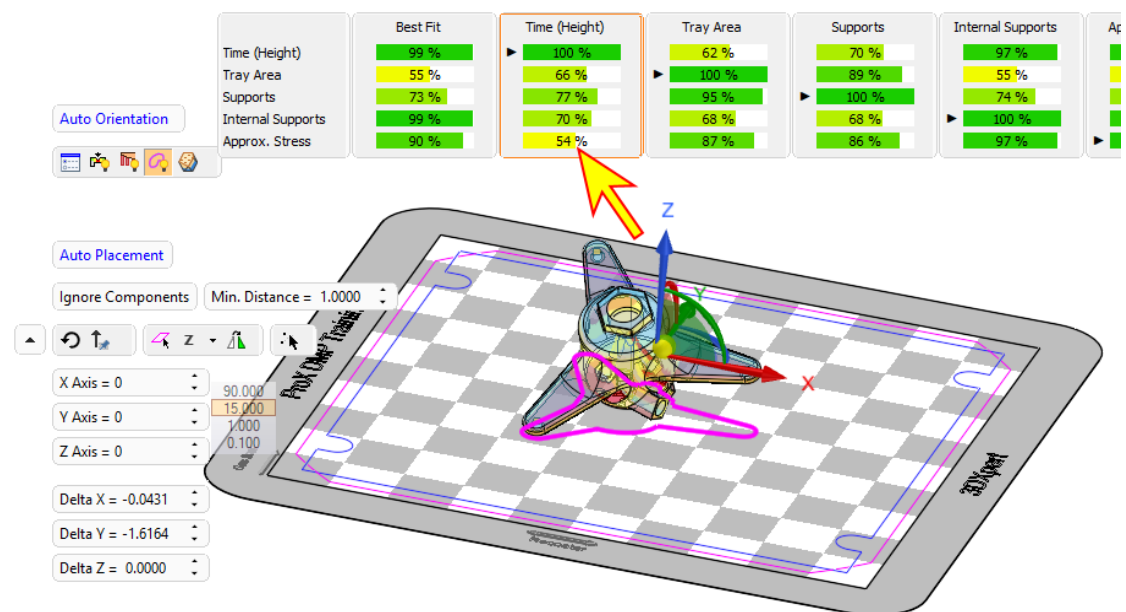


35. Press the **Tray area** selection in the panel. This results in the orientation that will yield the least amount of tray area used (based on the part's bounding box). The bounding box is positioned so that its projection on the tray is the minimal.

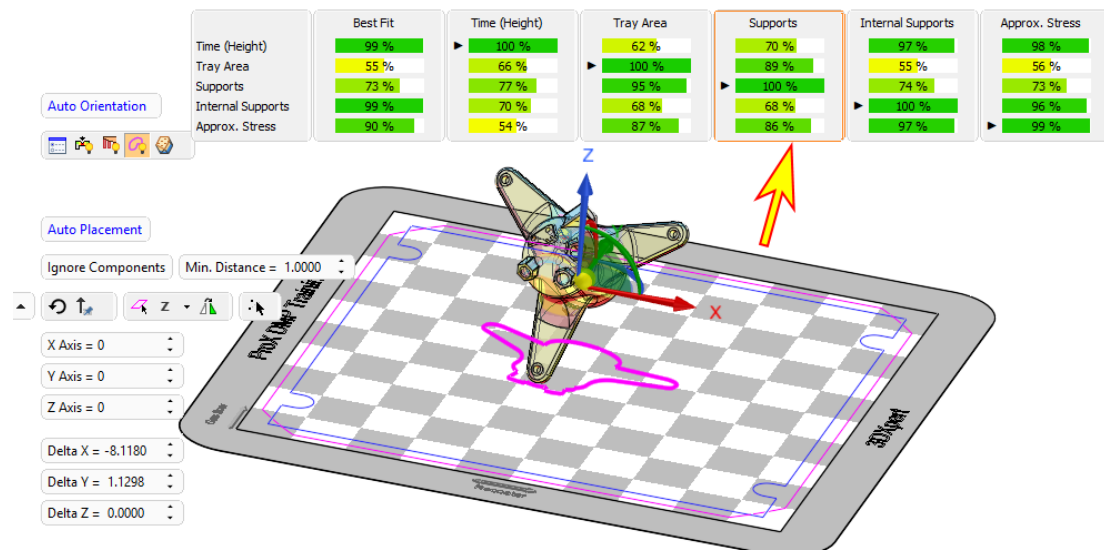


36. Now select the option **Time (Height)**. This results in the orientation based on the smallest height value, by which the part will be positioned (based again on the part's bounding box.).

The height of the bounding box of the part is the smallest possible.



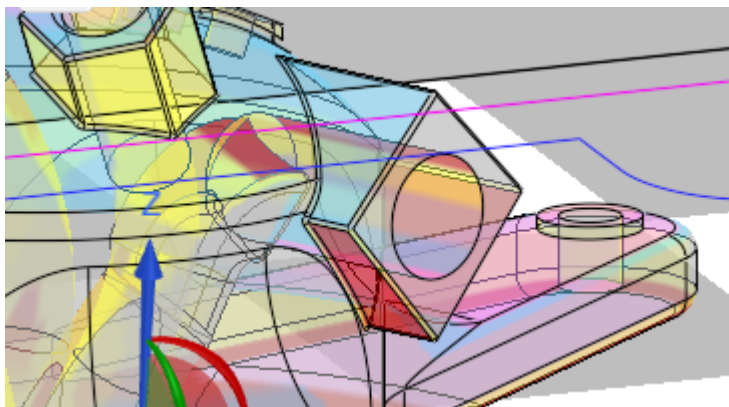
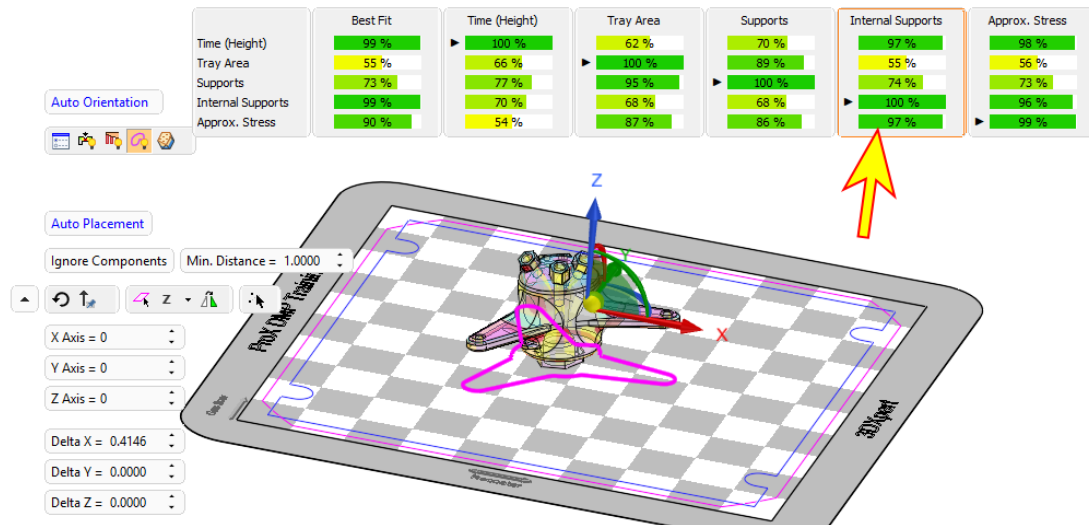
37. Select the option **Support**. This gives the orientation with the minimal support area.



In this orientation, the amount of external red faces is small.

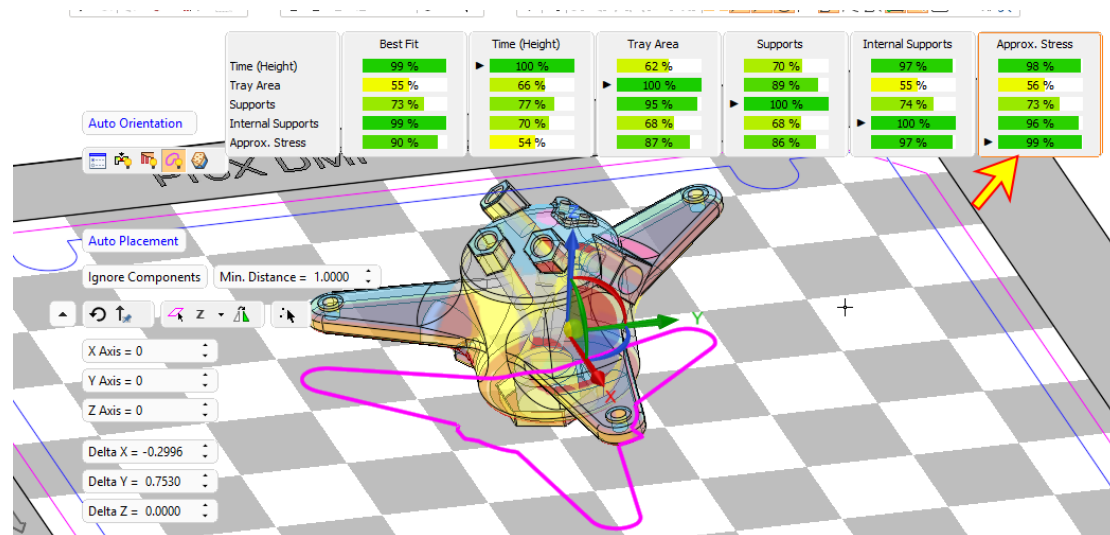
In all these positions so far, supports are required inside the pipes of this manifold part. Of course, these cannot be removed easily, definitely not by machining.

38. Therefore, select the option, **Internal Supports**. This orientation is based on the minimal support for internal open areas.

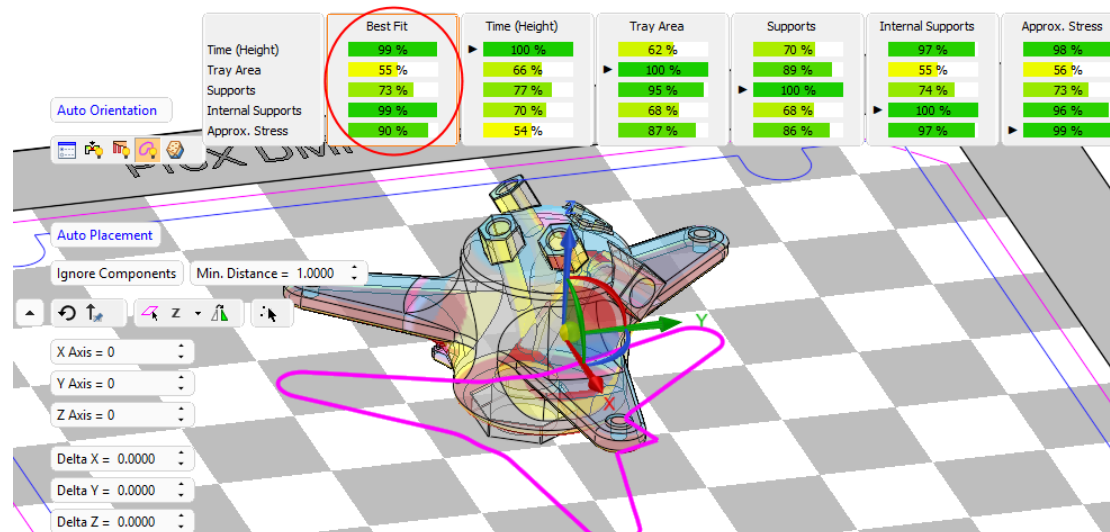


You can see that in this orientation the pipes in the part are mostly colored yellow, except for some small area at the bottom.

39. Select the option, **Approx.Stress**
40. The inclusion of stress approximation (**Approx. Stress**) in the panel (as an analysis tool for design decisions) is controlled in the Orientation Settings dialog and also the default settings in the Best Fit Positioning Preferences.
41. The **Approx. Stress** data/options are only displayed when a printer with MPB technology is used.

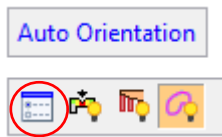


42. Press the option **Best Fit** again.



43. As mentioned earlier, the **Best Fit** option displays an optimized orientation that **Best Fits** all the analysis criteria, based on the weight importance given to each of criteria in the **Orientation Settings** dialog, or the default weight values defined in the **Best Fit Positioning Preferences**.

44. Press the **Orientation Settings** icon.



The **Orientation Settings** dialog is displayed.

This dialog enables you to set various presets before starting the **Auto Orientation analysis**.

Here you may set the display, value and color of the Position Angles.

The **up-facing angle** defines the angle above which the faces are considered as up-facing. Up-facing areas are those that are not considered as down-facing.

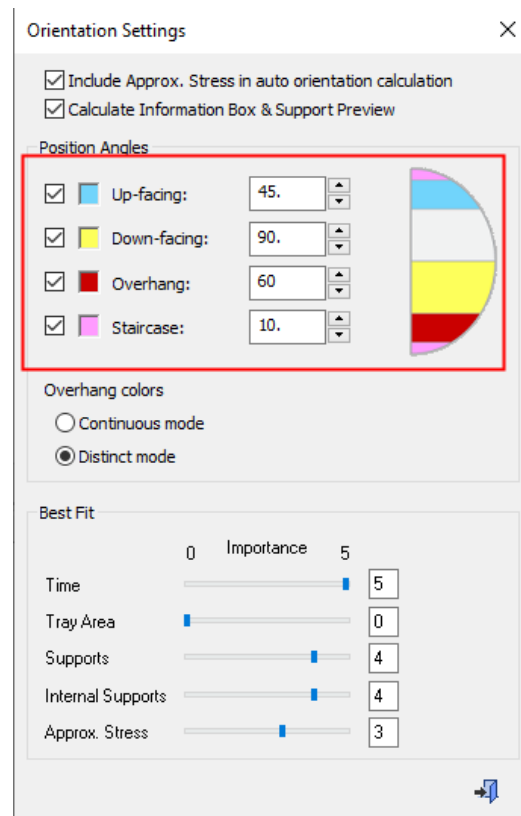
(The default angle depends on the material selected and is stored in the relevant Material.XML file).

A **down-facing surface** is a surface that is facing downwards, towards the build tray, given the selected build orientation.

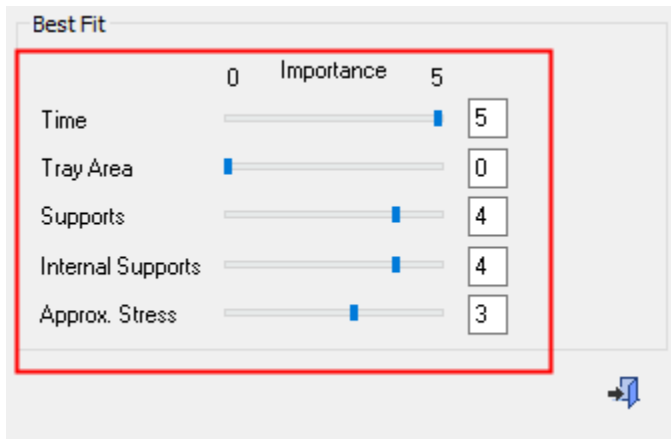
**Overhang:** This angle defines the degree of overhang after which some support structure should be added.

The Default Min. Overhang Angle is set in the relevant technology XML file and can be changed in the Edit Printer Parameters and Technology Settings dialogs.

The **Staircase** Effect is where edges or lines appear jagged, similar to staircase steps.

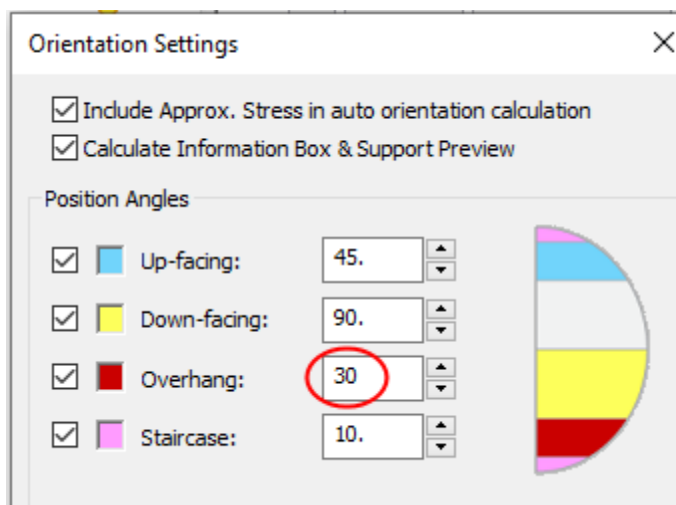


Set the level of importance (from 0 - 5) of the following criteria when calculating the best fit, where 0 = least important and 5 = most important. The importance weight can either be set by using a slider or an edit box. The default values are defined in the Preferences, as will be explained in the next step. The number of orientations to be calculated to find the best fit, is also defined in the same Preference.



45. For this exercise, we will not change the Criteria.

46. Change the **Overhang** angle to **30**.

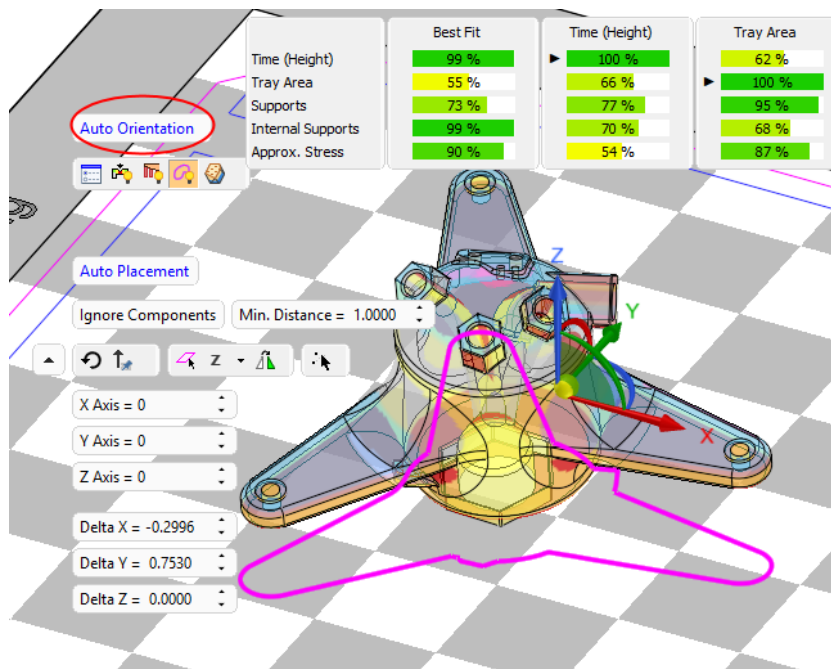


47. Exit the dialog.

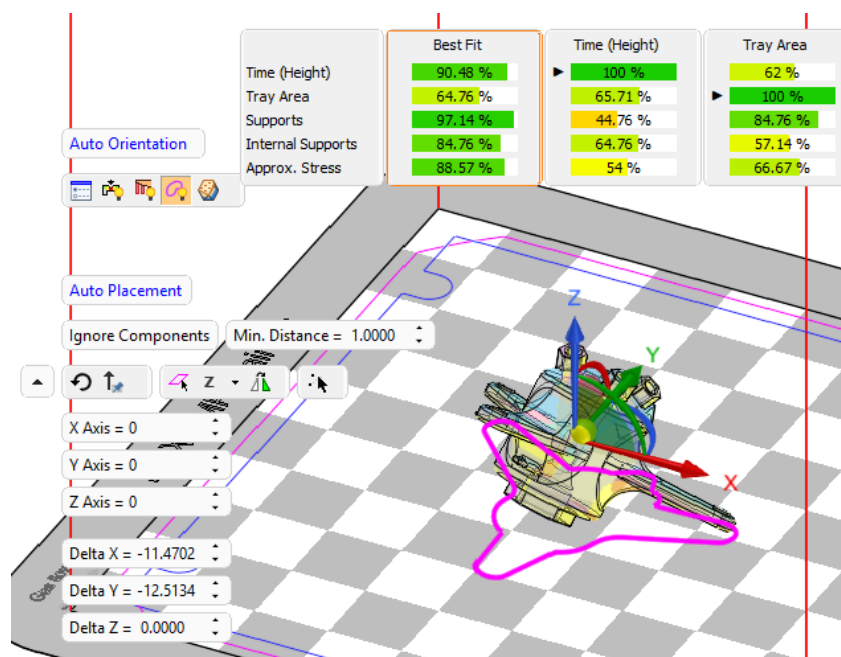


48. Press the Auto Orientation button to recalculate the analysis. Notice the new orientation of the part according to Best Fit criteria.

Before re calculation:

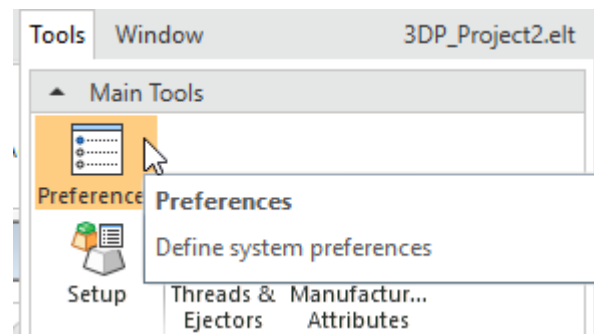


After re calculation using an **Overhang** angle of 30 :



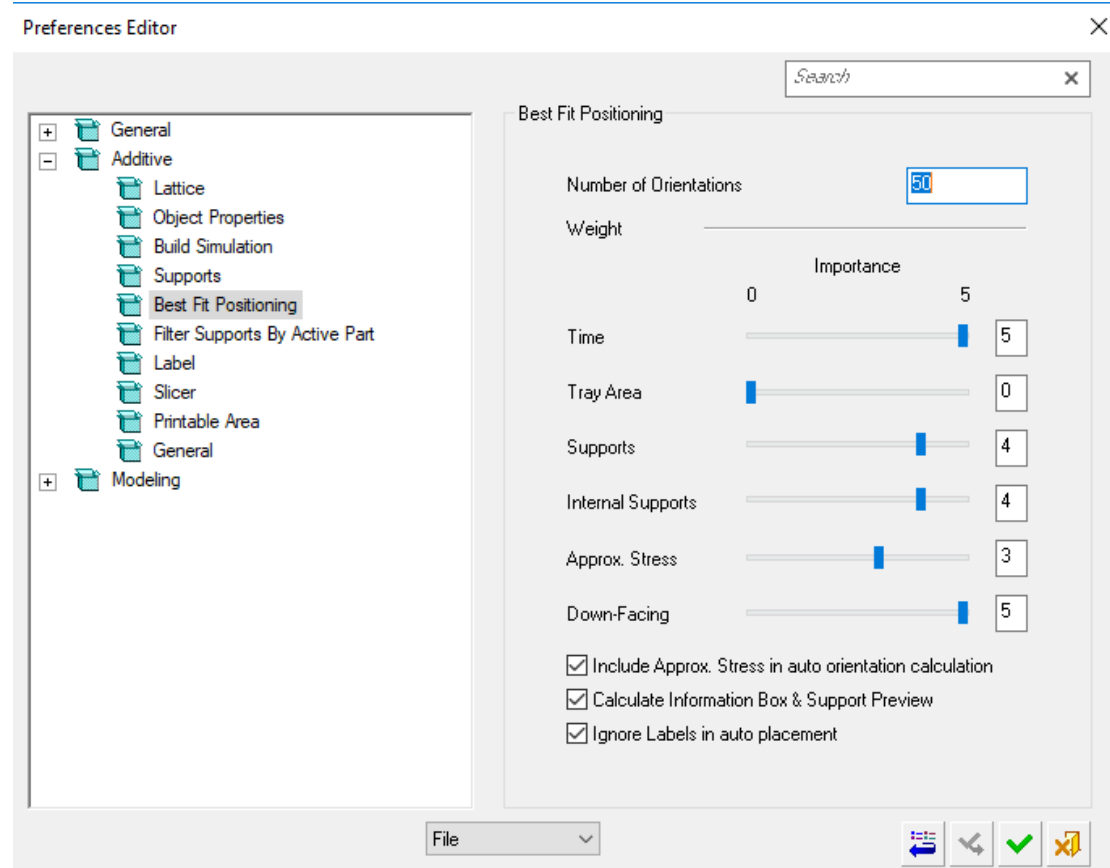
Setting up Best Fit criteria through the Preferences:

From the main menu, enter Tools - Preferences.



Browse to the Additive - Best\_Fit\_Positioning leaf.

Set the importance factor (0 = Not Important, 5 = Very Important), switch from 'File' to 'All Application' and Save the setup.

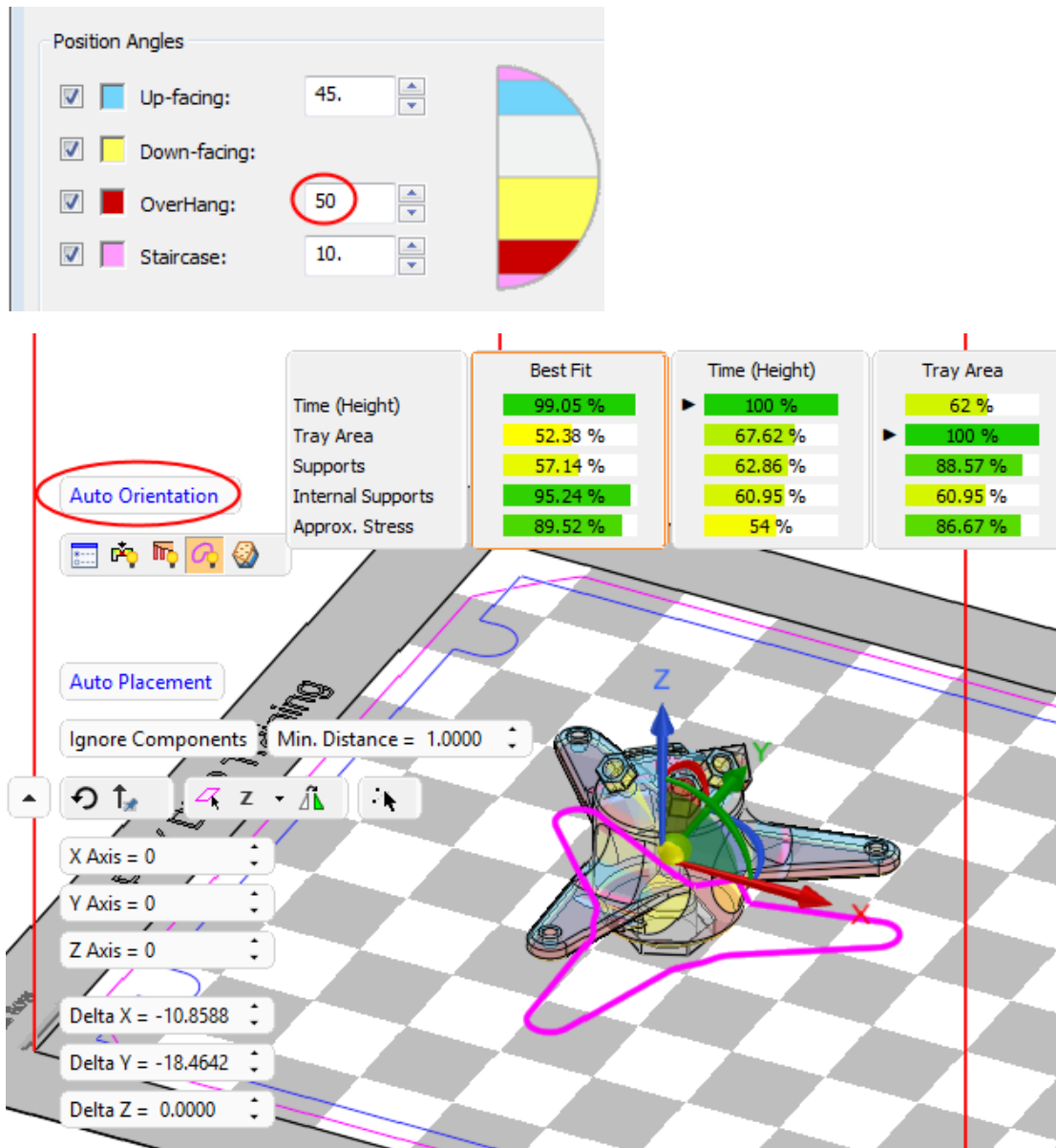


Enter Position Body, from the list select Best Fit, Press the Auto Orientation button and see the result.

Auto Orientation

Best Fit

49. Change the **Overhang** angle to **50** and recalculate the analysis:



**Position Angles**

- ☒ Up-facing: 45.
- ☒ Down-facing:
- ☒ OverHang: 50
- ☒ Staircase: 10.

**Auto Orientation**

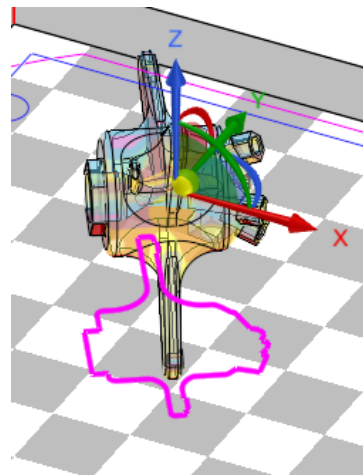
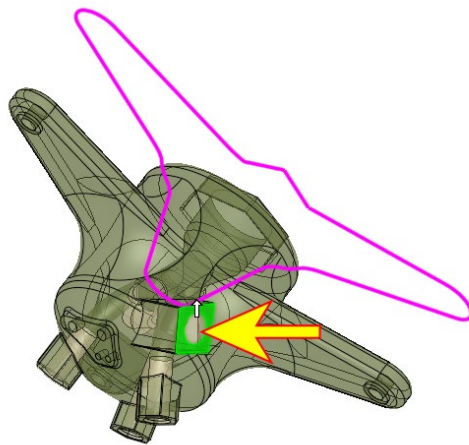
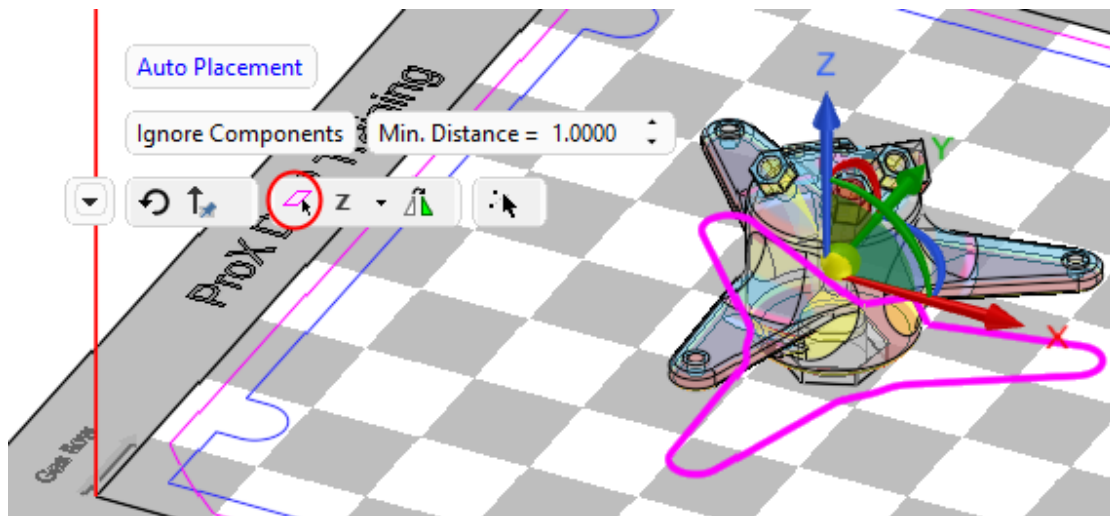
	Best Fit	Time (Height)	Tray Area
Time (Height)	99.05 %	100 %	62 %
Tray Area	52.38 %	67.62 %	100 %
Supports	57.14 %	62.86 %	88.57 %
Internal Supports	95.24 %	60.95 %	60.95 %
Approx. Stress	89.52 %	54 %	86.67 %

**Auto Placement**

Ignore Components: Min. Distance = 1.0000

X Axis = 0  
Y Axis = 0  
Z Axis = 0  
Delta X = -10.8588  
Delta Y = -18.4642  
Delta Z = 0.0000

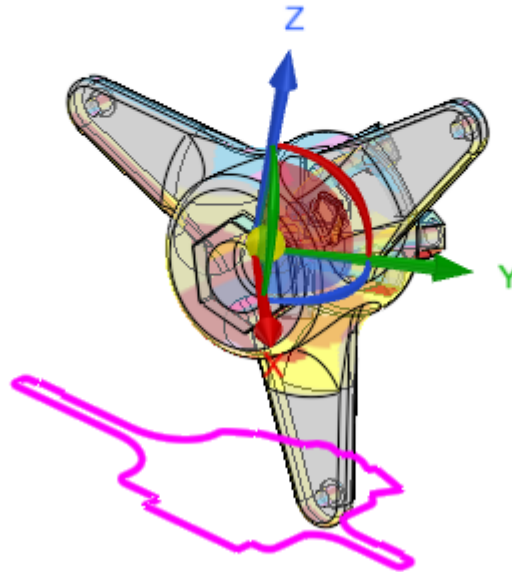
50. Sometimes you know how you want to place the part by placing one of its faces in parallel (or tangent) to the tray. Press the Select Plane button, and then pick the face highlighted in green :



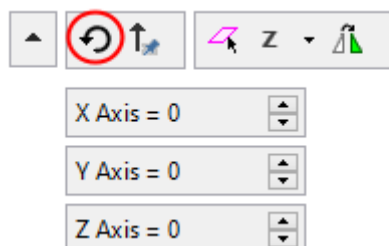
51. After placing the part with any of the above mentioned methods, you can fine tune the position by manually setting the rotation and position.

52. Once you have manually rotated the part, a new orientation named “Current” has been added to the analysis criteria options.

Supports	Internal Supports	Approx. Stress	Current
75.24 %	96.19 %	98 %	50.48 %
80.95 %	53.33 %	58.10 %	98 %
100 %	59.05 %	58.10 %	83.81 %
68.57 %	99.05 %	90.48 %	54.29 %
86.67 %	96.19 %	99 %	75.24 %

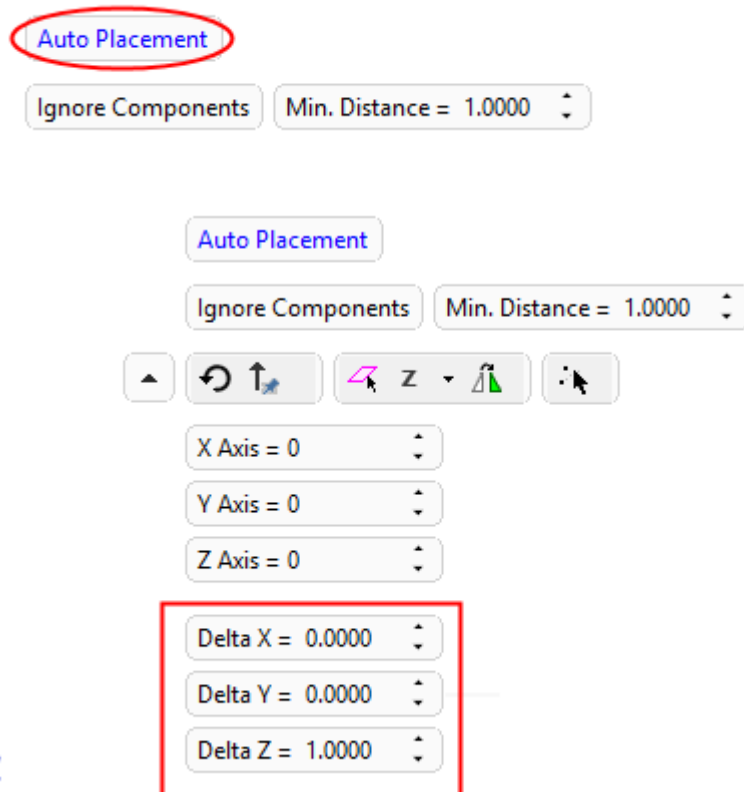


53. For this exercise, let's make sure that the X,Y,Z axes are back to zero (i.e., press the Reset Orientation button).

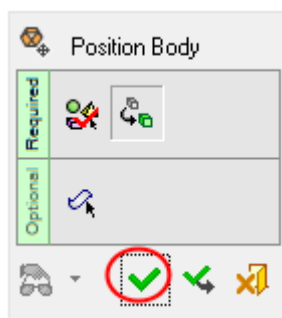


After Reset.

54. Click also Auto Placement to set Delta X Y & Z values back to zero: Set the Delta Z to 1.



Finally right mouse click on screen and press **OK** through the Feature Guide.



### Note on Scaling (Shrinkage Compensation)

As the printed part cools down, it shrinks.

Therefore, it may be required to scale it up so that it shrinks to the correct size.

3DXpert's Shrinkage Compensation has various options; the primary methods are:

Uniform (same on X, Y & Z)

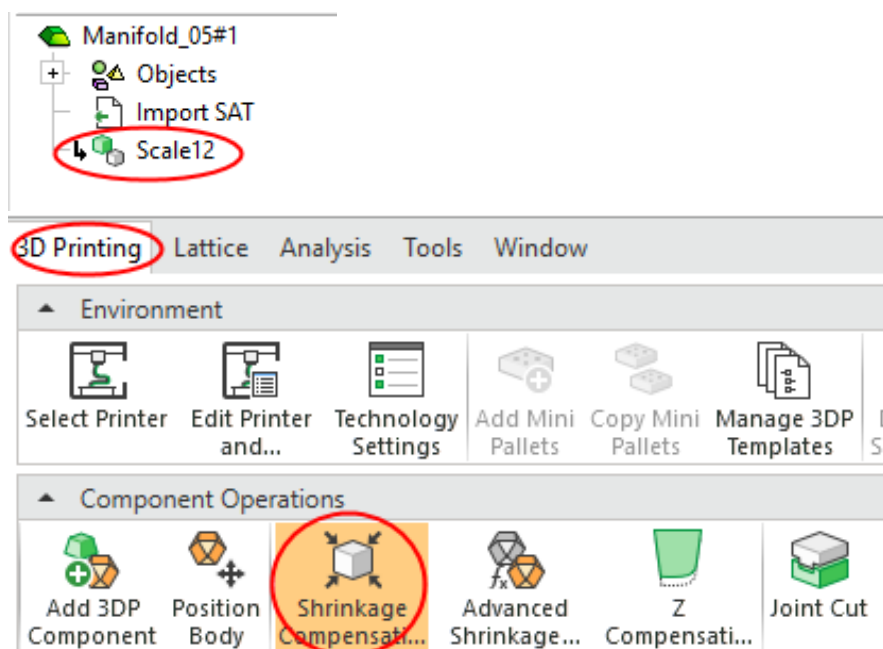
- By Percentage
- By Factor

Non-Uniform (can be different on each direction):

- By Ratio. Enter scaling factor for each axis
- By Bounding Box. Enter X,Y,Z lengths of new bounding box

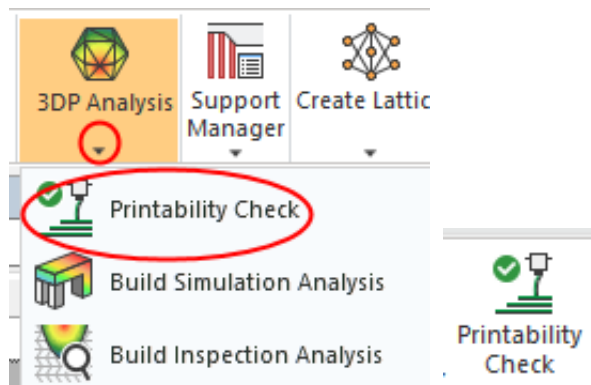
The default factor in Z is set to 1 because in printing, the shrinkage is not expected along the Z-Axis.

The part we use has already been scaled up, so we can continue with the next step.



## Part 3 – Analysis Tools

3DXpert offers a variety of Analysis tools, available from the 3DP Analysis menu or toolbar.

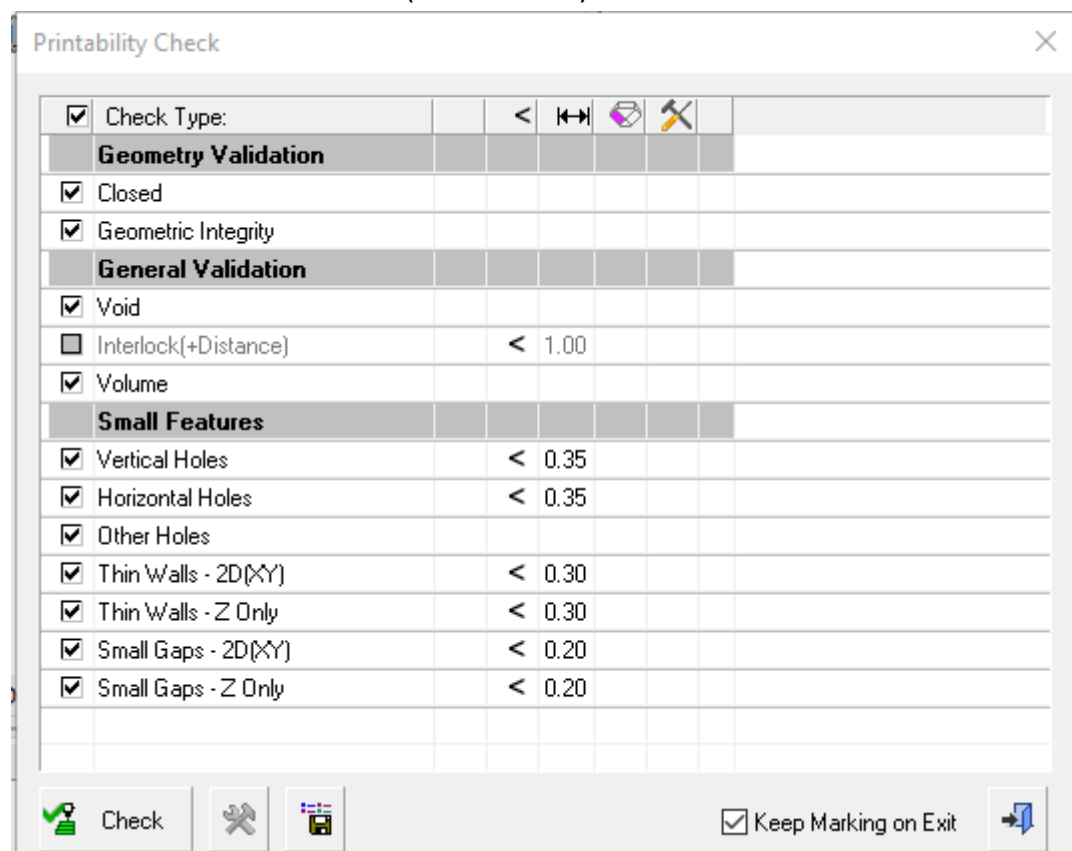


In this exercise, we will focus only on the **Printability Check**.

55. From the Toolbar, click **3DP Analysis** and select **Printability Check**. Pick the part.

The Printability Check interaction is launched, where you can use the boxes to select which of the checks you would like to perform.

The checks are divided into 3 categories: Geometry Validation, General Validation and Small Features (in the model):





### Geometry Validation

**Closed** – checks that the body is closed  
(i.e., that it is a stitched solid body)

**Geometric Integrity** - that the body is geometrically OK (remember that we are working with a CAD model)

### General Validation

**Void** – that there are no areas, where powder can be locked, without the ability to remove it.

**Interlock** – checks for interference, in case more than one part is placed on the tray.

**Volume** – Ensure that all models are located within the tray limits.  
This check is not relevant to this exercise.

### Small Features

**Vertical Holes** – looks for vertical holes whose diameter is below the specified threshold.

**Horizontal Holes** – looks for horizontal holes whose diameter is below the specified threshold.

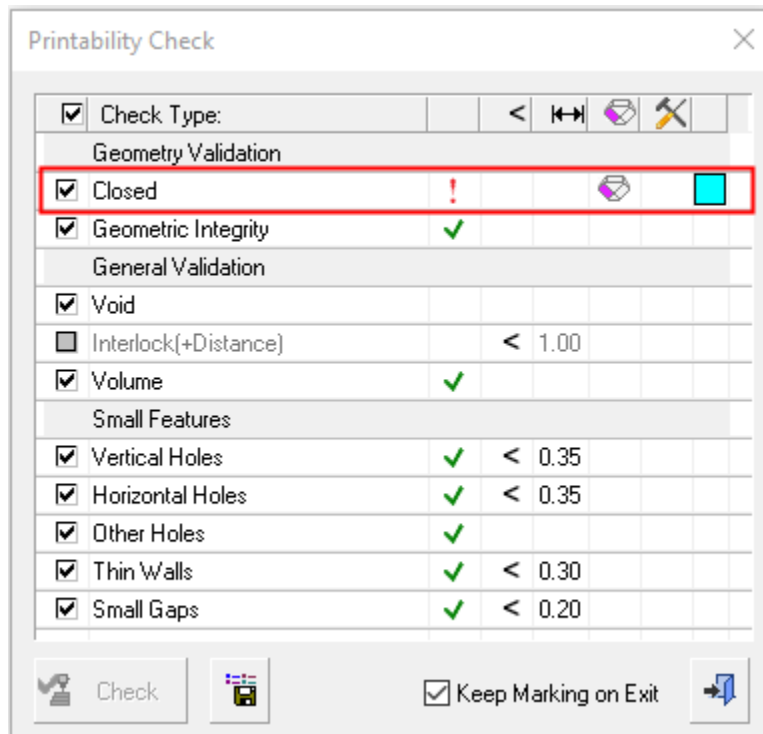
**Other Holes** – looks for other holes whose diameter is below the specified threshold.

**Thin Walls** - Check for thin walls, where the wall thickness is below the specified threshold. This includes checking the wall thickness in the 2D (XY) slice direction, as well as the thickness in the Z direction.

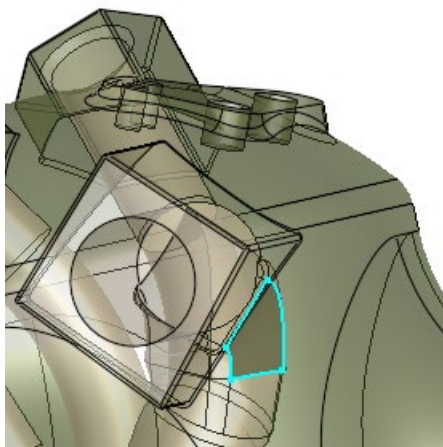
**Small Gaps** - Check for gaps, where the gap width is below the specified threshold. This includes checking for small gaps in the 2D (XY) slice direction, as well as small gaps in the Z direction.



56. Press the **Check** button and, as the results are displayed, see that there is one check that returns a warning - the model is marked as not closed.



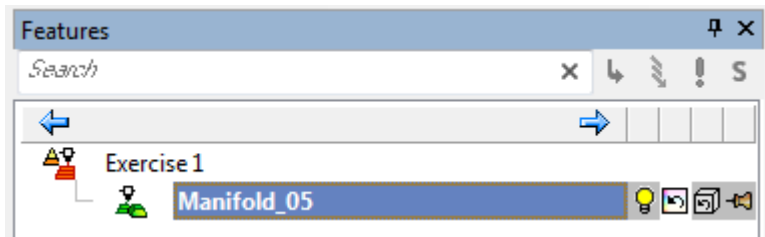
The system highlights the problem – a face that is not stitched to the body.



This face is the second object that is reported by the 3DP Objects Tree. We will now make this part a single object. As we are using a CAD system, we can use standard CAD tools to fix that.

57. **Exit** Printability Check.

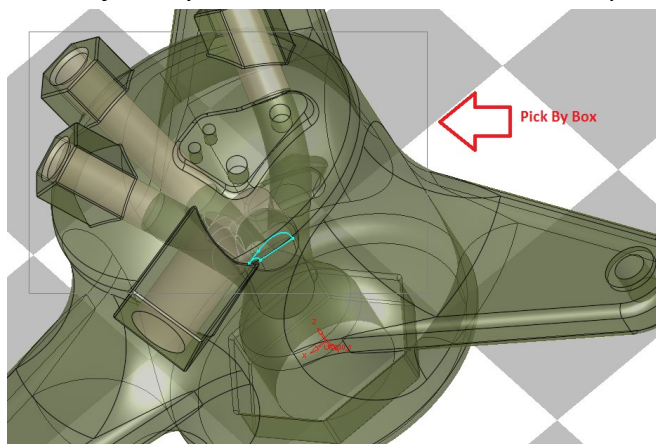
58. Activate the part by double clicking its name on the tree.



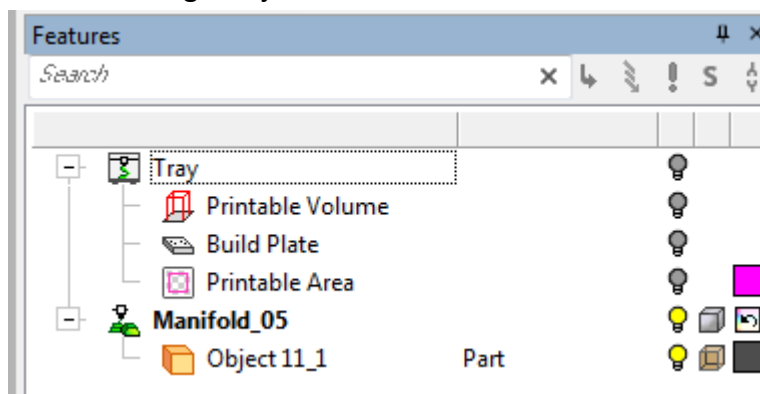
59. From the **Menu Bar**, click the **Stitch** function.



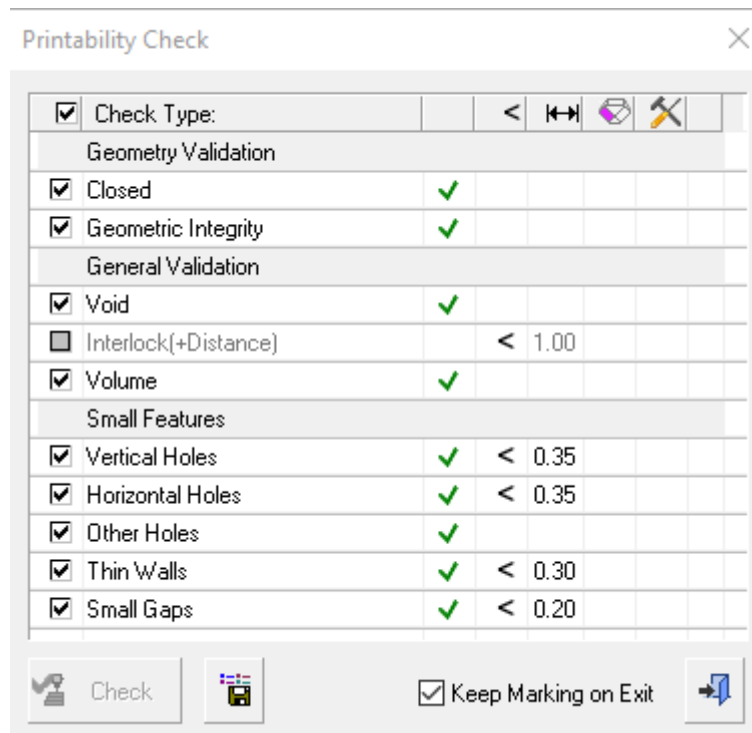
60. Pick the object 'By Box' and on the Feature Guide press **OK**.



61. Click the 3DP Objects Tab and see that, in addition to the build plate, the part now has a single object:



62. Re-Run the same analysis again. The result is OK, we now have a closed object.



63. Click the Close button to exit Printability Check.

End of Exercise