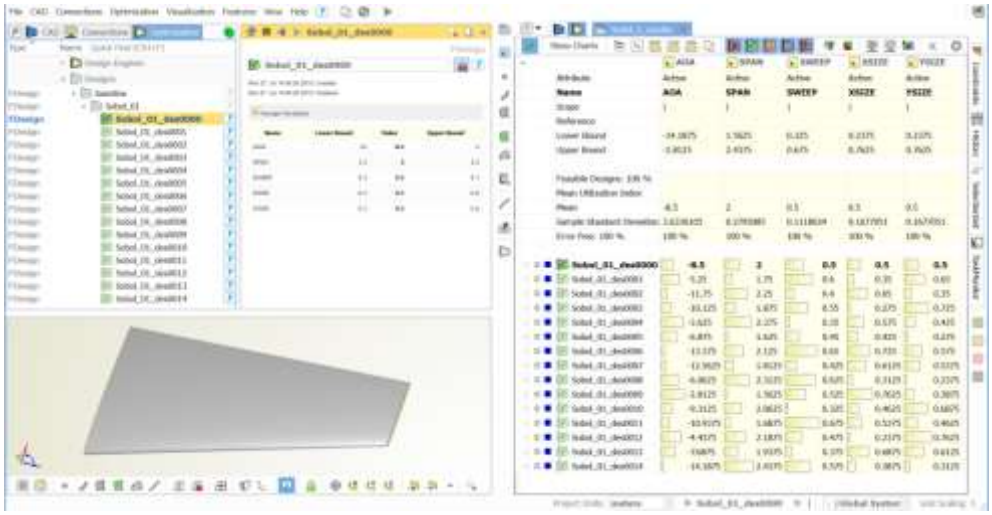
Geometry Variation and Assessment

This tutorial shows you how to automatically vary geometry by using design variables and design engines. In addition, you will be able to browse through created variants and display the different geometries.

Some basic information is also given about the *design results table* and its functionality.

You can check this helpful video giving you a good introduction. For more information about checking bounds of geometry variables, take a look at this video.



Note that, in this tutorial, geometry gets varied without considering any simulation software (e.g. CFD analysis of the new designs).

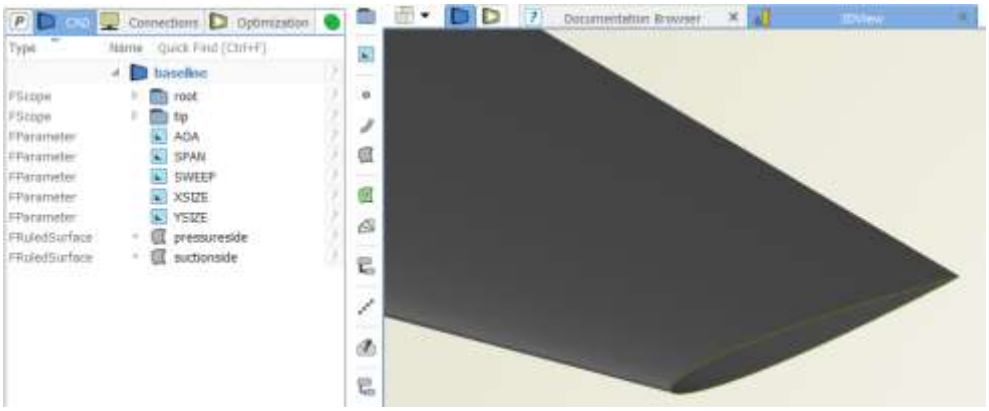
Integration of external software is covered in subsequent tutorials.

1

Initial Geometry

This tutorial is based on the tutorial *first modeling steps* for which a resulting project file is available:

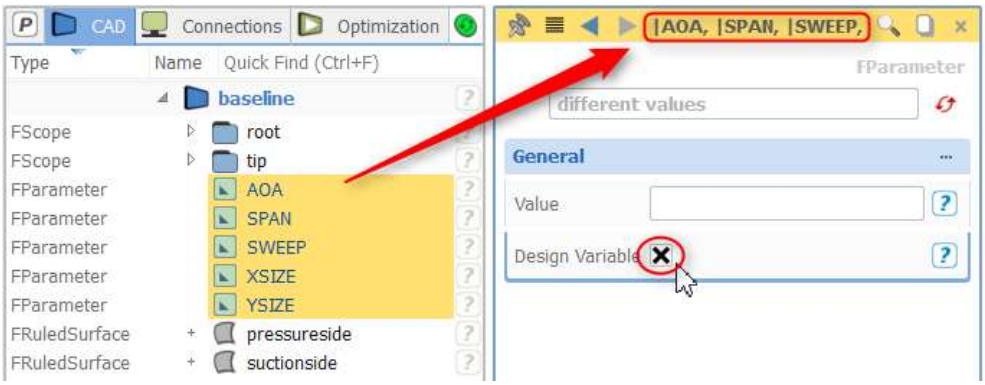
- Choose *file > open sample*.
- Open the project *tutorials > 01_First_Modeling_Steps.fdb.*
- Save this project via *file > save project as* so that we do not modify the original tutorial file.



2 Design Variables

For automated variant generation we need to have *design variables* available. These objects hold discrete numbers and can be controlled by *design engines* as will be shown in the step 3.

- Select all parameters at once: First, click on “AOA”, then keep the SHIFT-key pressed and click on “YSIZE”.
- Activate the toggle *Design Variable* for all parameters.



3 Design Engine

For variation and optimization so-called *design engines* are provided. They can access and modify *design variables* automatically. For each modification they create a variant which is then available to the user.

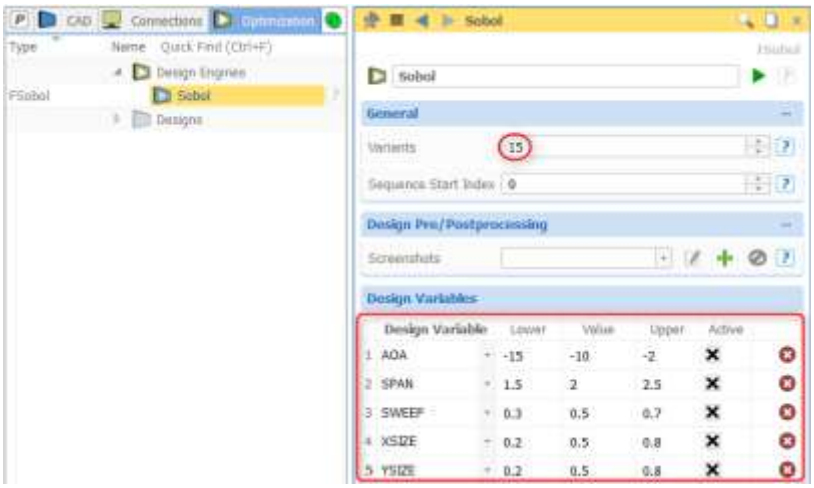
- Create a Sobol engine via *optimization > Sobol*. The Sobol will get a node in the object tree under *Design Engines* in the *Optimization* tab.

✓ This type of variation strategy is typically used for *Design of Experiments* (DoE). It is a pseudo random-number generator which distributes design variables uniformly in the design space. For single- and multiobjective optimization, the procedure is identical apart from specifying objectives. Note that optimization strategies in CAESES always minimize the given objectives. In order to find a Maximum you can simply multiply the objective with "-1".

- As an example, set the number of variants to 15 (if you use CAESES Free to 3).

Note that in the CAESES Free edition a project can only hold up to 5 variants including the baseline design.

- Select the variables from the pull down menu of the category *design variables* and set lower and upper bounds for all variables (see the screenshot for reasonable boundaries).

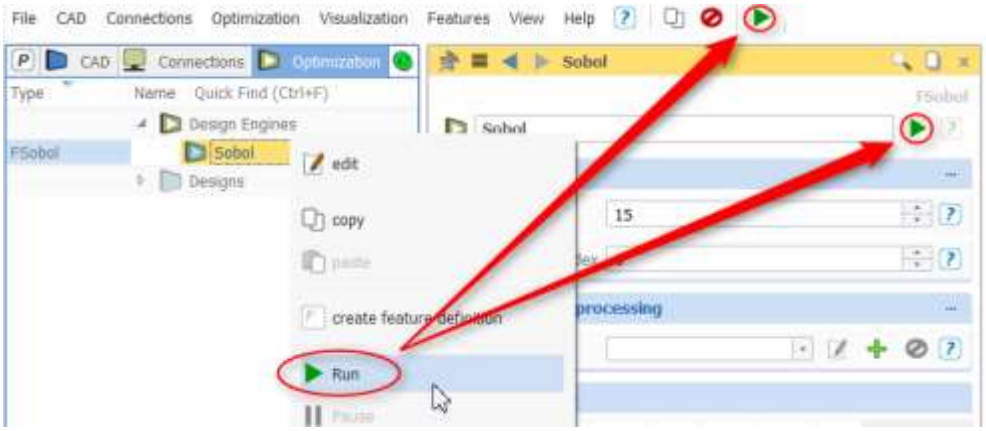


✓ Remember: Note that only design variables are listed in the pull down menu i.e. parameters that have been switched to be design variables.

4 Run the Design Engine

The design engine has been configured and is now ready to run. There are three ways available to start engines:

- For the Sobol design engine, choose *Run* from the context menu or click on the green play icon in either the top toolbar or next to the name field.

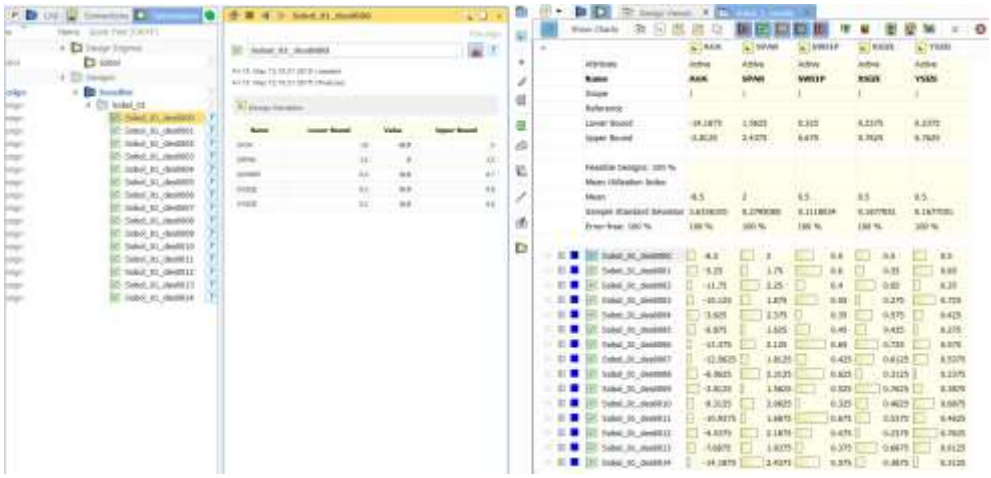


Now, the variants are getting created along with a table which documents them. Wait until the generation process is finished, which in this case is very fast.

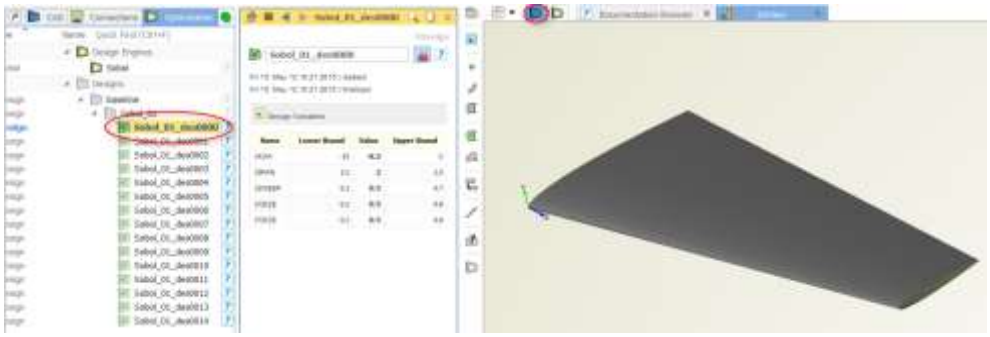
5 Browsing through Designs

Now we want to browse through the different variants. In particular, we want to look at the individual geometries.

- See the new node *Designs* in the tree with all variants (on the left-hand of the screenshot).
- Make a single mouse click on a design (either in the tree or the design results table) in order to display the design settings in the object editor.

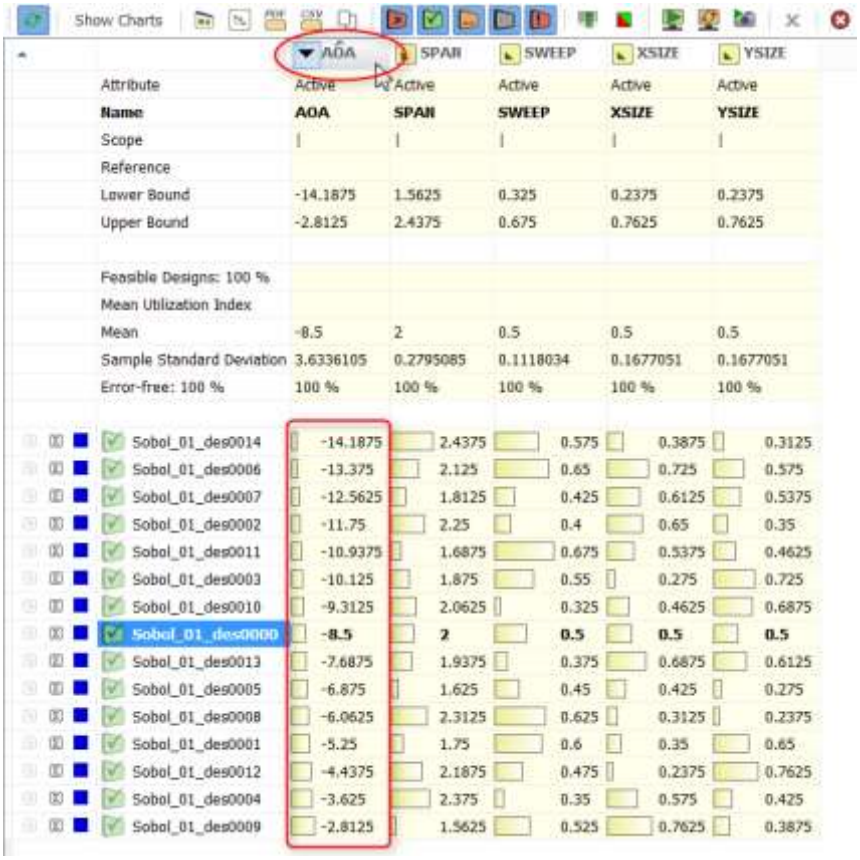


- Click on the *3DView* tab of the central widget (at the top where the table is given) in order to have a look at the geometry.
- Double-click on the first design “Sobol_01_des0000” in the design tree in order to activate it i.e. make it the current design. This updates the variant and shows it in the 3D view.
- Continue browsing via double-click on the other designs in the tree.
- Go back to your initial design via double-click on “baseline” in the design tree.



6 Design results table

The design results table provides sorting mechanisms with regard to its entries. Sorting can easily be done by clicking on the header of the parameter or design variable once or twice for increasing or decreasing order.



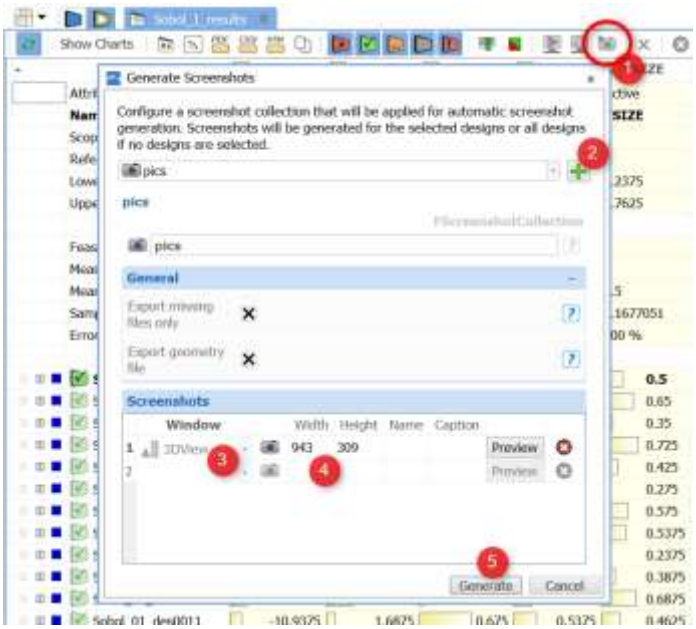
✓ Sorting is more exciting if objectives are involved e.g. sorting for minimum pressure loss or minimum resistance coefficient etc.

✓ Result tables can also be customized. New tables can be created via *view > new > viewer > design results table*. Parameters, design variables, constraints from the model and even designs from the design tree can be inserted via drag & drop to an empty table widget. Also, designs can be dragged into a generated result table like the one above e.g. to compare designs from different engine runs.

7 Screenshot Collection

To be able to compare your designs visually it can be helpful to generate screenshots from a fixed perspective. In CAESES this can be done automatically in the design results table.

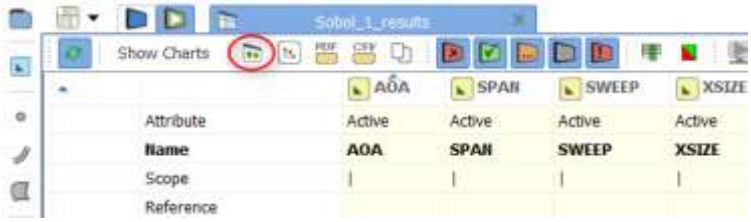
- Click on the camera symbol in the top right of the design results table. (1)
- Click on the green plus icon to generate a new screenshot view. (2)
- In the drop down menu “window” select the *3DView.* (3)
- You can now adjust the height and width of the screenshot, as well as add a caption. To control the result you can check the preview. (4)
- Click on Generate. (5)



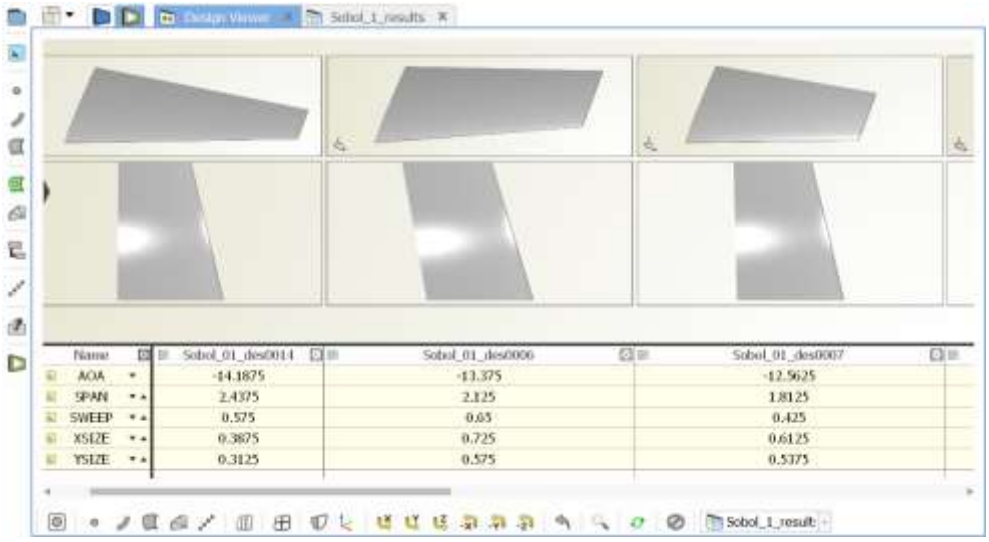
8 Design Viewer

If you created a *screenshot collection* it is easy to compare these within the *design viewer*.

- Click on the *design viewer* icon in the top left of the *design results table*.

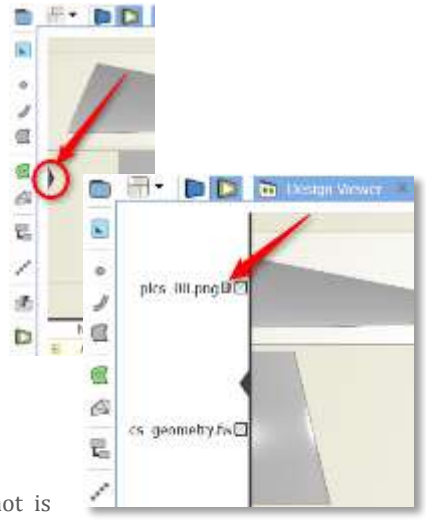


- In the *design viewer* scroll to zoom in and out.
- Left click into free space and drag the mouse to move the screenshots.



9 Create a Gif Animation

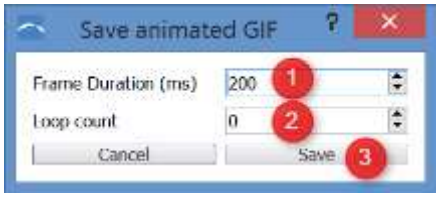
In the *design viewer* you can directly create a gif animation of the available screenshots.



- Click on the black arrow in the middle on the left side of the design viewer in order to expand the side bar.
- Click on to create a gif animation for the selected row of screenshots.

A *Save Dialog* window will be opened.

- Choose a folder location to save your gif file.
- Click on *save*.
- Choose the *frame duration* (1). Time a screenshot is displayed.
- Choose *loop count* (2). How often should the loop of screenshots be shown when you open the gif file (0 means continiously playing the gif, 1 the gif will stop after one loop.).



- Click on *Save*.

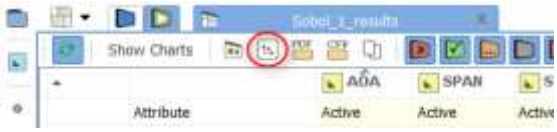
Now you can find and open the saved gif file in your choosen folder location.

✓ Gif Animation: *Frame Duration (ms)*: Time each screenshot (frame) is displayed. *Loop Count*: Number of played loops when you open the gif file (0 = infinite loop, 1 = just one loop, 2 = two loops, ...).

10 Diagrams

To visualize the change of *parameters* and *design variables* off all variations it is possible to create 2D and 3D diagrams.

► Click on the second icon in the top left corner of the *design results table* to create a diagram.



► Select the kind of diagramm you want to create and then select the mapping tab to insert the variables.

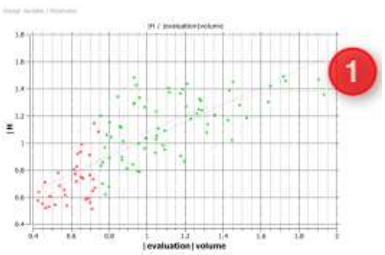
► Set the inputs and click ok to see the diagram.

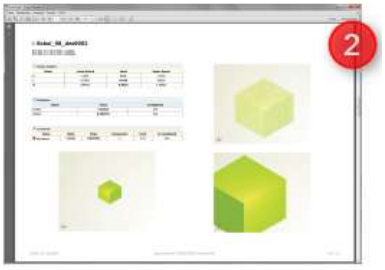
✓ As there is no evaluation in this project the diagram isn't that helpful but if you are evaluating an objective and set that objective as e.g. point size the diagram can enable you to see connections between single parameters and the results.

11 PDF Reports

To exchange and present the data of a variation it is easily possible to create pdf reports with informations about the infulence of different *parameters*, *design variables* and the created variations.

- Click on the pdf icon in the top left corner of the *design results table* and select if you want to export a report with diagrams based on the displayed columns in the *design results table* (1) or if you want to export a report with tables showing *design variables*, *parameters* and *contraints* as well as screenshots (2).





✓ It is also possible to export the tables of the *design results table* with as csv file by clicking on the csv icon next to the pdf icon.

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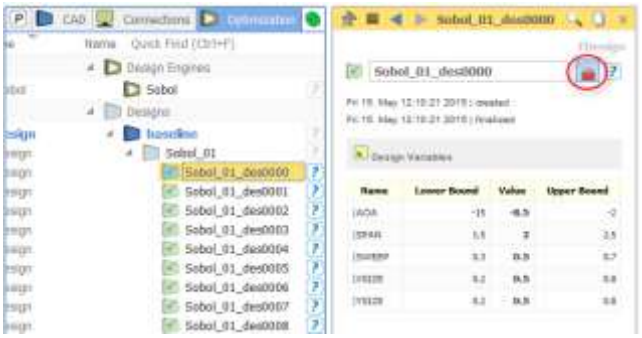
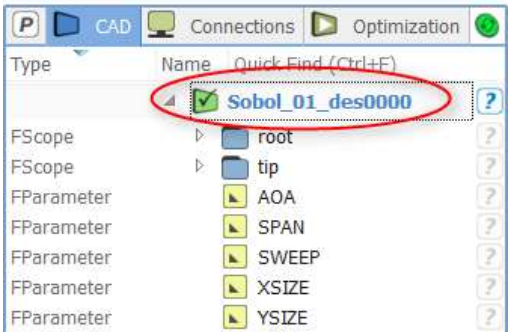
Editing Variants

If you browse through variants (by double-clicking on a design) note that they are in a read-only mode by default for protection purposes. If you want to edit, modify or continue design work on such variants deactivate the lock next to the name field:

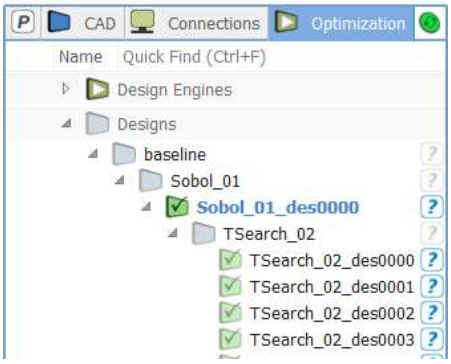


- In the design tree, double-click on a variant to select it as current design.
- Click on the red lock icon in order to remove the modification protection. The icon will turn green to indicate that the variant can now be edited.
- Change to the *CAD* tab: The read-only mode has disappeared and the variant can be edited.



Note that the name of the current variant is always on the top of the model tree.

✓ A typical optimization process might start with a simple variation. After that, a good variant is picked and activated as well as unlocked. Now, in this new design, an optimization design engine can be created to start from this chosen variant. The design tree will then have a new node below the variant name and both optimizations will have their own *design result table*.



13

Conclusion

This is a first example that shows the basics of variant generation and variant management. As seen in this tutorial, *design variables* and *design engines* are closely related.

CAESES provides *design engines* for variation as well as single- and multiobjective optimization. The different engines can be found under the *optimization* menu in their respective categories.

So far, no external simulation software has been involved. The coupling and integration of your external tools is shown in subsequent tutorials. Once they are connected, they can be utilized to analyze the created design variants – either in a simple design studies or in a comprehensive optimization. We will also see how key values from CFD results (pressure losses, drag, flow rate etc.) can be extracted and how inequality constraints can be considered.