

# **SIMSOLID QUICK OVERVIEW**

## **MODULE 2 – USER-INTERFACE / MODAL ANALYSIS**

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# SimSolid Vision - A new paradigm for simulation

Altair **SimSolid** is **structural simulation** that operates directly on **original, un-simplified CAD assemblies**, **does not create a mesh..**

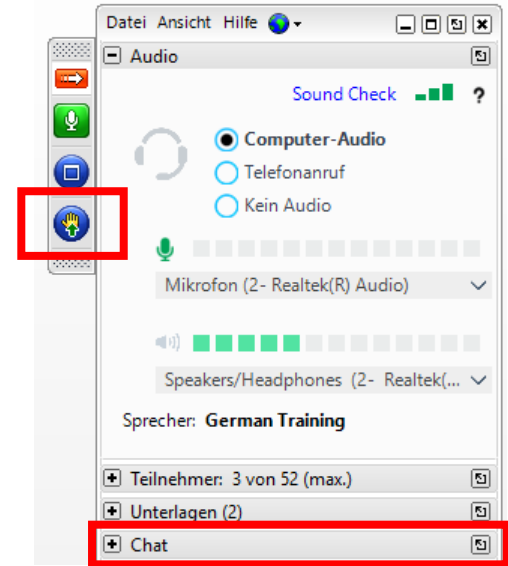
..and provides results in **seconds to minutes**

## Quick Overview Series

- |                                             |          |           |
|---------------------------------------------|----------|-----------|
| • Module 1: Introduction                    | February | 5th 2021  |
| • Module 2: User Interface + Modal Analysis | February | 12th 2021 |
| • Module 3: Linear Analysis                 | February | 19th 2021 |
| • Module 4: Non-Linear Analysis             | February | 26th 2021 |
| • Module 5: Dynamic Analysis                | March    | 5th 2021  |
| • Module 6: Thermal and SimSolid news       | March    | 12th 2021 |
| • Module 7: Inspire/SimSolid Solver         | March    | 19th 2021 |
- (all Fridays)

# Organisational

- Session is recorded
- Q/A-block at end of session (not recorded)
- Raise hand and audio will be activated or use chat for questions
- Combined presentation of all modules can be shared



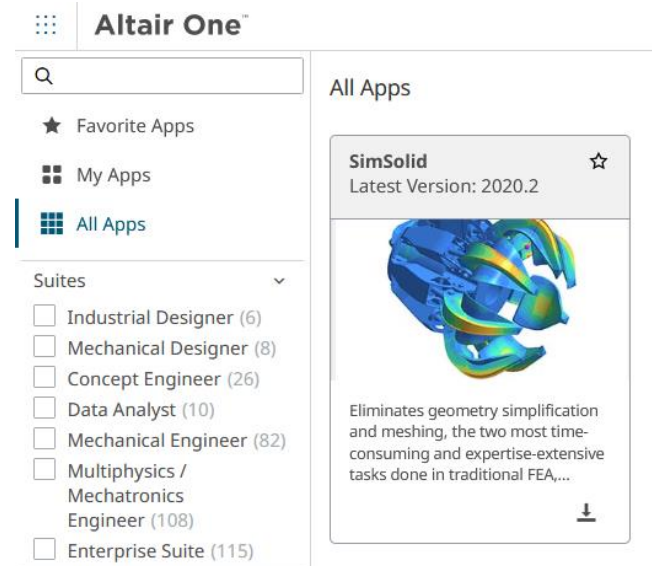
# Have a look at...

- Contact us for later communication etc. - [trainings@altair.de](mailto:trainings@altair.de)
- Check out [www.altair.com/SIMSOLID](http://www.altair.com/SIMSOLID)



**What Customers Are Saying  
About SimSolid**

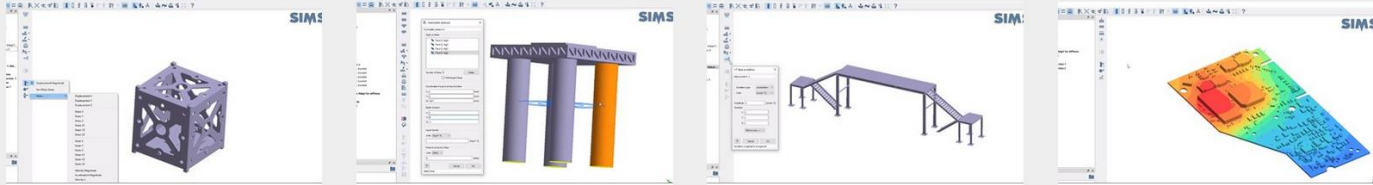
- Download - [www.altairone.com](http://www.altairone.com)



# Have a look at...

- [www.altair.de/resource/altair-simsolid-tutorial-projects](http://www.altair.de/resource/altair-simsolid-tutorial-projects)

**All SimSolid Demo Models, Training Materials, and Tutorials**



**Altair SimSolid - ERP with Constant Loading Tutorial**  
Learn how to perform a dynamic frequency response...

**Altair SimSolid - Hydrostatic Pressure Tutorial**  
Learn how to simulate an hydrostatic pressure in Altair...

**Altair SimSolid - Random Response Analysis Tutorial**  
Learn how to perform a random response analysis in Altair...

**Altair SimSolid - Thermo-structural Coupling Tutorial**  
Learn how to perform thermo-structural coupling analyses in...

**Altair SimSolid - Vibration Analysis Tutorial**  
Learn how to perform a vibration analysis in Altair...

**Altair SimSolid - Fatigue Analysis Tutorial**  
Learn how to perform a fatigue analysis in Altair...

**Altair SimSolid - Buckling Analysis Tutorial**  
Learn how to perform a buckling analysis in Altair...

**Altair SimSolid - Contact Analysis Tutorial**  
Learn how to perform a contact analysis in Altair...

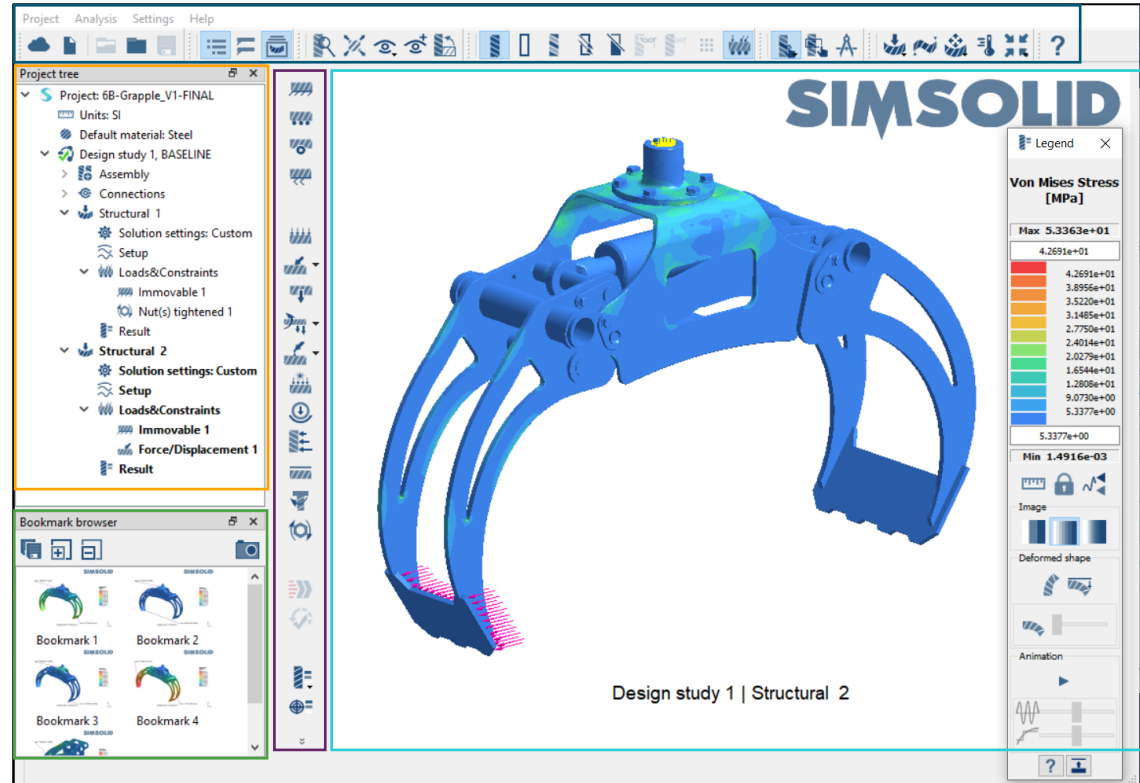
# POLL

# USER-INTERFACE



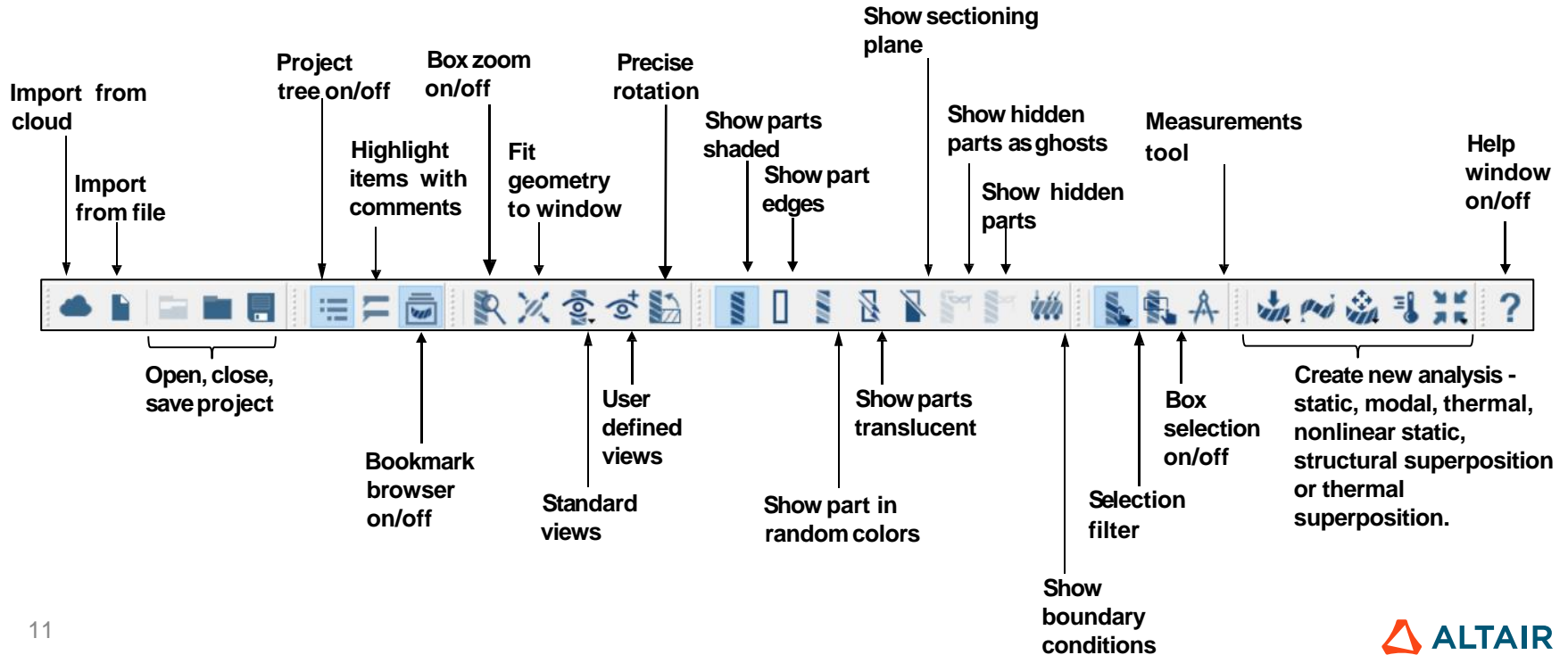
# User Interface

- **Main Toolbar** - is used to access the most commonly used tools.
- **Project Tree** - is used to view and manage individual model entities.
- **Bookmark Browser** - is a convenient way to record the simulation and result images.
- **Workbench toolbar** - every workbench has a corresponding vertical workbench toolbar.
- **Graphics Area**



# User Interface


## Main Menu Toolbar

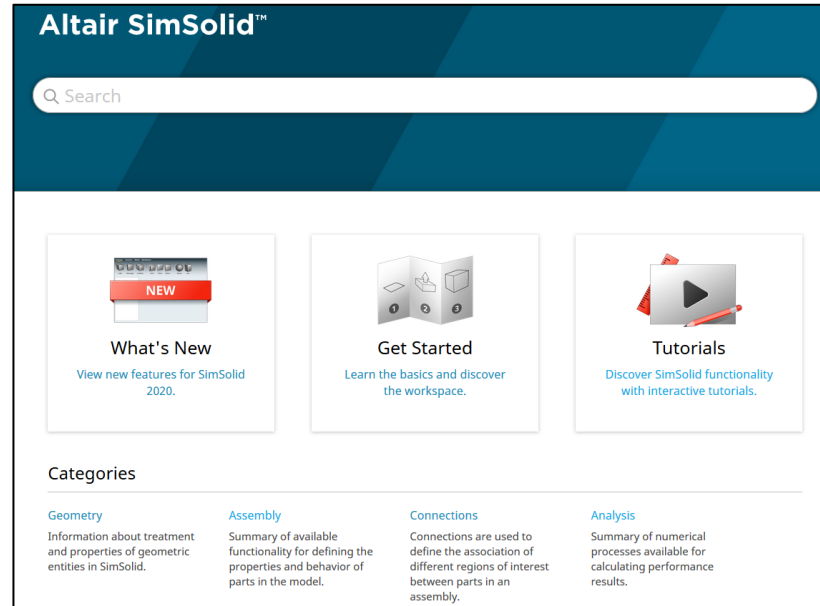
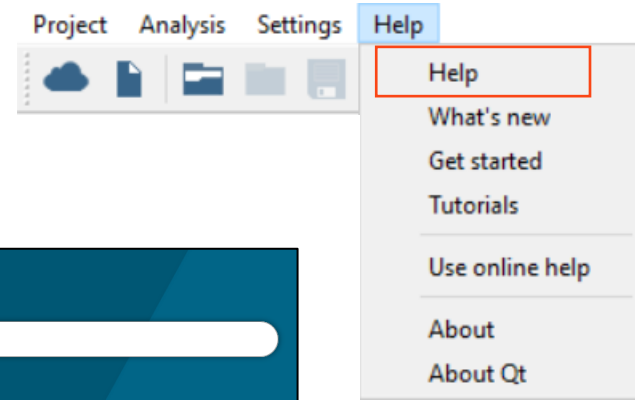


# User Interface

## Altair SimSolid Documentation

Access Altair SimSolid Help in the following ways:

- In the pull-down menus click **Help** > **Help**.
- In the **Main Menu Toolbar** click on 
- Click **F1**.



# User Interface

## Altair SimSolid Documentation

View new features, learn the basics and discover the workspace, also with interactive tutorials.

**Altair SimSolid™**

- > What's New
- Get Started
    - Product Introduction
    - License Setup
    - Hints and Tips
    - Quick Start
    - User Interface
  - > Workflow Guidelines
    - Mouse Controls
    - Keyboard Shortcuts
    - Command Line Execution
  - > Units
  - > Measurements
  - > Solution Settings
    - Hardware Settings
    - Set Model Front View
  - SimSolid Theoretical Background
  - > Tutorials
  - > Geometry
  - > Assembly
  - > Connections
  - > Analysis

[Get Started](#) > SimSolid Theoretical Background
 ← Previous
Next →

### Theoretical Background

An abstract boundary value problem is formulated as to find a function  $U$  which fulfills the equations:

$$AU = h \text{ inside the domain } \Omega \quad (1)$$

$$LU = g \text{ at the domain boundary } \Gamma \quad (2)$$

where  $A$  and  $L$  are differential operators.

Some boundary value problems can be equally formulated in a variational form such as to find a function  $U$  which provides a functional  $F(U)$  at minimum value, where the functional  $F(U)$  is usually an energy functional.

In 1908 W. Ritz proposed a method of finding an approximate solution of a boundary value problem by approximating it with a linear combination of some basis-functions

$$U_h = \sum_{i=1}^n a_i p_i \quad (3)$$

where  $a_i$  are unknown factors, and  $p_i$  are basis approximation functions.

The factors  $a_i$  are found by minimizing the energy functional









$$F(\sum_{i=1}^n a_i p_i) = \min \quad (4)$$

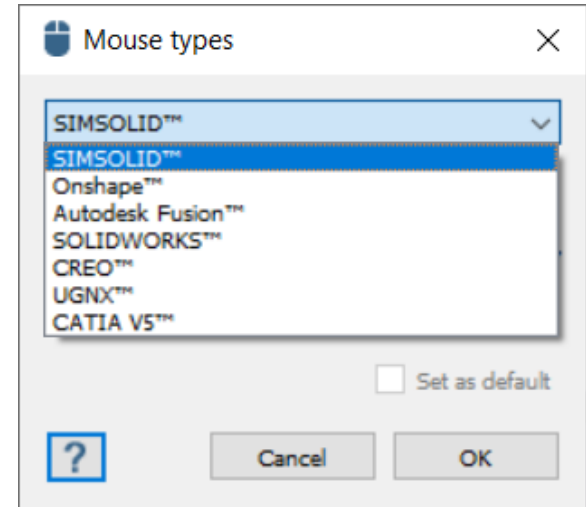
**ON THIS PAGE**

- [Overview of Initial Research](#)
- [Theoretical Background](#)
- [External Approximations by Finite Elements](#)
- [Geometry-Function Decoupling](#)

# User Interface

## View Manipulation

- **Model Rotation:**  click and drag to rotate model.
- **Model Translation:**  click and drag to pan model.
- **Model Zoom:** rotate  to zoom the model.
- **Model Zoom Extents (Fit):**
  - pick  on the main toolbar
  - click in the window background with  and select **Fit geometry to window**.
- **Box Zoom:**
  - use  from the main toolbar then click and drag box, using .
  - Hold **Shift** + .
- Alternative CAD system mouse mappings are available from **Settings > Mouse settings** menu.



# User Interface

## Shortcut Keys

### File management:

Shortcut Keys	Function
<b>Ctrl</b> + <b>I</b>	Import CAD file
<b>Ctrl</b> + <b>O</b>	Open project
<b>Ctrl</b> + <b>S</b>	Save project
<b>Ctrl</b> + <b>W</b>	Close project
<b>Ctrl</b> + <b>Q</b>	Quit application

### Interface:

Shortcut Keys	Function
<b>F</b>	Fit View
<b>H</b>	Hide selected parts
<b>I</b>	Isolate selected parts (hide all other parts)
<b>S</b>	Suppress selected parts
<b>U</b>	Suppress unselected parts
<b>D</b>	Delete selected parts
<b>A</b>	Show all parts
<b>B</b>	Create new bookmark
<b>Esc</b>	Cancels any open dialog

# User Interface

## Shortcut Keys

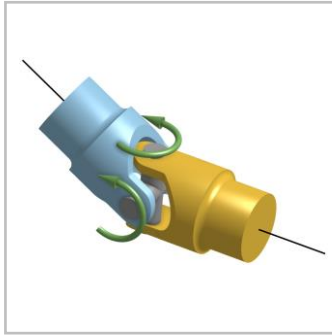
### Show/hide:

Shortcut Keys	Function
<b>Ctrl</b> + <b>F1</b>	Show/hide welcome dialog
<b>F1</b>	Show/hide help
<b>F2</b>	Show/hide project tree panel
<b>F3</b>	Show/hide bookmark browser panel
<b>F4</b>	Show/hide project comments

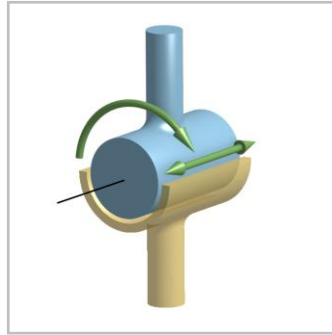
### View:

Shortcut Keys		Function
<b>Shift</b>	+ drag box	Box zoom
<b>Shift</b>	+ <b>1</b>	<b>Ctrl</b> + <b>F7</b> Front view
<b>Shift</b>	+ <b>2</b>	<b>Ctrl</b> + <b>Shift</b> + <b>F7</b> Back view
<b>Shift</b>	+ <b>3</b>	<b>Ctrl</b> + <b>Shift</b> + <b>F8</b> Left view
<b>Shift</b>	+ <b>4</b>	<b>Ctrl</b> + <b>F8</b> Right view
<b>Shift</b>	+ <b>5</b>	<b>Ctrl</b> + <b>F6</b> Top view
<b>Shift</b>	+ <b>6</b>	<b>Ctrl</b> + <b>Shift</b> + <b>F6</b> Bottom view
<b>Shift</b>	+ <b>7</b>	<b>Ctrl</b> + <b>F9</b> Isometric view

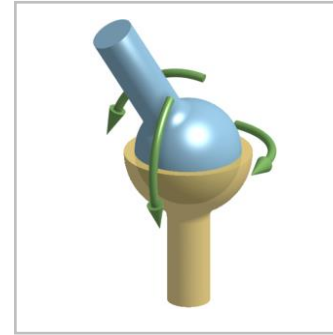
# Virtual Joints v2020



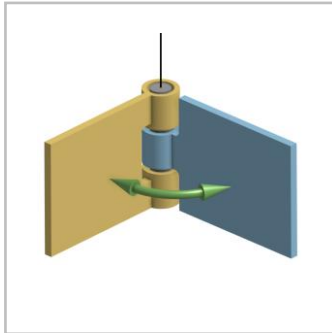
**Universal**  
2 DOF, 2 axes



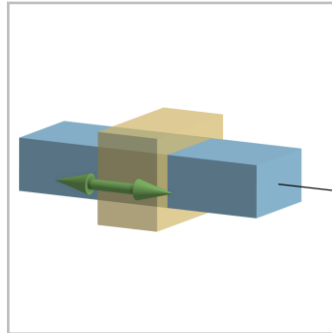
**Cylindrical**  
2 DOF, 1 axis



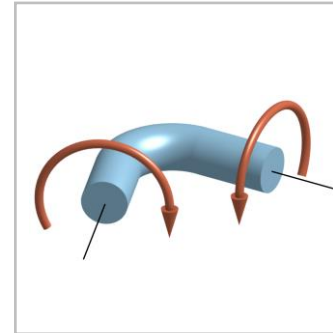
**Ball**  
3 DOF, no axes




**Hinge**  
1 DOF, 1 axis



**Linear guide**  
1 DOF, 1 axis



**Flexible shaft**  
5 DOF, 2 axes

 Virtual connector ✕

Ball joint 1

Joint type

☒ Ball

☐ Hinge

☐ Cylinder

☐ Linear guide

☐ Universal


☐ Flexible shaft

Apply to

☒ Face

☐ Spot

Create new spot

 Face 11, Trim/Extend...


Delete

Joint center

X 700 [mm]

Y 542.5 [mm]

Z -1450 [mm]

 Close OK

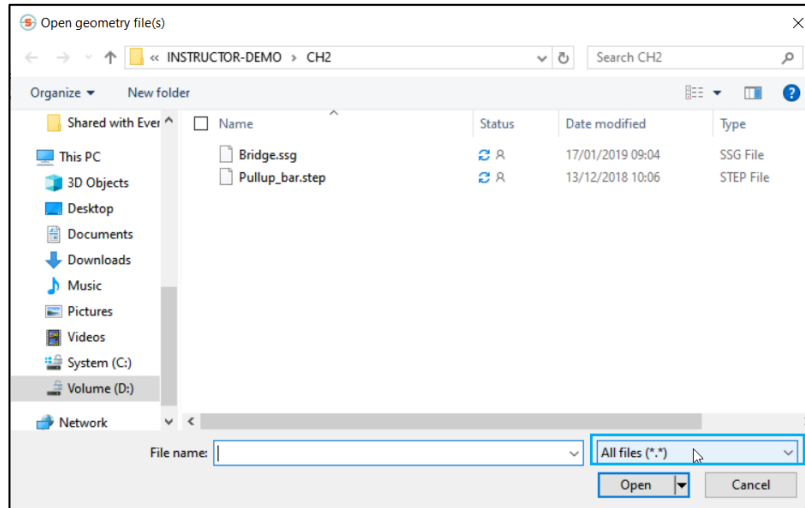
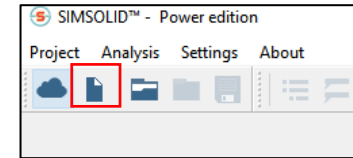
Select faces to connect



# Geometry Import

## Direct geometry import from CAD files

- SimSolid provides **integration** to the **SolidWorks**, **Fusion 360** and **Onshape** CAD systems as well as **direct access** to all popular CAD formats
- You can directly import geometry, by clicking on **Import from file.**
- Select the CAD file type from the **selection filter** and press **Open** button.



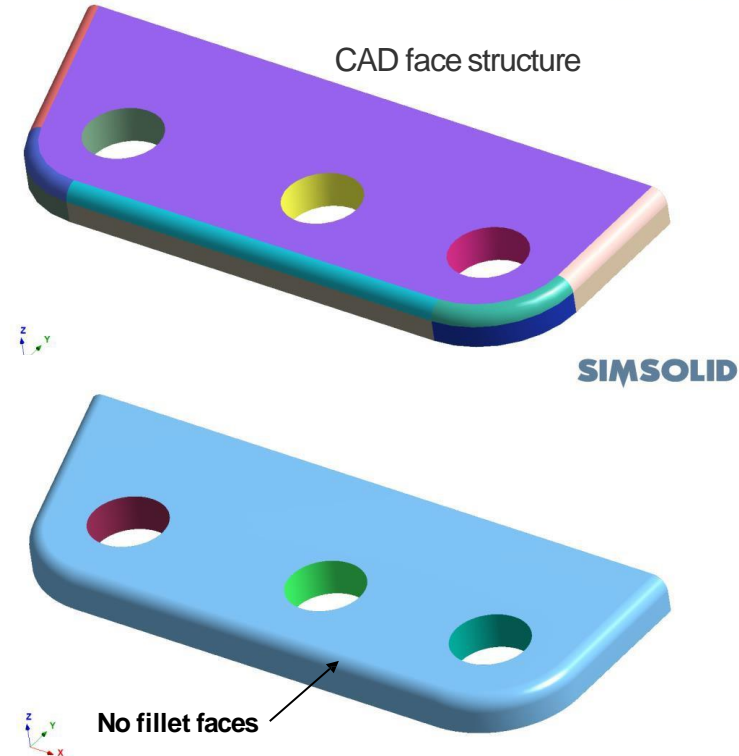
**All files (\*.\*)**

- SIMSOLID geometry (\*.ssg \*.ssj)
- STL (\*.stl)
- ACIS (\*.sat \*.asat \*.sab)
- CATIA V4 3D (\*.model \*.dlv \*.dlv3 \*.exp \*.session)
- CATIA V5 3D (\*.CATPart \*.CATProduct)
- CATIA V6 / 3DEXPERIENCE 3D (\*.3dxml)
- CGR (\*.cgr)
- Inventor (\*.ipt \*.iam)
- JT (\*.jt)
- Parasolid (\*.x\_t \*.x\_b \*.xmt\_t \*.xmt\_bin)
- ProE / Creo Parametric 3D (\*.prt \*.prt \*.xpr \*.asm \*.asm \*.xas)
- SOLIDWORKS 3D (\*.sldprt \*.sldasm)
- STEP (\*.stp \*.step \*.stpZ)
- UG NX 3D (\*.prt)

# Geometry Considerations

**SimSolid** does not import CAD surface or solid geometry. Instead it uses a more efficient faceted geometric approach.

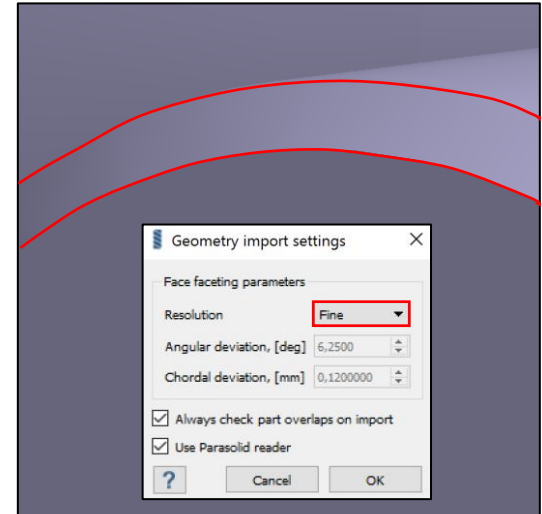
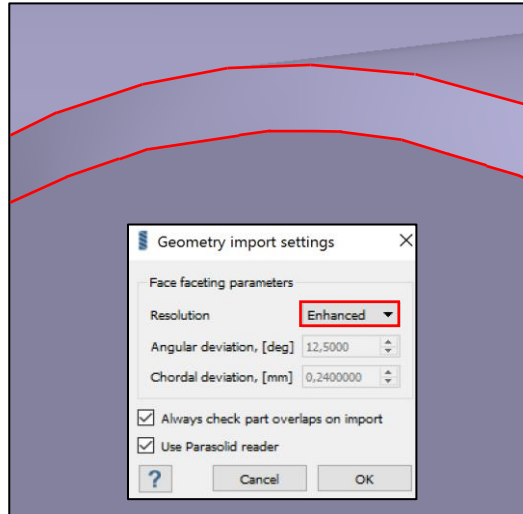
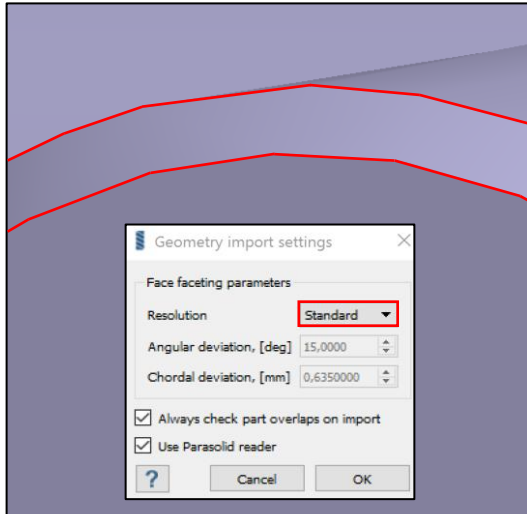
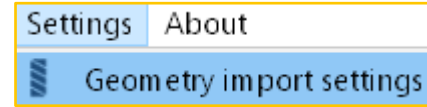
- From **CAD** (SolidWorks, Fusion 360 or Onshape)
  - Full CAD hierarchical assembly tree structure used
  - CAD part faces used (preferred)
  - Facets are based on CAD add-in faceting parameters
- From **STL**
  - Multi-body STL used. Flat assembly tree structure only
  - **SimSolid** determined part face structure based on surface curvature (will miss fillet faces, see example on right)
  - Facets are based on STL file export parameters (must take care, as some CAD system export poor quality STL)



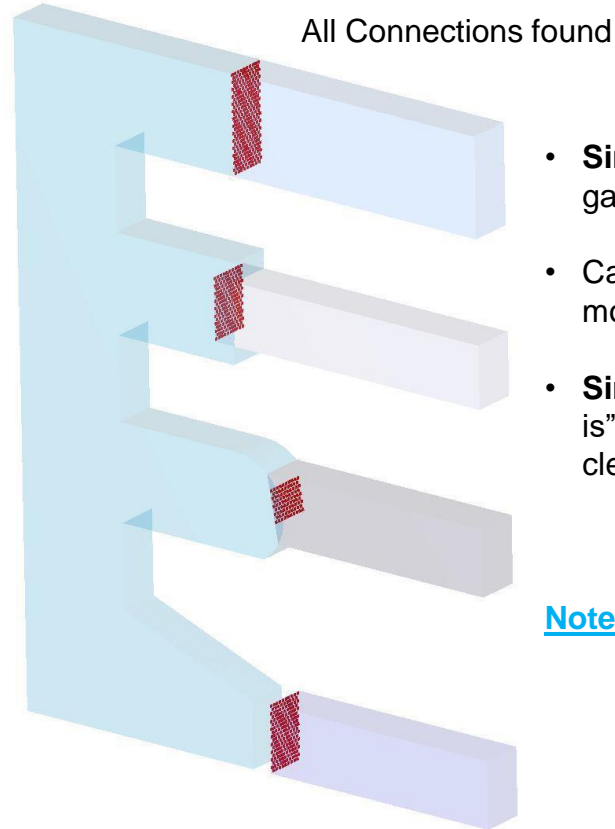
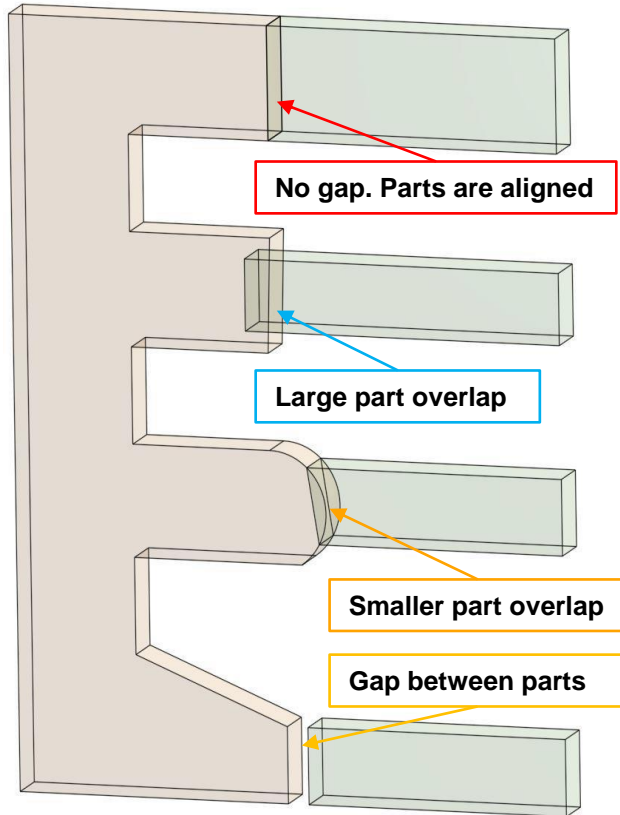
# GEOMETRY CONSIDERATIONS - Facet Settings

## Resolution

- **4 levels:** standard (default), enhanced, fine, custom.
- Increasing the level of resolution the run time increases, so should be used only when necessary.
- **Faceting best practice** - use a level of tessellation that is sufficient to capture the general part shape but not be overly fine. Too much detail does not improve the solution accuracy and only slows down the solution sequence.



# Examples of Permitted Connections



- **SimSolid** is tolerant of geometry gaps and overlaps.
- Can find connections automatically more often than other systems.
- **SimSolid** accepts CAD geometry “as is” without the need for tedious cleanup and repair.

**Note:** While these contact are permitted, it is not a good practice to have excessive overlap in areas where stress detail is desired.

# Automatically Create Connections - Resolution

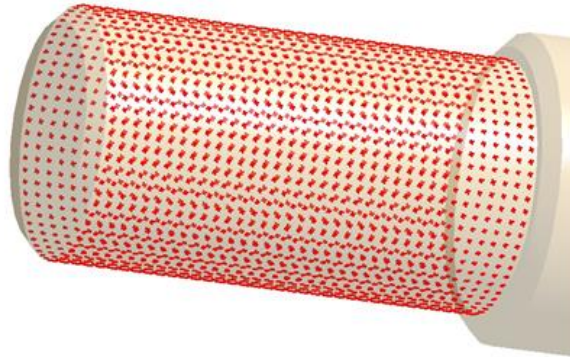
## Resolution

- Connections resolution is visualized by icon density.
  - Make sure there is adequate coverage in thin or curved regions.
  - Connections that are too weak may lead to mechanisms (rigid body motion).

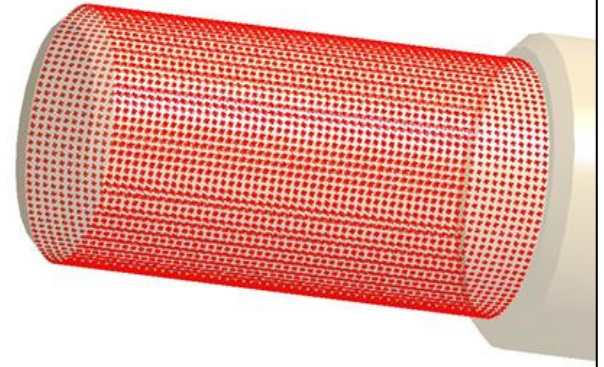
NORMAL



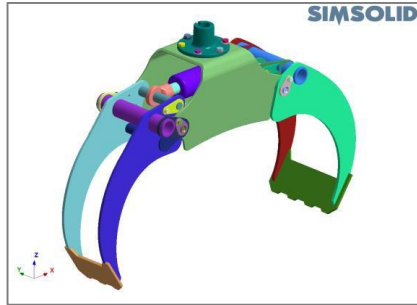
INCREASED



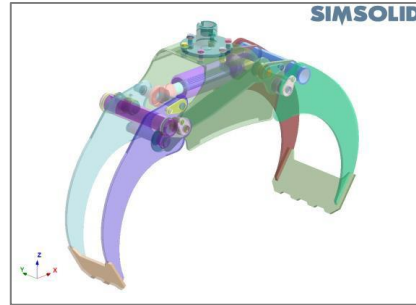
HIGH



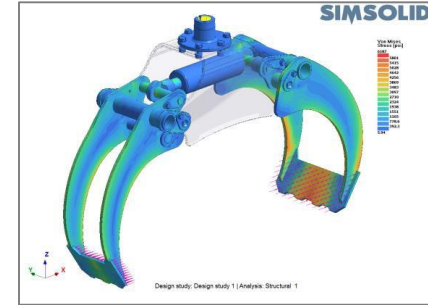
# Visualization Examples



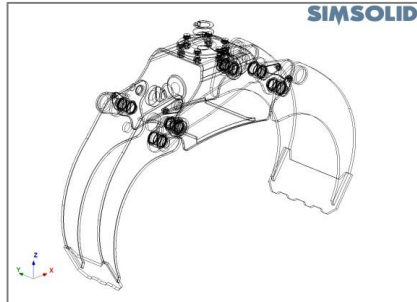
Random colored parts



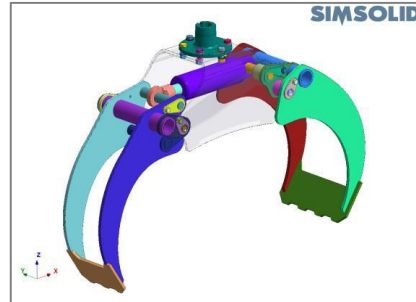
Translucent parts



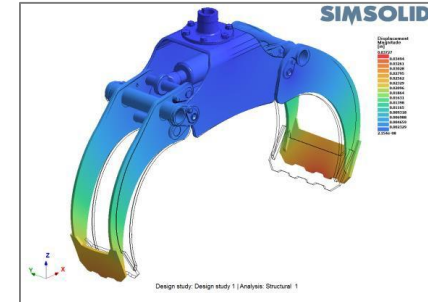
Results plot with hidden parts shown as ghosted



Edge only display



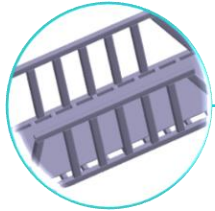
Hidden parts shown as ghosted (light transparent)



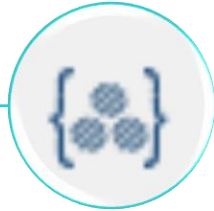
Edges on (undeformed), deformed shape with continuous contour plot

# MODAL ANALYSIS

# Modal Analysis - General Workflow



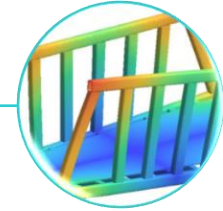
**Import CAD file**  
Automatically  
create connections



**Apply material**  
property



**Create Modal**  
Analysis & run



**Examine**  
frequencies and  
mode shapes



# Modal Participation Factors



Every structure has the tendency to **vibrate at a given set of natural frequencies**.

Each natural frequency is associated with a **shape**, or **mode shape**, that the model tends to assume when vibrating at that frequency.

In dynamic analysis, two related topics need to be considered:

- 1. Resonance** - occurs when the input load excitation frequency matches one of the natural frequencies of the structure. In this case, the load amplifies the mode and large displacements can result.
- 2. Participation Factor** - is a measure of how strongly a given mode contributes to the response of the structure when subjected to force/displacement excitation in a specific direction.

So, it is possible that the excitation could match a natural frequency (i.e. a resonance condition), but if the participation factor of the mode is close to 0, then no energy will get into that mode and no dynamic response will occur.

# Modal Participation Factors



SimSolid calculates **modal participation**, **effective mass** and **cumulative mass** factors for each mode in a specified global or local coordinate reference frame.

- **Modal participation factors** are **scalars** that measure the interaction between the modes and the directional excitation in a given reference frame.
- Larger values indicate a **stronger contribution** to the dynamic response.
- **Cumulative mass** for mode “n” is the **sum of the Effective mass factors** for modes 1 through “n”.
- A common rule of thumb for linear dynamic analysis is to include sufficient modes such that the Cumulative mass is at least 80% in the predominant direction of excitation vibration.

Modal participation factors

Coordinate system: Global coordinate system

Modal participation factors | Effective mass | Cumulative mass

Flexible mode	Frequency	X	Y	Z
1	2.2634e+1	3.6837e-2	7.6713e-1	2.7152e-3
2	2.4393e+1	5.3096e-1	5.2971e-2	1.1978e-2
3	3.0563e+1	1.8626e-3	2.2635e-1	1.4126e-3
4	4.4216e+1	3.5784e-3	4.5994e-1	2.4989e-3
5	5.5277e+1	6.2815e-3	1.1313e-1	1.1196e-2
6	8.9310e+1	4.5783e-2	1.8312e-2	4.0278e-1

Total ---> |X: 6.2530e-1 |Y: 1.6378e+0 |Z: 4.3258e-1

? Show histogram Save to CSV Close

Modal participation factors

Coordinate system: Global coordinate system

Modal participation factors | Effective mass | Cumulative mass

Flexible mode	Frequency	X, %	Y, %	Z, %
1	2.2634e+1	0.14	58.85	0.00
2	2.4393e+1	28.33	59.13	0.01
3	3.0563e+1	28.33	64.25	0.01
4	4.4216e+1	28.33	85.40	0.01
5	5.5277e+1	28.33	86.68	0.02
6	8.9310e+1	28.54	86.71	16.24

Total ---> |X: 28.54 |Y: 86.71 |Z: 16.24

? Show histogram Save to CSV Close

# Modal Participation Factors



SimSolid calculates **modal participation**, **effective mass** and **cumulative mass** factors for each mode in a specified global or local coordinate reference frame.

- **Effective mass factors** associated with each mode, represents **the amount of system mass** participating in that mode in a given excitation direction.
- This value is given as a **percentage of the total system mass**.  
Therefore, a mode with a large effective mass will be a significant contributor to the system's response in the given excitation direction.
- A common rule of thumb for linear dynamic analysis is that a mode should be included if it contributes more than 1-2% of the total effective mass.

Modal participation factors

Coordinate system: Global coordinate system

Modal participation factors		Effective mass	Cumulative mass	
Flexible mode	Frequency	X, %	Y, %	Z, %
1	2.2634e+1	0.14	58.85	0.00
2	2.4393e+1	28.19	0.28	0.01
3	3.0563e+1	0.00	5.12	0.00
4	4.4216e+1	0.00	21.15	0.00
5	5.5277e+1	0.00	1.28	0.01
6	8.9310e+1	0.21	0.03	16.22

Total ---> X: 28.54 Y: 86.71 Z: 16.24

? Show histogram Save to CSV Close

# Modal Participation Factors



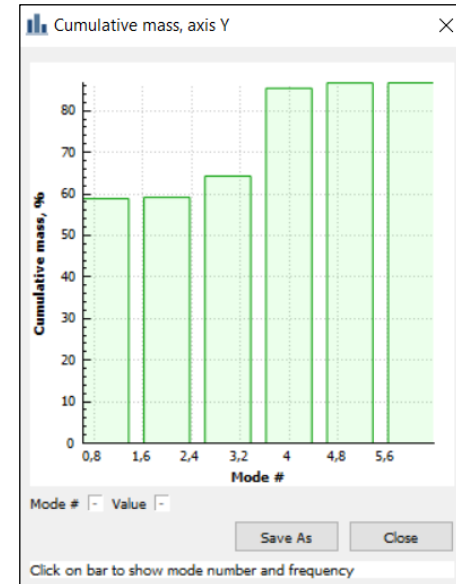
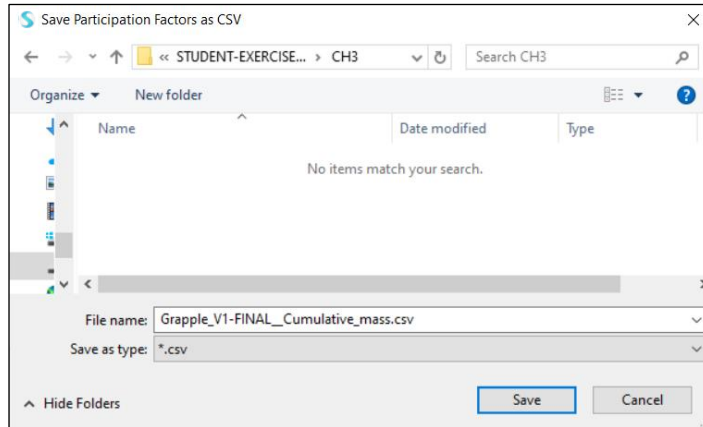
## Plotting

**Histogram plots** of modal contribution versus mode number can be easily displayed for a given factor and direction.

- Simply **pick the column header label** of the desired contribution direction (for example y), then select the **Show Histogram** button.

On the histogram plot, you may select any individual bar to display its value and mode number details.

## Save to csv

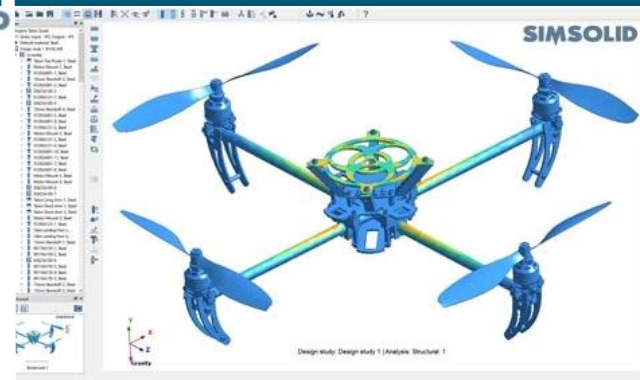
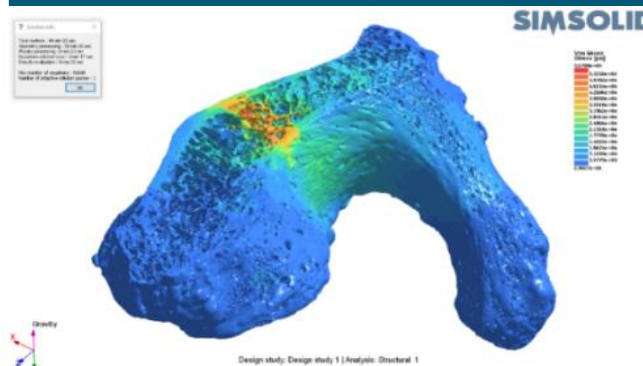
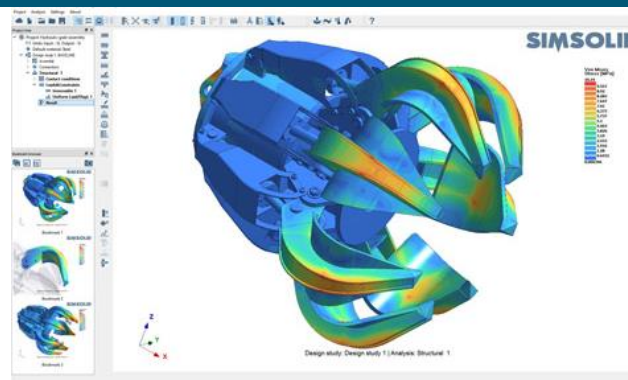


# JOIN THE SIMULATION REVOLUTION

Fast, Easy to Use &  
Accurate

Expand What is  
Possible to Solve

Enables Simulation  
Driven Design



## Quick Overview Series

- Module 1: Introduction February 5th 2021
- Module 2: User Interface + Modal Analysis February 12th 2021
- Module 3: Linear Analysis February 19th 2021
- Module 4: Non-Linear Analysis February 26th 2021
- Module 5: Dynamic Analysis March 5th 2021
- Module 6: Thermal and SimSolid news March 12th 2021
- Module 7: Inspire/SimSolid Solver March 19th 2021

(all Fridays)

- Contact: [trainings@altair.de](mailto:trainings@altair.de)
- or give feedback after meeting finished

# QUESTIONS / ANSWERS



# THANK YOU

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