

Rotordynamic simulation

SyMSpace Days

September 18-19, 2024

Introduction

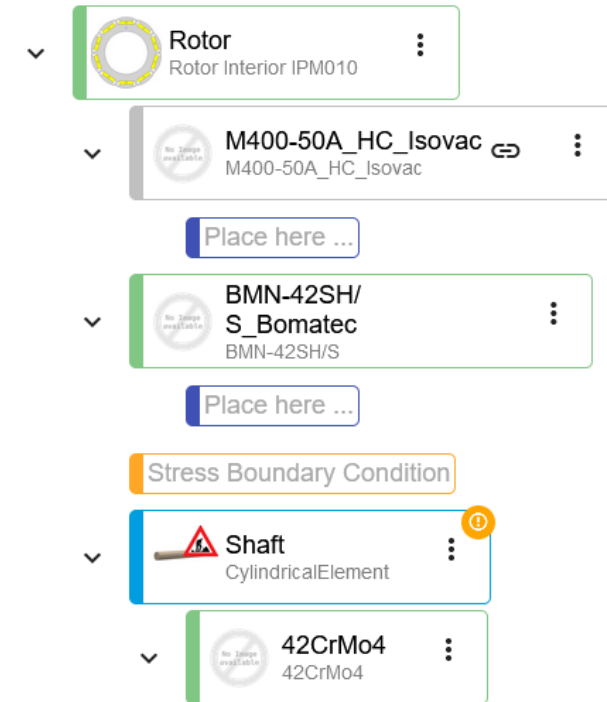
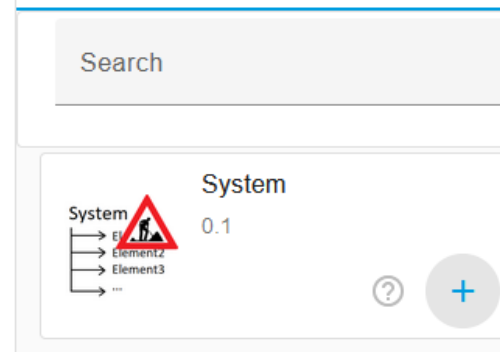
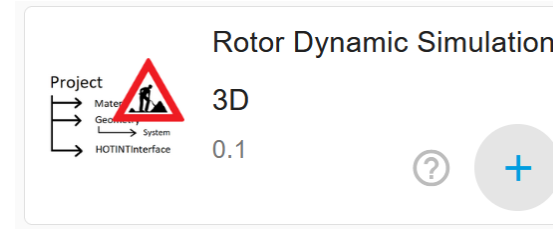
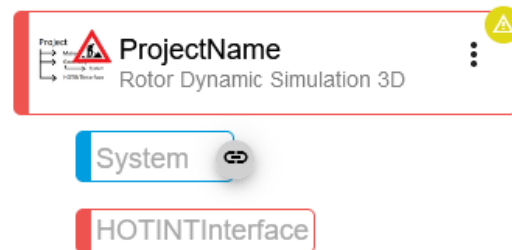
- Calculation of bending frequencies important for high-speed systems
 - High-speed compressor systems
 - Electrically assisted turbochargers
 - Close link to magnetically levitated systems
- Integration in optimization loop preferable
- Simulation of time transient problems interesting
 - Estimation of deflections during runup
 - Especially important with magnetic bearings



Quelle: Pankl Turbosystems GmbH

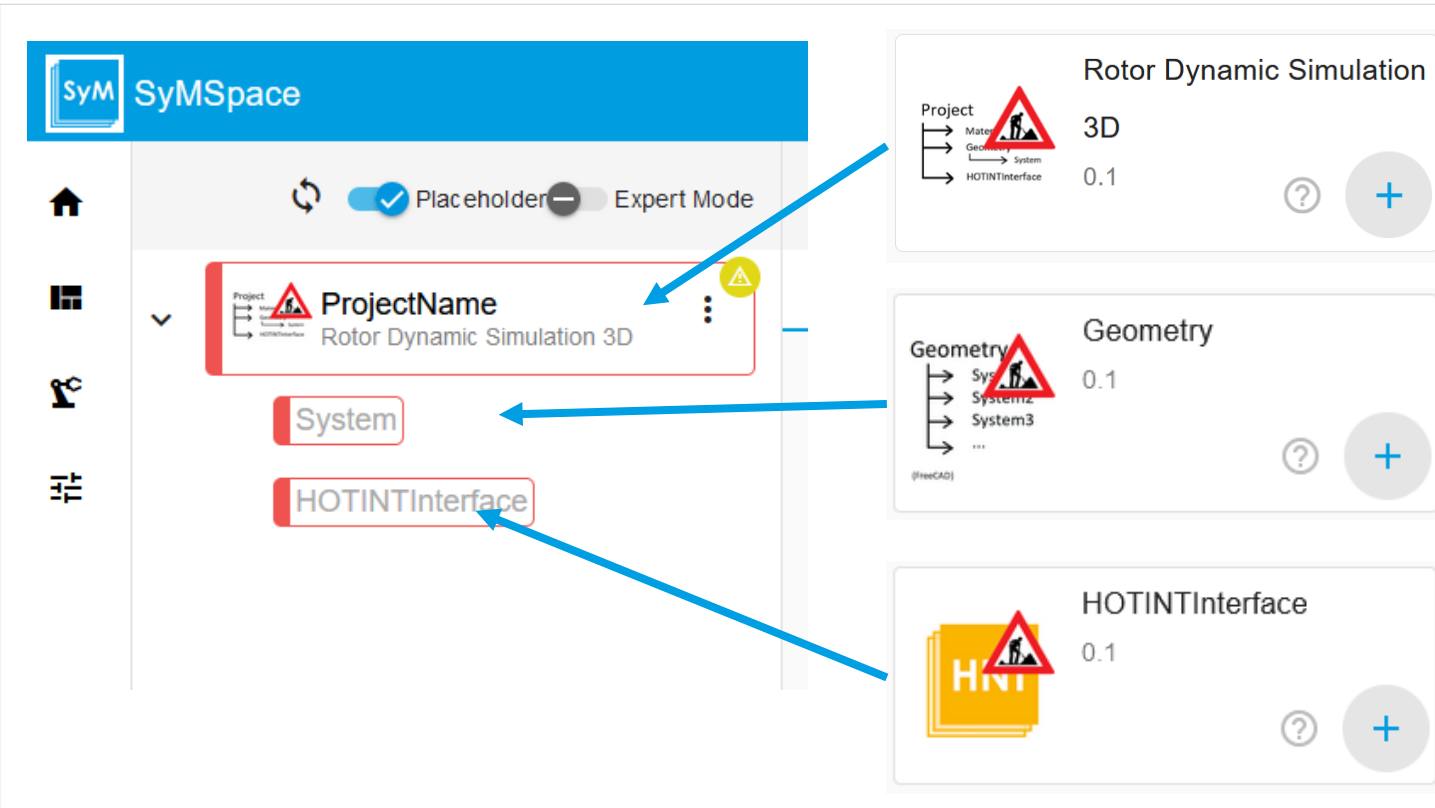
SyMSpace Component

- Special workflow implemented
- Integrable in standard motor model
 - Combined simulation of motor and rotor dynamic aspects possible



Workflow

Stand alone project



The screenshot displays the SyMSpace software interface. At the top, the SyMSpace logo is visible. Below it, there are navigation icons and a toolbar with 'Placeholder' (checked) and 'Expert Mode' (unchecked) buttons. The main workspace shows a project structure for 'ProjectName' (Rotor Dynamic Simulation 3D). The structure includes a 'System' component and a 'HOTINTInterface' component. Three component cards are shown on the right, each with a red warning triangle icon and a '+' button:

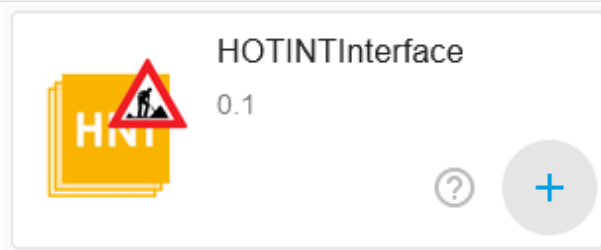
- Rotor Dynamic Simulation**: 3D, 0.1. Includes sub-components: Project, Material, Geometry, System, and HOTINTInterface.
- Geometry**: 0.1. Includes sub-components: System1, System2, System3, and ... (FreeCAD).
- HOTINTInterface**: 0.1. Includes sub-components: HNT.

Blue arrows point from the 'ProjectName' card to the 'System' and 'HOTINTInterface' components in the workspace, and from the 'HOTINTInterface' card to the 'HOTINTInterface' component in the workspace.

- Add basic project structure
 - Material Container
 - Geometry
- Add system structure
 - Serves as container for elements
 - Modeling of multiple systems possible
- Add interface to calculation software
 - Converts geometry into HOTINT structure
 - Sets general parameters
 - Provides calculation results

Interface

Settings



- HOTINT:
 - Multibody simulation tool for ridged and flexible structures
 - Free software package (<https://hotint.lcm.at/>)
 - Provides calculation of eigenfrequencies
 - Provides calculation of time transient processes

Basic elements

The image displays a software interface for a rotor dynamic simulation. On the left, a project hierarchy is shown with the following levels:

- ProjectName** (Rotor Dynamic Simulation 3D)
- System** (System)
- Element** (highlighted with a blue box and a blue arrow pointing to the right)
- HOTINTInterface** (HOTINTInterface)
- System** (highlighted with an orange box)

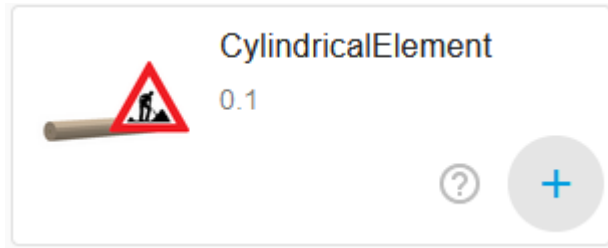
On the right, a library of basic elements is presented in a grid:

- Bearing** (0.1)
- CylindricalElement** (0.1)
- RigidBody** (0.1)
- Unbalance** (0.1)
- Disk** (0.1)
- DiskGeneric** (0.1)

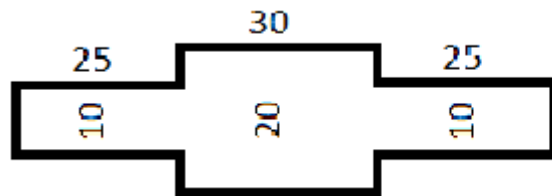
Each element card includes a representative icon, a warning symbol (a triangle with an exclamation mark), a question mark icon, and a plus sign icon for adding the element.

Basic elements

Cylindrical element



- **First Row:** Length
- **Second Row:** Outer Diameter
- **Third Row:** Inner Diameter

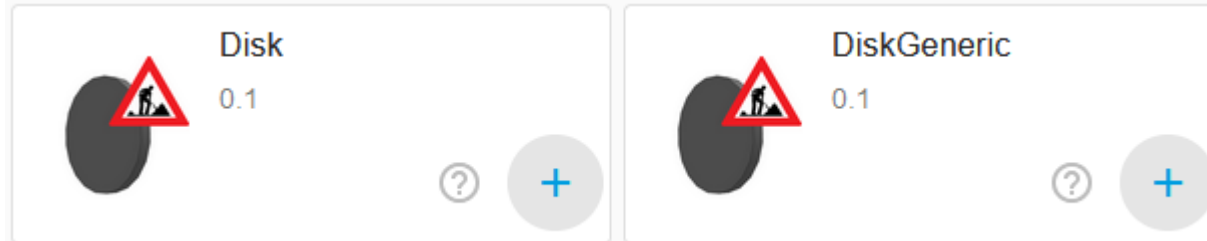


	0	1	2
0	25.0	30.0	25.0
1	10.0	20.0	10.0
2	0.0	0.0	0.0

- Most important element
 - Freely definable geometry
 - 2 beam types
 - RotorBeamXAxis
 - Most stable for time transient simulation
 - No gyroscopic effects implemented
 - ANCFBeamShear3DLinear
 - Implements gyroscopic effects
 - Beam also implements shear stress (important for shafts increased diameters)
- Geometry can be coupled with other parameters

Basic elements

Disks

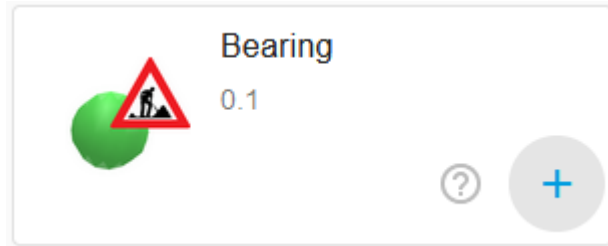


- Essential for RotorBeamXAxis to integrate gyroscopic effects
- Not necessary for ANCFBeamShear3DLinear
- Parameters:
 - Inertia and mass as input
 - Or self calculated
- STL overlay possible
- No bending of the disk itself



Basic elements

Bearing

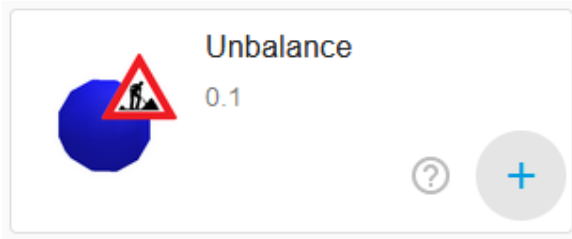


- Parameters:
 - Position
 - Stiffness (x,y,z)
 - Damping
 - Definition of constrained directions possible
- Allows connection to ground
- Allows coupling of two systems

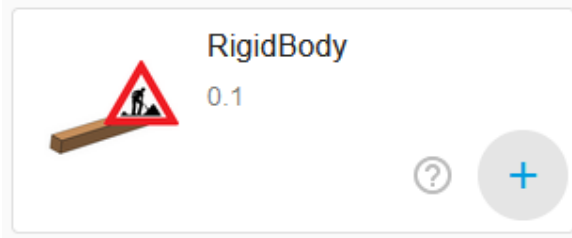
U Bearing	
Misc	
position	0.0
stiffness	[100000.0 100000.0 100000.0]
damping	10.0
Constrained Directions	[1.0 1.0 1.0]

Basic elements

Unbalance, rigid body



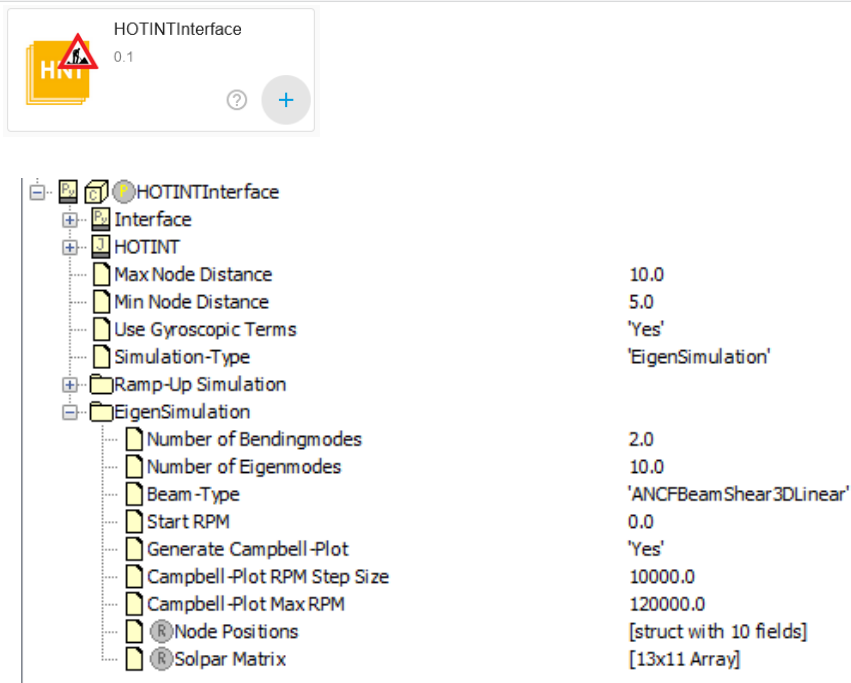
- Unbalance
 - Used to implement an unbalance of a rotor
 - Leads to deflections during run-up processes



- Rigid body
 - Can be used to model housings,...

Interface

Settings



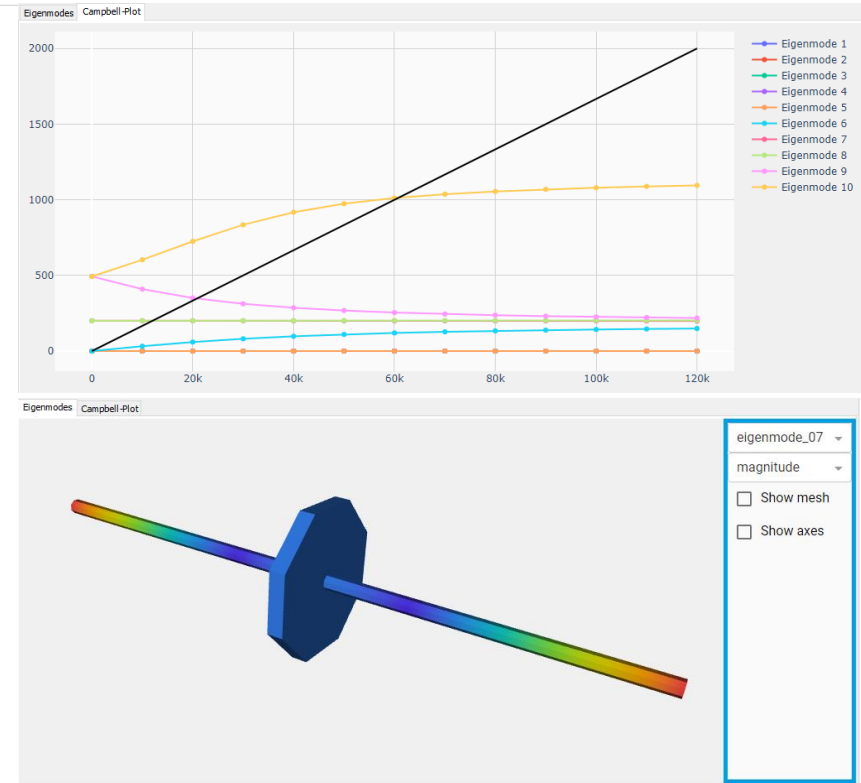
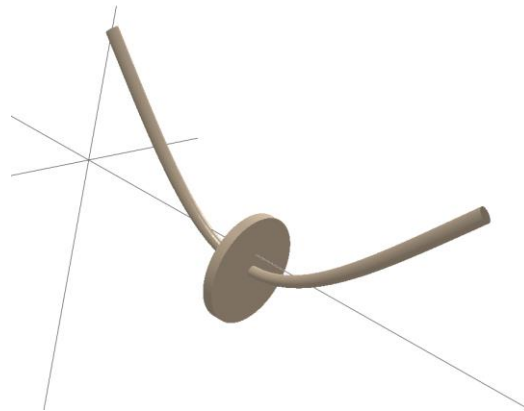
Setting	Value
Max Node Distance	10.0
Min Node Distance	5.0
Use Gyroscopic Terms	'Yes'
Simulation-Type	'EigenSimulation'
Number of Bendingmodes	2.0
Number of Eigenmodes	10.0
Beam-Type	'ANCFBeamShear3DLinear'
Start RPM	0.0
Generate Campbell-Plot	'Yes'
Campbell-Plot RPM Step Size	10000.0
Campbell-Plot Max RPM	120000.0
Node Positions	[struct with 10 fields]
Solpar Matrix	[13x11 Array]

- Adjustable Max. and Min. Node Distance
- Setting of beam type to use in simulation
- Setting of considering gyroscopic effects
- Setting simulation type:
 - Eigensimulation
 - Ramp-up simulation (time transient)
- Setting start speed
- Speed increment and end speed for campbell plot

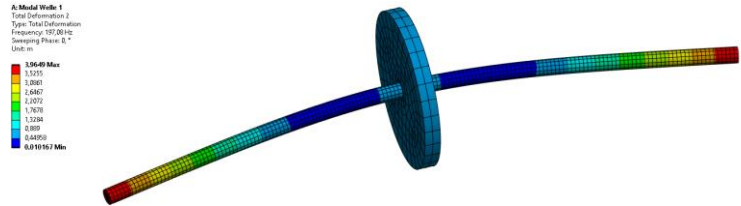
Interface

Results

- Exports occurring eigenmodes (rigid body and flexible modes)
- Exports deflection during runup (sensor element needed)
- Provides Preview:
 - Campbell Plot
 - Vtk preview of deflections

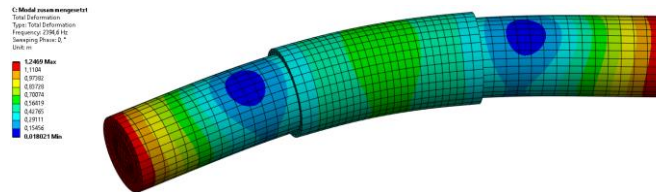


Comparison with Ansys



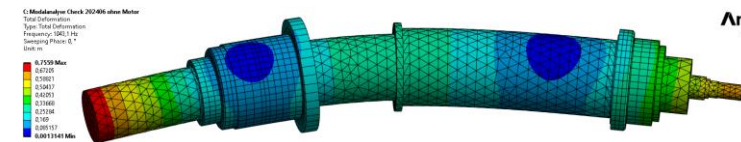
Ansys
2024 R1

- SyMSpace Mode1 200,8Hz/ Ansys 196,9Hz
- SyMSpace Mode1 347,2Hz/ Ansys 339,65Hz



Ansys
2024 R1

- SyMSpace Mode1 2300Hz/ Ansys 2273Hz



Ansys
2024 R1

- SyMSpace Mode1 1030Hz/ Ansys 988,6Hz
- SyMSpace Mode2 1135Hz/ Ansys 1100,6Hz

Outlook

- Completion of time-transient run-up simulation
 - Stability of simulation must be improved
- Visualization of bending line in vtk-preview
- Implementation of impeller approximation
 - Error minimization of mass, inertia and center of gravity considering geometric boundaries
 - Approximation with multiple disk (cylindrical) elements

Science becomes
reality