Josef Passenbrunner, Team Leader Motor Technology, Tel: +43 (0)732 2468 6087, www.lcm.at

Rotordynamic simulation

SyMSpace Days

September 18-19, 2024

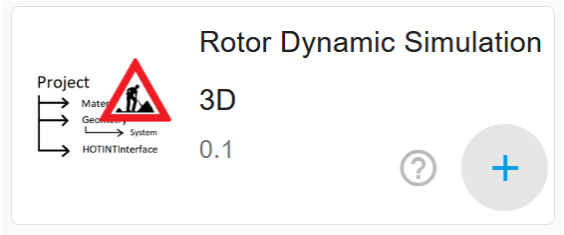
Introduction

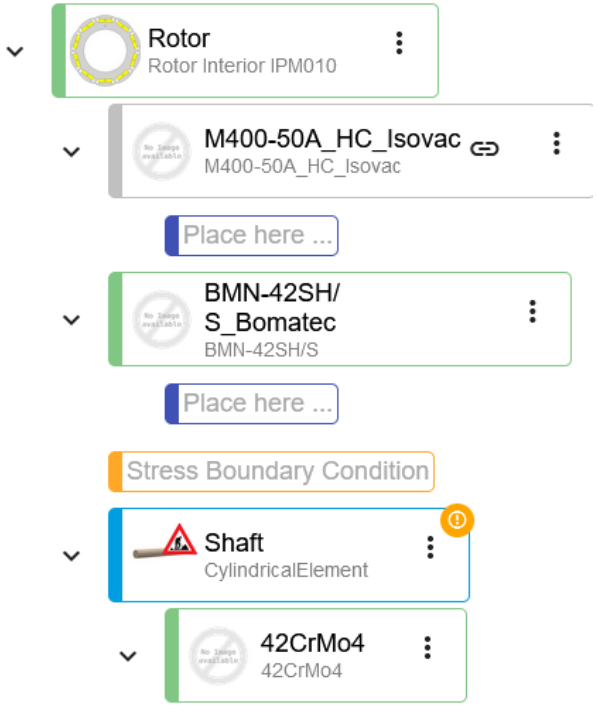
- Calculation of bending frequencies important for high-speed systems
  - High-speed compressor systems
  - Electrically assisted turbochargers
  - Close link to magnetically levitated systems
- Integration in optimization loop preferable
- Simulation of time transient problems interesting
  - Estimation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

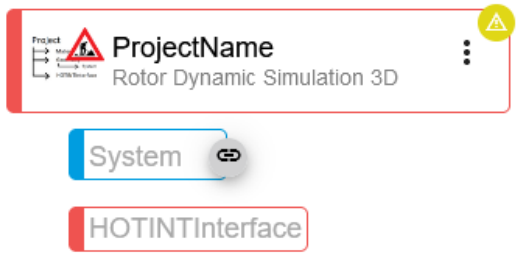
Quelle: Pankl Turbosystems GmbH

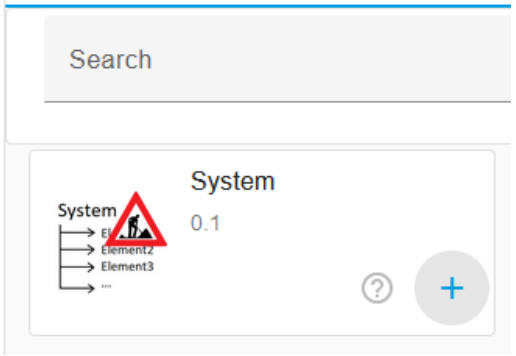
SyMSpace Component

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



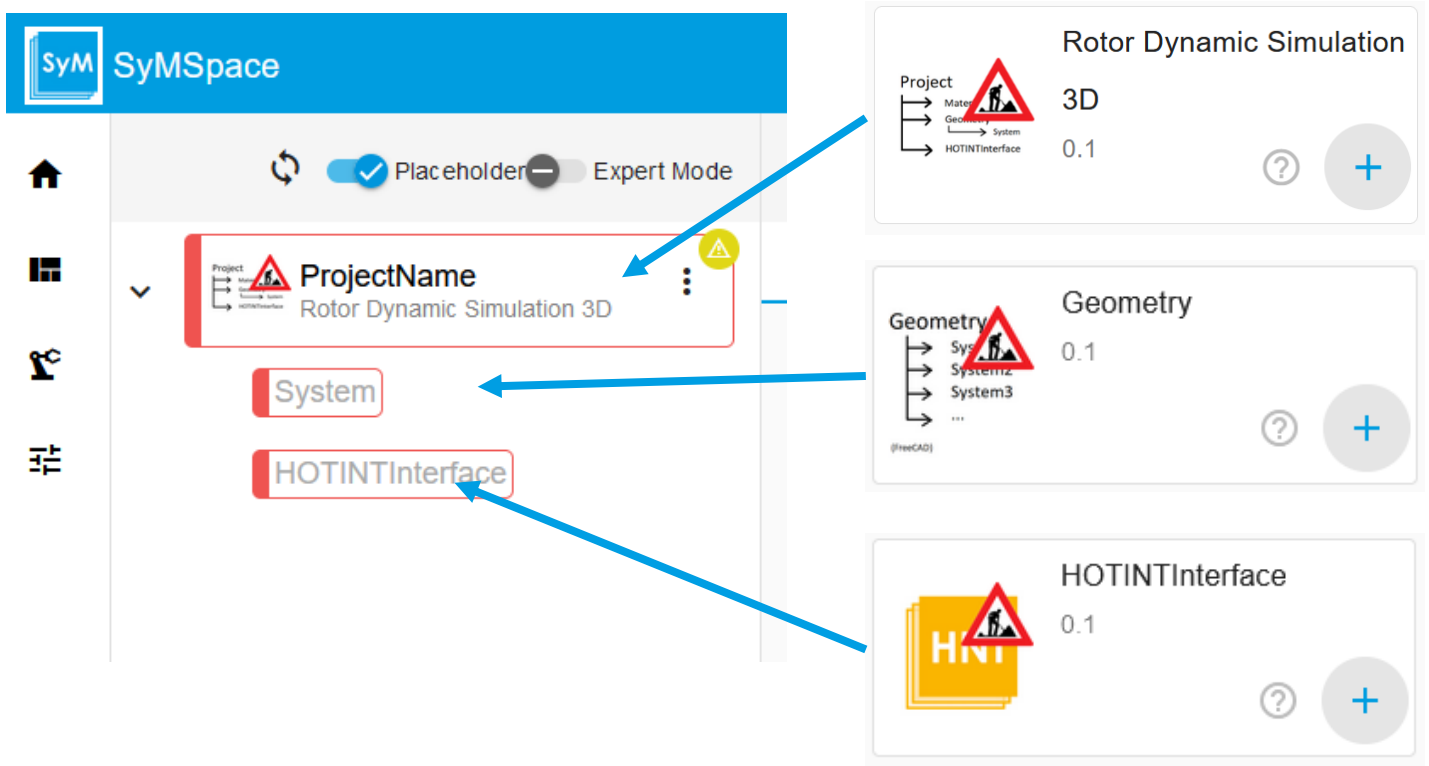






Workflow

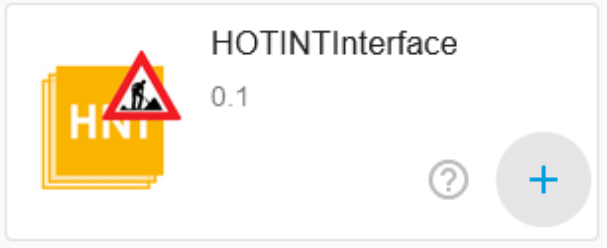
Stand alone project



- 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

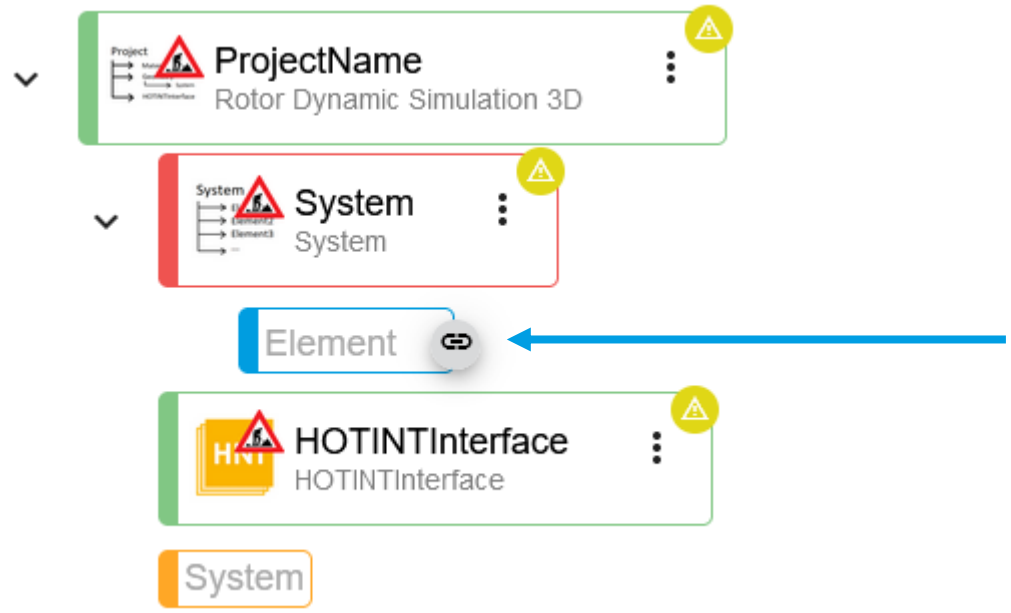
Interface

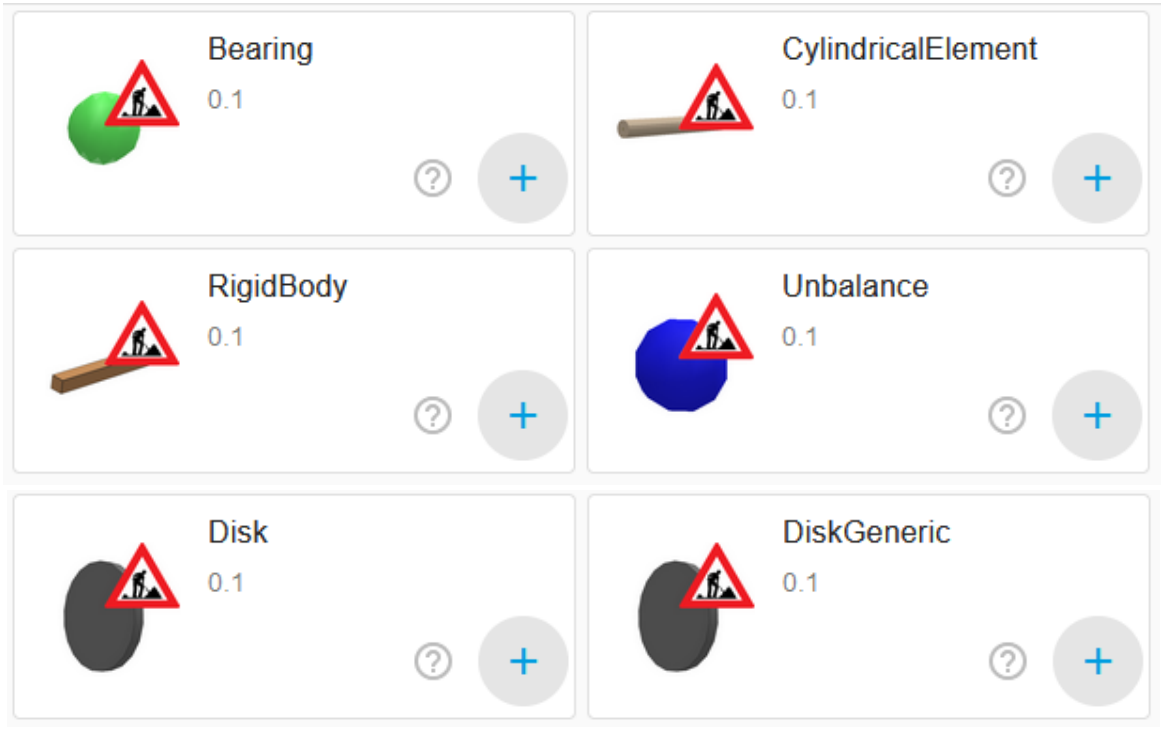
Settings



- 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

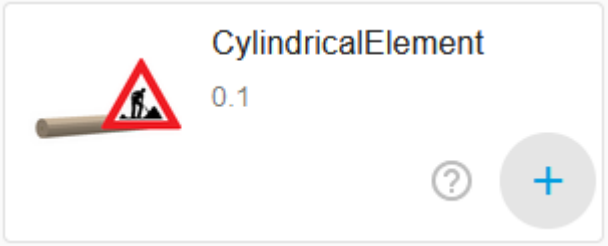
Basic elements



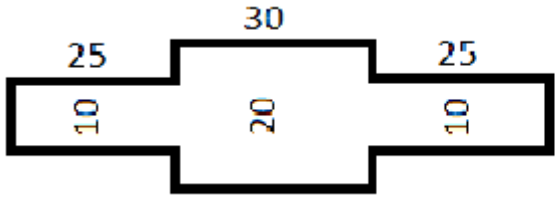


Basic elements

Cylindrical element



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

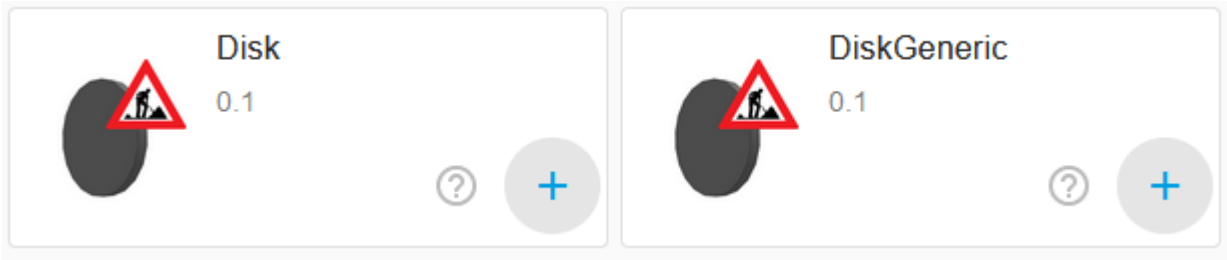


- Most important element
  - Freely definable geometry
  - 2 beam types
    - RotorBeamXAxis
      - Most stable for time transient simulation
      - No gyroscopic effects implemented
    - ANCFBeamShear3DLinear
      - Implements gyroscopic effects
      - Beam also implements shear stress (important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

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

Basic elements

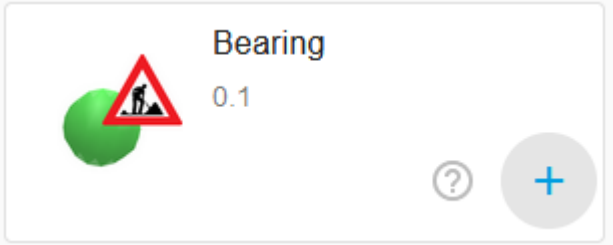
Disks



- 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

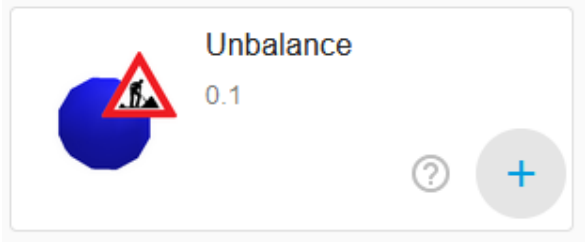
Bearing



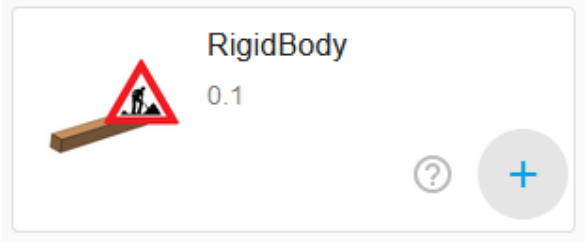
- Parameters:
  - Position
  - Stiffness (x,y,z)
  - Damping
  - Definition of constrained directions possible
- Allows connection to ground
- Allows coupling of two systems

Basic elements

Unbalance, rigid body



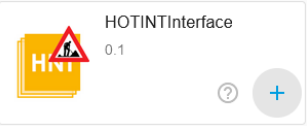
- Unbalance
  - Used to implement an unbalance of a rotor
  - Leads to deflections during run-up processes

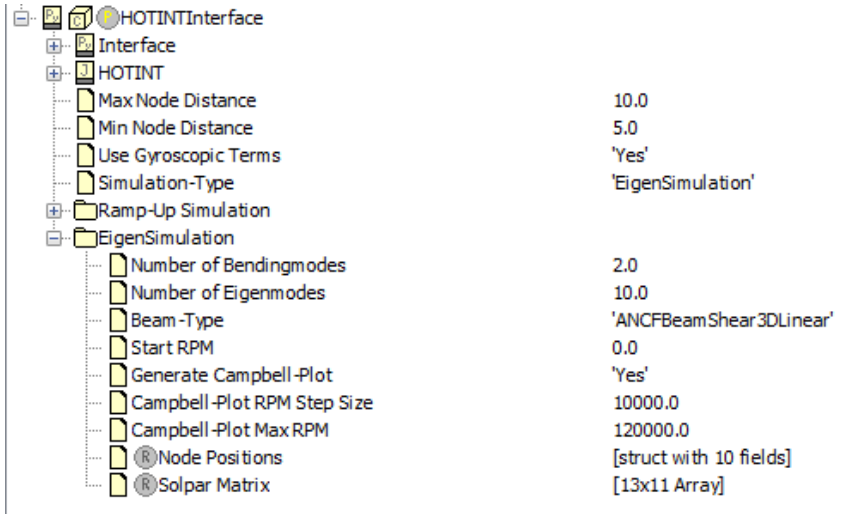


- Rigid body
  - Can be used to model housings,…

Interface

Settings



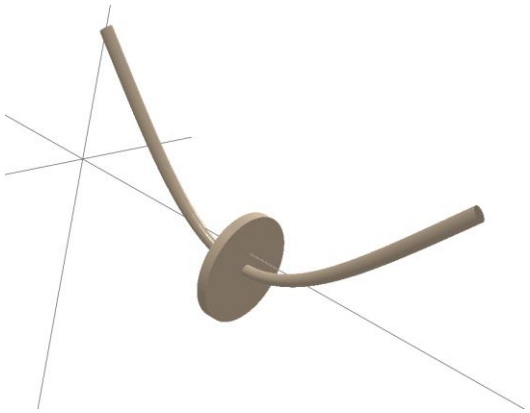


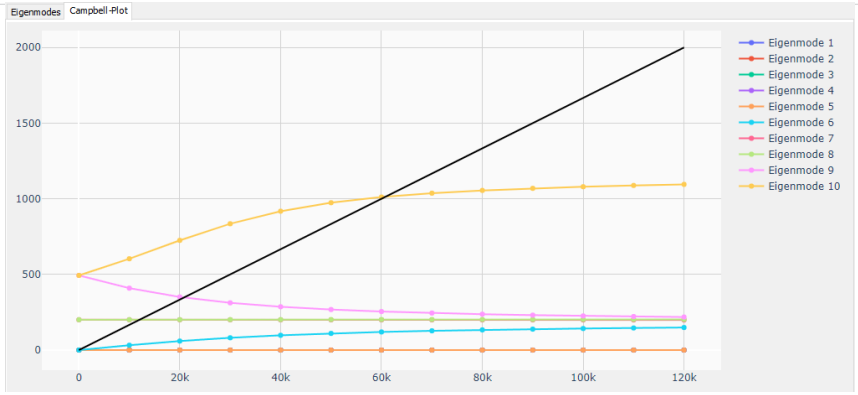
- Adjustable Max. and Min. Node Distance
- Setting of beam type to use in simulation
- Setting of considering gyroscopic effects
- Setting simulation type:
  - Eigensimulation
  - Ramp-up simulation (time transient)
- Setting start speed
- Speed increment and end speed for campbell plot

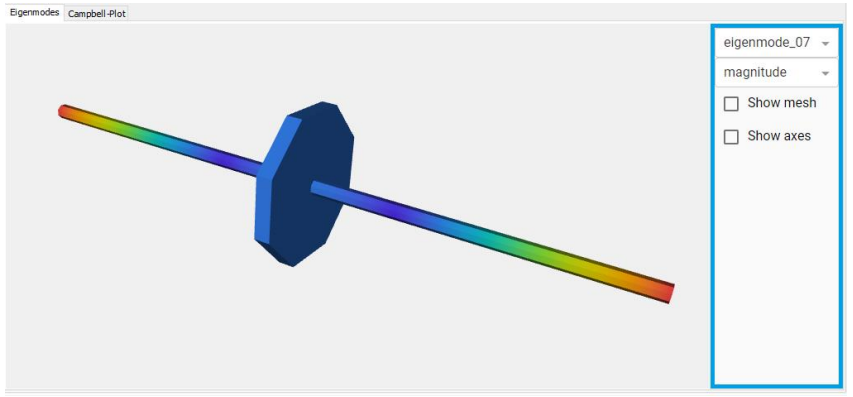
Interface

Results

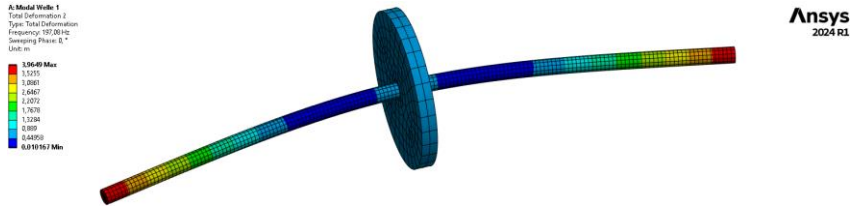
- Exports occurring eigenmodes (rigid body and flexible modes)
- Exports deflection during runup (sensor element needed)
- Provides Preview:
  - Campbell Plot
  - Vtk preview of deflections



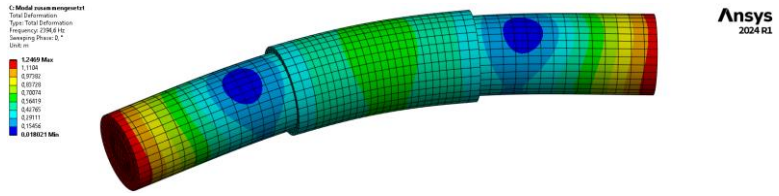




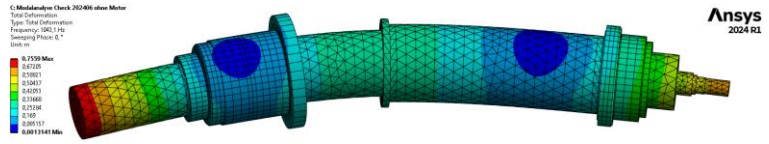
Comparison with Ansys



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



- SyMSpace Mode1 2300Hz/ Ansys 2273Hz



- 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

LINZ CENTER OF MECHATRONICS