# NX-Magnetics: an industrial implementation of GetDP & Gmsh in Siemens' Simcenter 3D

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First Gmsh Usermeeting
Liège, Belgium

# Agenda

- Company Dr. Binde Ingenieure GmbH
- Use-Cases of Magnetics for NX/Simcenter3D
- Simcenter‘s Datamodel & Process
- Physical Master Library
- Major Capabilities
- Self Learning Course

MAGNETICS
Dr. Binde Ingenieure Design & Engineering
ElectroMagnetic FEM in NX/Simcenter or standalone

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# Company Dr. Binde Ingenieure GmbH

- Founded in 1997 as a spin-off from the Technical University of Darmstadt

- Consulting and Software Company, Specializing in Siemens simulation tools „Simcenter“

- Holds, through this product, the title „Siemens Solution Partner for Software and Technology“

- Head of the German User Group in the Simulation Division (PLM-Connection). Meetings twice a year

- ~10 Engineers, mechanical and electrical, Locations in Wiesbaden, Chemnitz, Berlin

Dr. Binde Ingenieure Design & Engineering

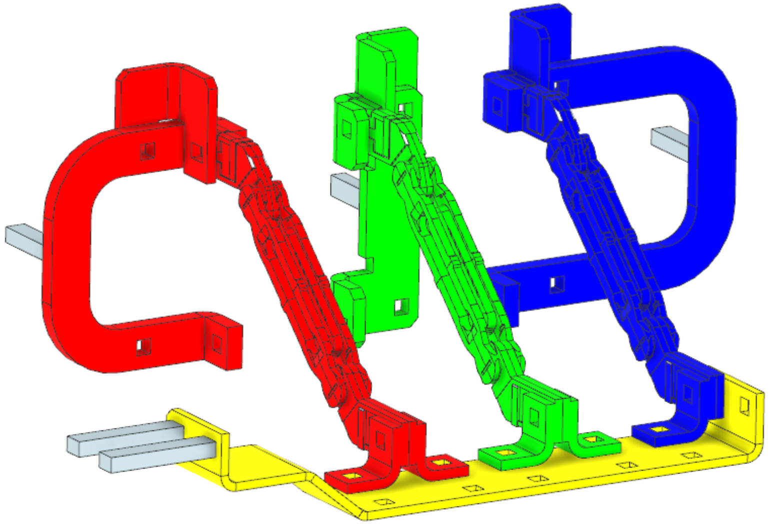
Your Simcenter Experts

# Use-Cases of Magnetics for NX/Simcenter3D

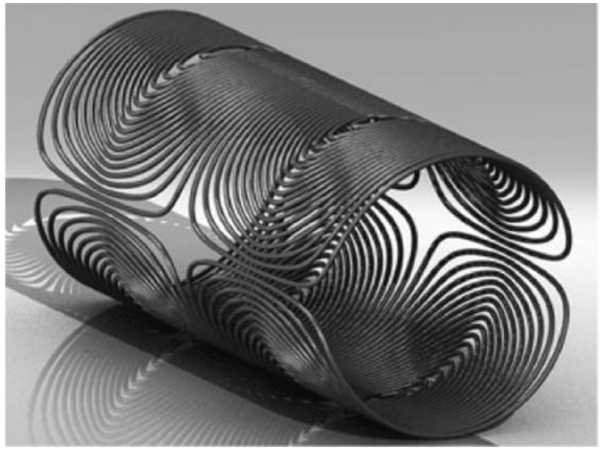
BINDE

1. Switchgears
    - Medium and high-voltage
    - short-circuit conditions, temperature field
2. Insulators
    - electric field
3. Electric motors for
    - tunnel construction
    - satellite spin wheels
    - consumer products
4. Healthcare: MRI scanners
    - electromagnetics, lorentz-forces
    - mechanical oscillations
    - acoustics
    - heating
5. Automotive
    - Camshaft Actuators (electromagnetic, motion)
    - High-Current Connectors (electromagnetic, temperature field)

Grounding bus bar (source: Siemens AG)



MRI gradient coil (Siemens Healthineers)



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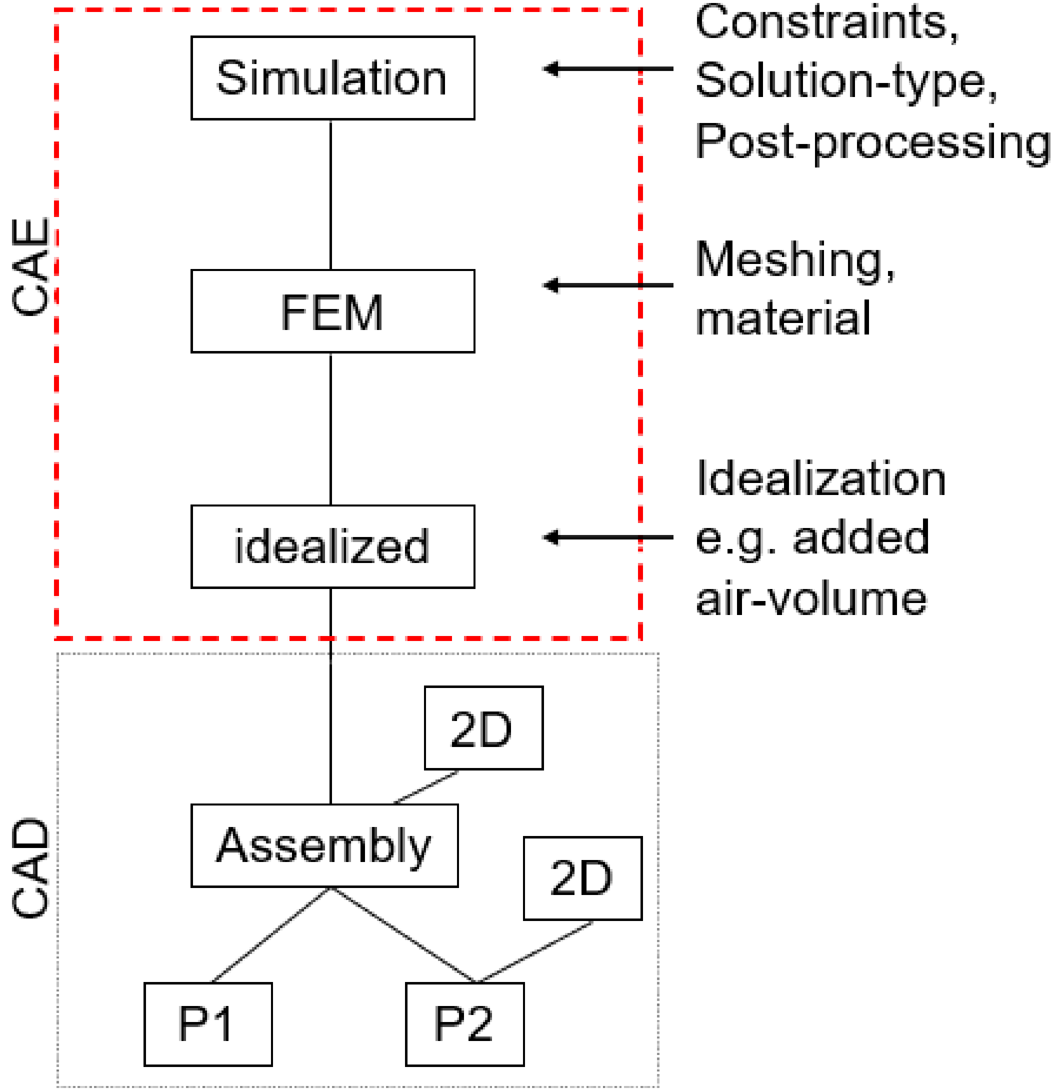
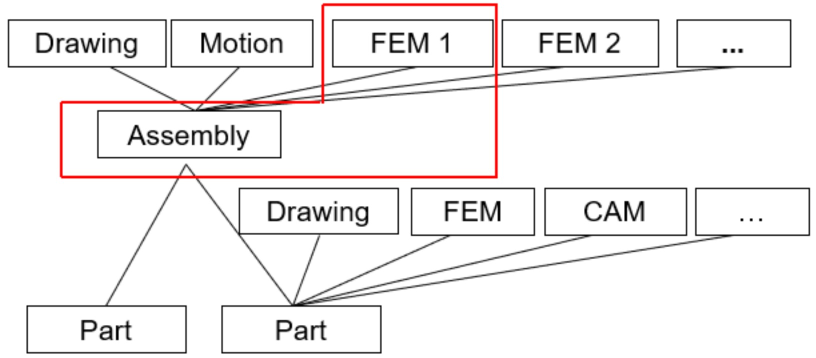
# Simcenter‘s Datamodel & Process (same for all simulations)



CAE-file structure




full Master-Model Concept

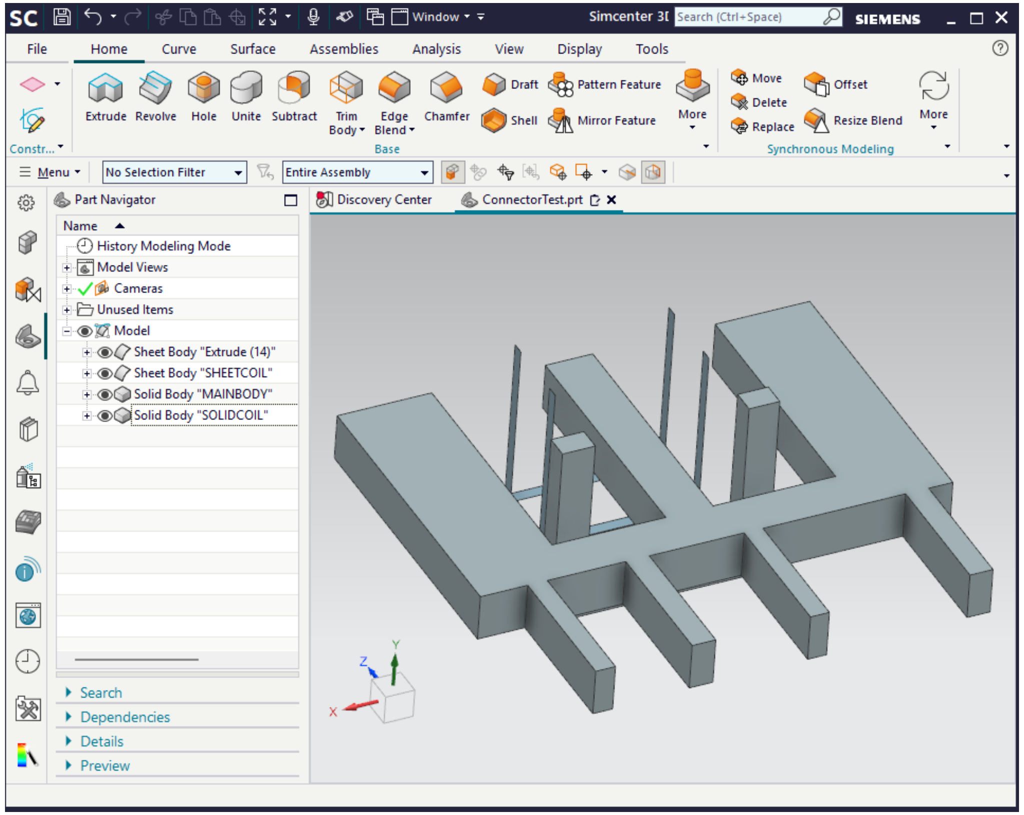


# Simcenter‘s Process: 1 a, b, c

## 1a) Open or create CAD

Assemblies with thousands of parts

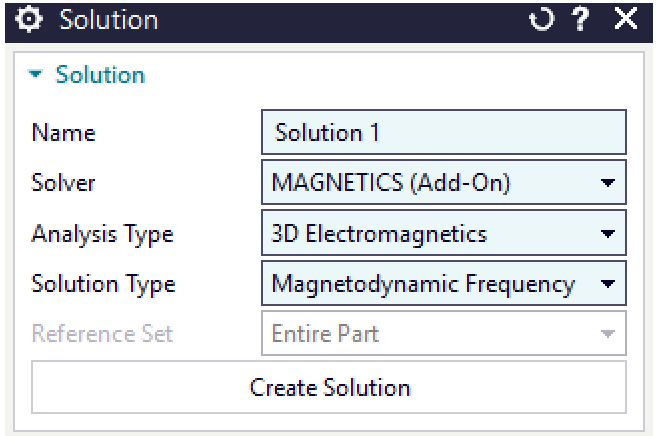
PLM access, Siemens’ Teamcenter backbone




## 1b) Create CAE-Files


## 1c) Select solver & solution-type

each solver defined by language-xml




Simcenter Nastran
Simcenter Samcef
Simcenter 3D Thermal/Flow
Simcenter 3D Space Systems Thermal
Simcenter 3D Electronic Systems Cooling
Simcenter 3D Multiphysics
Simcenter 3D Acoustics BEM
Simcenter 3D Acoustics Transient BEM
Simcenter 3D Ray Acoustics
Simcenter 3D Noise and Vibration
Simcenter 3D Smart Virtual Sensing
Simcenter MAGNET
NX Design Simulation
MSC Nastran
ANSYS
Abaqus
LS-DYNA
Ideas Unv
ADINA Nastran Interface
Test Data
SC03
MAGNETICS (Add-On)

Magnetostatic
Magnetodynamic Frequency
Magnetodynamic Transient
DC Conduction Steady State
Electrostatic
Electrodynamic Frequency
Electrodynamic Transient
Full Wave Frequency
Full Wave Transient
Eigenmodes
Waveguides

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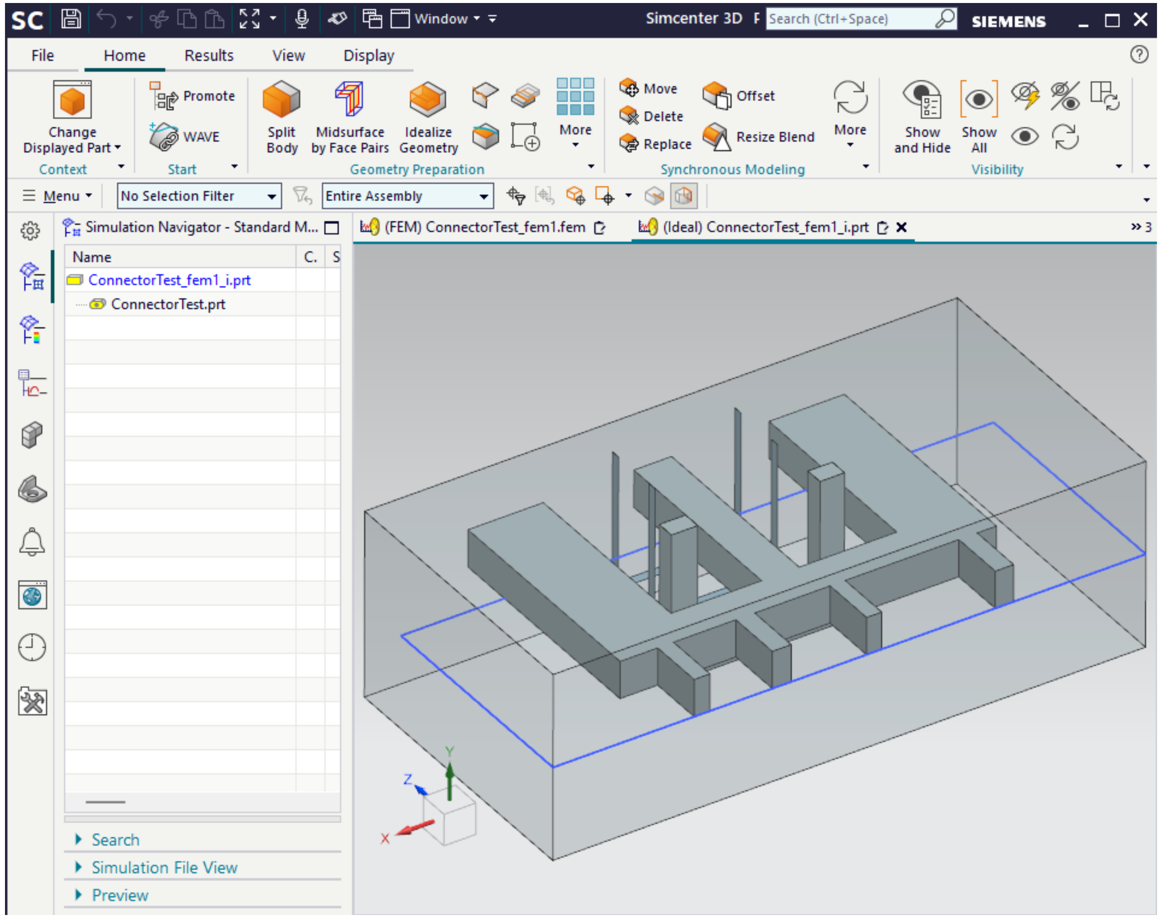
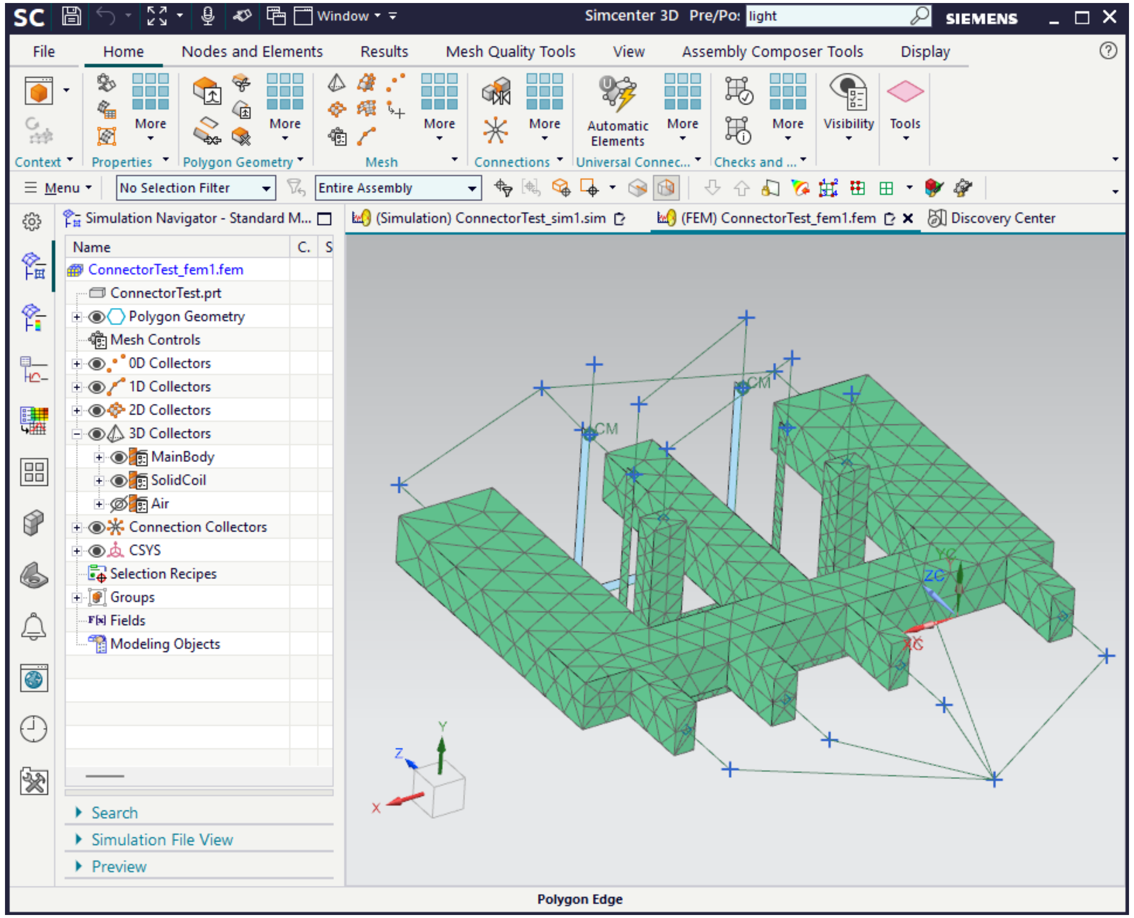
# Simcenter‘s Process: 2. Idealizations: Air-Volume, ...
# 3. Meshing and Physical Properties

2. Geometry-idealizations do not affect the CAD-master.
But changes of the CAD-master do affect the idealization.

3. Meshing, 3D, 2D, 1D, 0D
(coarse meshes here – test only)

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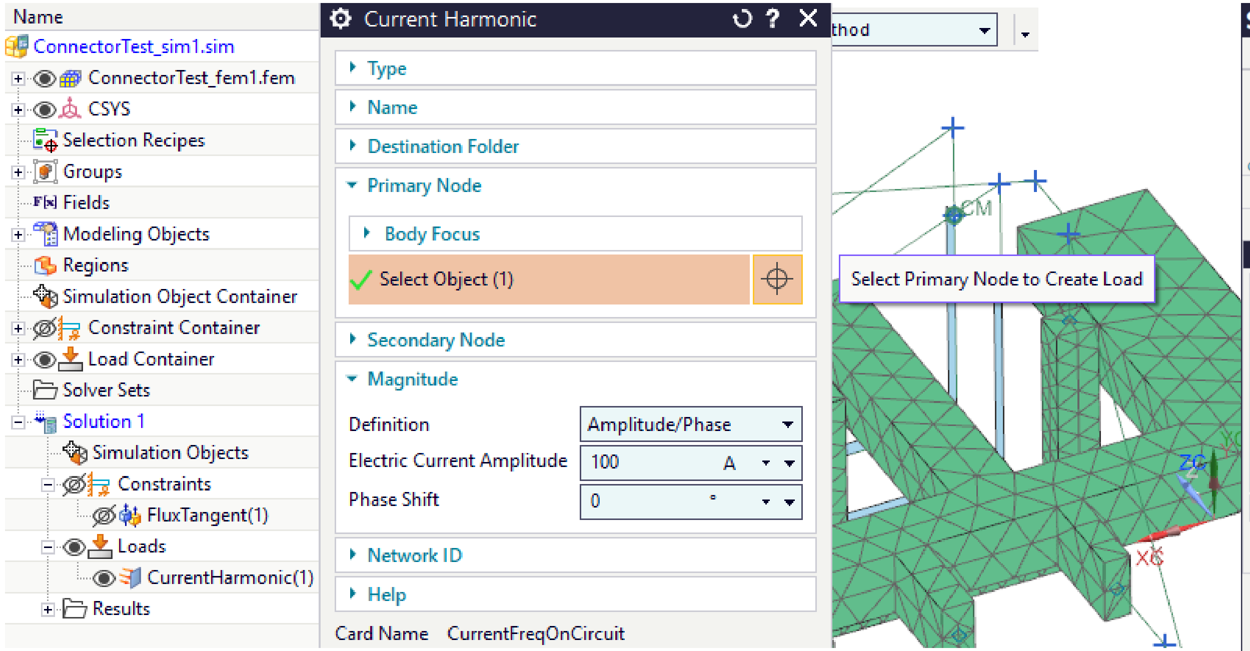
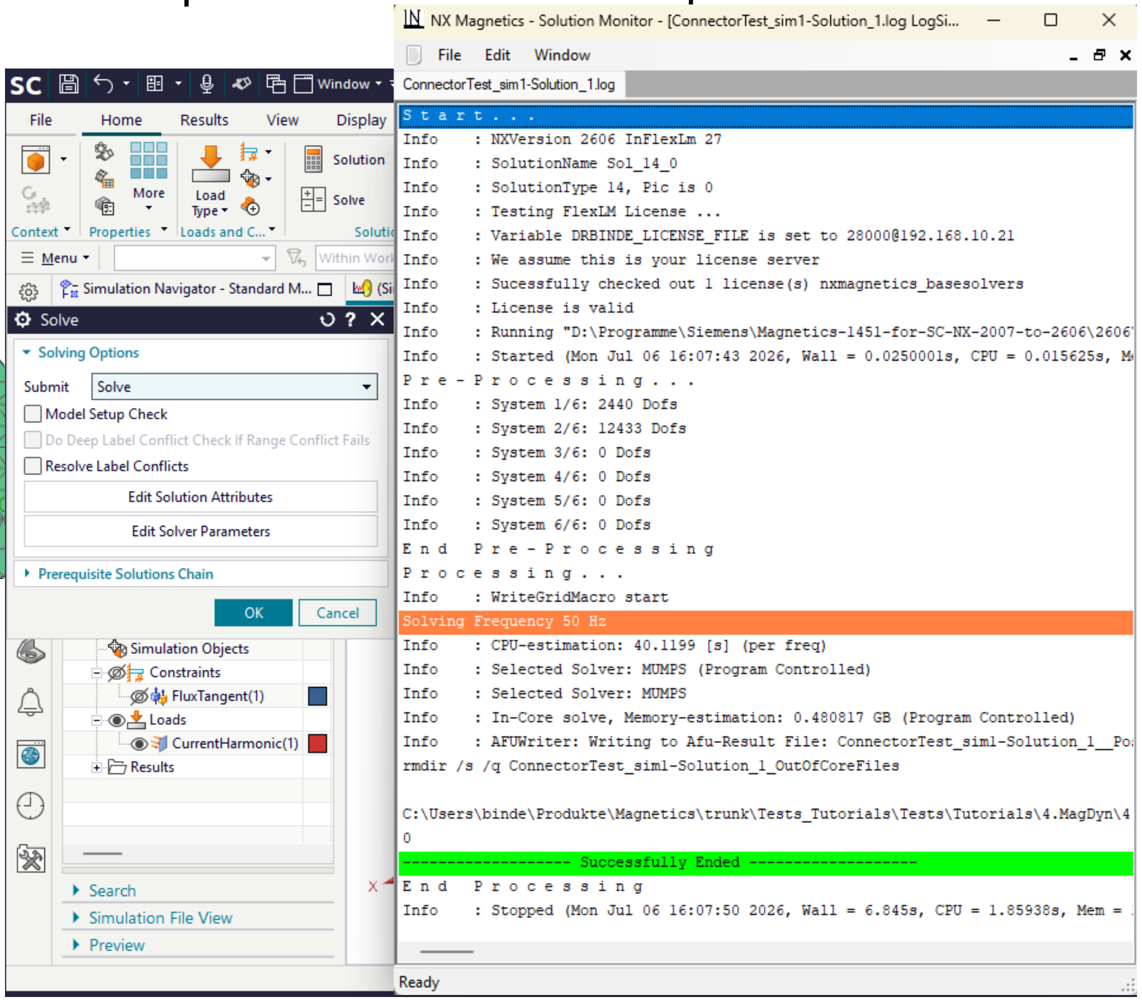
# Simcenter‘s Process: 4. Boundary-Conditions
# 5. Solve

4. Define conditions like current or voltage
Gmsh/Getdp Region IDs are internally generated




5. Start the solve job
Mesh- and pro-file are sent to Getdp

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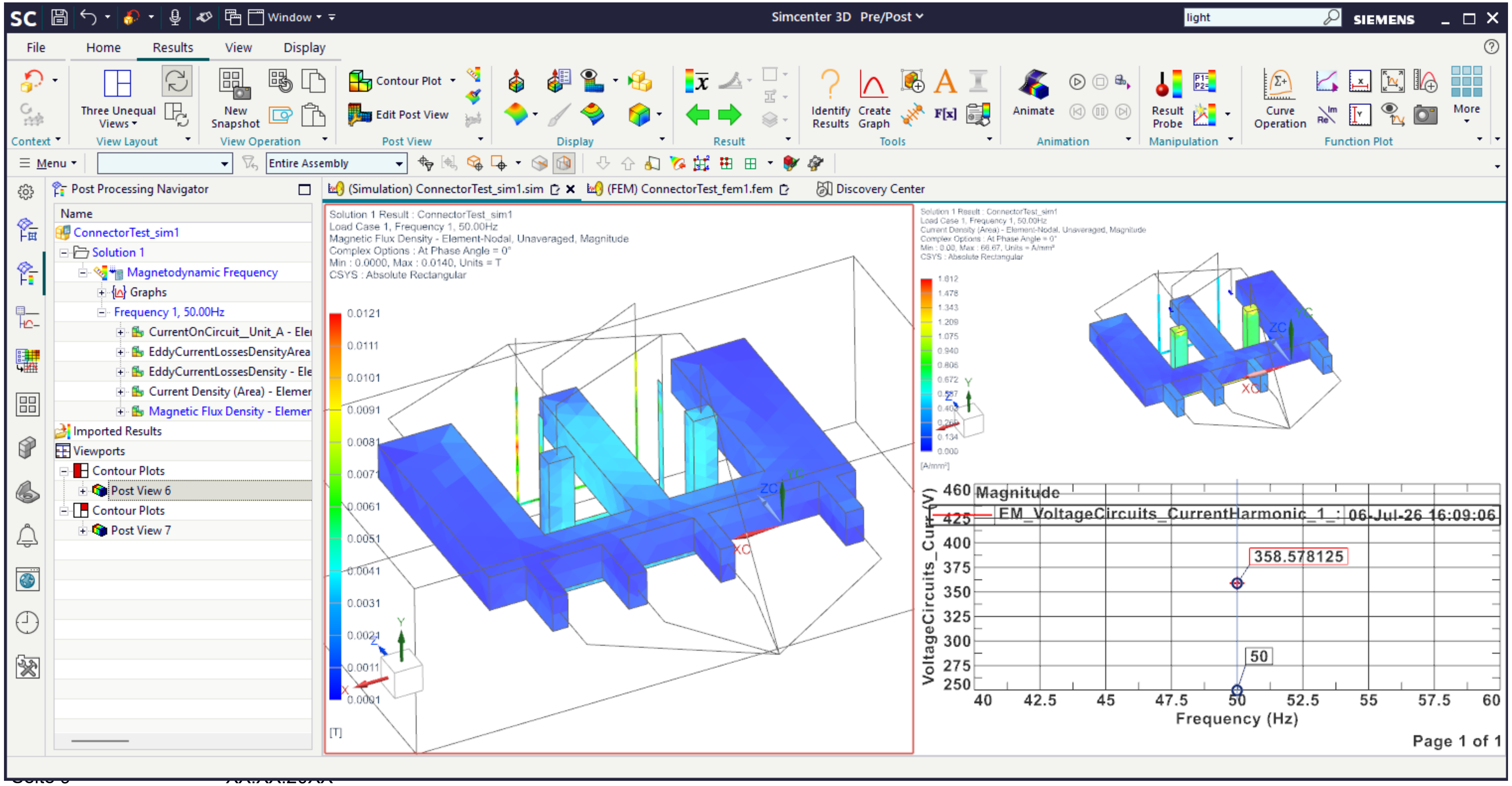
# 6. Post-processing

Solver writes binary unv formatted results, usual for Simcenter. All special features of the PP can be used.



# Physical Master Library

- All predefined Galerkin-formulations, PostProcessing-formulas, Resolutions, Functions, … are in <u>one</u> library. This is included in each job

- ~9000 code lines are in a visible library file
- ~2500 additional code lines are in a hidden library

- Users can modify the visible library. A popular example is adding post-processing formulas

- Backbone formulation: MagStaDyn_a_3D
  - Vectorpotential a-v-form
  - Usable for static, time-harmonic and transient,
  - robust and extendable

lib_Master.pro | lib_Function_Header.pro | lib_Defines_Header.pro

```
DefineConstant[ /* Defaults for Solution Parameter: Output Requests (EM) */
DefineConstant[ /* Defaults for Solution Parameter: Frequency */
DefineConstant[ /* Defaults for Solution Parameter: Thermal */
DefineConstant[ /* Defaults for Solution Parameter: Elasticity */
DefineConstant[ /* Defaults for Solution Parameter: Motion */
DefineConstant[ /* Defaults for Solution Parameter: Particle */
DefineConstant[ /* Defaults for Solution Parameter: Time Steps */
DefineConstant[ /* Defaults for Solution Parameter: Adaptivity */
DefineConstant[ /* Defaults for Solution Parameter: 2D */
Group { /* Group preparations */
Function { /* Additional derived Functions */
Group {  /* Group Logic */
Jacobian {
Integration {
Constraint {
Call LibFunctionSpaces_Coils;
Call LibFunctionSpaces_Force;
FunctionSpace {
Call LibFormulations_Force;
Formulation { { Name LorentzForceNodal ;
Formulation { { Name FormName_Mag~{Electrostatics_v};
Formulation { { Name FormName_Mag~{Electrokinetics_v};
Formulation { { Name FormName_Mag~{Electrokinetics_v0_v};
Formulation { { Name FormName_Mag~{Electrostatics_a0v0_v};
Formulation { { Name FormName_Mag~{ElecDyn_v};
Formulation { { Name FormName_Mag~{MagStaDyn_a_2D};
Formulation { { Name FormName_Mag~{MagStaDyn_a_2D}~{ErrorEstim};
Formulation { { Name FormName_Mag~{FullWave_a_2D};
Formulation { { Name FormName_Mag~{Eigenvalues_e};
Formulation { { Name FormName_Mag~{MagStaDyn_a_3D};
Formulation { { Name FormName_Mag~{MagStaDyn_a_3D}~{Composite};
Formulation { { Name Elasticity3D ;
Formulation { { Name Elasticity3D~{Composite} ;
Formulation { { Name Magnet_Update ;
Formulation { { Name Projection;
Formulation { { Name Projection_The;
Formulation { { Name DummyFormulation;
Formulation { { Name Thermal ;
Formulation { /* Helmholtz */
PostProcessing { { Name ElectroMagnetic;
PostProcessing { { Name ElekinPos;
PostProcessing { { Name EleStaPos;
PostProcessing { { Name ElectroMagnetic_ErrorEstim;
PostProcessing { { Name RigidBodyMotion_ini;
PostProcessing { { Name ProjectionCheck;
PostProcessing { /* Thermal */
PostProcessing { /* Elasticity */
```

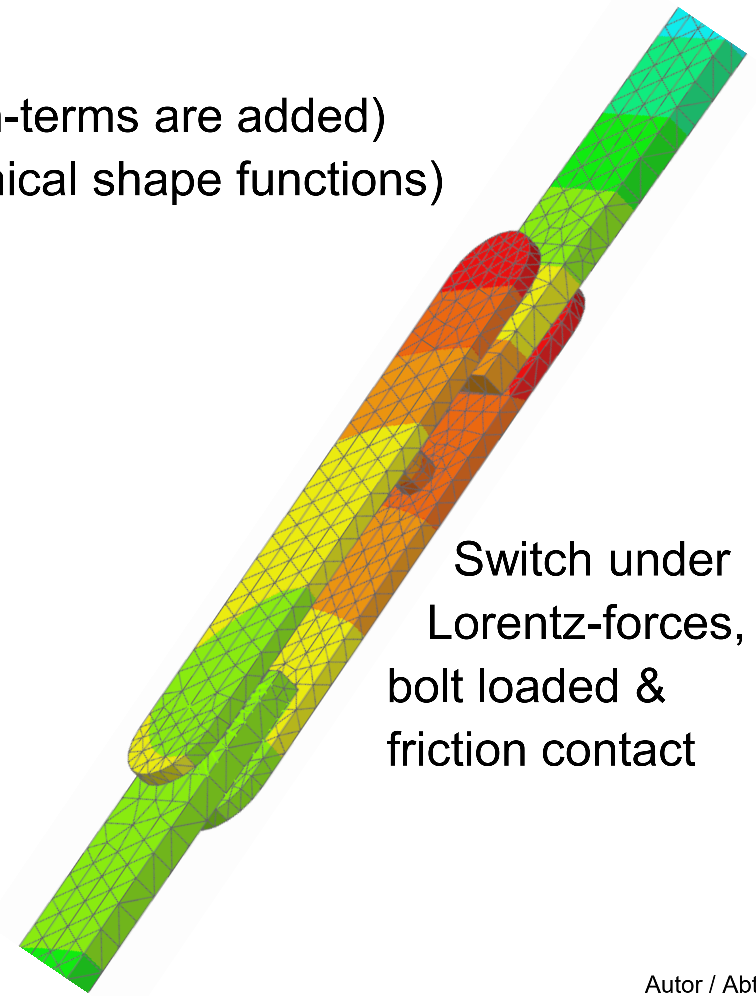
# Major Capabilities

BINDE

- GetDP with Gmsh and our extended formulations, is compiled on Windows 64 bit, with OpenBlas, MUMPS and DMP, licensed by FlexLM

- Electromagnetics
  - Low/medium or high-frequency selection by one button (4 galerkin-terms are added)
  - 3D elements (tetrahedral, hexahedral, pyramids, wedges, hierarchical shape functions)
  - 2D (conductors, thin layers) and 1D (tube) elements
  - Circuit network elements
  - Nonlinear (b-h-curve) materials, orthotropic materials

- Elasticity (coded in getdp)
  - coupled with EM (Lorentz-forces, speed-effect, position-update)
  - Statics, frequency- or time-domain
  - 3D-solids, 2D-shells, 1D-beams and rods
  - Nonlinear contact, contact-gap affects EM
  - Preloaded Bolts
  - Alternatively, use of Nastran solver instead of getdp



Switch under Lorentz-forces, bolt loaded & friction contact

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# Major Capabilities

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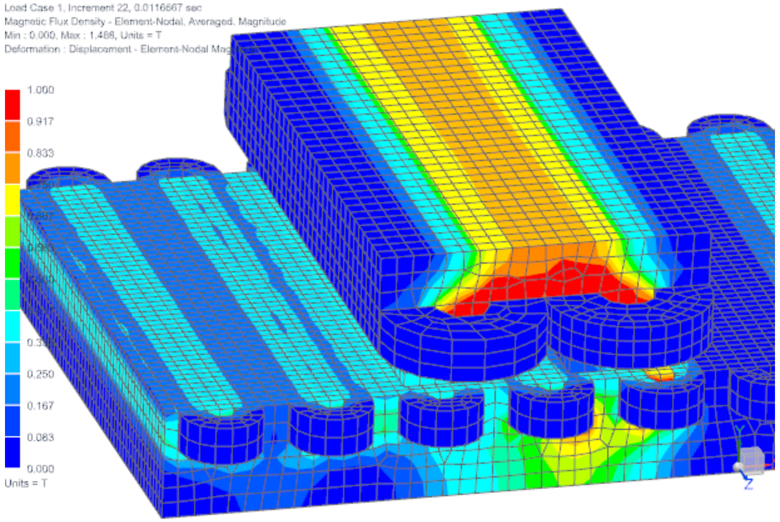
- Thermal (coded in getdp)
  - Coupled with Electromagnetics (power-loss, material-update)
  - Thin gaps
  - Thermal couplings
  - Alternatively, co-simulation with Siemens’ CFD solver

- Motion (coded in getdp)
  - Moving-Band for 2D and 3D
  - Stepping motion for translation and rotation
  - Alternatively, co-simulation with Siemens’ MKS solver

- Charged particles (coded in getdp)
  - Particle in cell (PIC) implemention
  - Electromagnetic fields affect the particle movement
  - Particle movement back-affects the electromagnetic fields

Linear motor simulation

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# Self Learning Course

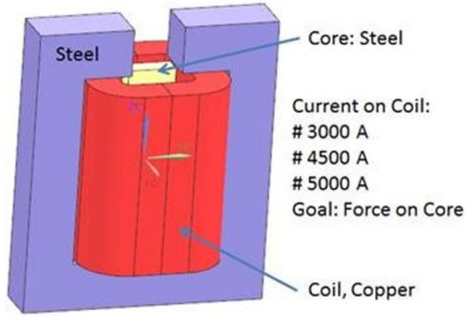
- A comprehensive self-learning course is available online. It includes PDF manuals for each chapter, featuring detailed explanations and step-by-step instructions.

- See  www.magnetics.de - Training  - Hands-On Tutorials pdf


### 2.2 Static Force on Solenoid (TEAM 20) (Beginner)

This example is a convenient training for all those who want to do electromagnetic analysis with complex 3D geometries, because it contains most necessary skills for dealing with this.

The Team20 benchmark is a test example for electromagnetic analysis software tools. There are measured force-results available that we will use for comparison with the simulation-results. We will use a nonlinear B-H curve that includes saturation effects for the core and iron parts.




For meshing, we want to exploit the 'Non-Manifold' strategy, which automatically finds adjacent face pairs and creates conformal meshes (e.g. coincident nodes) at those interfaces. Thus, no Mesh-Mating conditions are needed any more. This feature is very powerful but only available in the newer versions of Simcenter/NX (best in 2406 or later).

Necessary time: 1 h.

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## Thank you for your attention

## Questions?

*Contact:*

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