A knowledge-based master modelling approach for whole engine design

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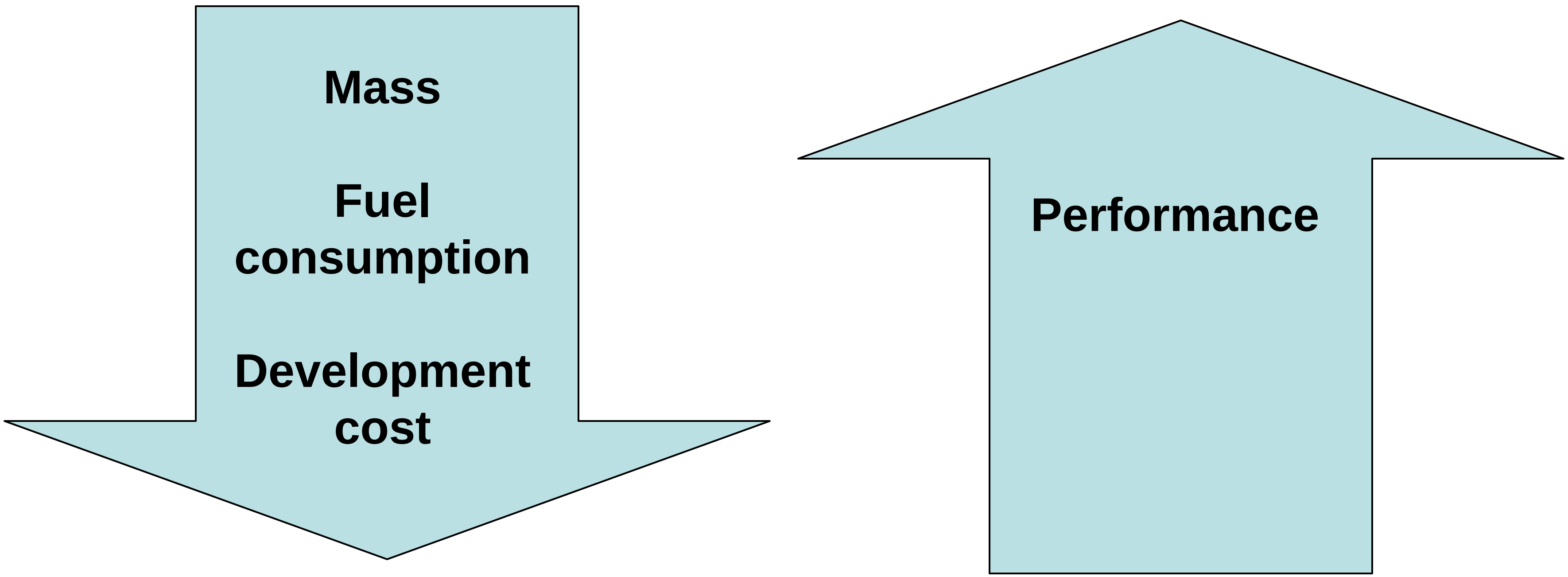
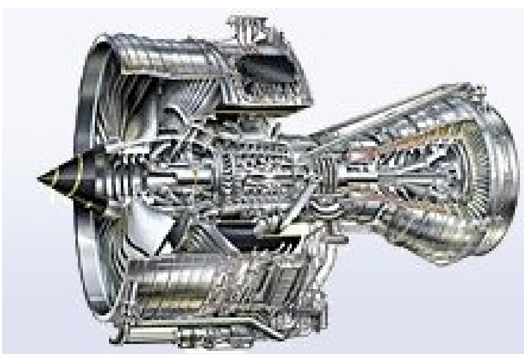
Some challenges of jet engine development



System-level performance



SYSTEM LEVEL

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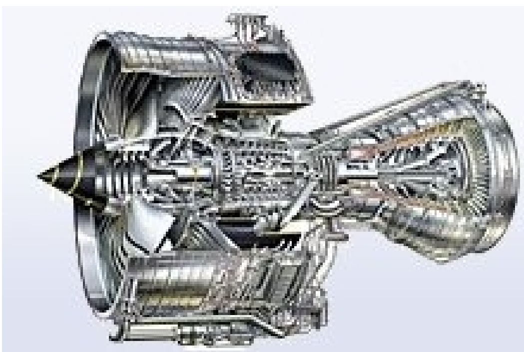
OEM vs. component developers



OEM

Component developer

- Continuous updates on configuration and design at system level not readily available
- Need for whole engine models for component developers

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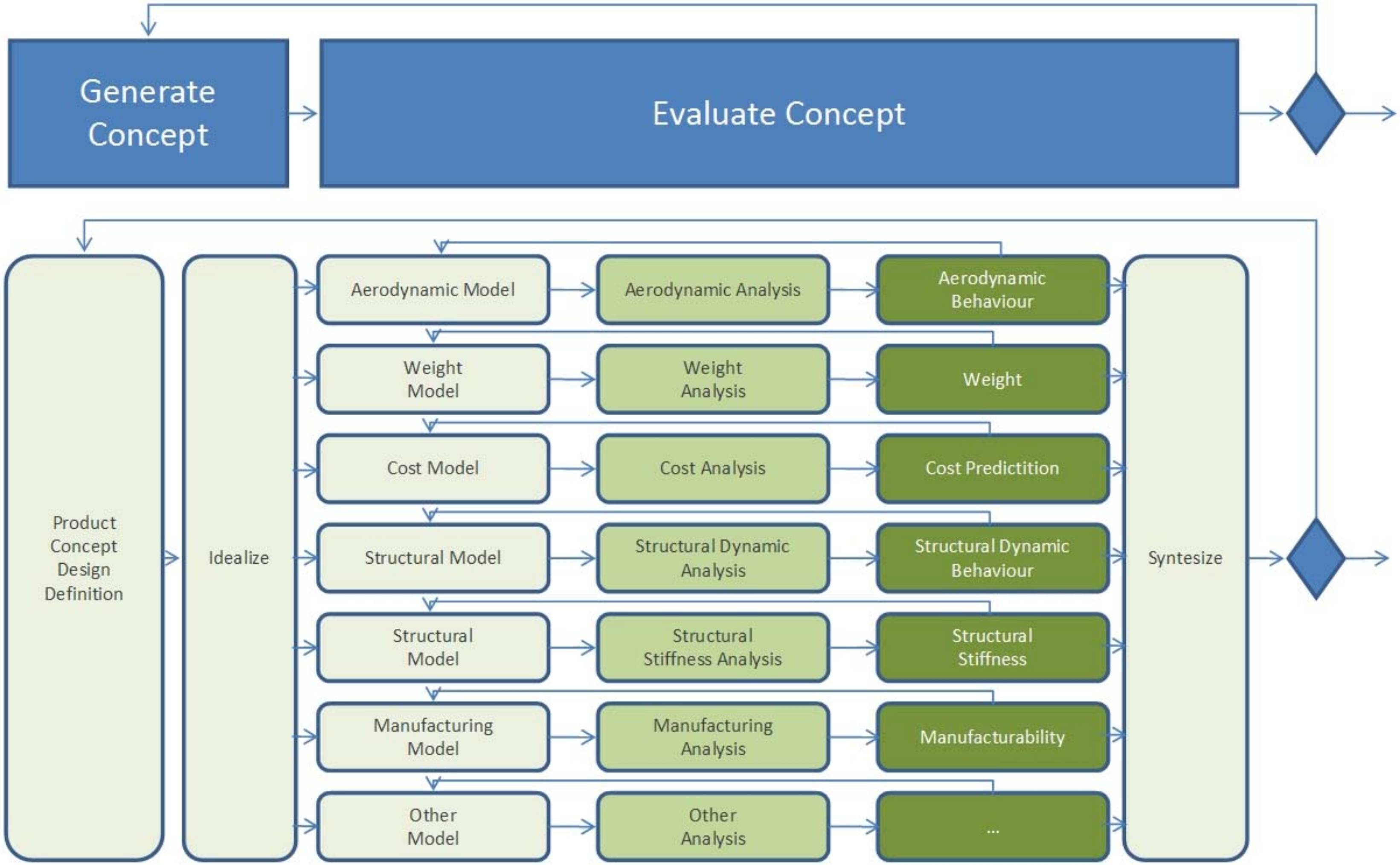
AS-IS: Unlinked simulation models



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NFFP5 - METOPIA

- Mechanical whole engine conceptual design and analysis
  - **MET**hod for **OP**timization **I**ntegration and **A**utomation
- Continuation of the pilot project NFFP4 Mechanical whole engine modeling
- Luleå University of Technology
- Volvo Aero Corporation

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METOPIA research questions

- How to **integrate** the product definition with analysis models to enable effective mechanical optimisation of different jet engine architectures?
- How can a common information be **distributed** effectively between several disciplines during whole engine system optimisation?

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State-of-the-practice

- VITAL, FP6
- VIVACE, FP6
- CRESCENDO, FP7

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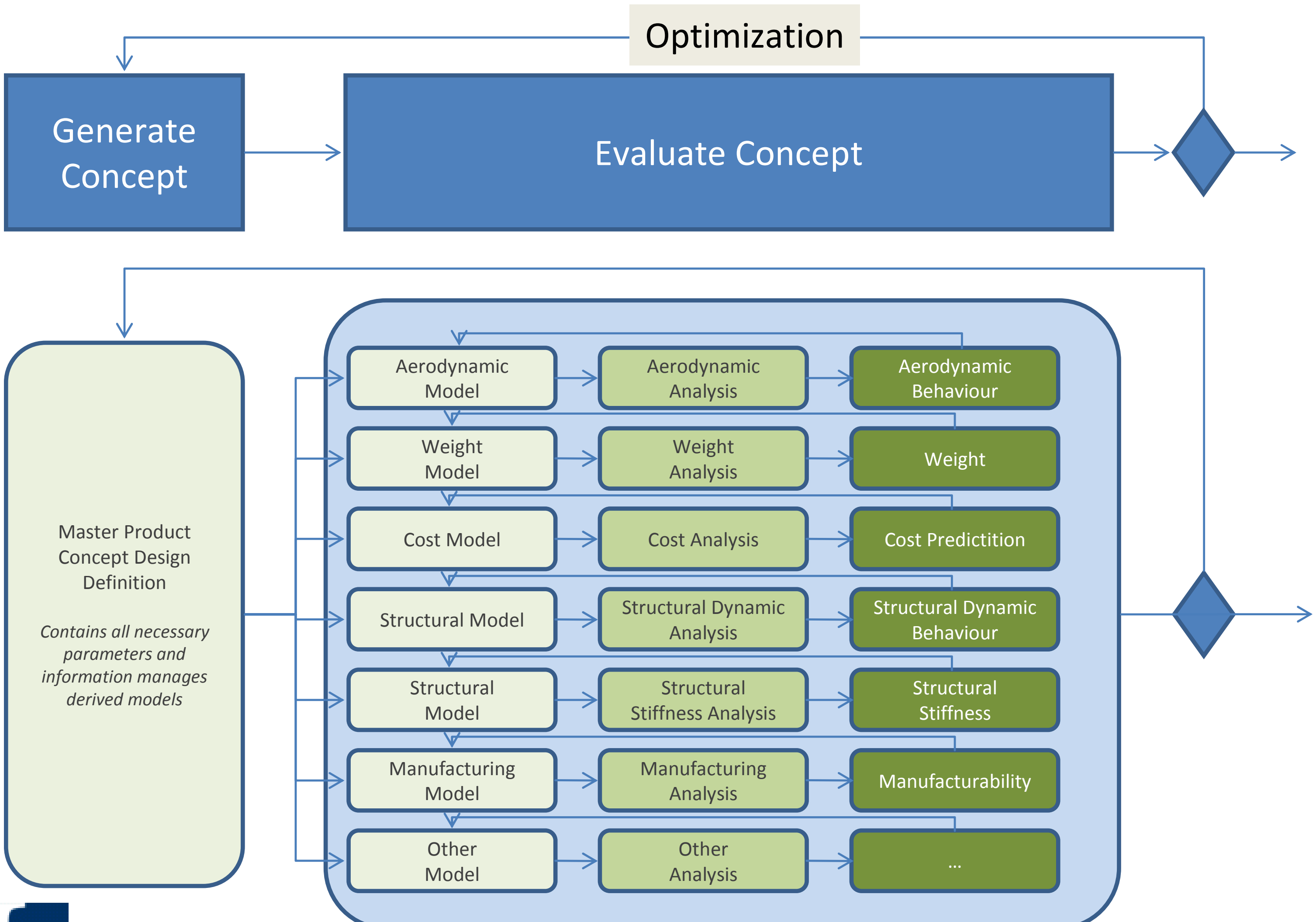
TO-BE: Knowledge-based master model approach



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Knowledge based engineering (KBE)

- Fundamental concept of the Master-model approach
- KBE-definition by Stokes (2001):
  - *"the use of advanced software techniques to capture and re-use product and process knowledge in an integrated way"*
- KBE aims at making engineering design more effective by
  - Automating repetitive CAD/CAE tasks
  - Showing design change implications on downstream activities

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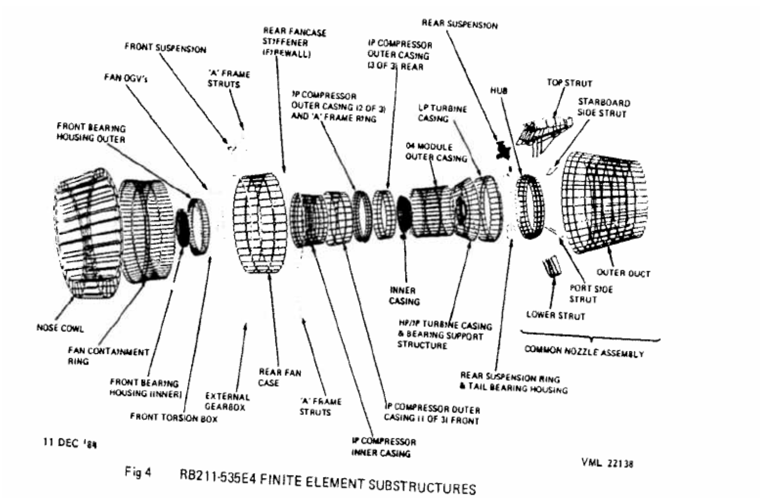
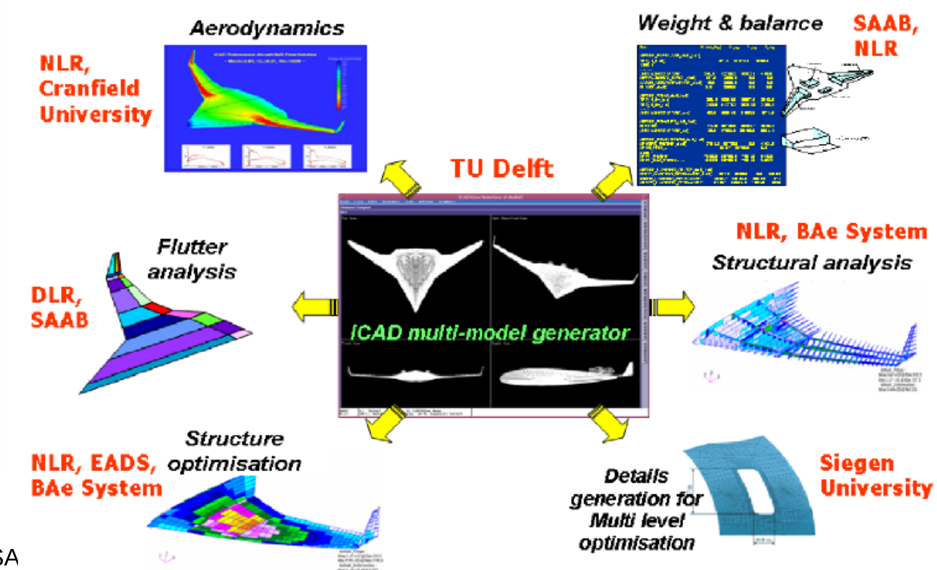
The State-of-the-art

- Semi configurable finite-element models
  - Lacking effective integration with e.g. the CAD-definition
- Common limitation
  - Either stand-alone integrated solutions or
  - supports only domain specific applications
- Opportunity for modelling methods that handle and create models for multidisciplinary applications
- Knowledge-based master models: an upcoming topic





METOPIA technology

- Fully automated design and analysis process
- Analysis
  - Weight
  - Rotordynamics
  - Displacement

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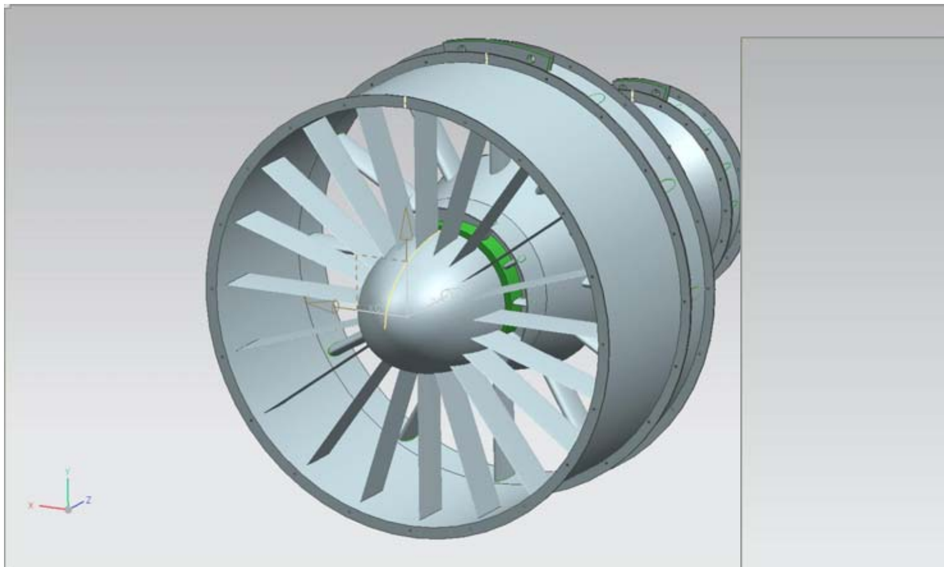
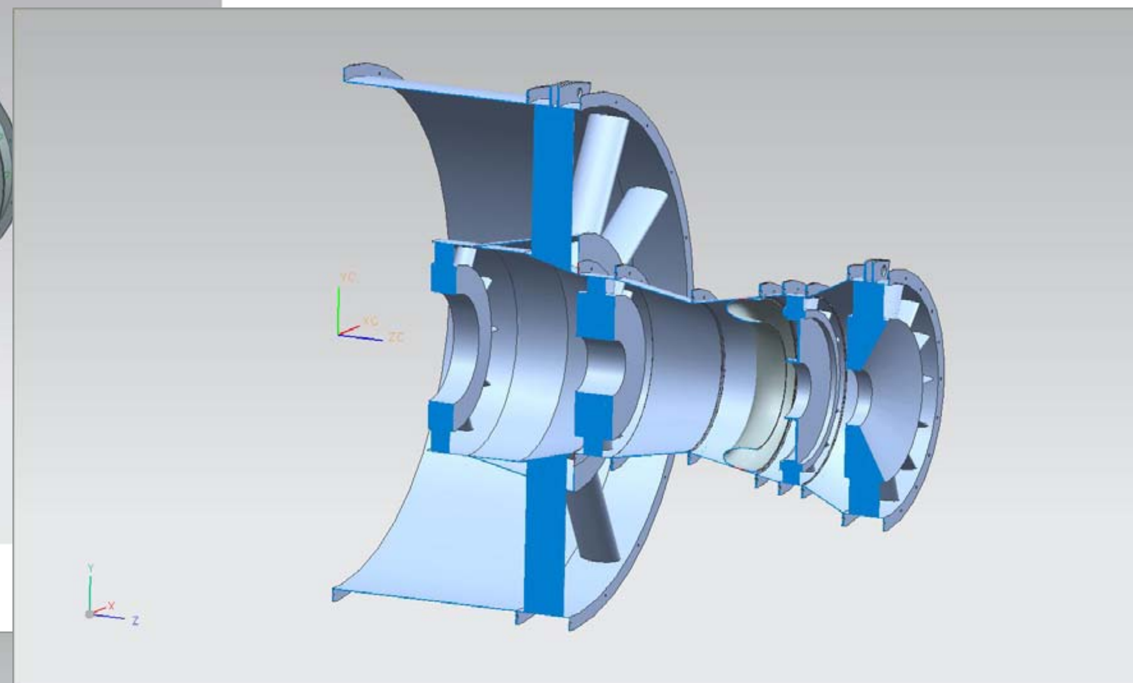
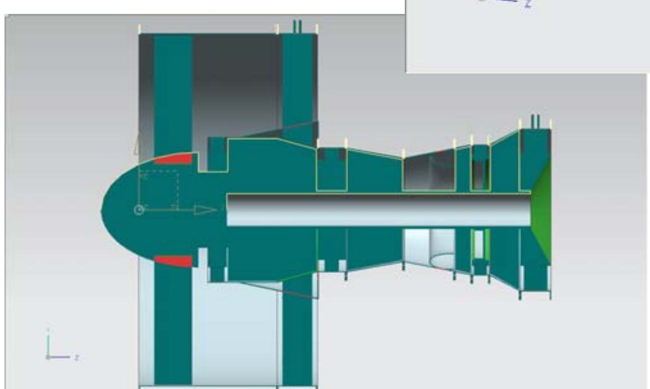
METOPIA geometry







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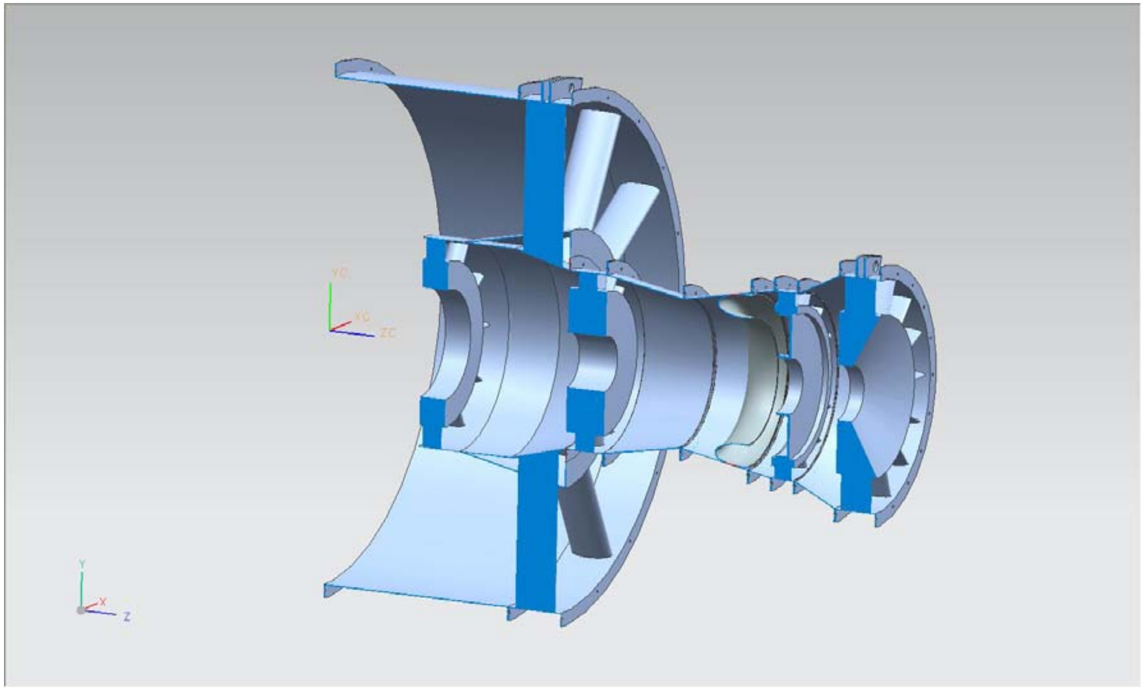
Automatic geometry configuration

- Number of struts
- Thicknesses
- Radii
- Lengths
- Cone angles
- Mount lugs



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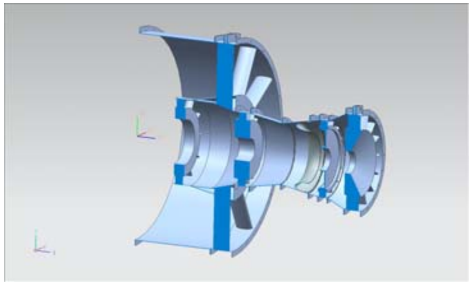
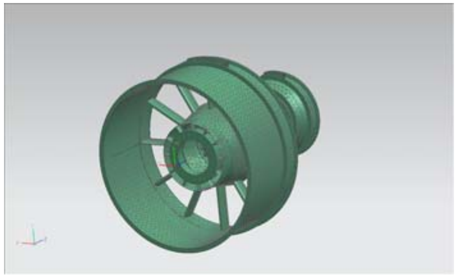
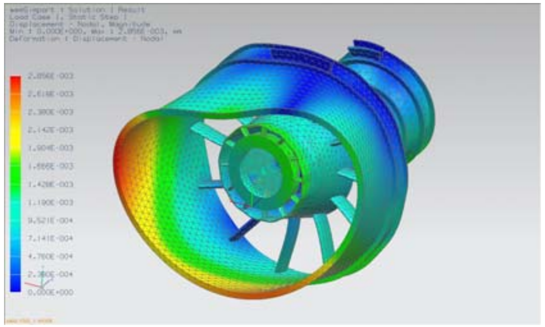
Automated design and analysis

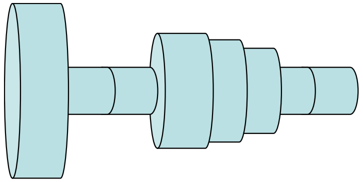


Automatic geometry generation and weight analysis



Automatic finite element model generation





1-D cylindrical beam elements

Automatic Rotordynamics analysis

Automatic displacement due to rotordynamical loads analysis

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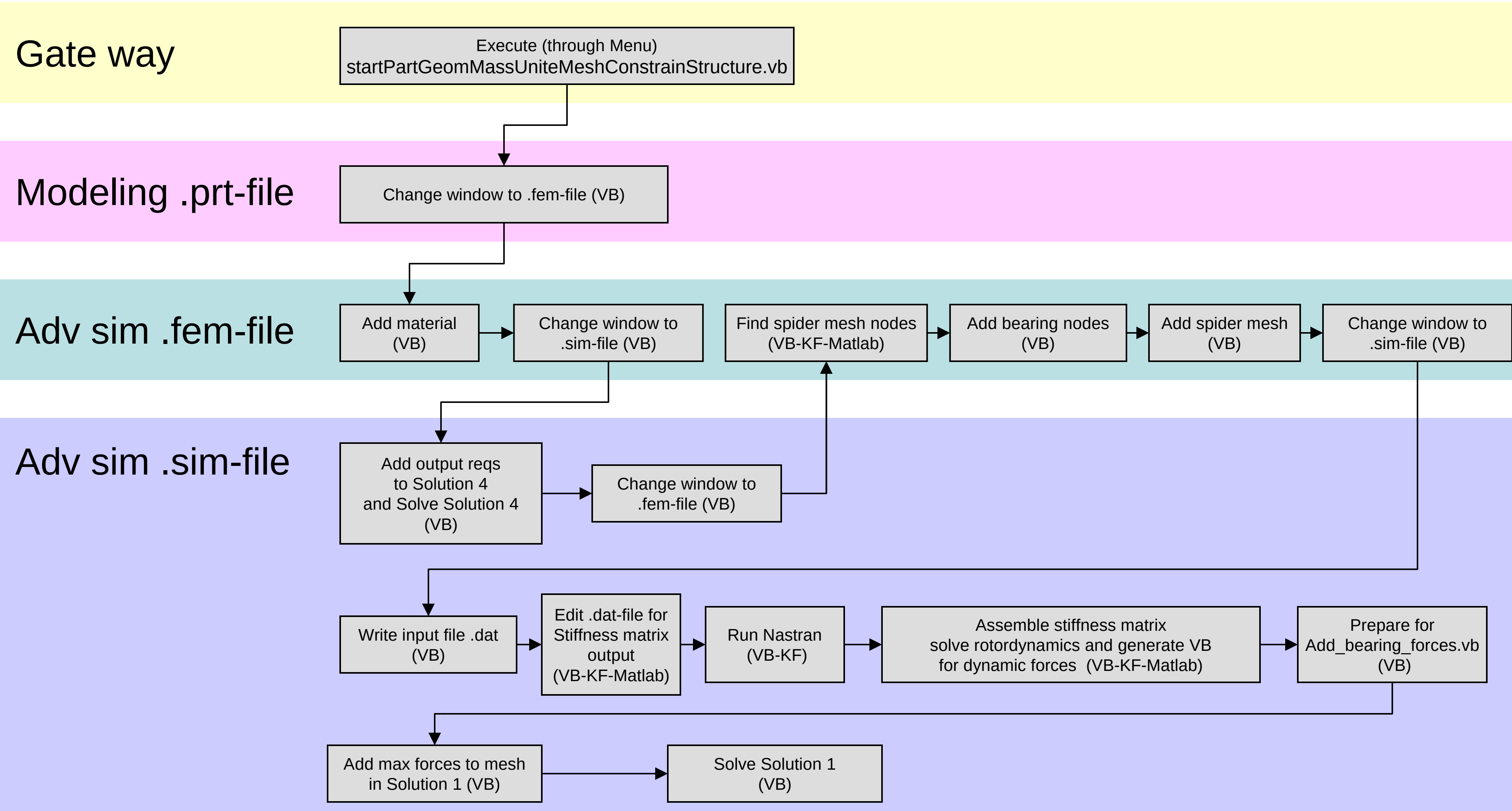
Journal chain



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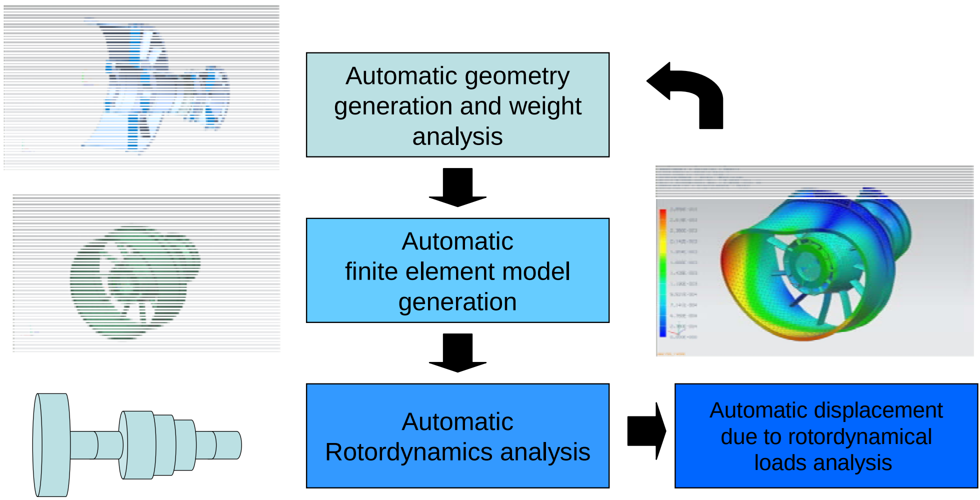
Siemens PLM NX - Matlab

- Knowledge fusion (KF)
  - Generate geometry
  - 3D meshing
  - Constraints
  - Start Matlab-executables
  - Start Nastran for stiffness matrix
  - Calculate weight
- Matlab
  - Write journals
  - Edit Nastran input file
  - Find spidermesh nodes
  - Assemble stiffness matrix
- Journals
  - Add childrule (KF)
  - 1D meshing
  - Add material
  - Write Nastran input file
  - Add rotordynamical loads
  - Switch windows



1-D cylindrical beam elements

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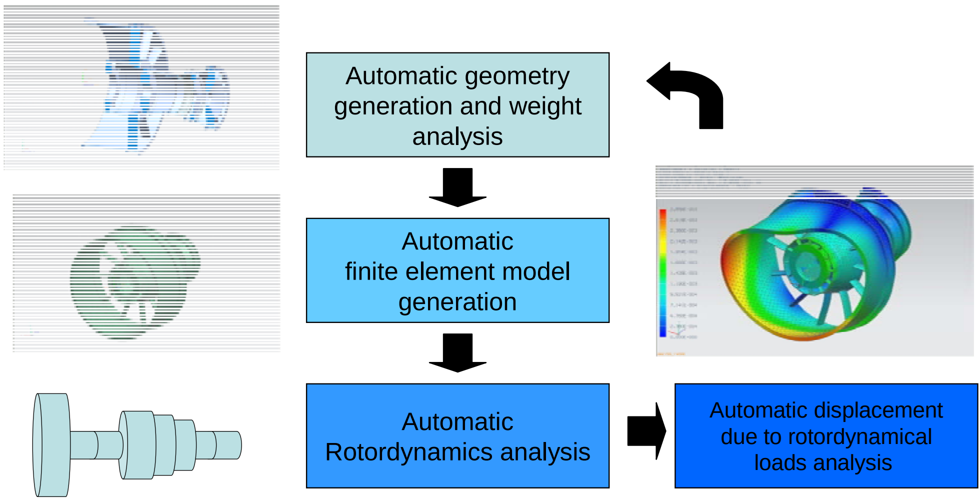
Knowledge fusion classes

- Geometry
  - 17 classes
- Mass
- Meshing and constraints
  - 8 classes



1-D cylindrical beam elements

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Benifits

- Develop components to optimise whole engine
- Automatic design
- Get boundary load more frequently
  - Swift change of model according to OEM requirements
- One product definition to rule them all!

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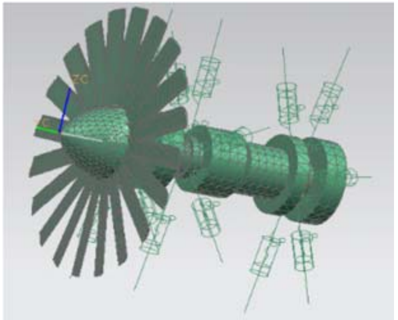
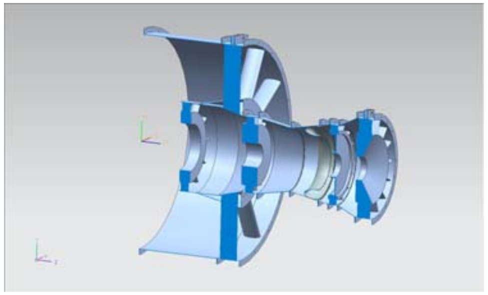
Ongoing work

- Optimisation
- 3D rotordynamics
- Validation
- More models
- More geometry
- Architectures





Thank you!