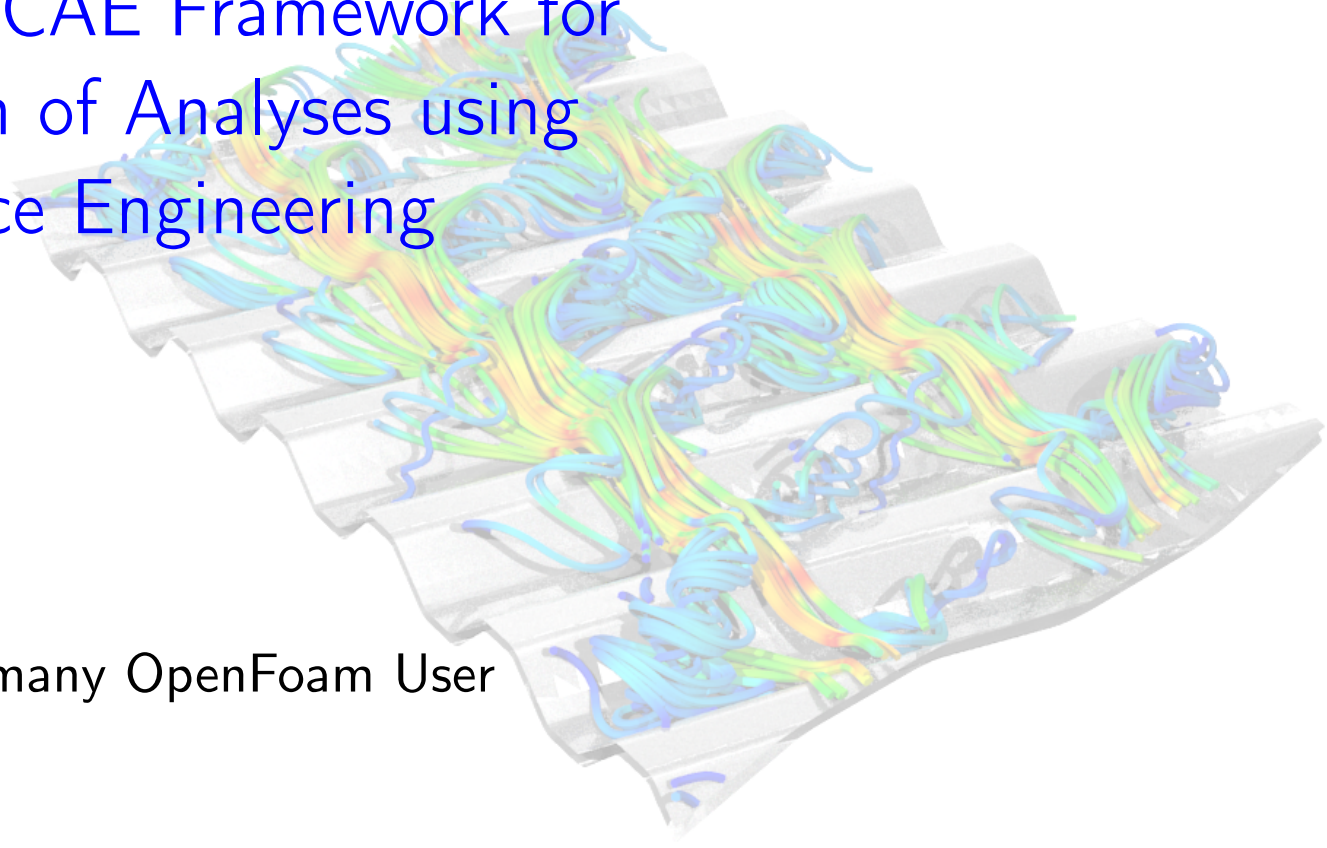
silentdynamics

The InsightCAE Framework for Automation of Analyses using Open Source Engineering Software



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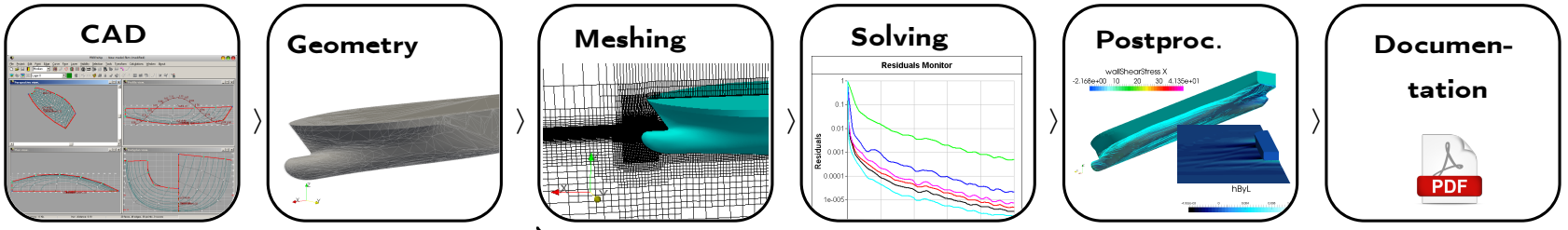
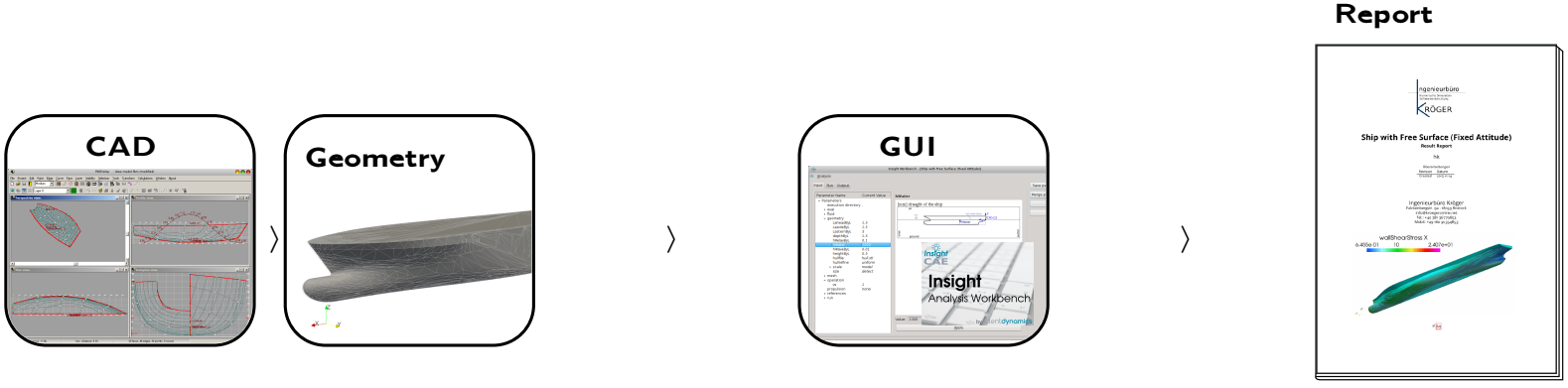
4th Northern germany OpenFoam User meetiNg 2016

Common practice: *manual* analysis workflow:



- labour consuming
- potentially complicated, error prone

InsightCAE: *automated* workflow:



Using CAE (CFD and/or FEM) productively for design tasks

- involves repeated analysis of numerous similar variants
  - quick and efficient, with minimum pre/post processing effort
  - accurate, following a best-practice
  - safe, without need to repeat things because of user errors!
- a thorough documentation of every analysis is needed
  - to review trends
  - backtrace errors

Using **open source** CAE software productively

- OSS often has open architecture with many possibilities for automation
- many independent software tools for similar tasks are available but with different strengths and weaknesses
  - need to combine and support multiple tools
  - one quickly ends up in complicated workflows
- $\Rightarrow$automation can hide complexity of the workflow

What is the idea/aim of "InsightCAE"?

- Conduct an "analysis" as much automated as possible

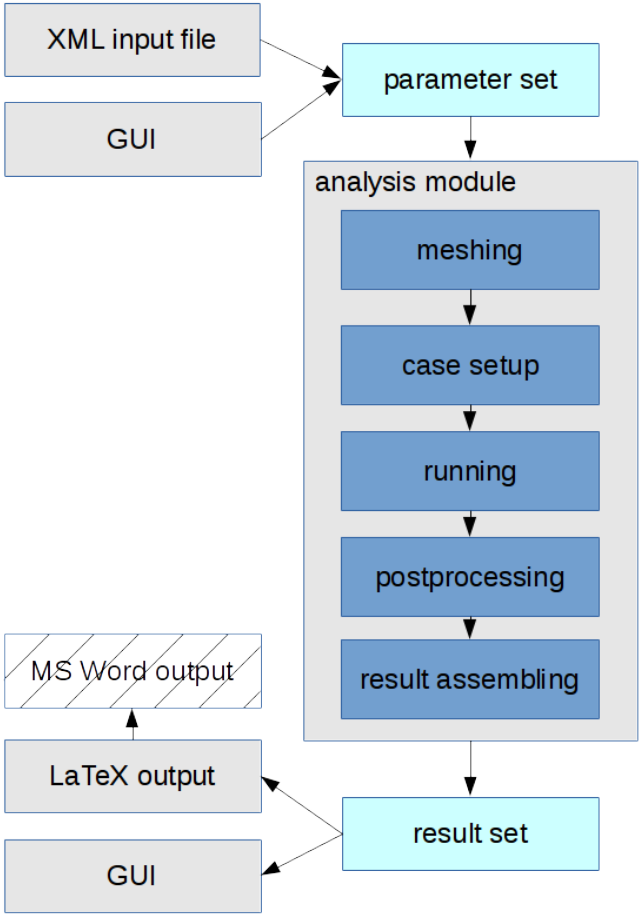
- Take a minimum of necessary parameters, include documentation of the parameters
- Implement a best practice for a given analysis/task
- Bundle addons, extensions and interfaces for all required external software utilities
- Deployment: provide installation package for all workflow-related software components

Applications in mind

- Design computations
  - manual investigation of many variants
- Optimization
  - automatic computation of many variants, e.g. by DAKOTA
- Quality control
  - implementation of testsuites and a standardized way for perfoming certain analyses

1. Shell scripts
   - Pro: simple, next logical step after command line
   - Con: limited, even floating point arithmetics is a mess
2. Python scripts
   - Pro: scalable, much freedom
   - Con: if project grows large: very difficult to debug and maintain
3. C++ project
   - Pro: mature, all possibilities, best maintainability
   - Con: programming skills, more boilerplate in project setup

⇒InsightCAE is written in C++
⇒with python wrappers



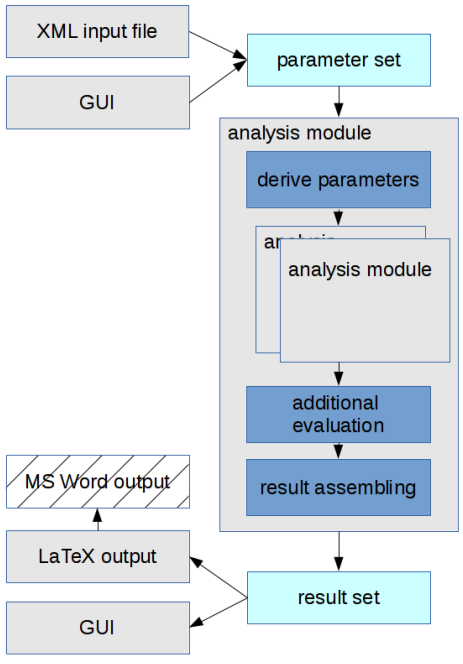
Here: simple CFD workflow
meshing > case setup > running

- basic entity: analysis module
  - contains problem specific algorithms
  - currently written in C++,
  - optionally python

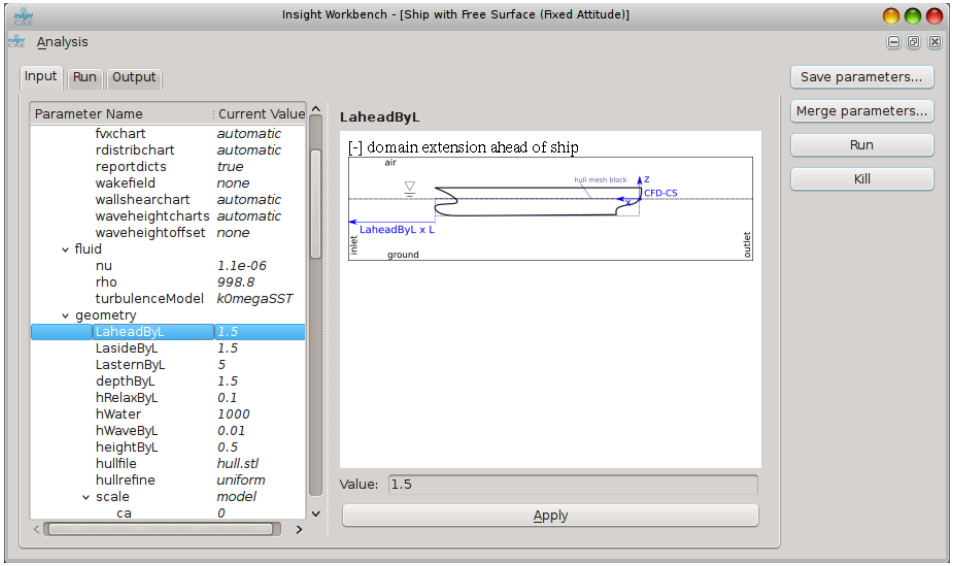
What is an “analysis”?
Can be:

- CFD simulation
- simple algebraic calculation
- call other analysis modules: e.g. parametric study

⇒Is not restricted to FEM/CFD!



- GUI for editing parameters / run analyses / preview results ("workbench")



Parameters Documentation / Help

- Alternative: Command line tool to perform analyses ("analyze")

```
$> analyze --double LaheadByL:2.3 inputfile.ist
```

- CAD module
  - emphasis on model processing
    $\Rightarrow$import model from any source
  - based on OpenCASCADE, import of IGES, STEP, BREP
  - models are described by scripts
  - graphical interpreter for scripts (“iscad”)
  - more features:
    - entity selection by filtering commands, e.g.

```
inlet=model.faces('isPlane && min(faceCoG.x)')
```

    - meshing (through gmsh)
    - fully parametric parts, constraint-based sketches, assemblies, part library, drawing export (DXF)

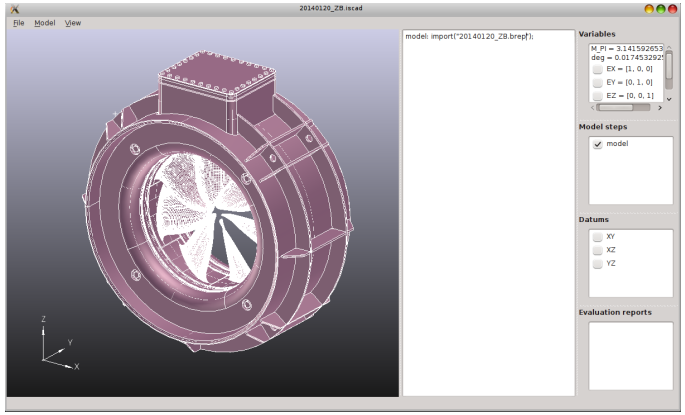
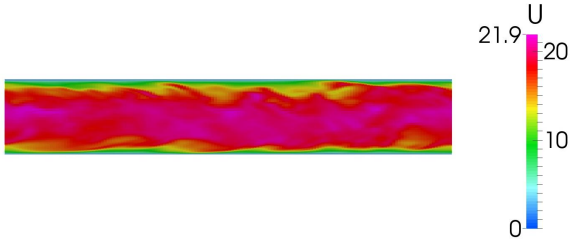


Figure: screenshot of “iscad”

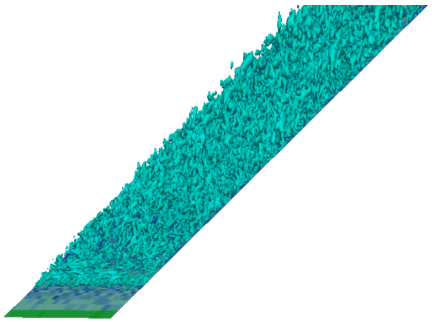
- in “toolkit”:
  - Execution of OpenFOAM commands through batch systems
  - When generating case setups, differences for multiple OpenFOAM version is accounted for (1.6-ext, 2.1, 2.2, 2.3)
  - Reasonable default solver settings for a number of solvers
  - Dictionary parser
- direct additions for OpenFOAM are included as well:
  - FEMDisplacement-BC for (steady) FSI with Code_Aster
  - additional discretization schemes
  - localized limited schemes for interpolation, gradient and sn-gradient
  - additional tools for post processing
  - additional BCs: inflowGenerator for LES/DNS

- in “toolkit”:
  - Generation of export-files
- direct additions (python modules):
  - other side of FEMDisplacement-BC for (steady) FSI with OpenFOAM
  - functions for analysis of bolted joints with bar elements and contact
  - through “iscad”: geometry handling, feature selection and meshing using Gmsh

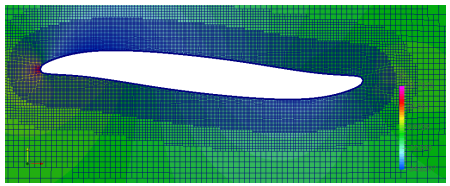
- simple generic analysis modules for validation (“modules”)
  - channel flow



  - flat plate



  - 2D airfoil

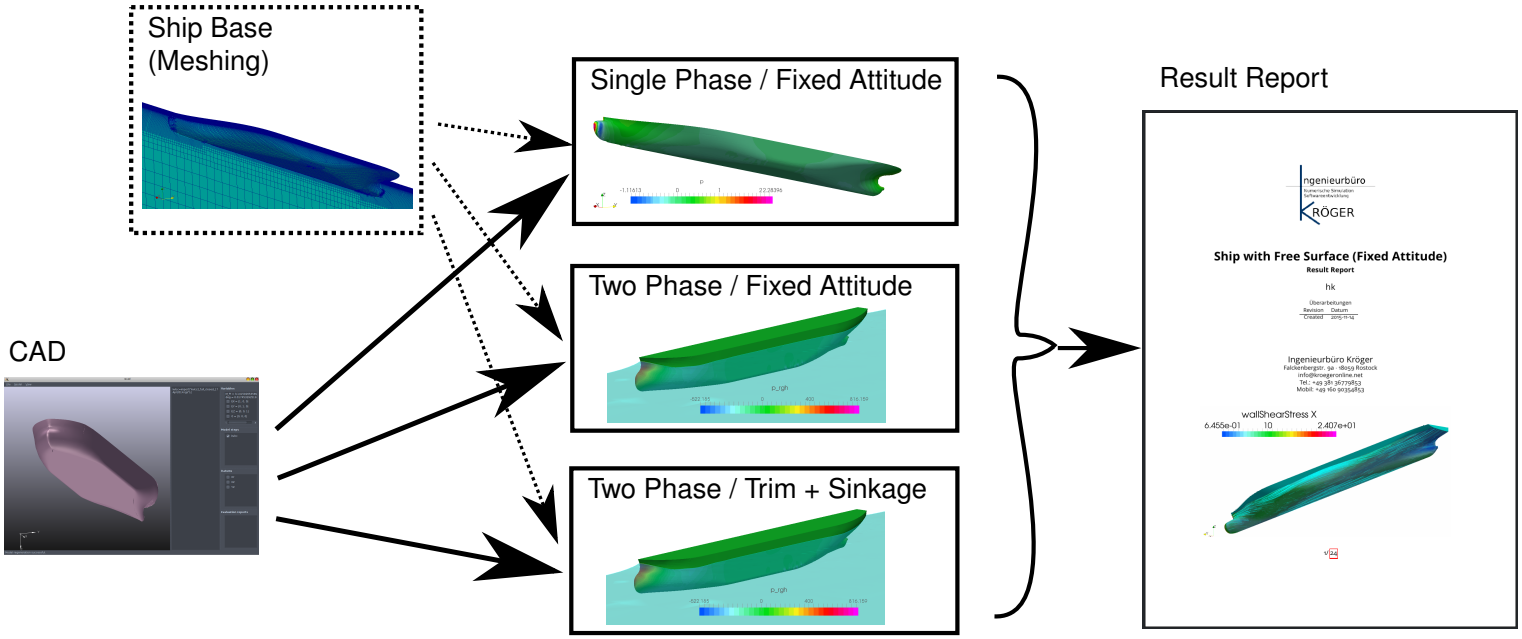


  - ...

- Addons are loadable containers for specific analysis modules.
- They need to be created for the specific problem under consideration
- Available so far:

Ship resistance analysis

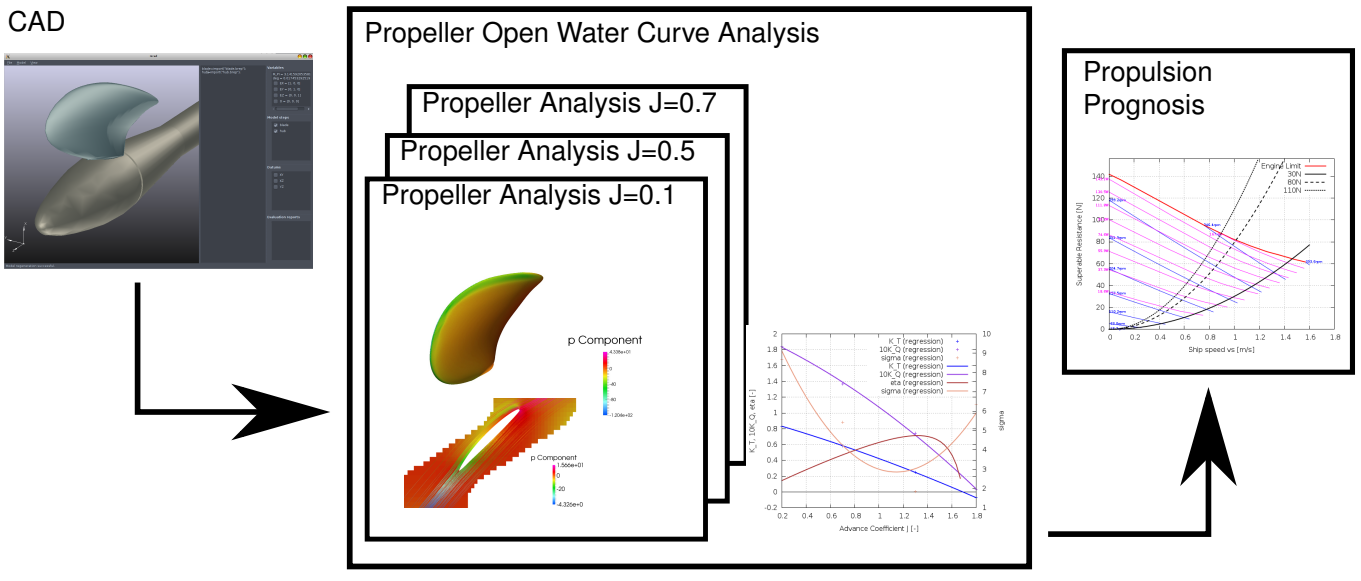
- CFD (OpenFOAM) of ship resistance
  - single phase (simpleFoam)
  - single phase with free surface (potentialFreeSurfaceFoam)
  - two phase (interFoam or LTSInterFoam)
  - two phase with trim and sinkage (LTSInterDyMFoam)



- inheritance: meshing is (almost) the same for all analyses
- minimum parameters:
  - geometry of domain can be computed from given STL geometry
  - single parameter for resolution n_{ax}
  - BL thickness is estimated, y^+ is set accordingly

Marine propeller and propulsion analysis

- CFD (OpenFOAM) of single operation points and open-water curves (meta analysis)
  - free propeller
  - ducted propeller
  - axial pump
  - optimal diameter, optimal rpm, propulsion prognosis



Hydrodynamic bearing analysis

- CFD (OpenFOAM) of hydrodynamic bearings, single excentricity or characteristic curve/field (meta analysis)
  - circular journal bearing
  - multi-segment journal bearing
  - multi-segment journal bearing with fluid-structure interaction (Code_Aster)

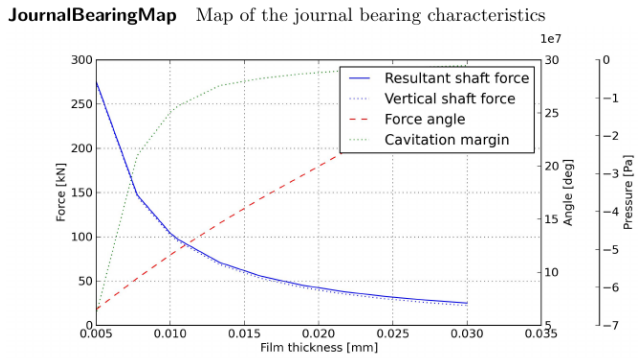
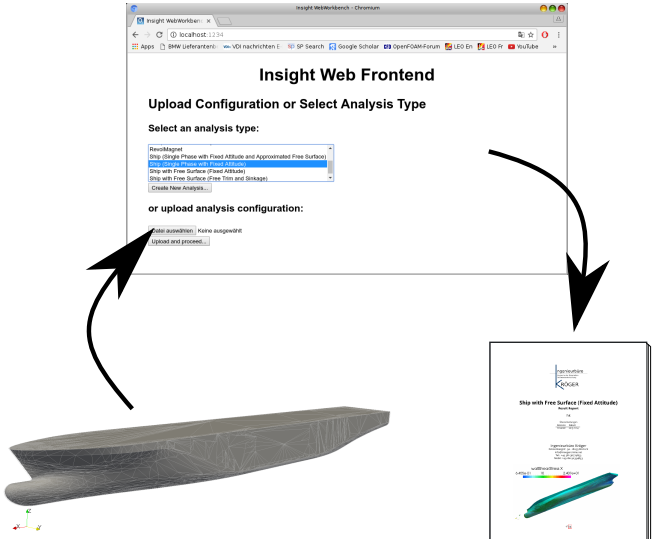


Figure: Journal bearing characteristic map

- WiP: Web-Frontend ("web-workbench") for usage e.g. in on-premise clouds
- Integration in graphical programming language (DICE?)
- Windows version of Workbench (Remote execution of external tools on linux machine or cluster)



- InsightCAE shall
  - be an automation framework for analysis tasks,
  - connect multiple necessary tools,
  - encapsulate complicated workflows,
  - thus help reducing errors
  - and increase quality of daily work

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