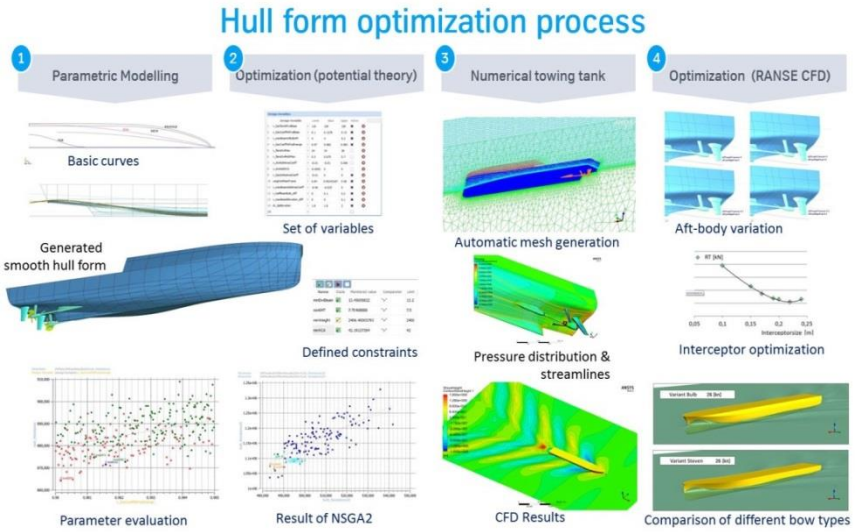
Virtual prototyping of fully appended naval vessels by integrating ANSYS-CFX into the hull form optimization process

September 28, 2017 | Tanja Richardt
thyssenkrupp Marine Systems



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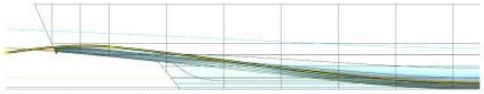
Agenda

- Introduction
- Parametric modeling of hull form and appendages
- Integration of ANSYS-CFX in CAESES
- Application
  - Optimization OPV
  - Aft-body parameter variation
  - Interceptor optimization
  - Comparison of different bow shapes
- Conformity to model test results
- Conclusion

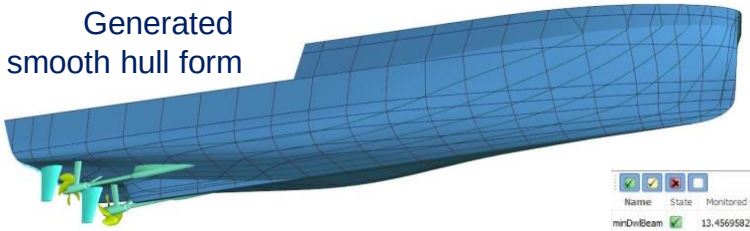
Hull form optimization process

1. Parametric Modeling
2. Optimization (Potential flow)
3. Numerical towing tank
4. Optimization (RANSE)

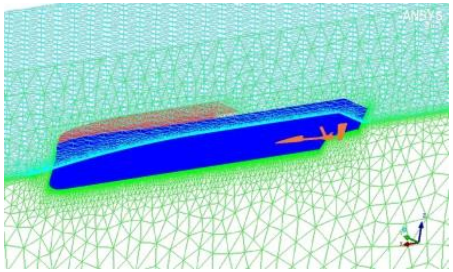
Basic curves



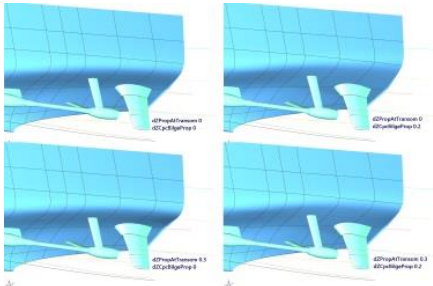
Generated smooth hull form



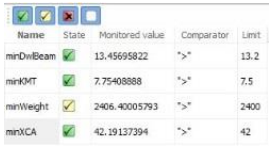
Variables



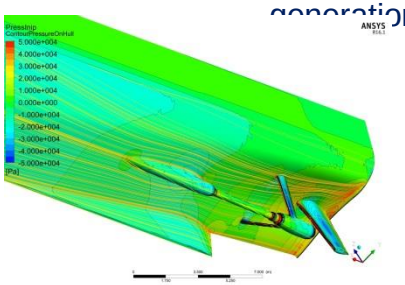
Automatic mesh generation



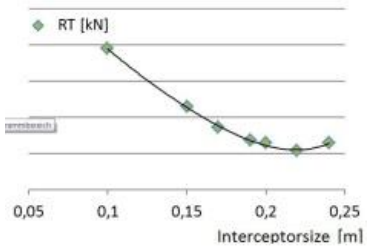
Aft-body variation



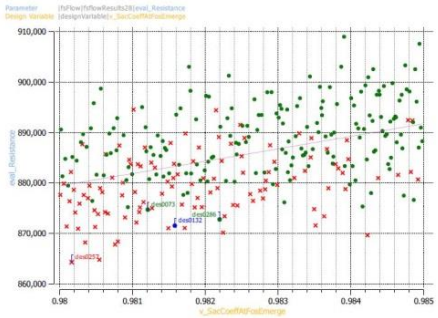
Constraints



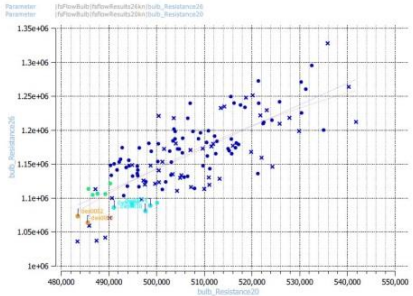
Pressure distribution & streamlines



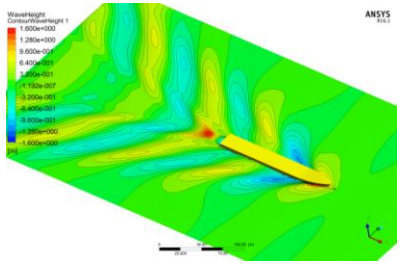
Interceptor optimization



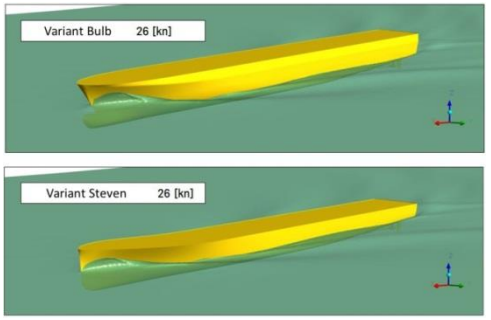
Parameter evaluation



Result of multi-objective optimization

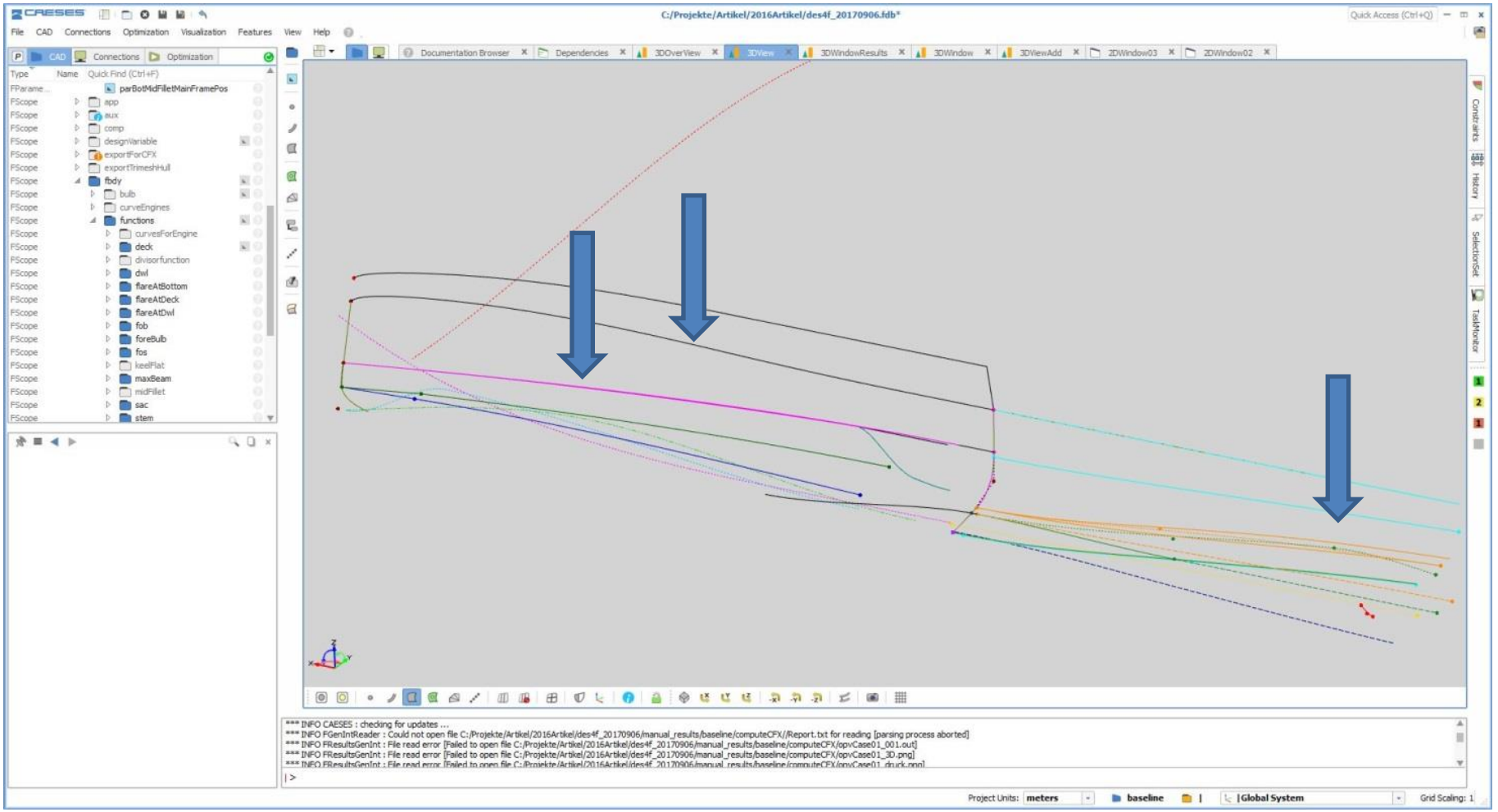


CFD Results

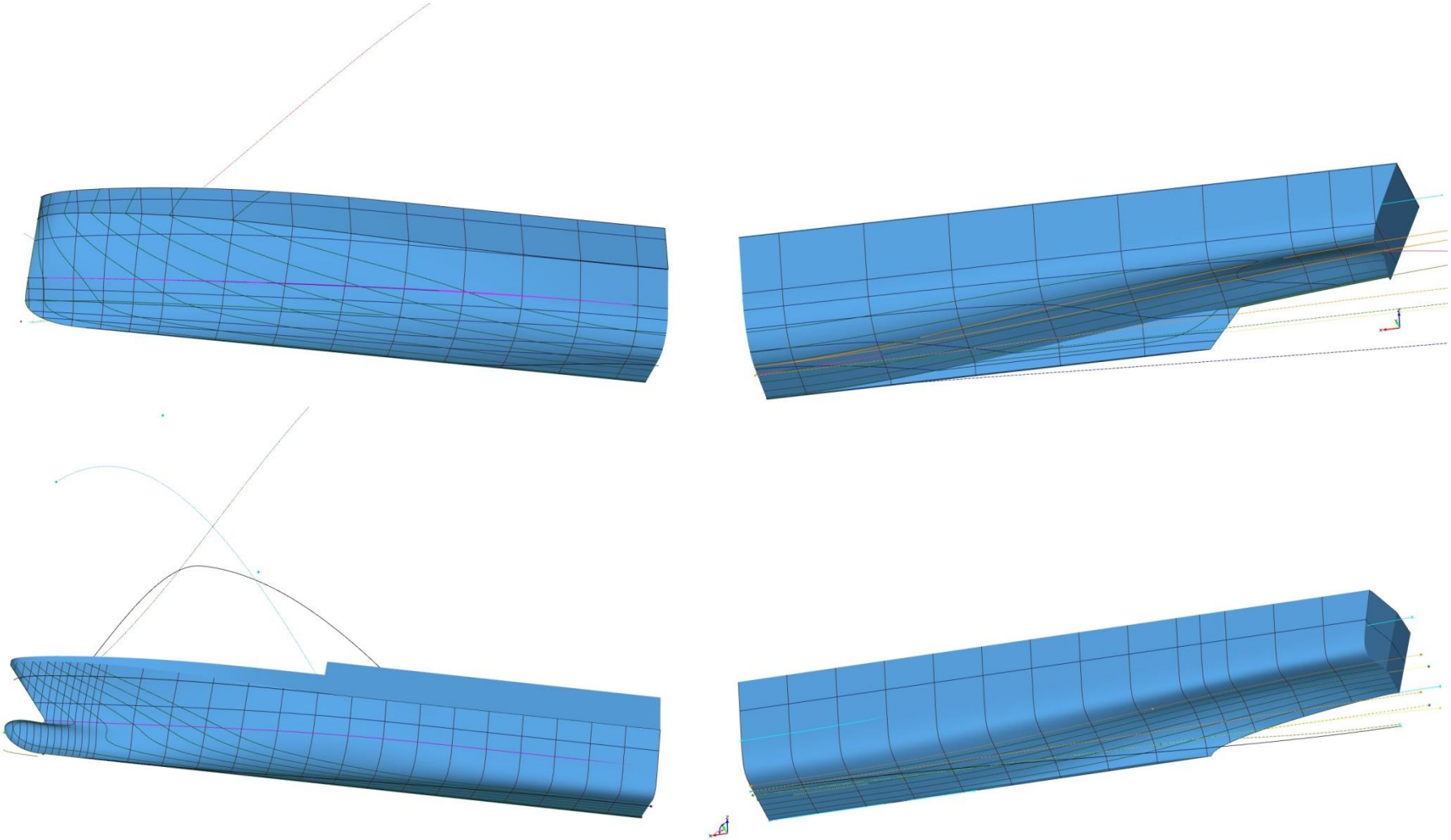


Comparison of different bow types

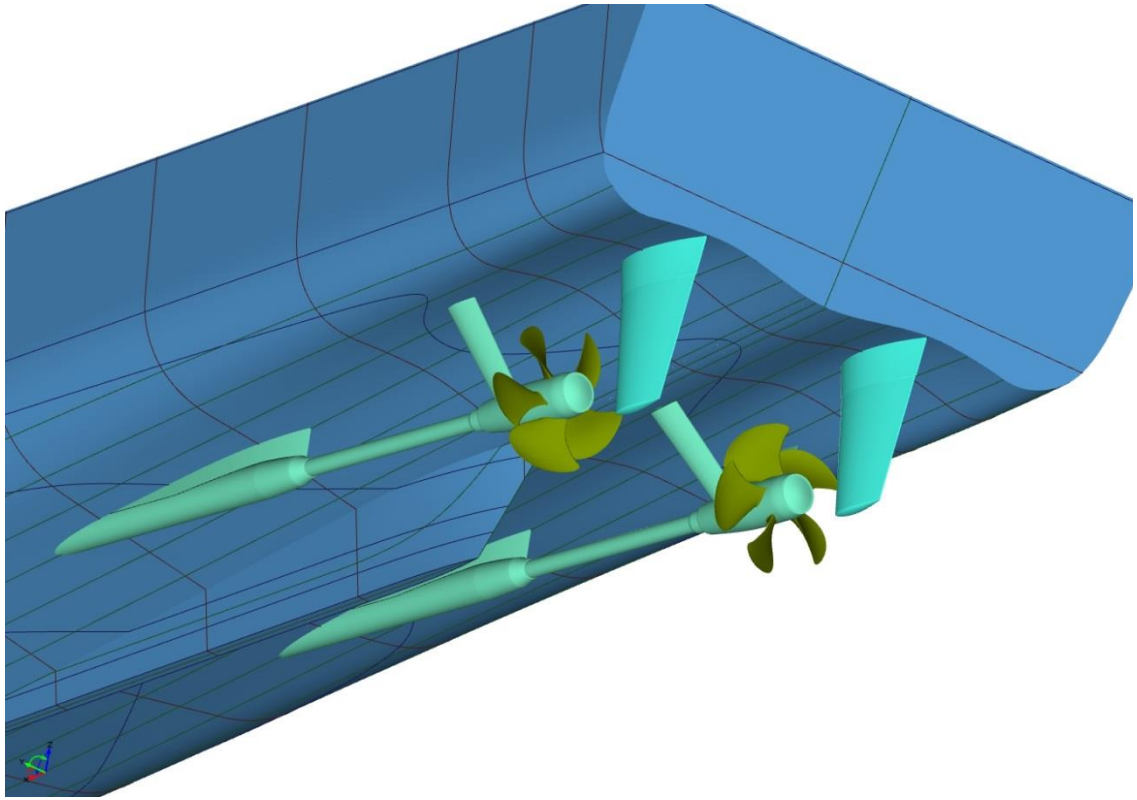
Parametric modeling

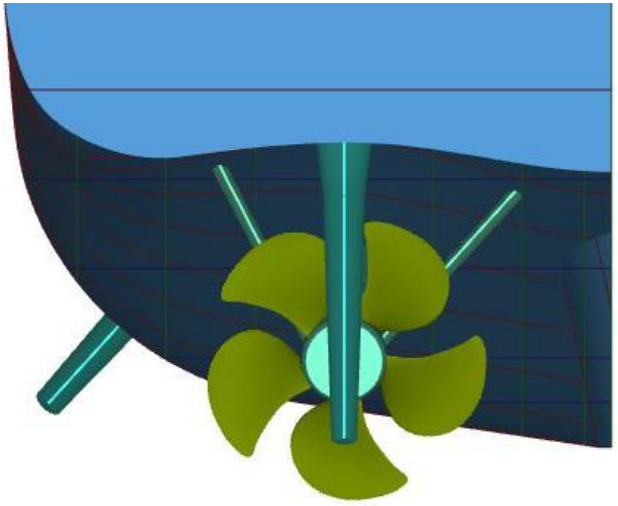


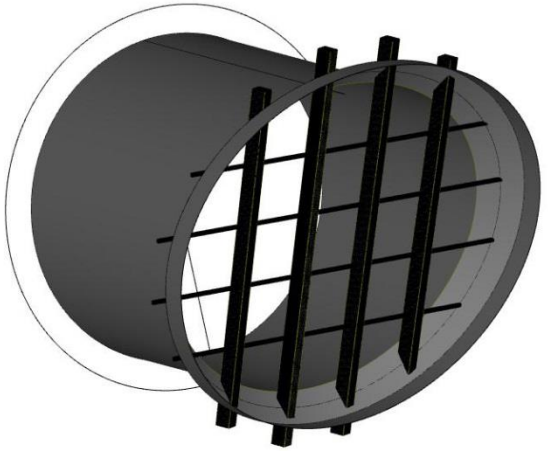
Parametric modeling



Appendages

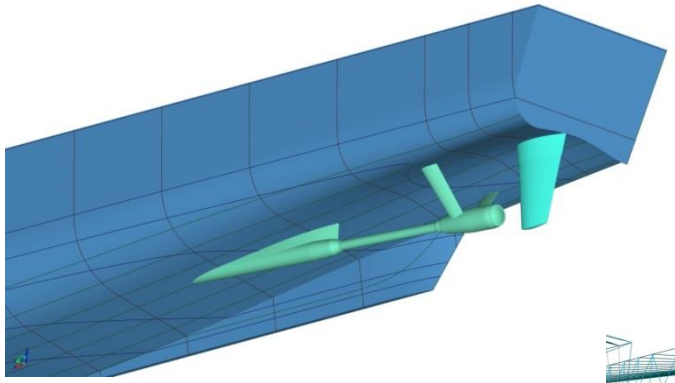


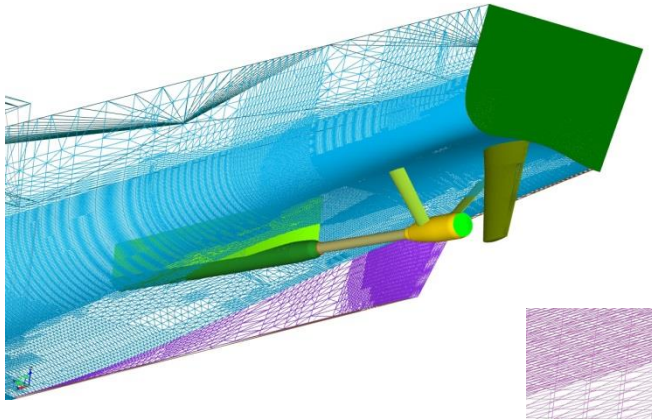


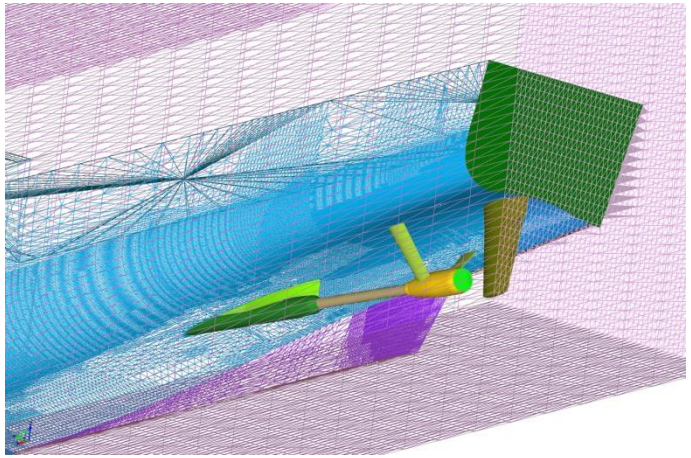


Geometry export

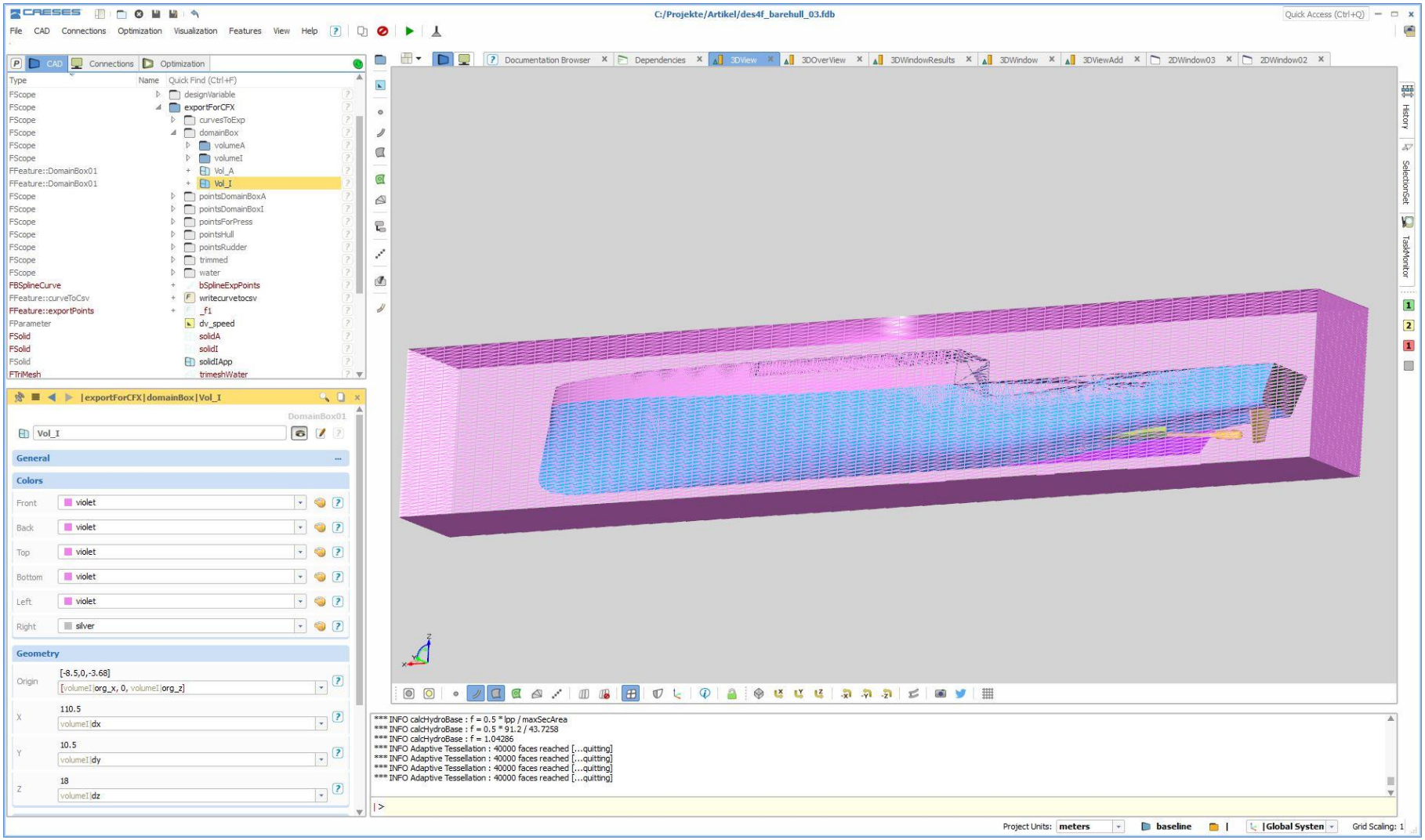
Surfaces → Trimeshes → Solids







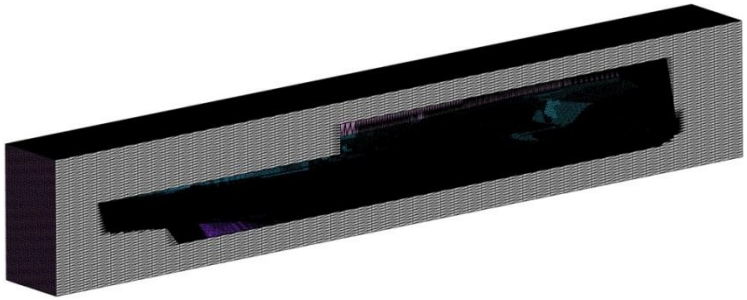
Geometry export

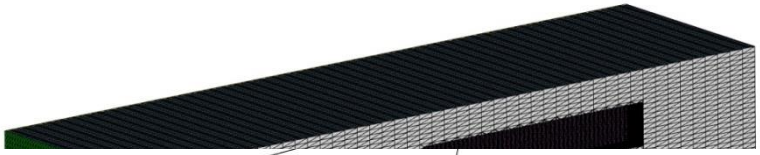


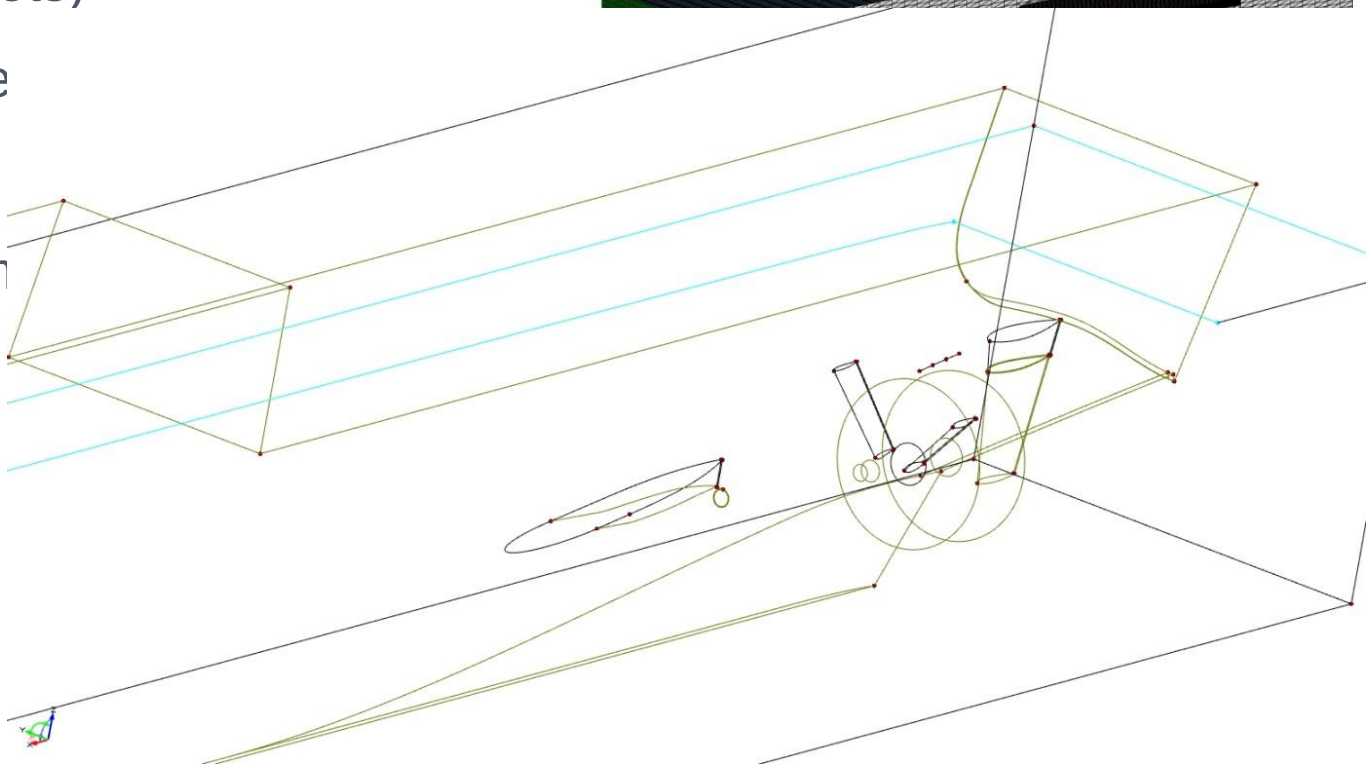
Integration of ANSYS CFX -Exports

Export:

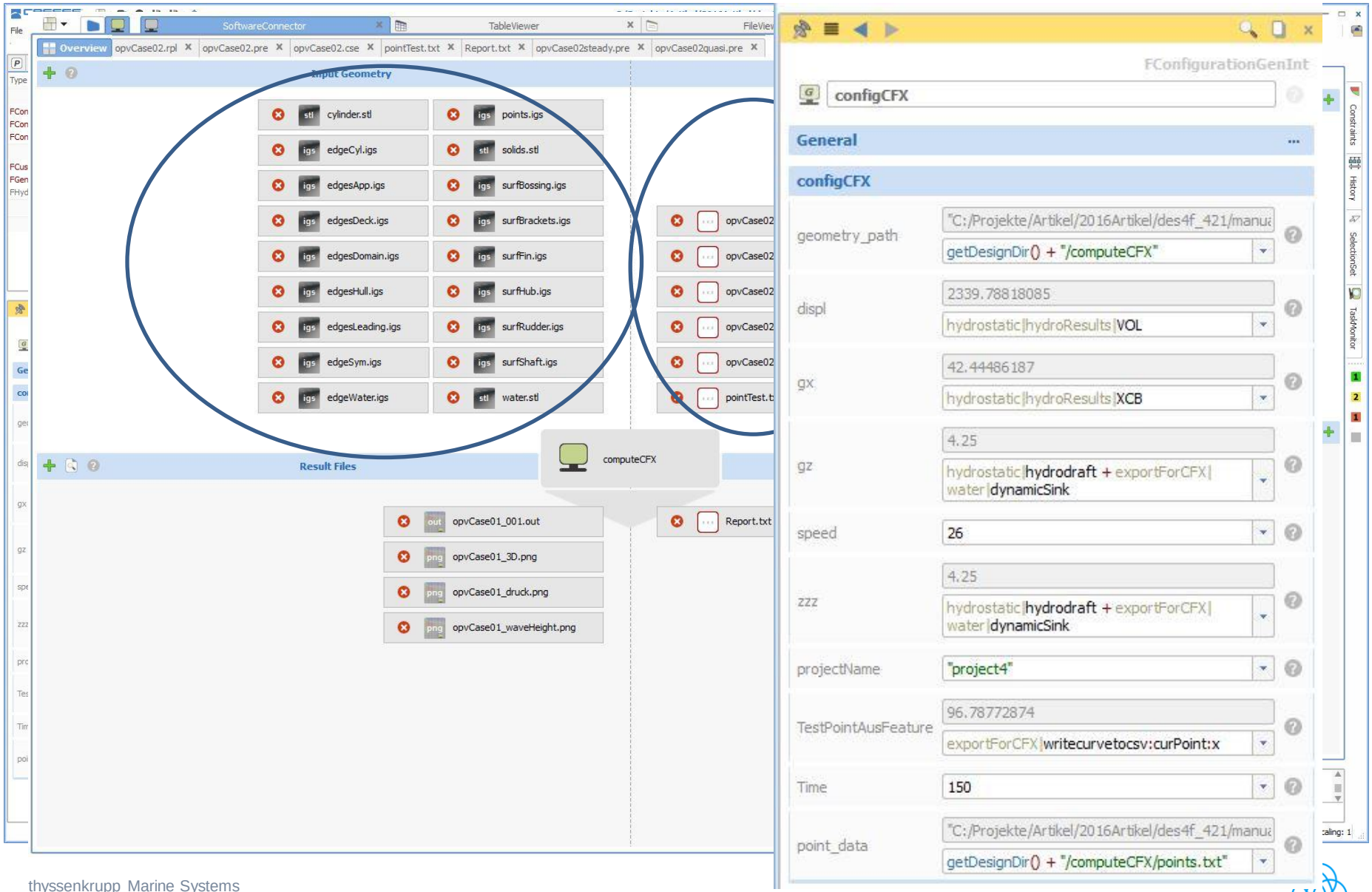
- Solids (Domain)
- Trimesh (Watersurface)
- Surfaces (Brackets)
- Curves (All edge
- Points
- Geometry inform







Integration of ANSYS CFX – Software connector

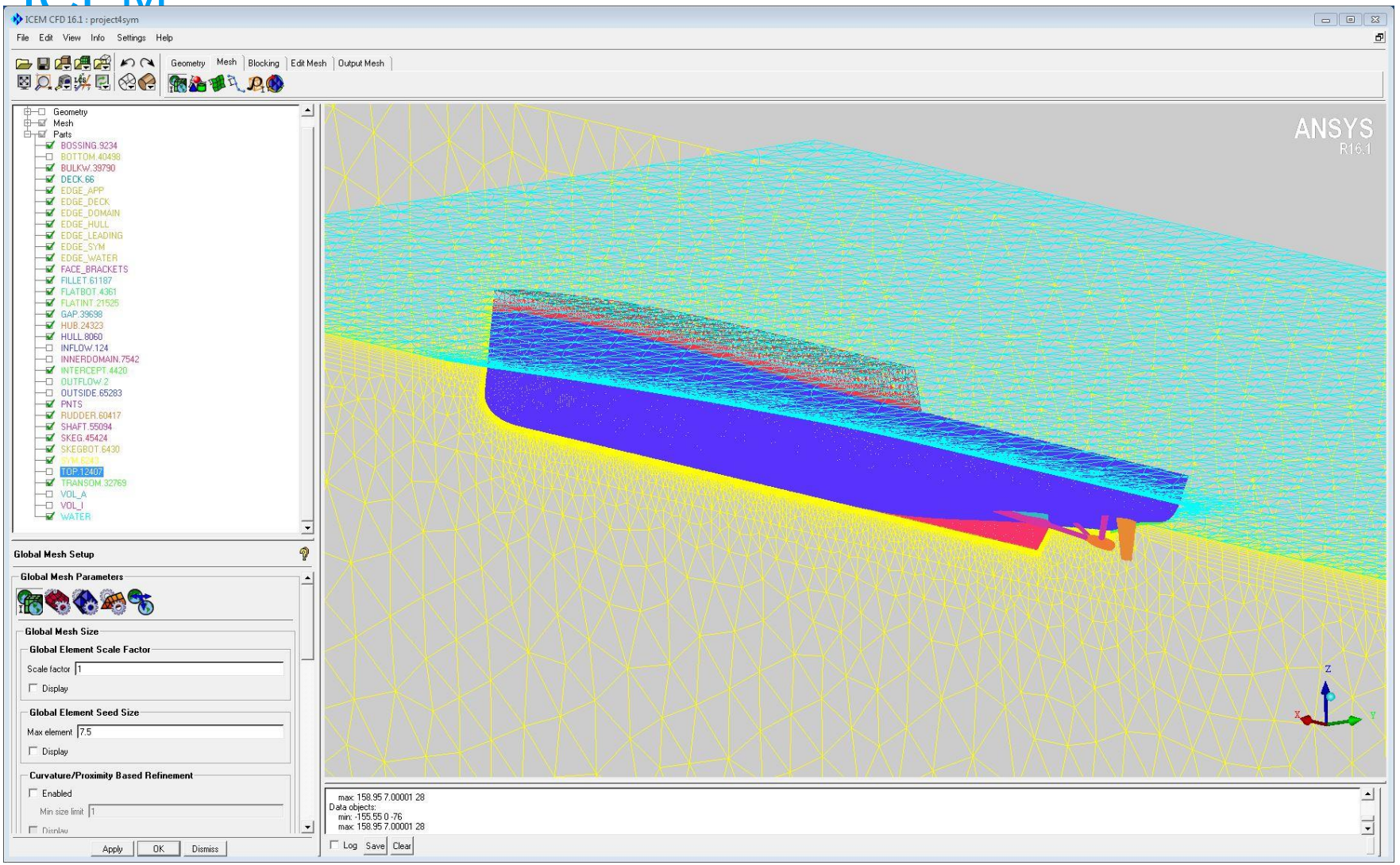


Integration of ANSYS CFX – Batch file

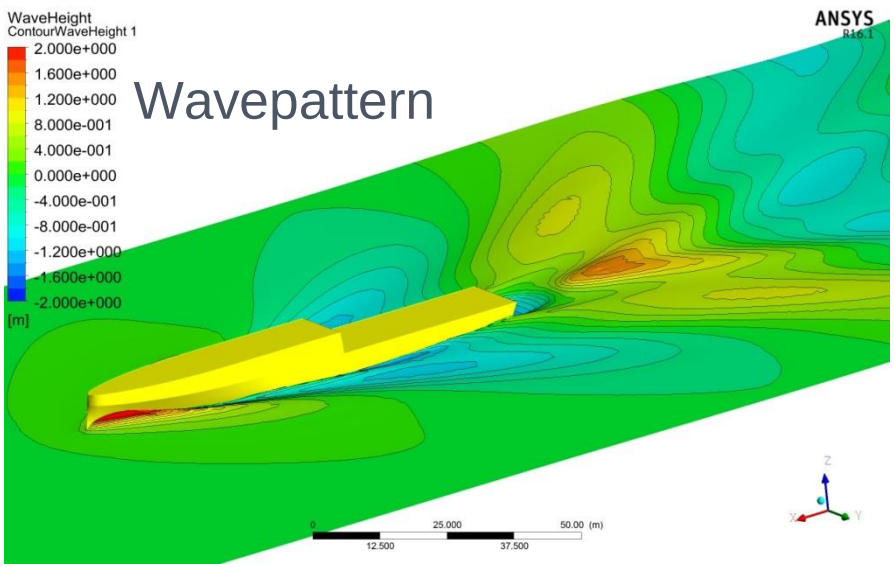
- ICEM - meshing
- CFX Pre - generating Input-Files
- CFX Solver - steady and transient calculation
- CFX Post - Evaluation of results

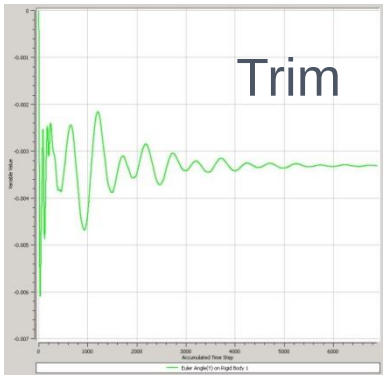
```
@echo off

cls

@echo Start Meshing.....
CALL "C:\Program Files\ANSYS Inc\v161\icemcfd\win64_amd\bin\icemcfd.bat" -batch -script opvCase02.rpl

@echo CFX PRE.....
"C:\Program Files\ANSYS Inc\v161\CFX\bin\cfx5pre.exe" -batch opvCase02quasi.pre

@echo CFX PRE.....
"C:\Program Files\ANSYS Inc\v161\CFX\bin\cfx5pre.exe" -batch opvCase02steady.pre

@echo CFX SOLVE...
"C:\Program Files\ANSYS Inc\v161\CFX\bin\cfx5solve.exe" -batch -parallel -partition 4 -par-local -def "opvCase02steady.def" -fullname opvCase02steady_001

@echo CFX SOLVE...
"C:\Program Files\ANSYS Inc\v161\CFX\bin\cfx5solve.exe" -batch -parallel -partition 4 -par-local -def "opvCase02.def" -initial opvCase02steady_001.res -fullname

@echo CFX POST...
"C:\Program Files\ANSYS Inc\v161\CFX\bin\cfx5post.exe" -batch opvCase02.cse"

```

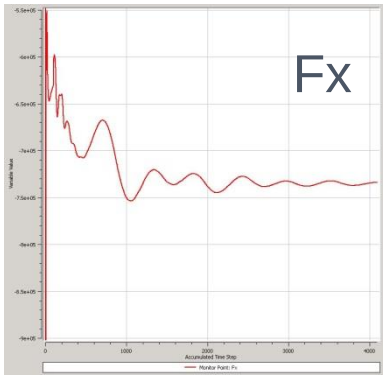
Integration of ANSYS CFX – Mesh generation by ICEM

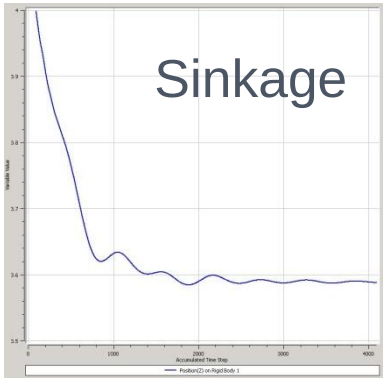


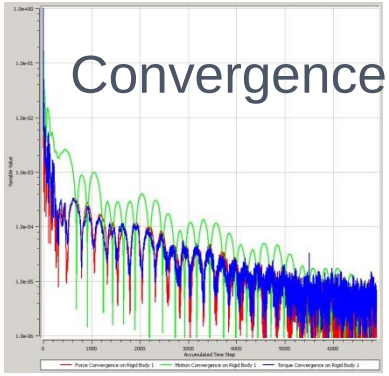
Integration of ANSYS CFX – CFX POST

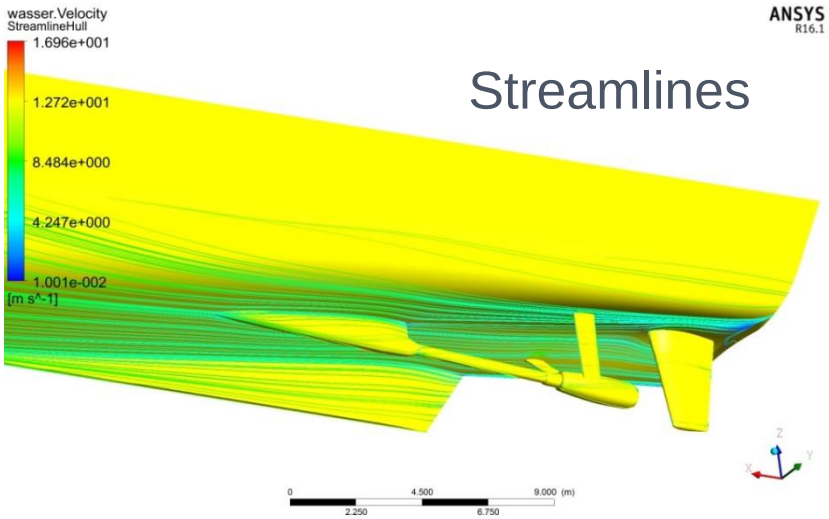


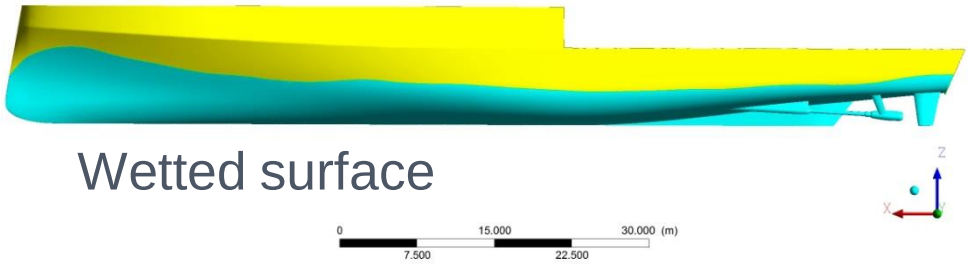












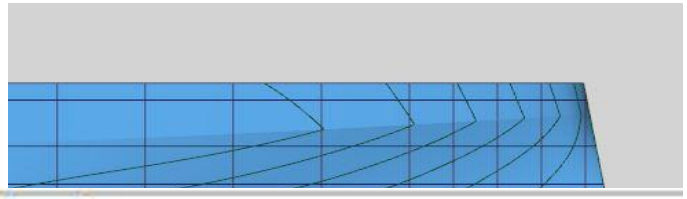
Hull form optimization – OPV (LoA = 91.2 m)

Displacement = 2400 t, v = 20 kn, 26kn

Displacement = 2200 t, v = 28 kn

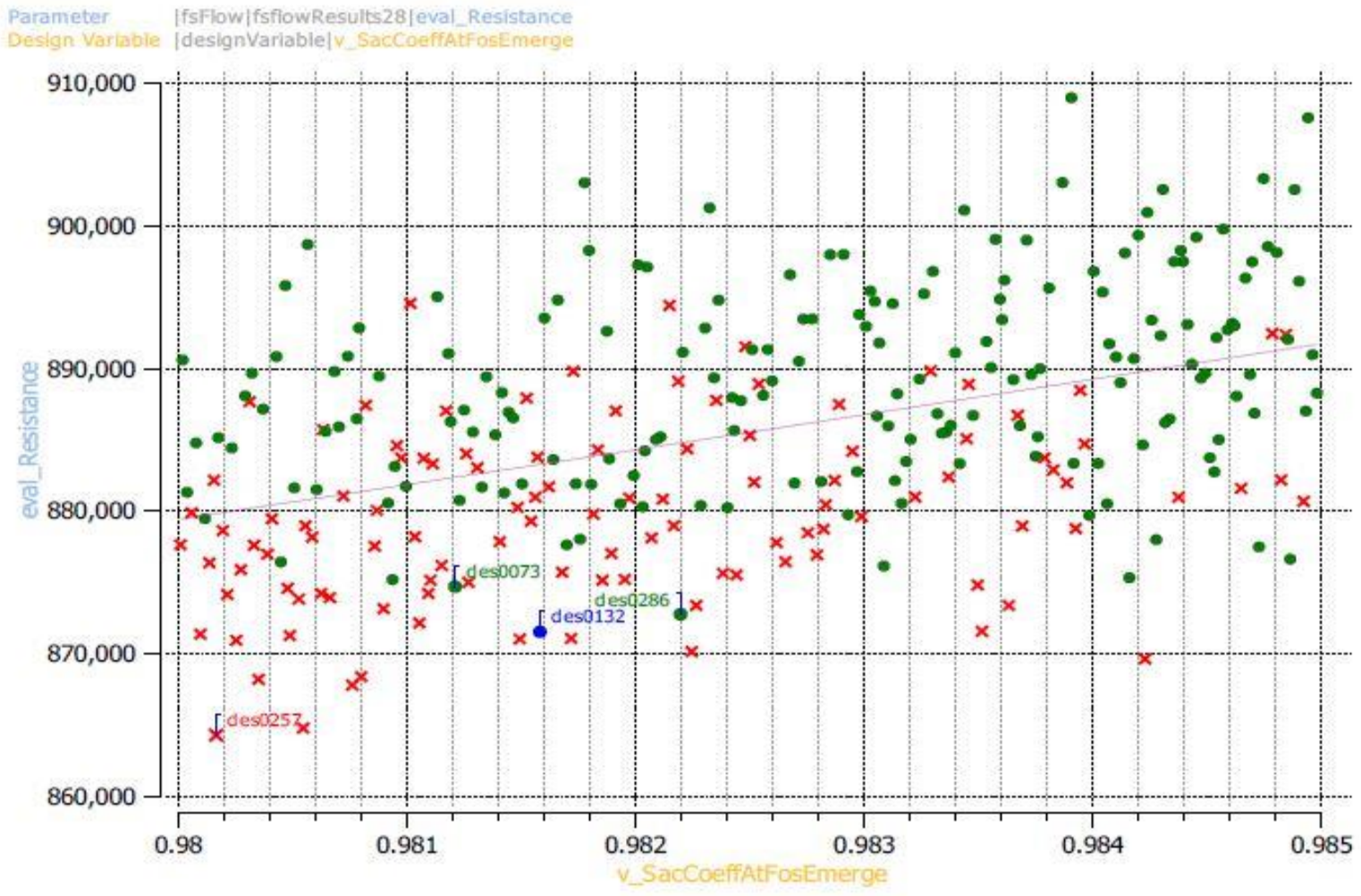
Design Variables

	Design Variable	Lower	Value	Upper	Active
1	v_SacTanAtFwdBase	110	128	150	✖
2	v_SacCoeffAtFwdBase	0.1	0.13	0.15	✖
3	v_maxBeamAtBulbAft	4	4.5	5.2	✖
4	v_SacCoeffAtFosEmerge	0.97	0.98	0.983	✖
5	v_flareDwlMax	24	34	38	✖
6	v_flareDwlRelXMax	0.5	0.675	0.7	✖
7	v_dwlAddAreaCoeff	-0.01	-0.01	0.006	✖
8	v_dwlAddXCA	-0.0005	0	0	✖
9	v_SacDeltaAreaCoeff	-0.01	-0.006	0	✖
10	weightAtMainFrame	0.84	0.75	0.96	✖
11	v_maxBeamAddAreaCoeff	-0.06	0	0	✖
12	v_halfBeamBulb_diff	0	0.2	0.2	✖
13	v_maxBeamElevation_diff	0	-0.25	0.1	✖
14	dv_tipElevation	1.8	1.8828125	2	✖
15					☐



Name	State	Monitored value	Comparator	Limit
minDwlBeam	✓	13.45695822	">"	13.2
minKMT	✓	7.75408888	">"	7.5
minWeight	✓	2406.40005793	">"	2400
minXCA	✓	42.19137394	">"	42

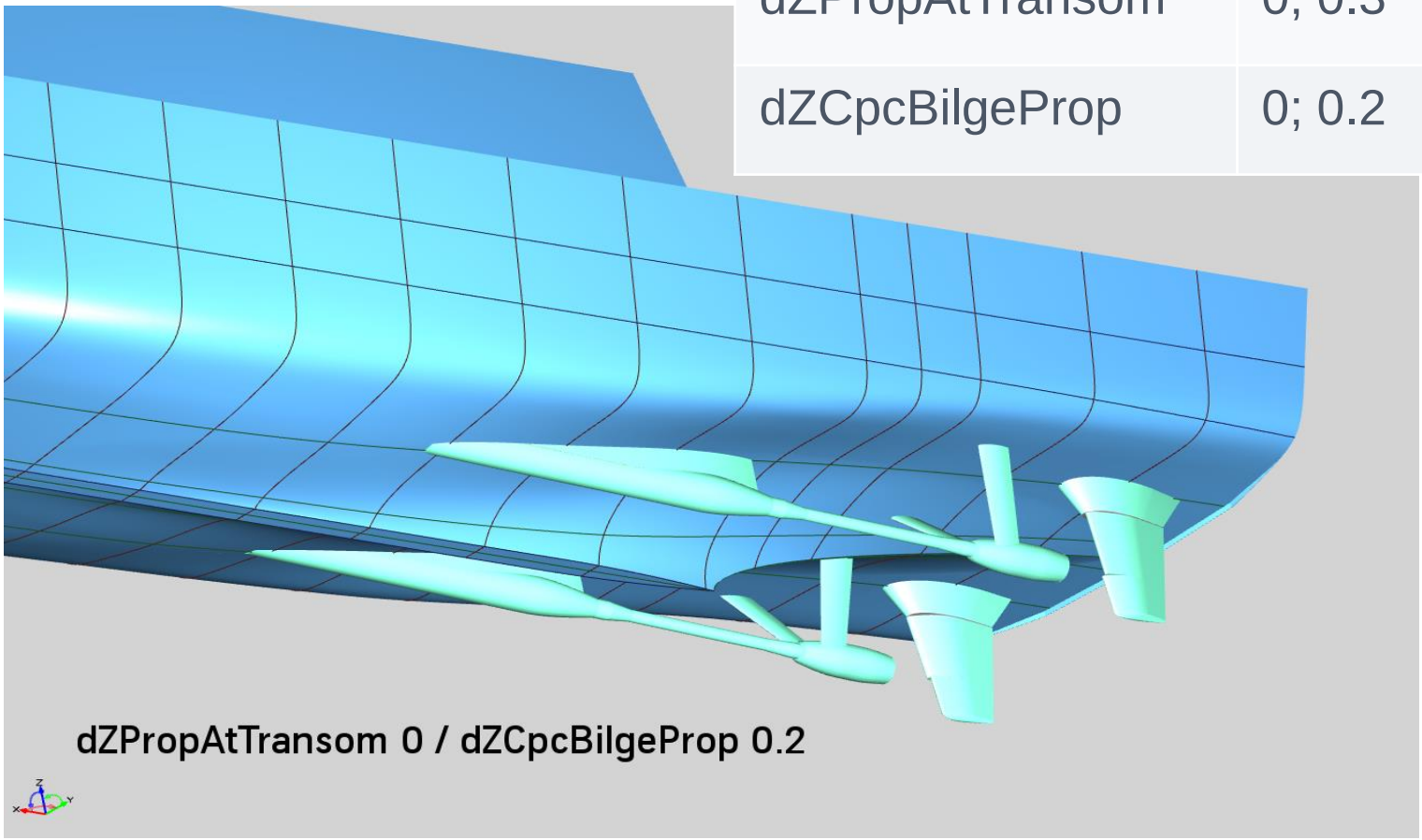
Evaluation of designs



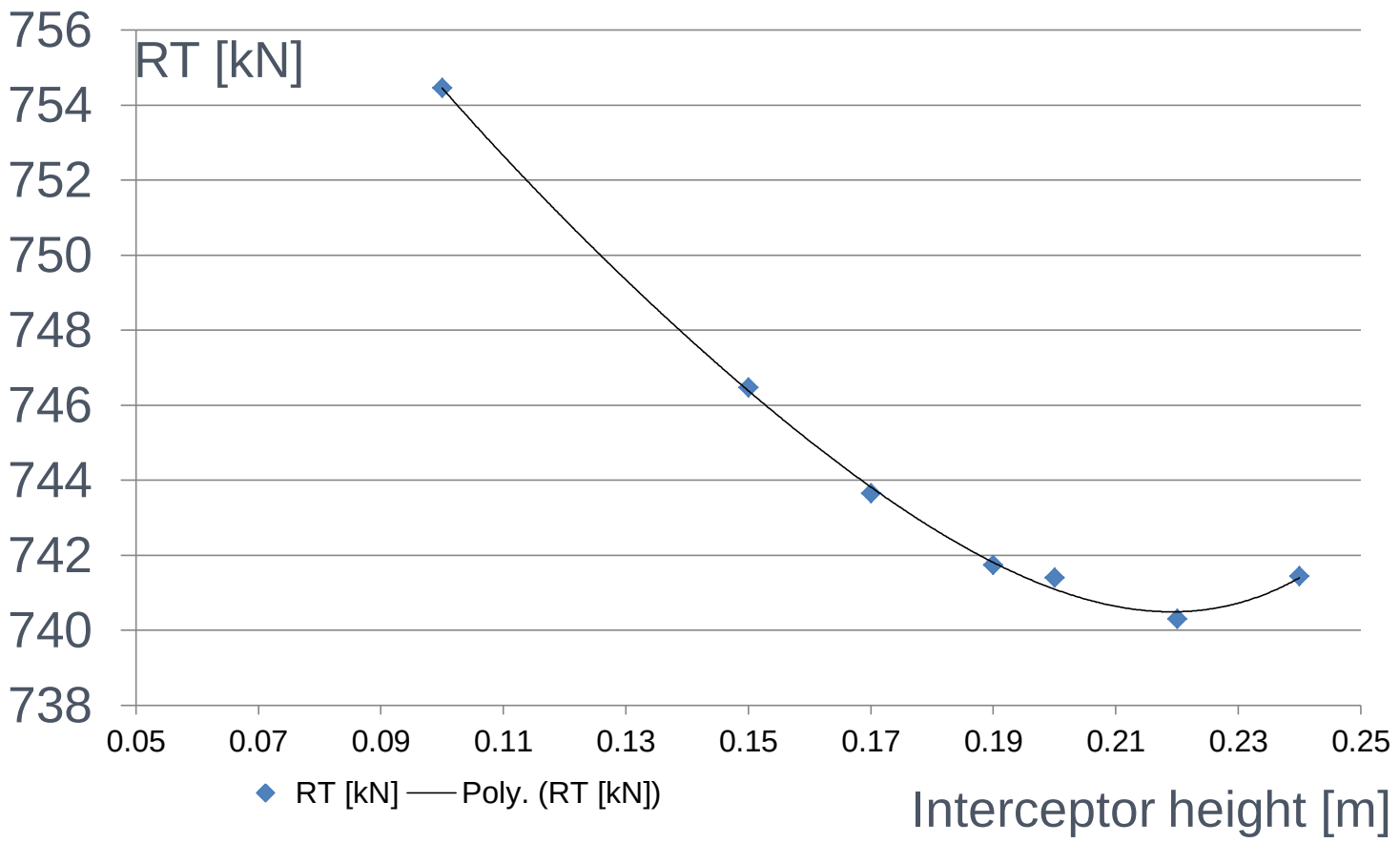
Aft-body optimization

Parameter	Value
Interceptorheight	0.1; 0.18; 0.22
dZPropAtTransom	0; 0.3
dZCpcBilgeProp	0; 0.2

Aft-body variation: 12 variants



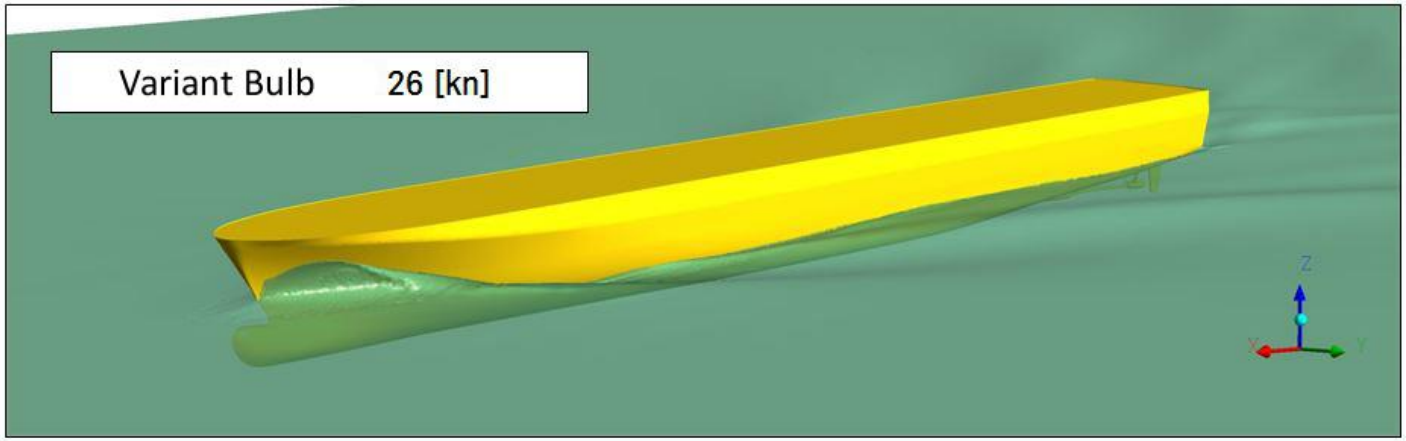
Interceptor optimization

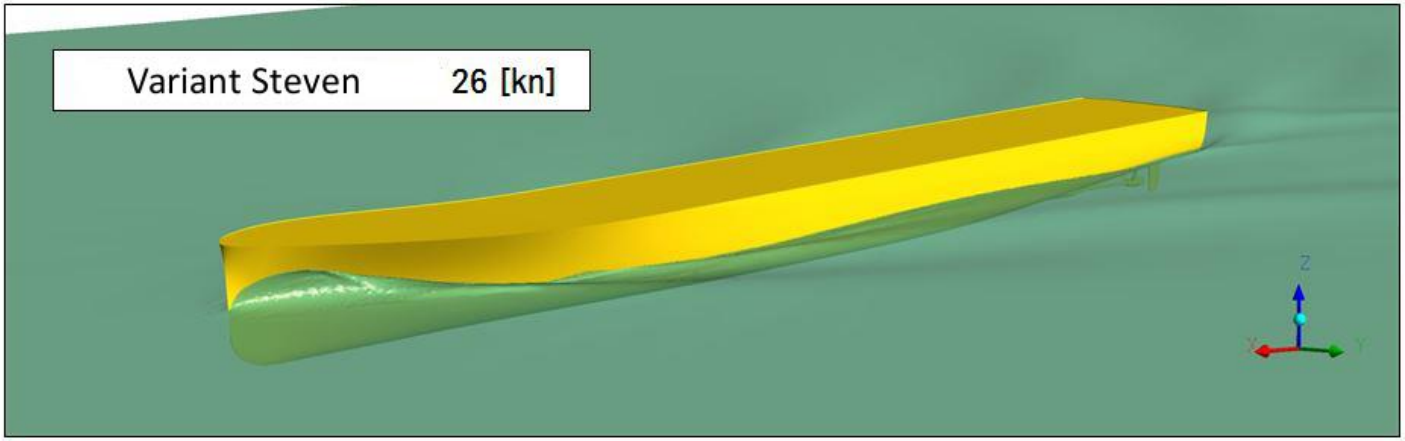


Comparison of different bow types

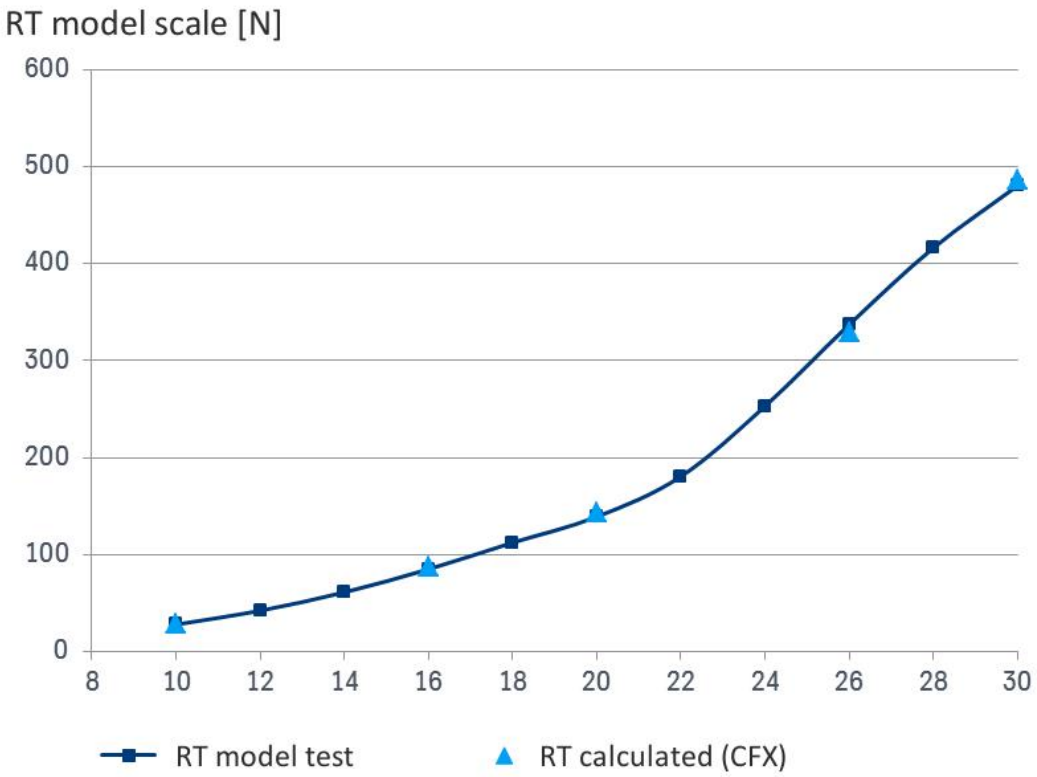
at two differnt load cases

Velocity: 20 kn & 26 kn
(Froude 0.34 & 0.26)

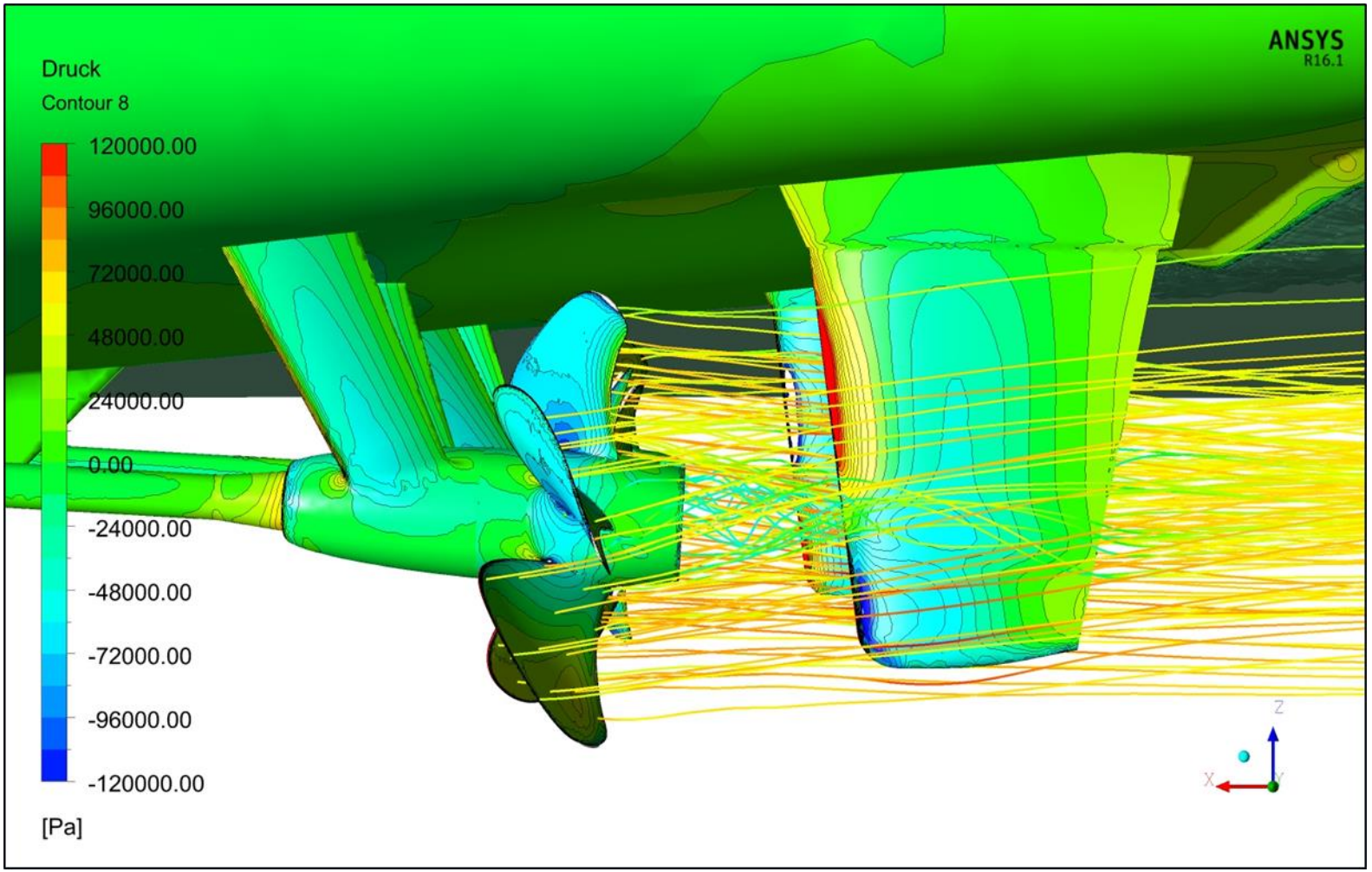




Comparison of calculated values and model test results



Next step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Z
X
Y

Conclusions

- Wide range of hull form variation in a short time frame
- Optimized hull form for different speeds and loads by fulfilling demanding requirements
- Maximum speed within the given cost and engine power and economic use at the operational profile
- Consideration of influence of aftbody variations, appendages and floating position caused by interecptor
- Reliable results in early design
- Minimized risk during the proposal stage

→ We can offer optimized hull shapes operating with minimum engine power at maximum speeds within a short time frame.