EMship Master Thesis

Sketched Parametric Modeling in CFD Optimization

by Martin A.B. Gundelach

Internship at: FRIENDSHIP SYSTEMS

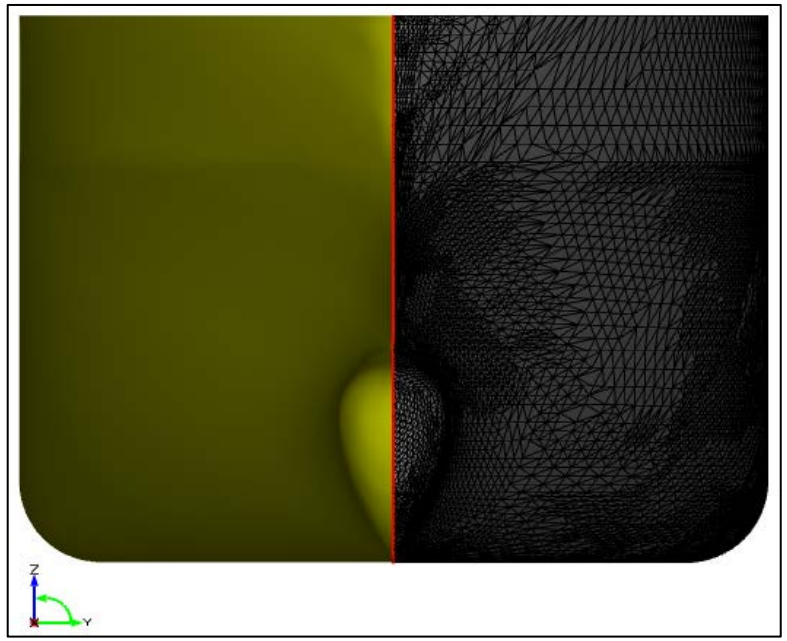
Supervisors: Dr.-Ing. S. Harries, Prof. R. Bronsart, M.Sc. S. Greshake

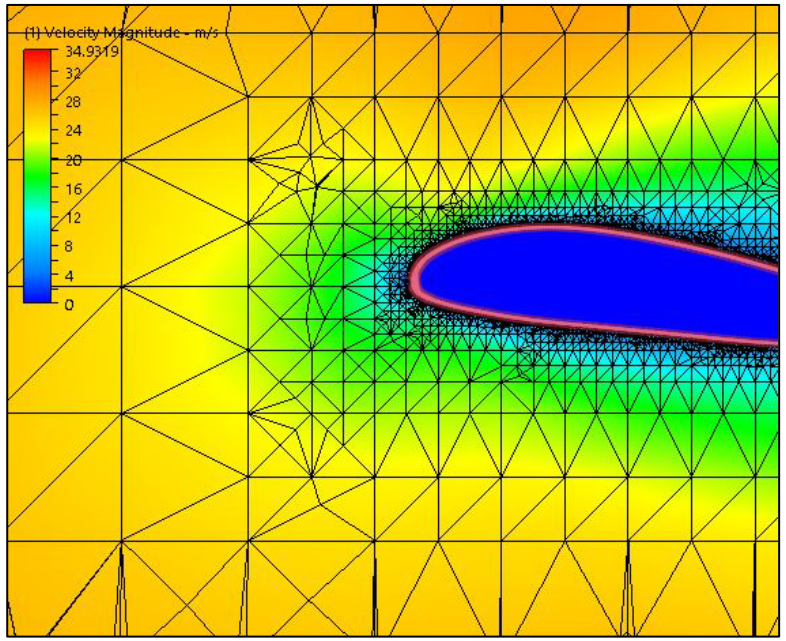
Feb/2017, University of Rostock (Germany)

Motivation: CAD vs CFD

CAD designers (hull design) → CFD engineers (hull optimization)

Different knowledge, different software!



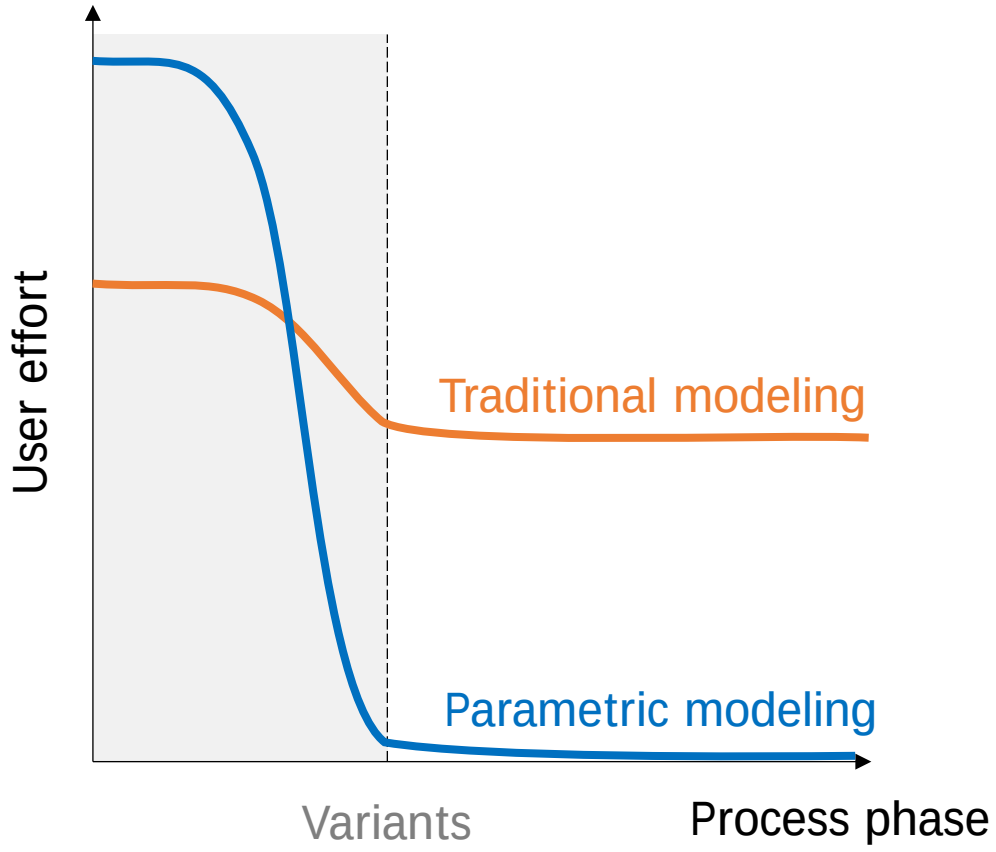


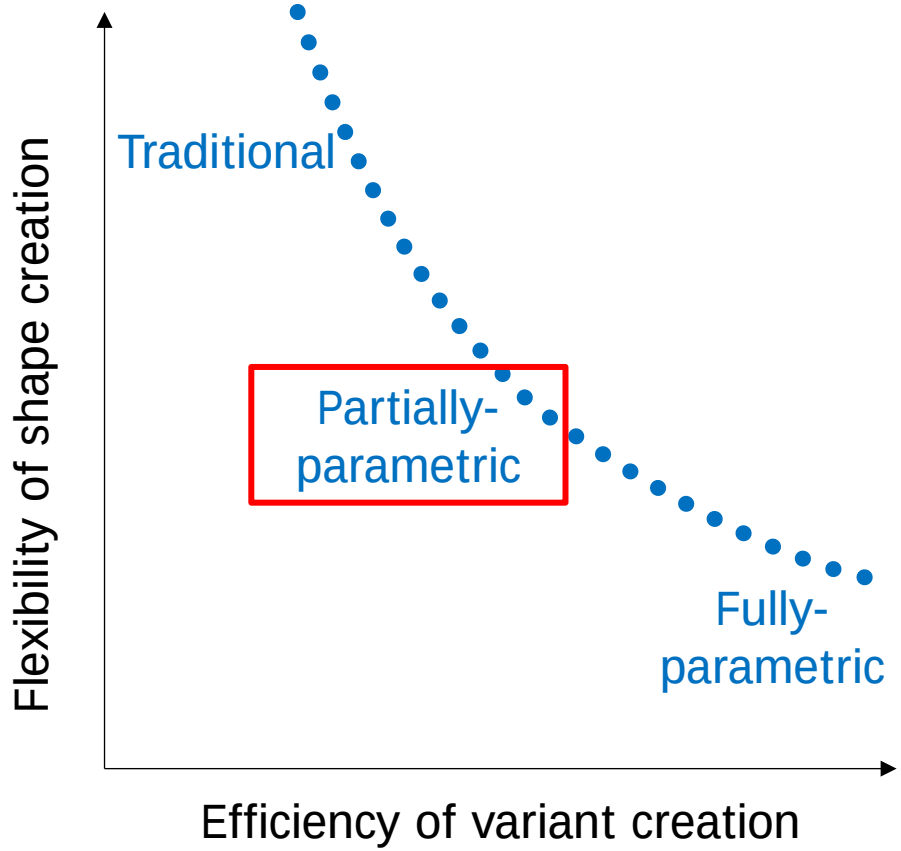
Picture (R) from: http://simhub.autodesk.com/discussions/threads/330/post/5339381

Motivation: Simulation-driven design with parametric modeling

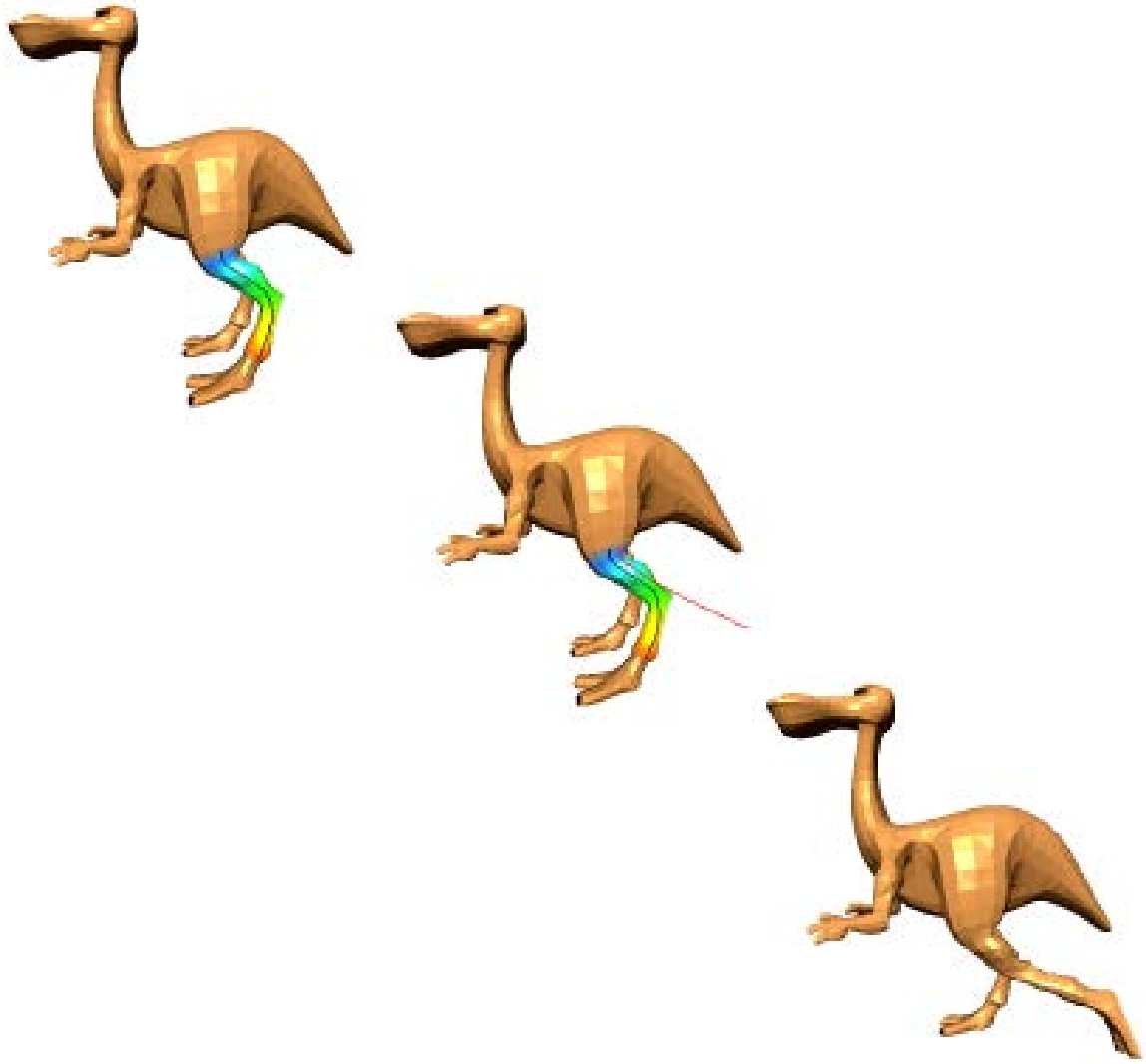
Scaling vector [x,y,z] = [1.25,1,1]

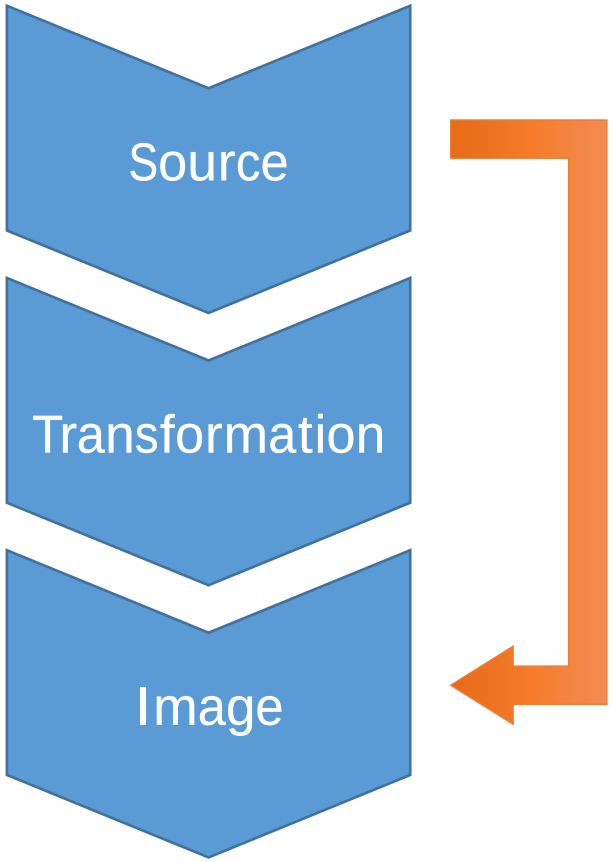
Motivation: Simulation-driven design benefits and shortcomings





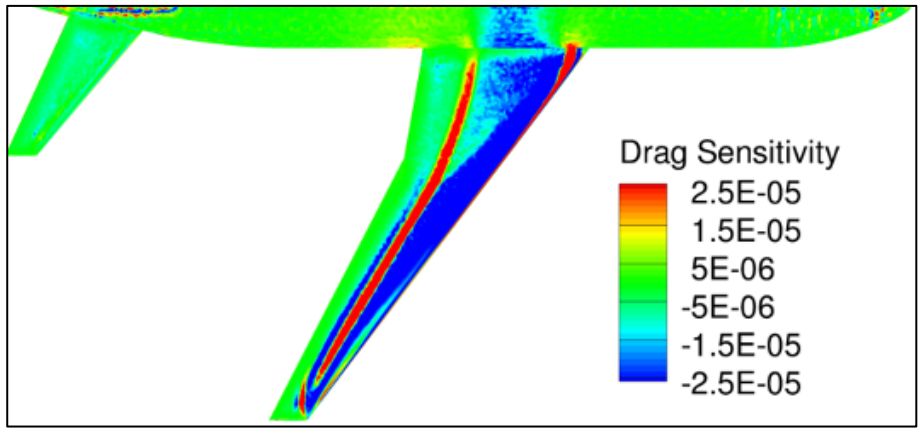
Motivation: Sketched Parametric Modeling

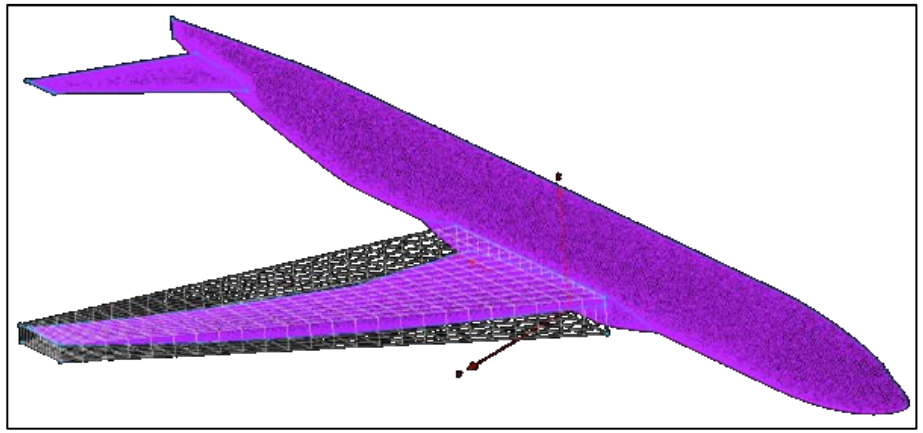




Pictures from: KHO, Y. & GARLAND, M., 2005. *Sketching Mesh Deformations*. ACM SIGGRAPH 2005, USA.

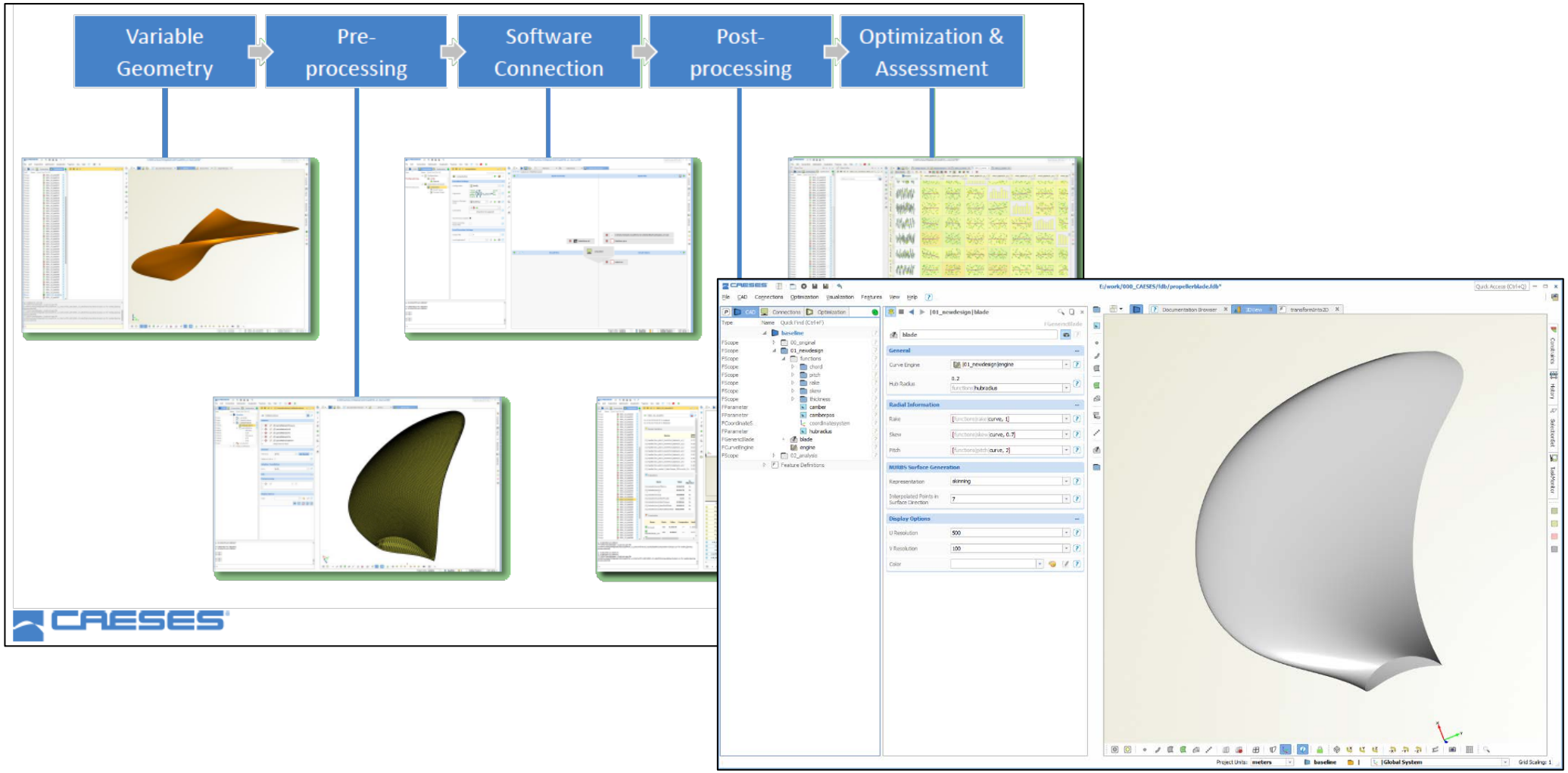
Motivation: Sketched Parametric Modeling and Adjoint CFD Method





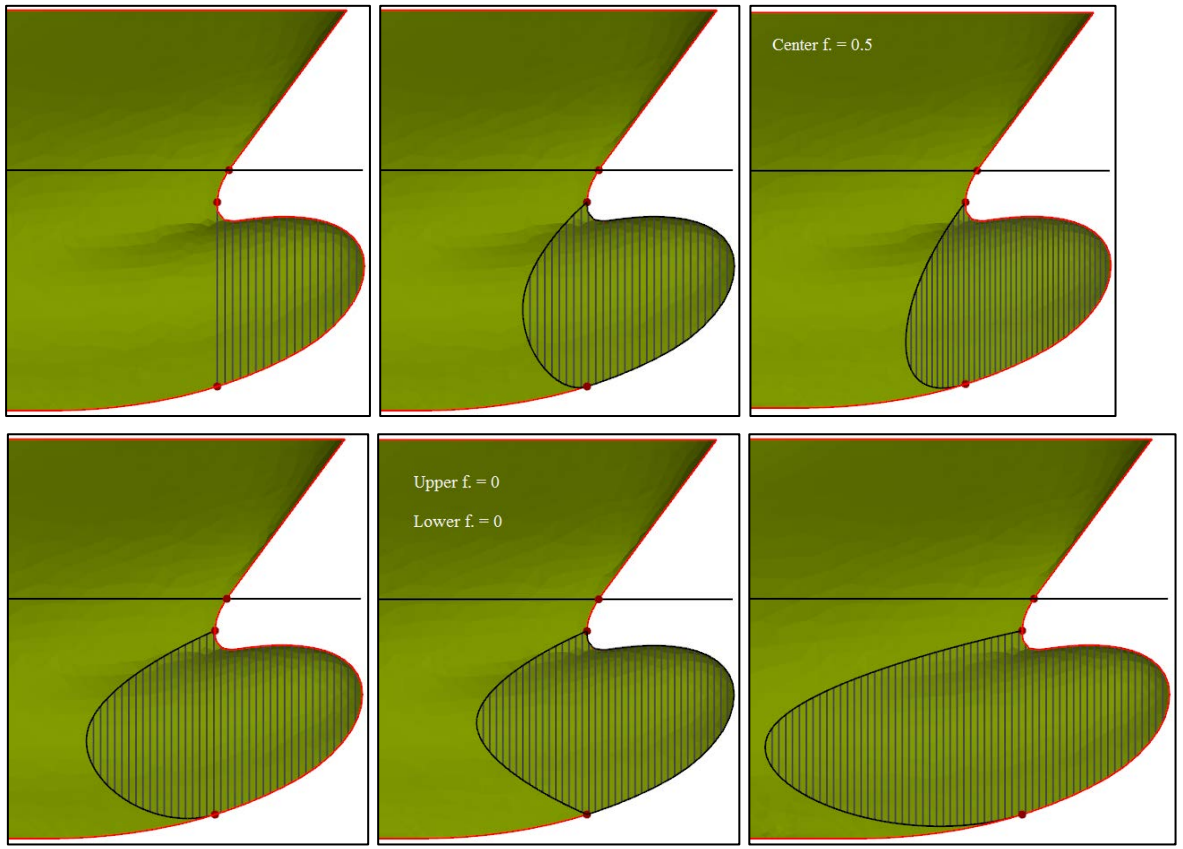
Pictures from: http://www.pointwise.com/theconnector/March-2015/Aircraft-Design-Using-SU2-Pointwise.shtml

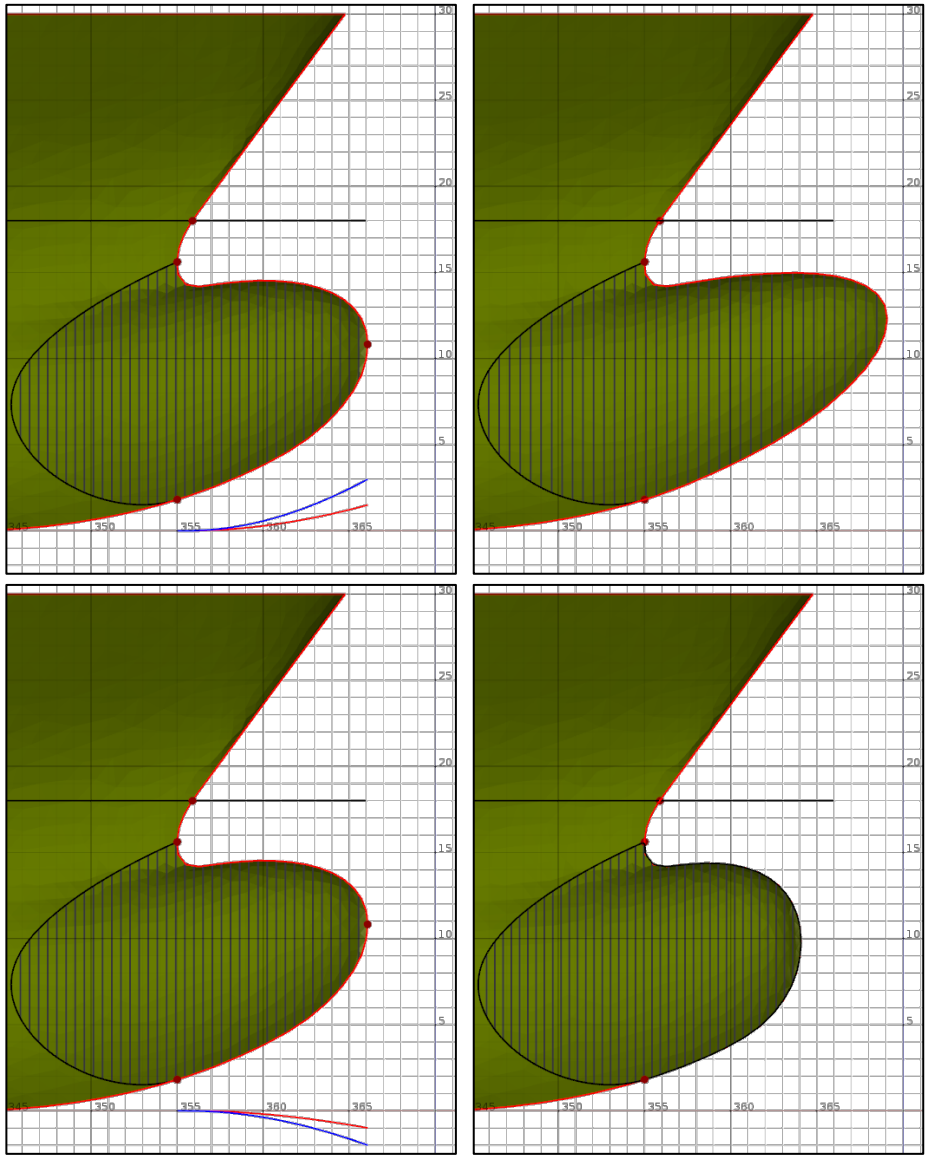
Tools used: Friendship Systems' CAESES



Pictures from: http://www.caeses.com/

Tools developed: Bulb Transformation Feature





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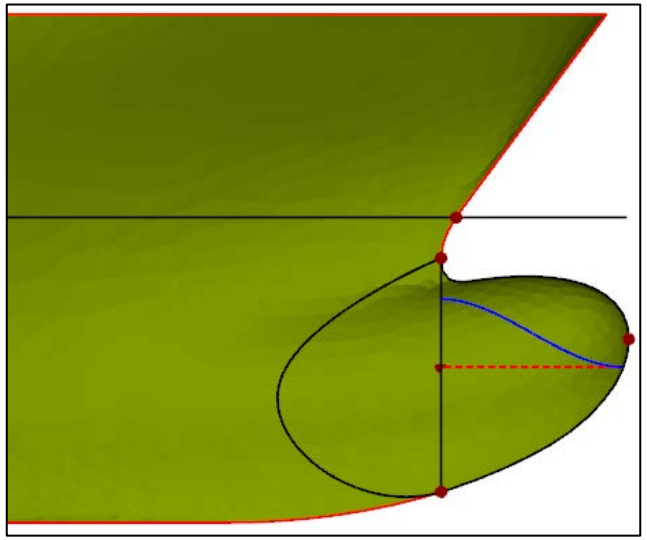
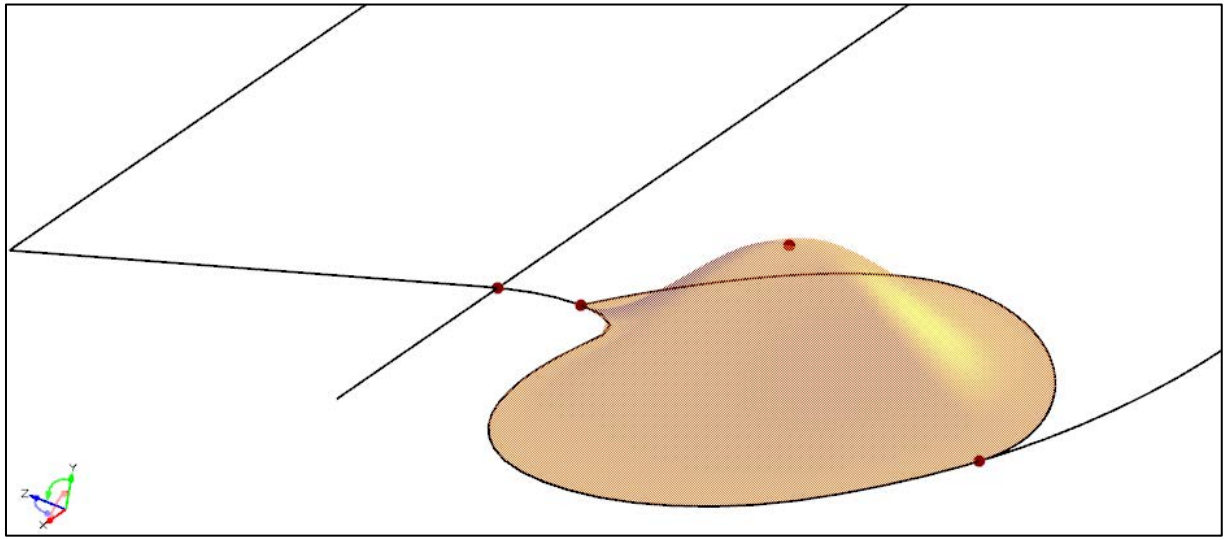
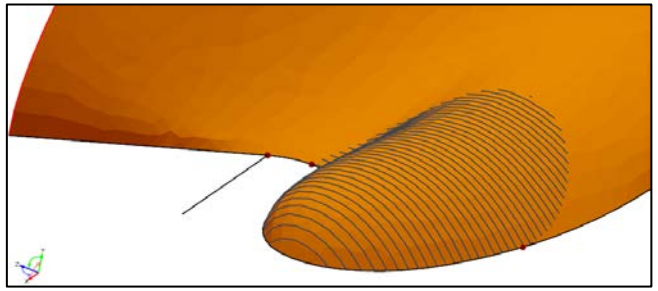
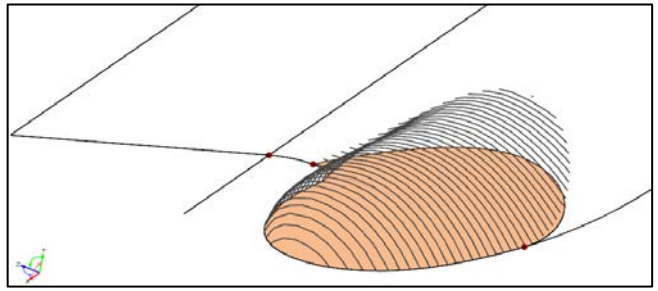
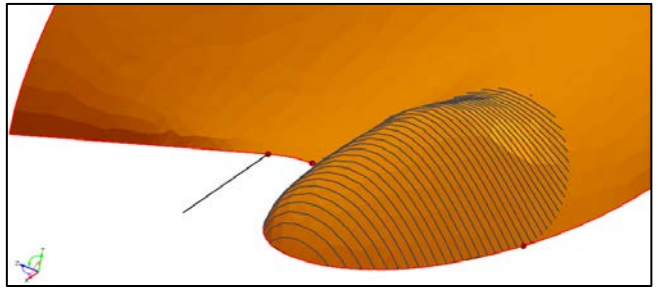
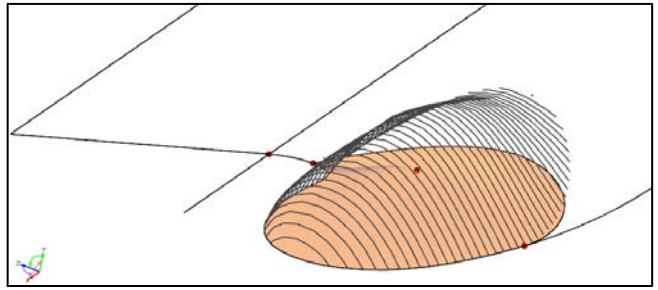




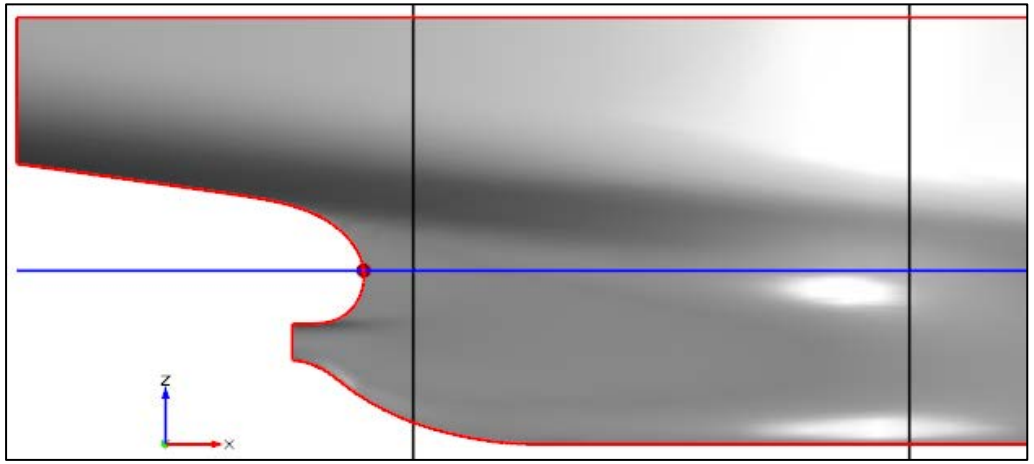


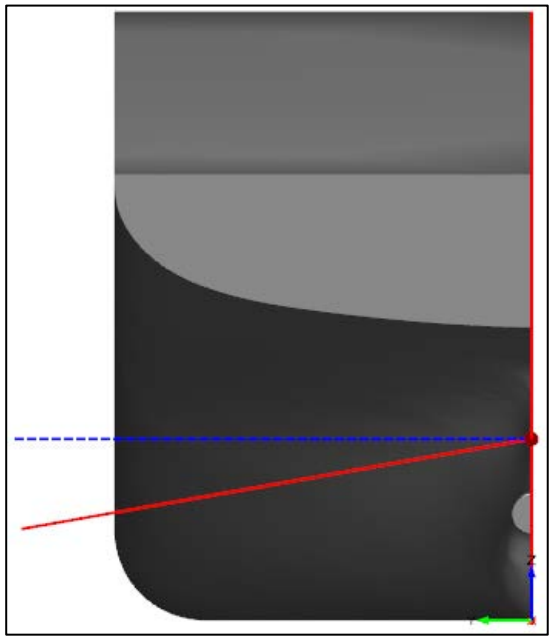


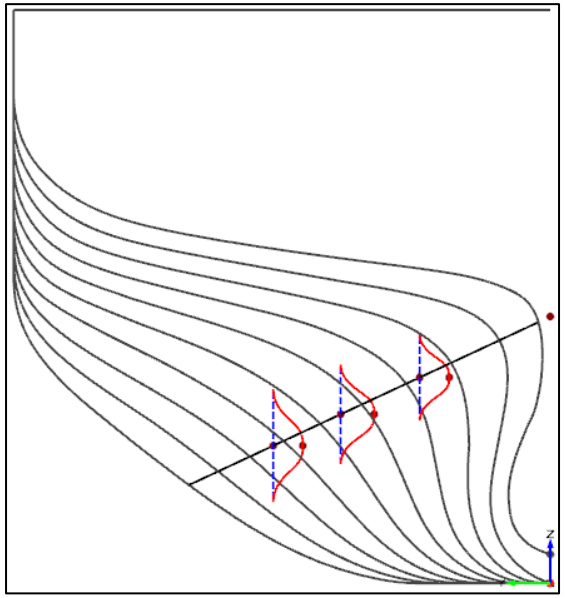


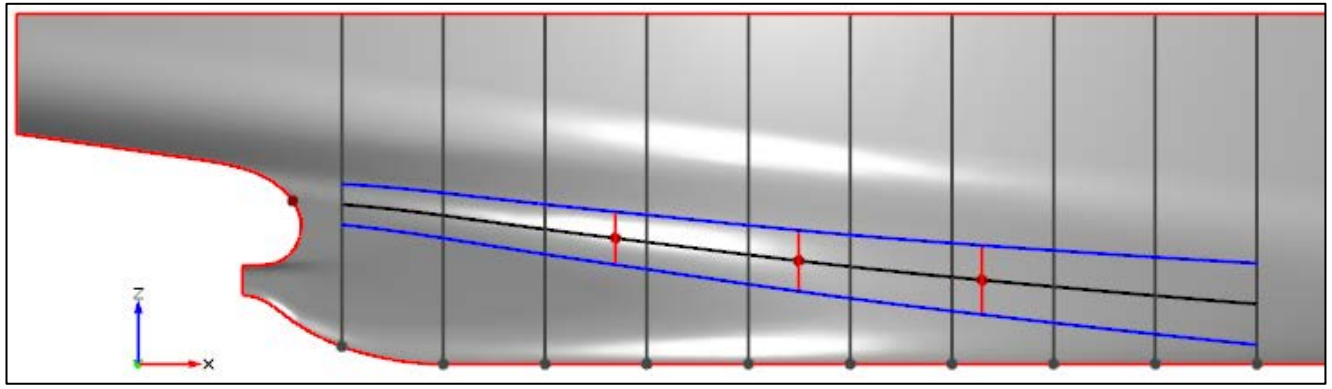


Tools developed: Aft Waterline/Diagonal Feature

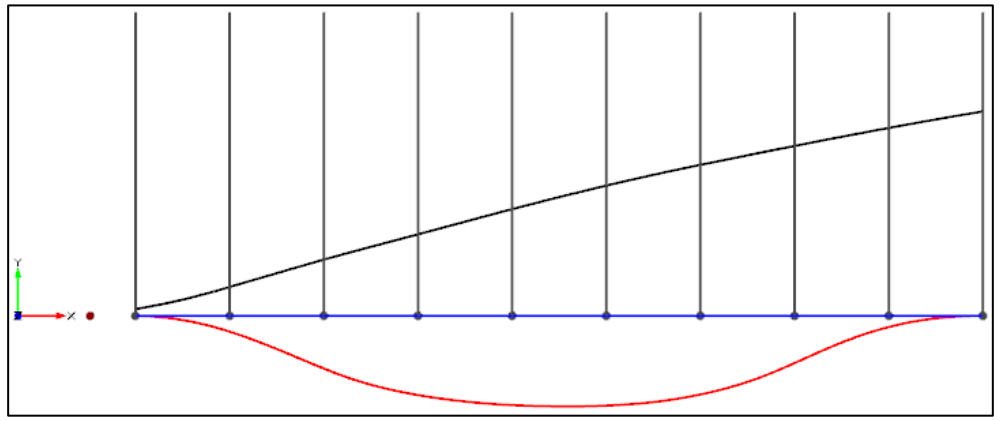


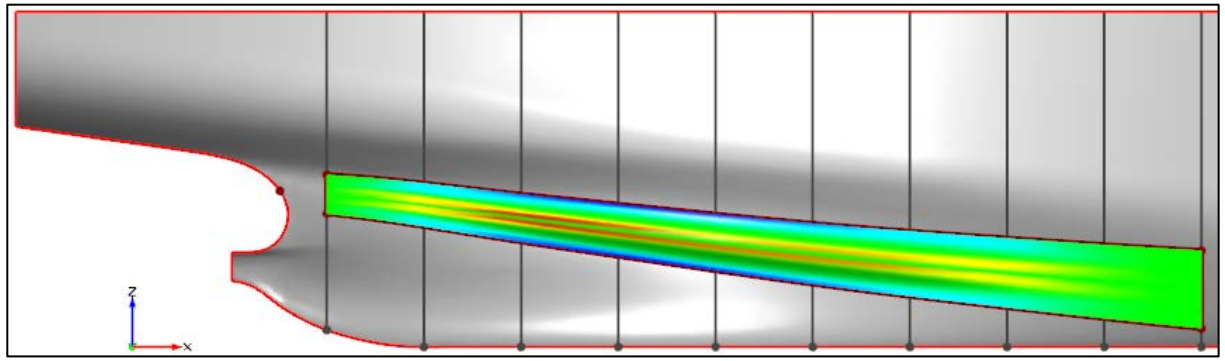


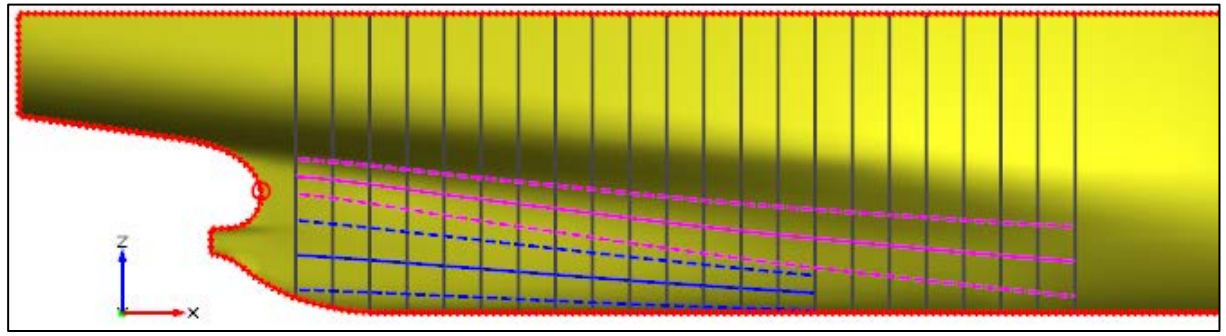


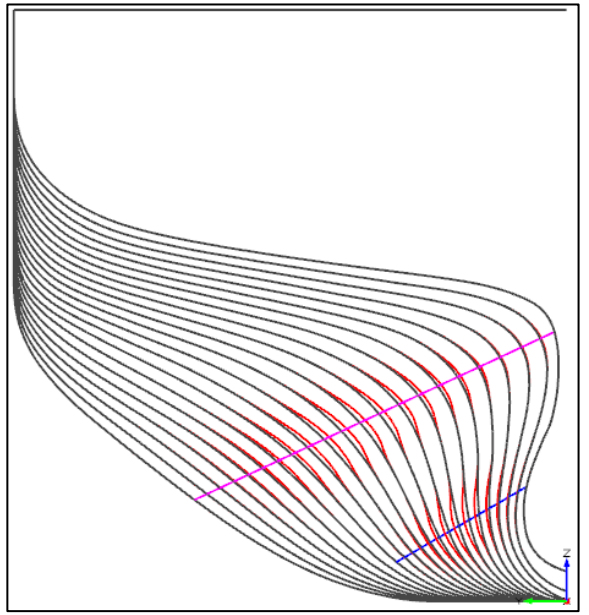


Tools developed: Aft Waterline/Diagonal Feature



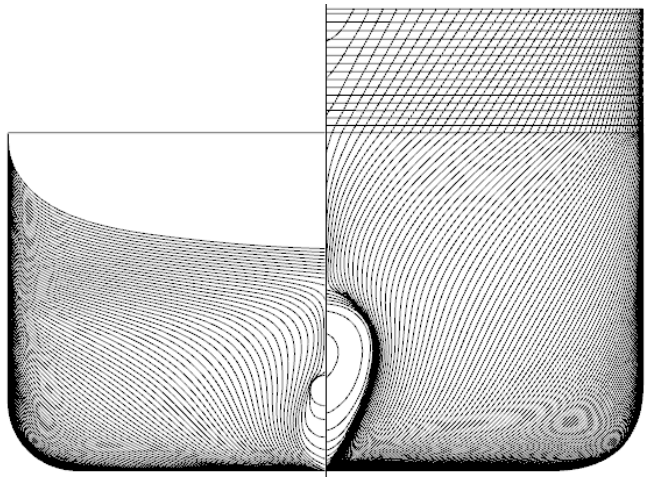


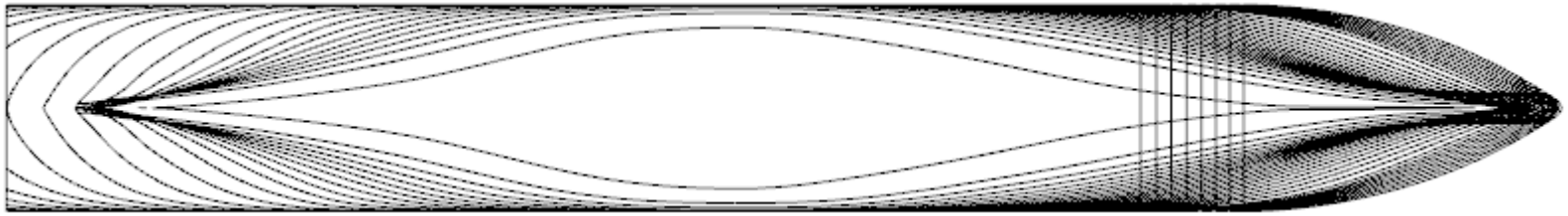




Problem description: KCS hull resistance optimization

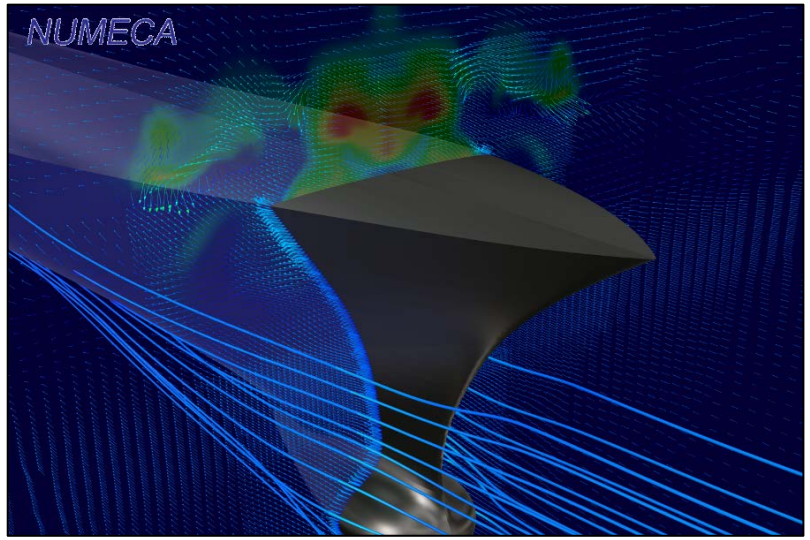
- C_T , R_T : ↓
- F_N = 0.26 , 0.23
- $V \geq V_0 - 200m^3$ (0.4%)
- -1 ≥ LCB ≥ -2 (-1.5%)

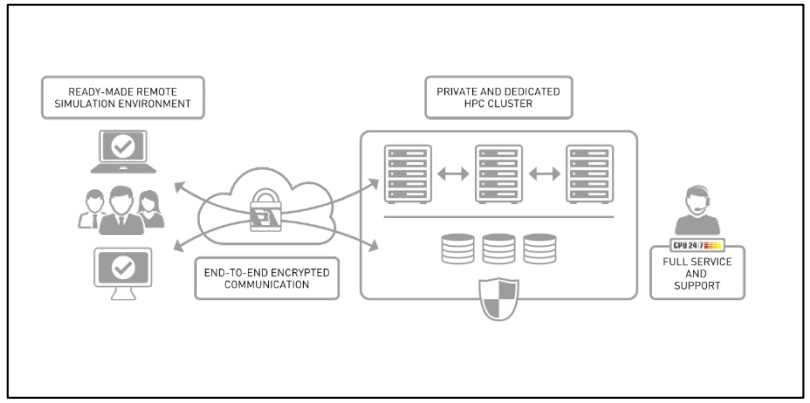




Tools used: NUMECA's FINE/Marine, CPU24-7 cluster

- Unstructured mesh
- VOF
- Finite volumes
- 2-eq. k-ω SST turbulence model

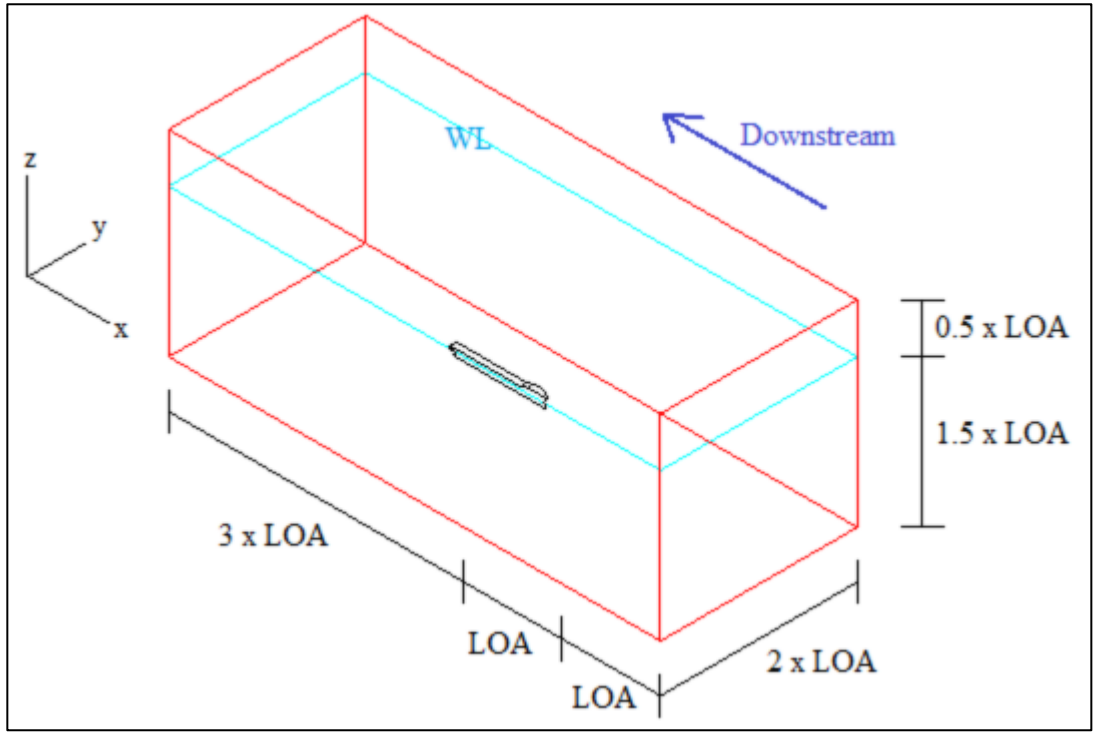




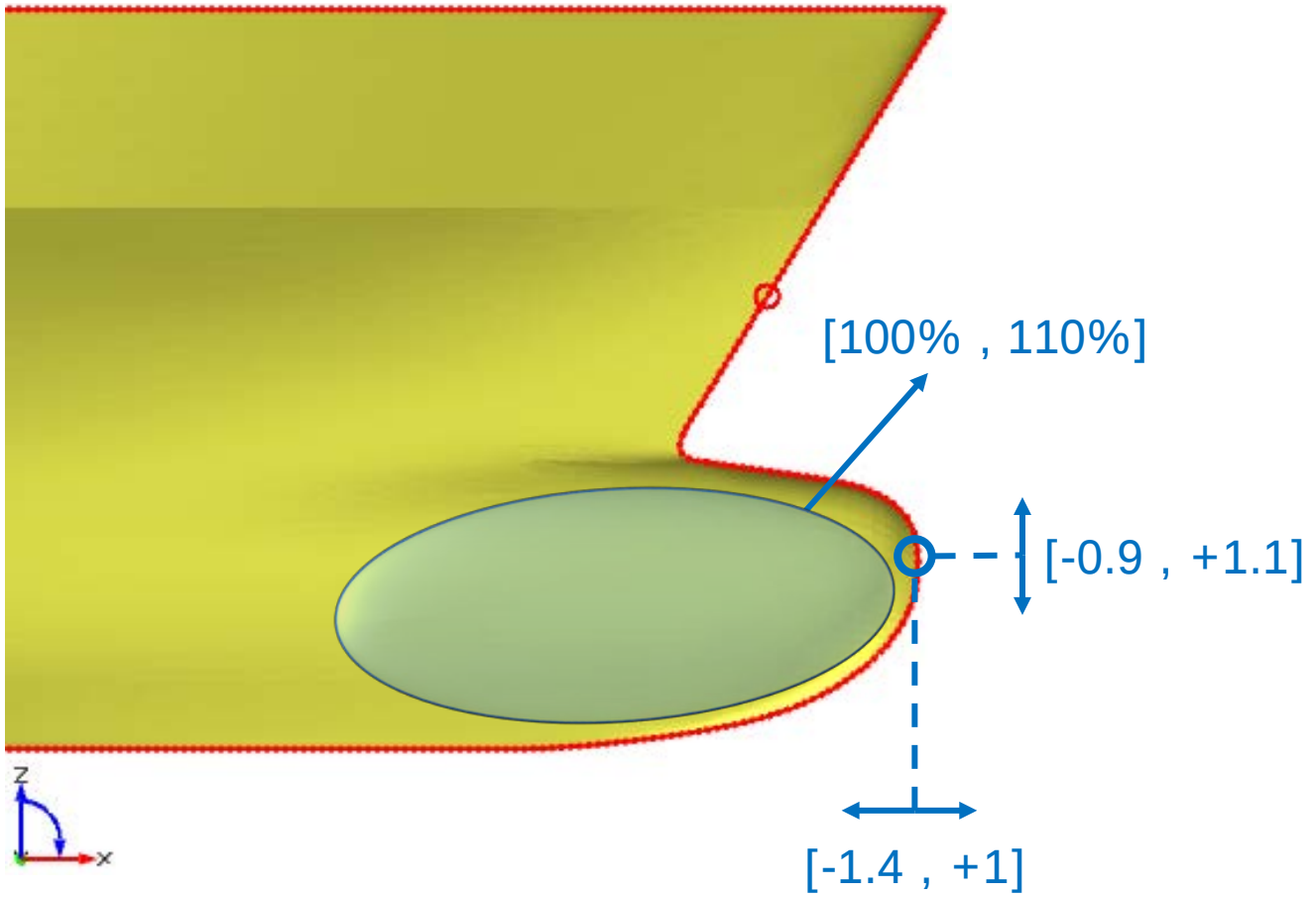
Pictures from NUMECA's brochure (T) and http://www.CPU-24-7.com (B)

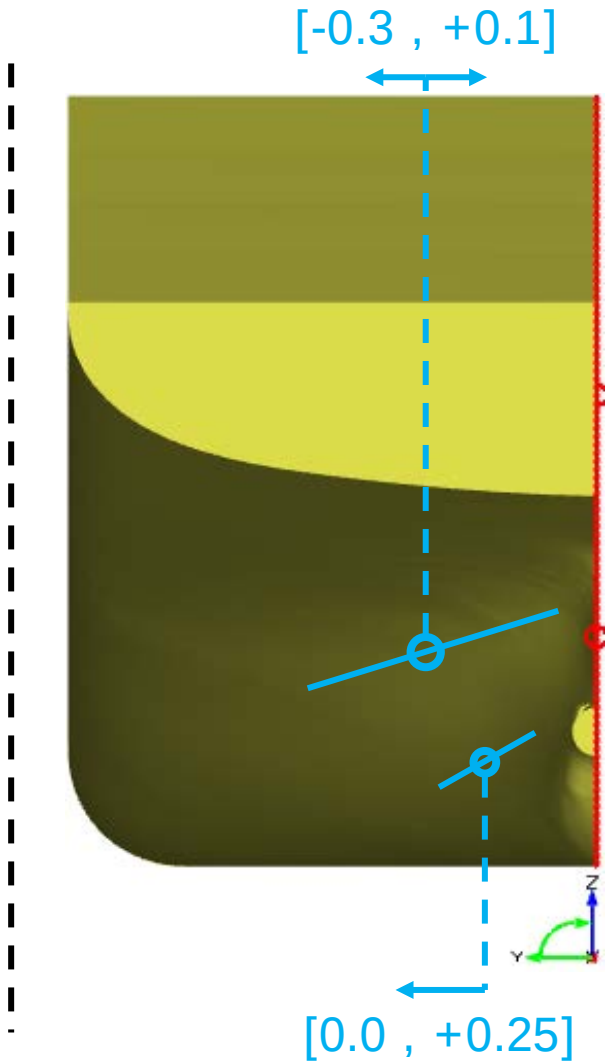
CFD Setup in FINE/Marine

- Time steps: 2000
- Average of last 10% for R_T
- Dynamic equilibrium (trim, sinkage)
- Convergence analysis
- 1 sim (~35s) = 1h real time
- 200 variants

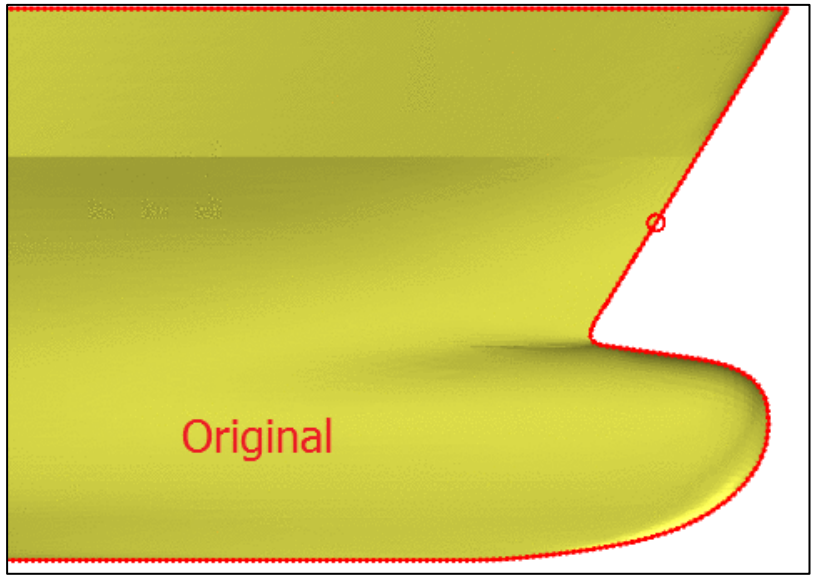


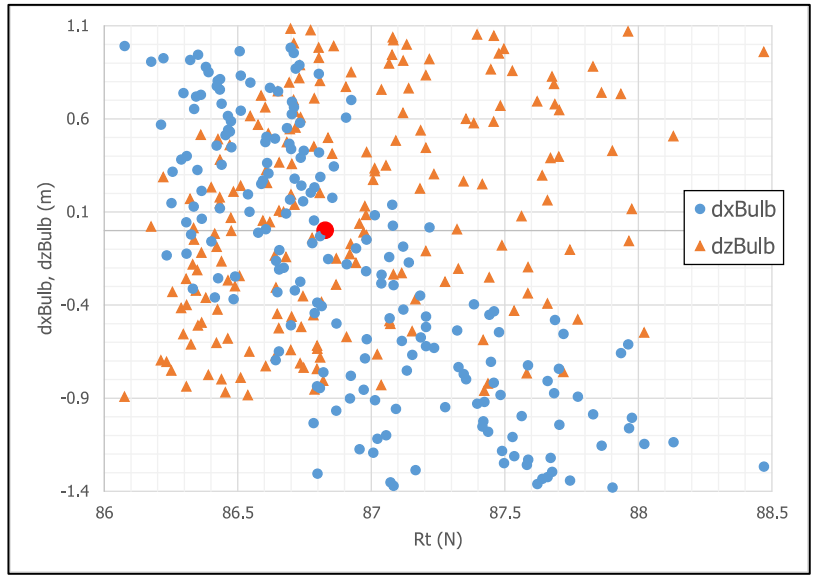
Design variables setup in CAESES

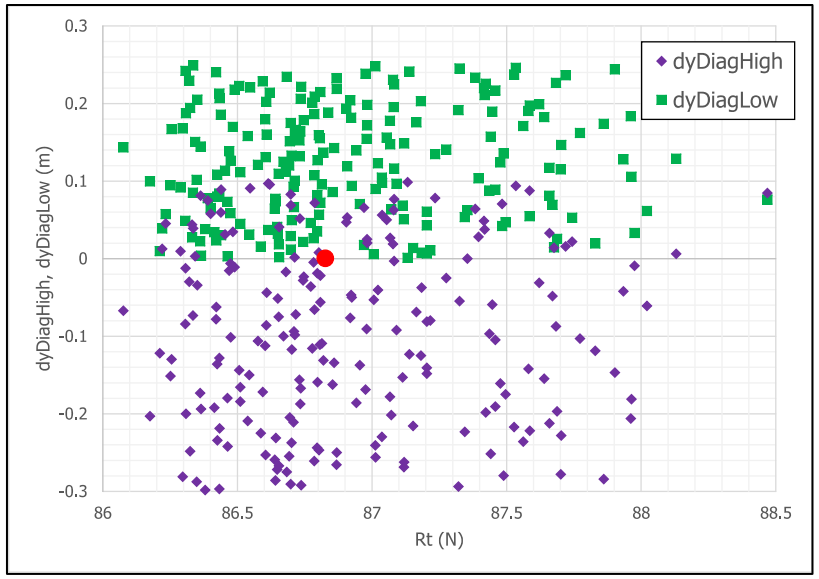


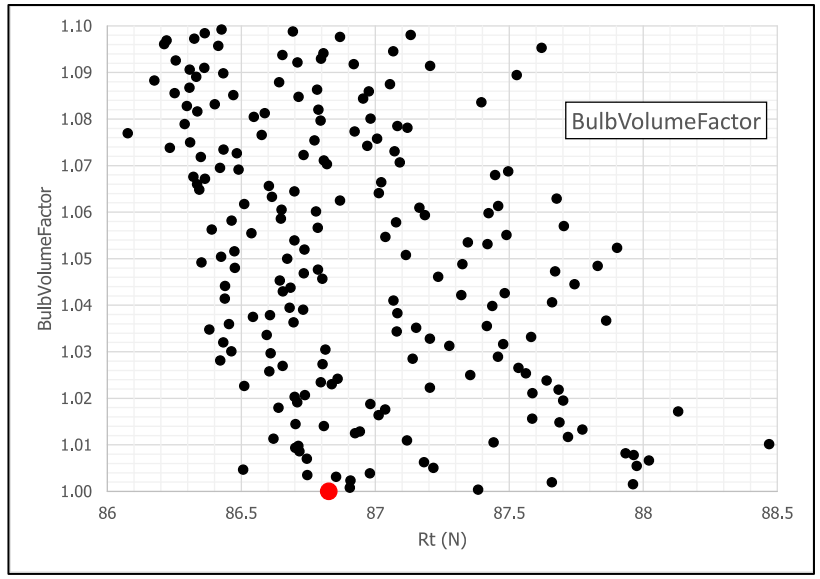


Optimization Results: geometry differences



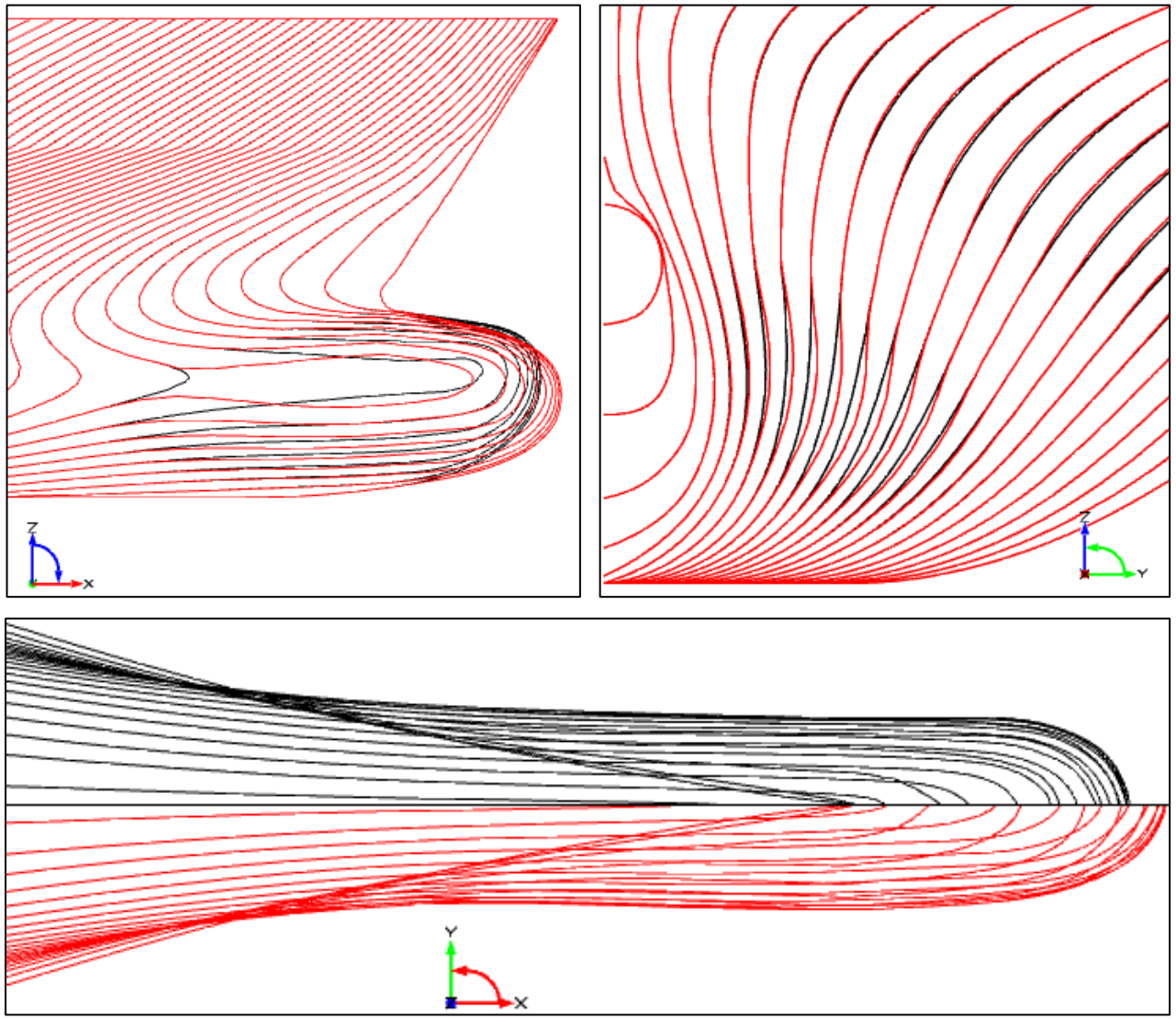






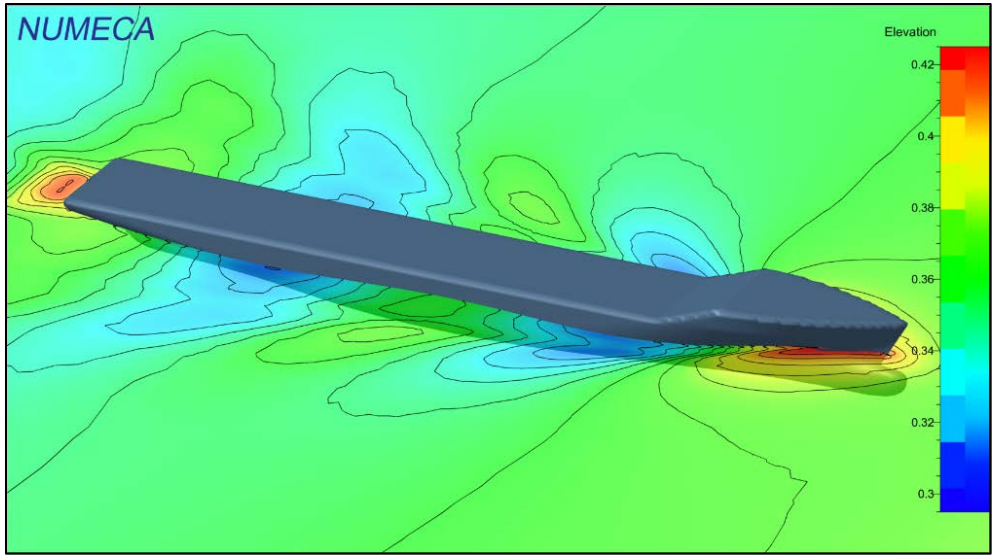
Optimization Results: optimum hull

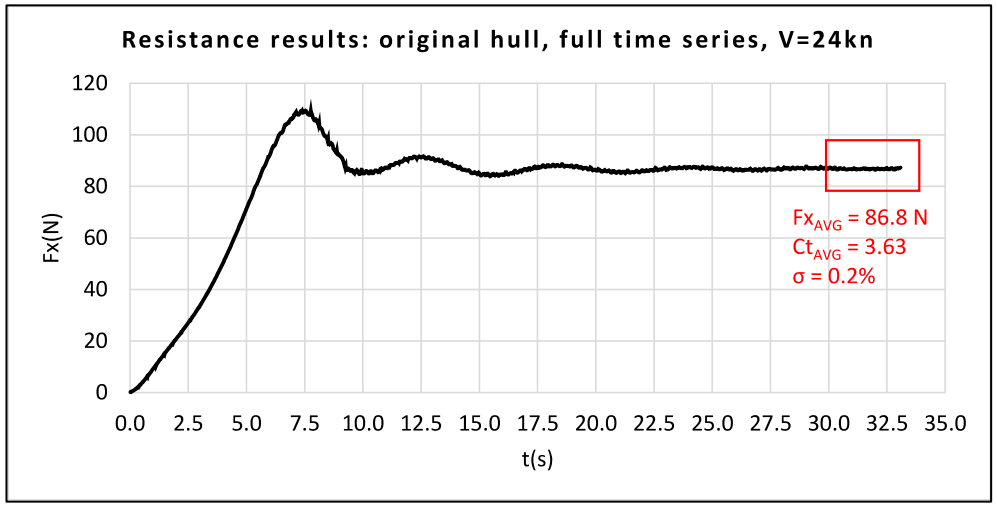
- L_{bulb} : 13% increase
- Z_{bulb} : 15% decrease
- V_{bulb} : 12% increase
- High diagonal: 7cm in
- Low diagonal: 14cm out

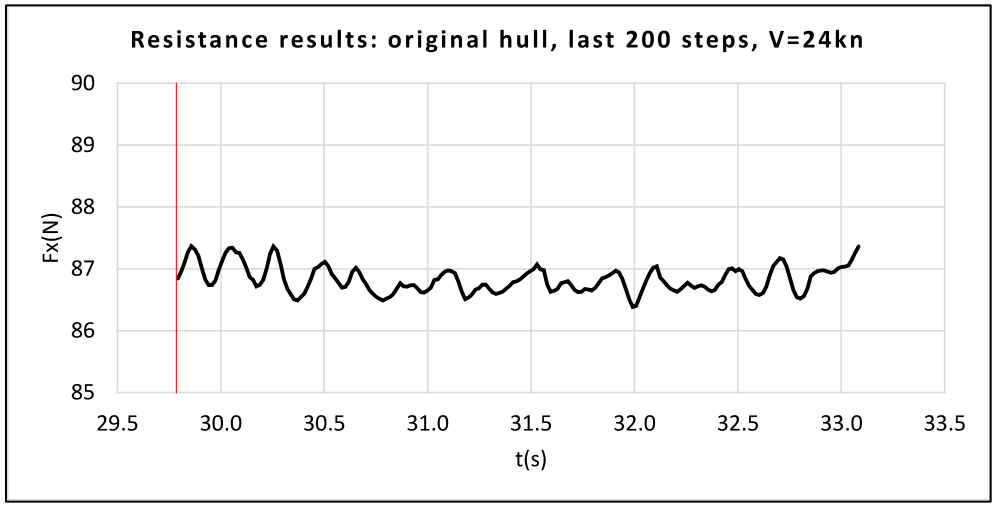


Original hull's resistance results

- Compared to experimental results [1]:
  - C_{T_CFD} : 2% smaller than C_{T_EXP}
  - Sw_{dyn}: 5% bigger than Sw_{static}
  - Exp. hull has rudder



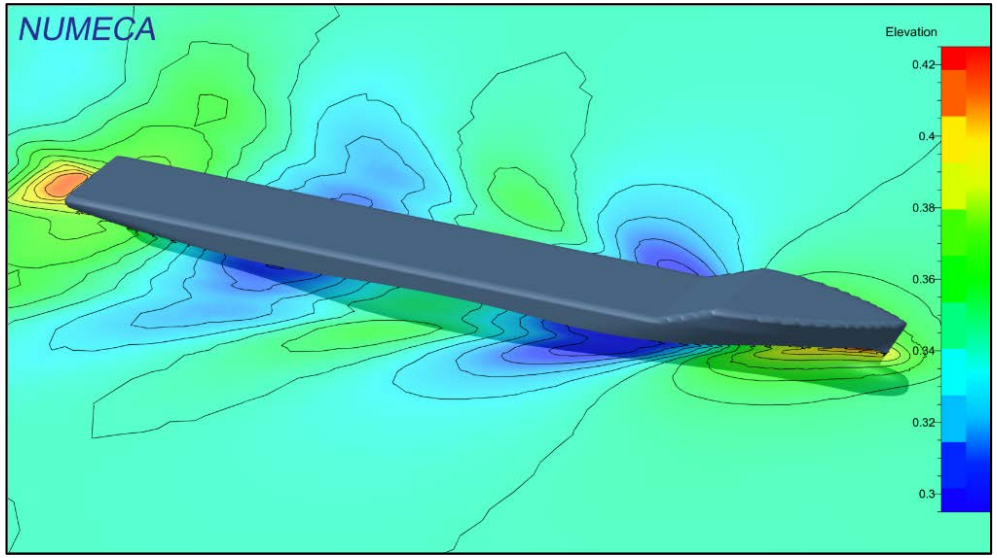


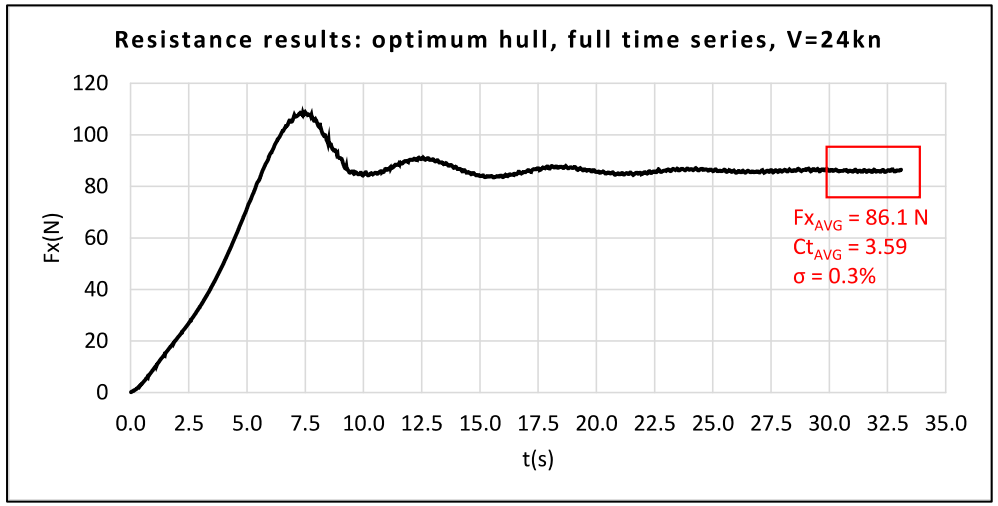


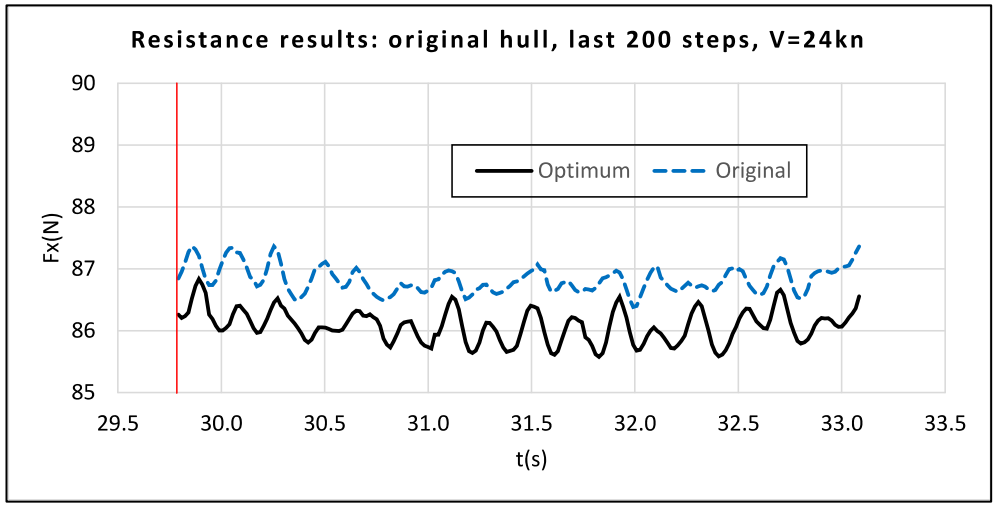
[1]: KLEINSORGE, L., LINDNER, H., & BRONSART, R., 2016. "A Computational Environment for Rapid CFD Ship Resistance Analyses". Proceedings of PRADS2016, September 2016, Denmark.

Optimum hull's resistance results

- Compared to original (CFD) results:
  - $C_{T\text{-}OPTM}$: 1% smaller than $C_{T\text{-}ORIG}$







Conclusions

- Sketched Parametric Modeling: making it easier for CFD engineers to optimize hulls
- Tools can be developed inside software, but requires knowledge of parametric modeling
- Shape optimization applied here was successful: only 1%, but from conservative approach