# Fully Automatic Design Space Exploration by RANS Computations

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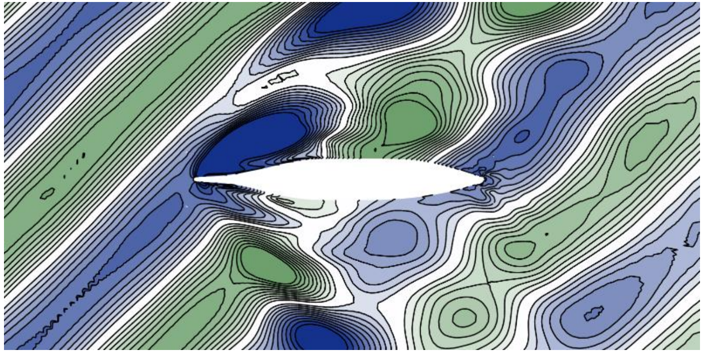
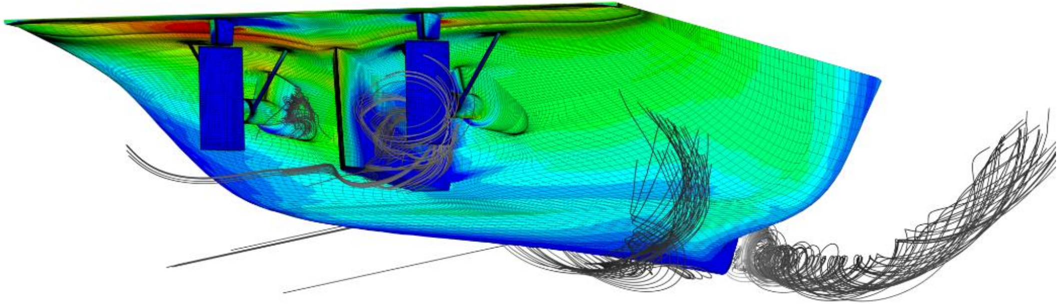
# About me

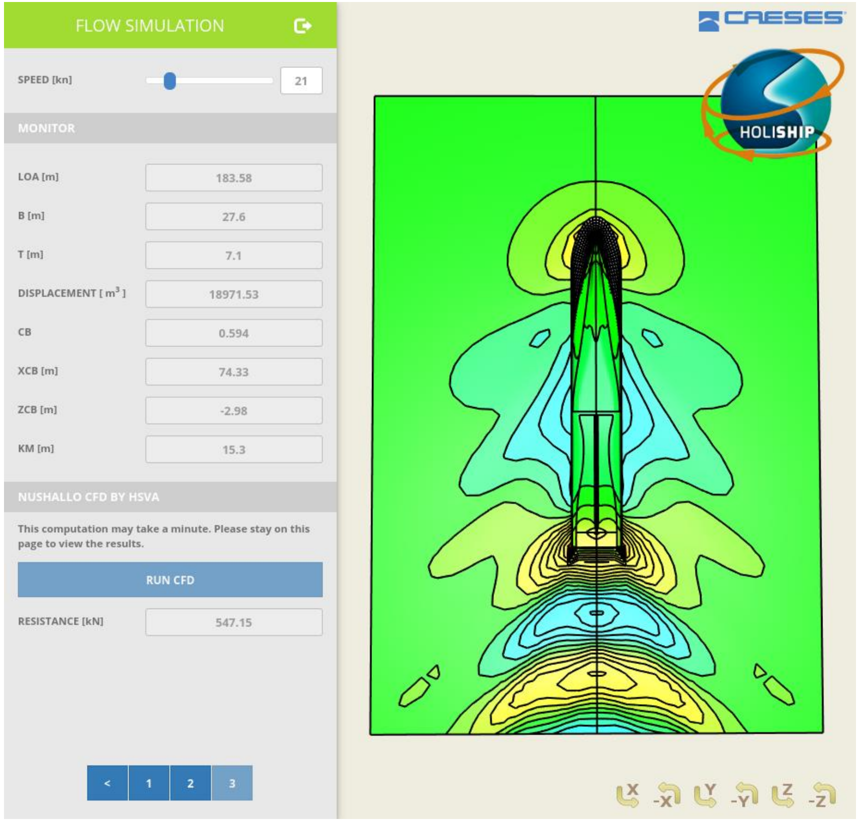
- Naval Architect from TU Berlin
- PhD Thesis on Numerical Prediction of Ship Manoeuvring Performance in Waves
- Working at Friendship Systems since April 2019





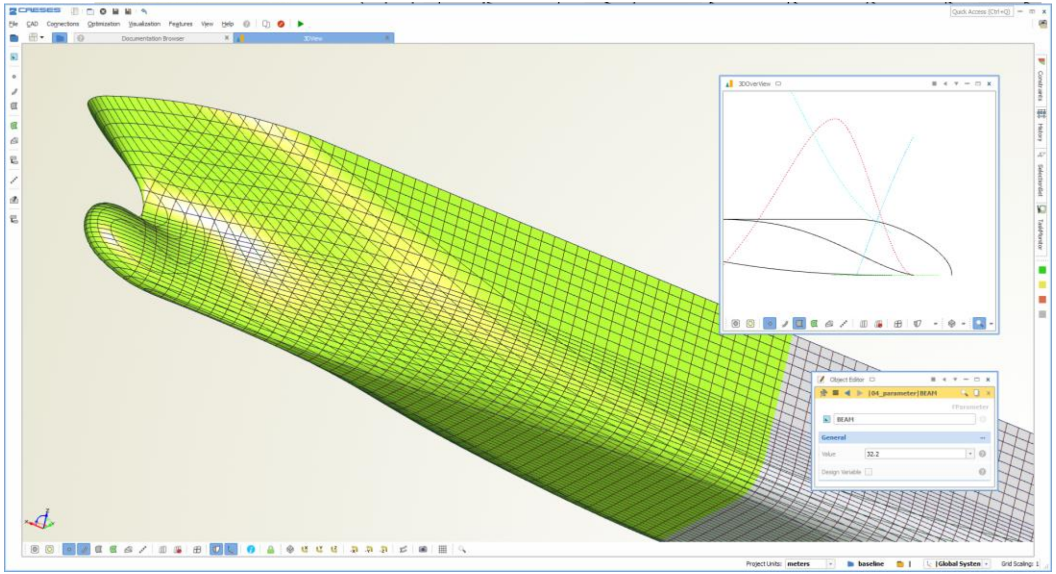
# Idea

- RANS code extensively used in R&D projects and for sophisticated applications
- Nevertheless, optimization projects in ship industry are often carried out using potential flow theory
- Drawbacks of RANS codes: More complicated setup, complicated grid design, increased computation time and more room for errors
- Goal is to undertake steps toward an easy to use and reliable setup



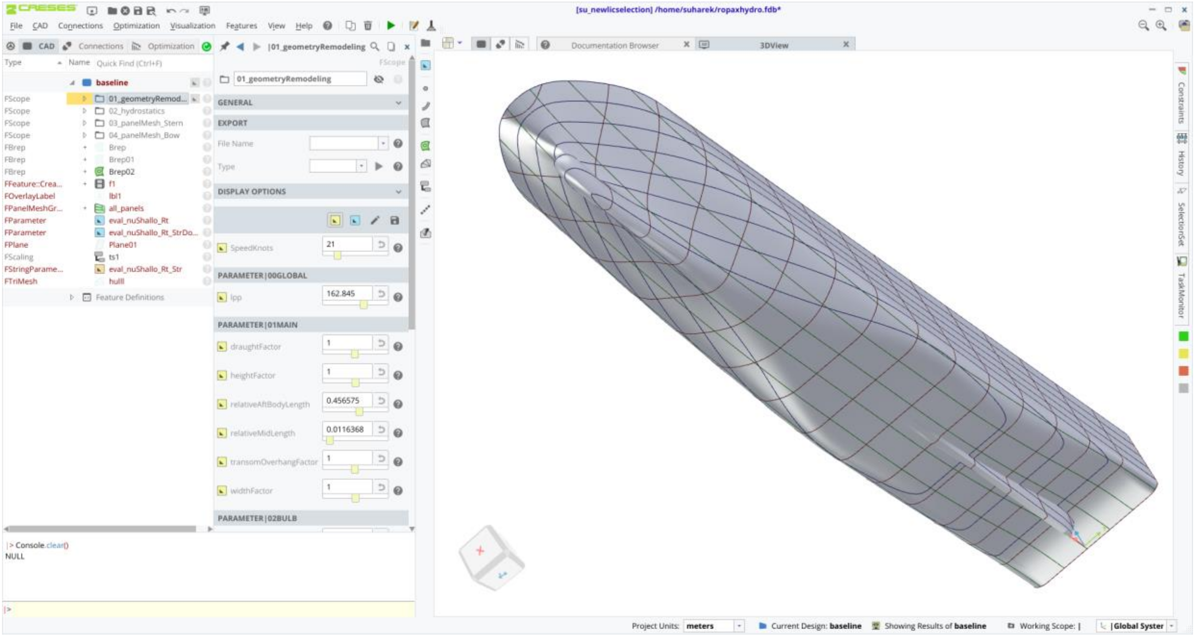
# CAESES

- PIDO Platform for integration of various tools
- Parametric modelling of hull forms
- Connection of external tools using Software Connectors
- Powerful Optimisation algorithms (Dakota)



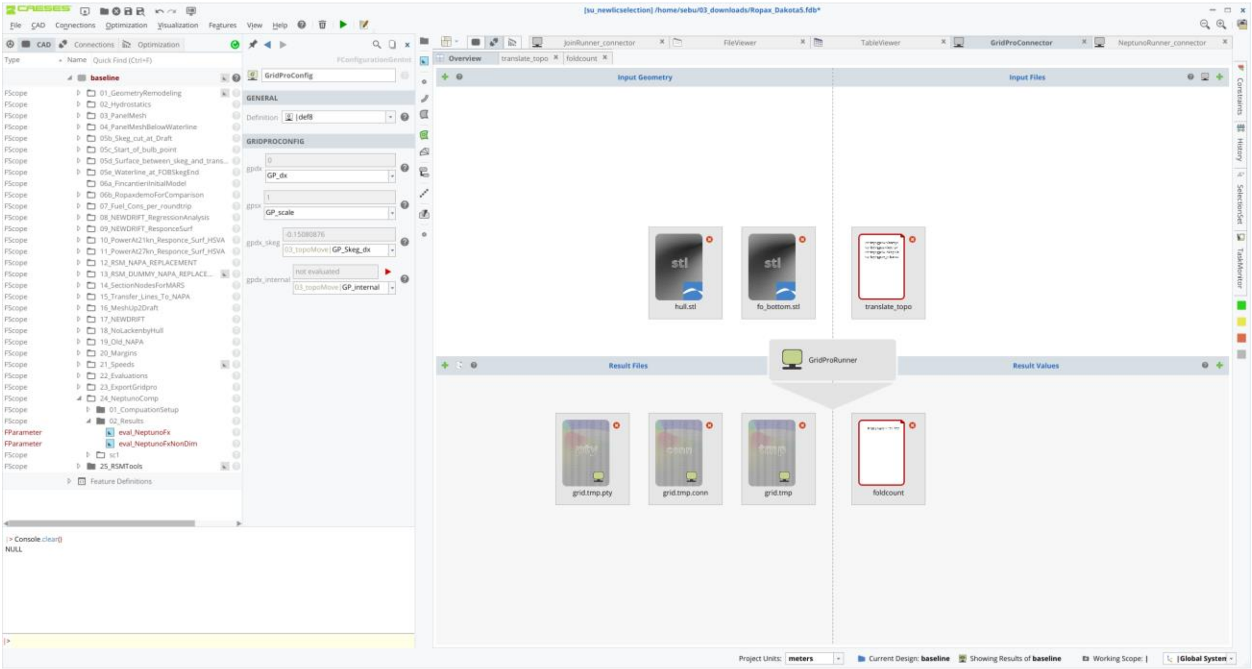
# Parametric model

- Parametric model of a Ropax Ship developed in the scope of the Holiship project
- Twin-screw ship with skeg
- Total of 23 design variables



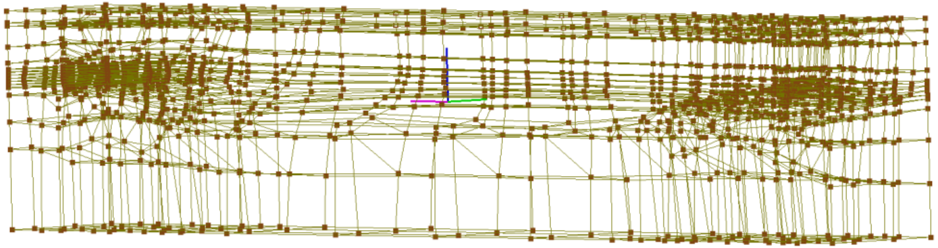
# Software connectors

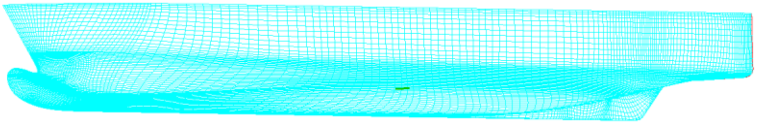
- Three chained connectors
  - Generate Grid
  - Preprocessing
  - Computation and basic postprocessing
- Execution of Jobs on HPC via Software Connector
- No manual interaction required after setup



# Gridpro

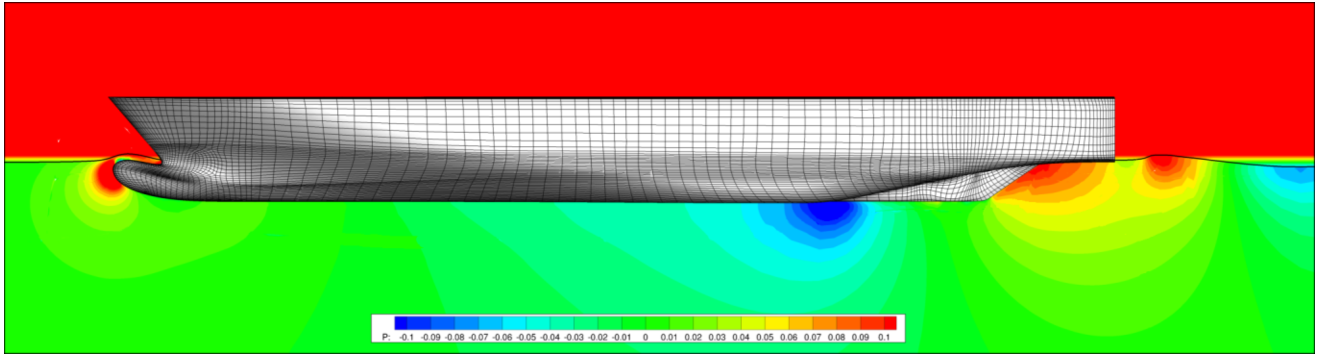
- Computational Grid created with GridPro
- Topology separated from Geometry
- Translation of parts of the topology using command line tools provided by GridPro
- Internal surfaces required by GridPro can be generated in CAESES
- 800.000 cells, 6 minutes to generate, 6 grids in parallel





# Neptuno

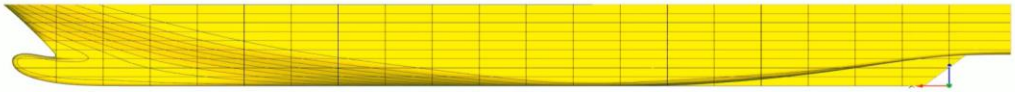
- In-House RANS code
  - Finite Volume
  - multi-block structured grid with non-matching interfaces
  - Standard kω turbulence model by Wilcox
  - Two phase level set method



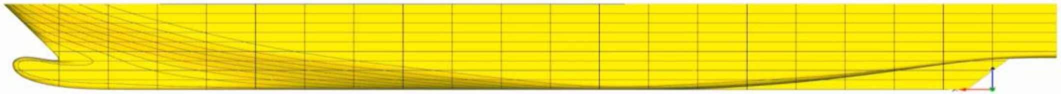
# What do we do?

- Different means of design space exploration
  - Ensemble investigation
  - Sobol algorithm
  - Latin Hypercube Sampling
- Varied Parameters:
  - Length between perpendiculars ($L_{PP}$)
  - Length of parallel midship ($L_{MS}$)
  - Position of parallel midship ($x_{MS}$)
- No additional constraints

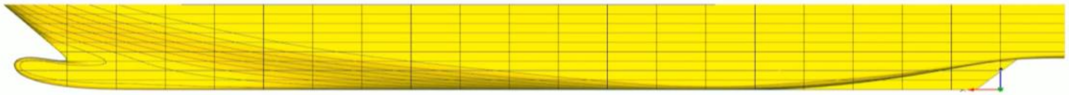
$L_{PP}$



$L_{MS}$

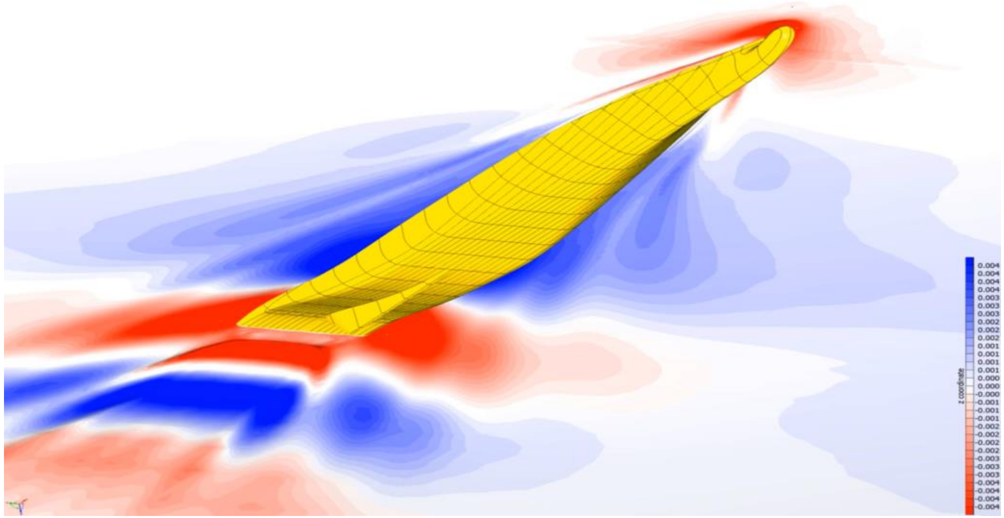


$x_{MS}$



# Results

- Total of 120 computations run in parallel
- Computations carried out at virtual model scale of λ= 25 and 21 kn (Fn = 0.27)
- Average computation time



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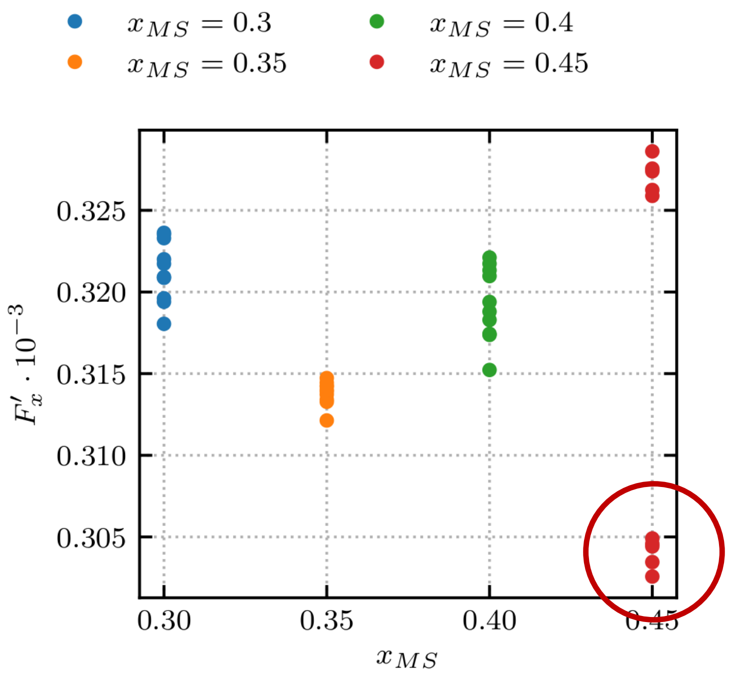
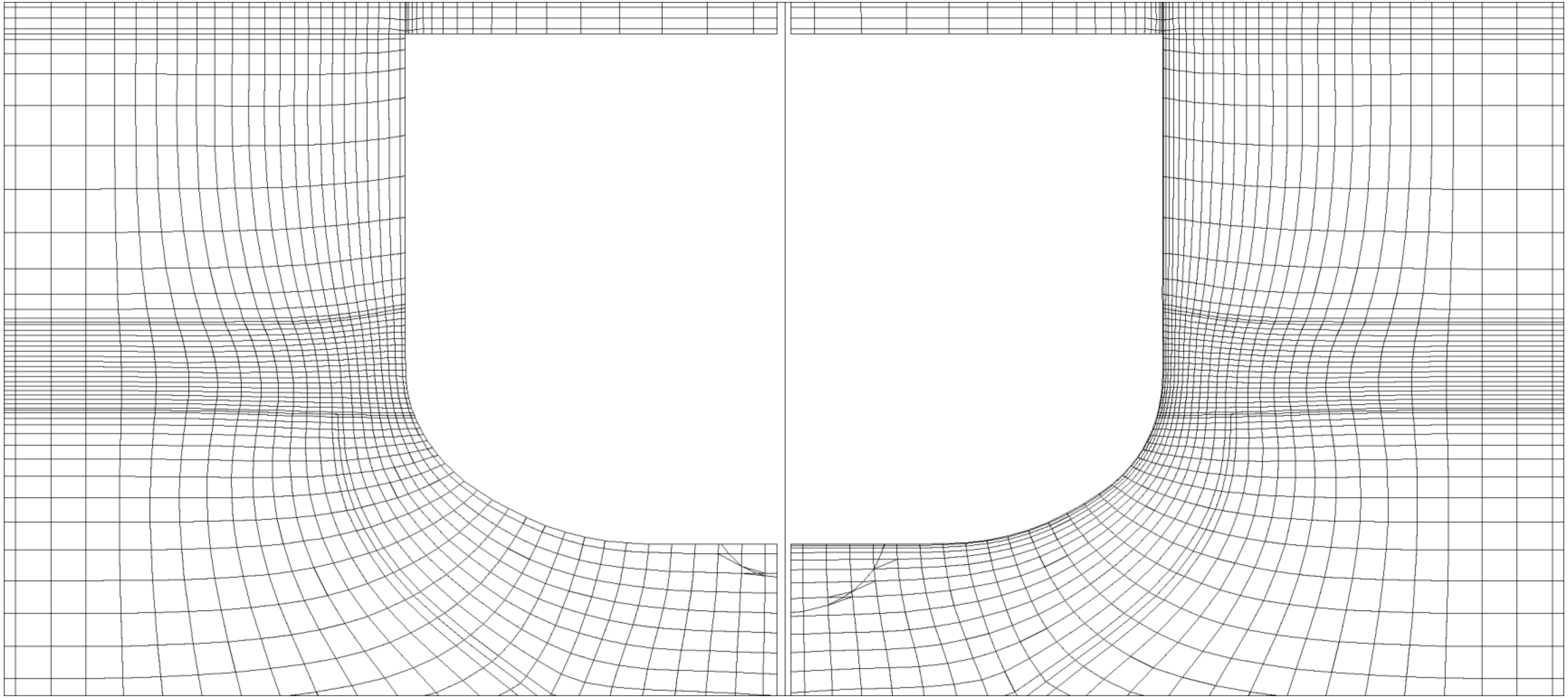
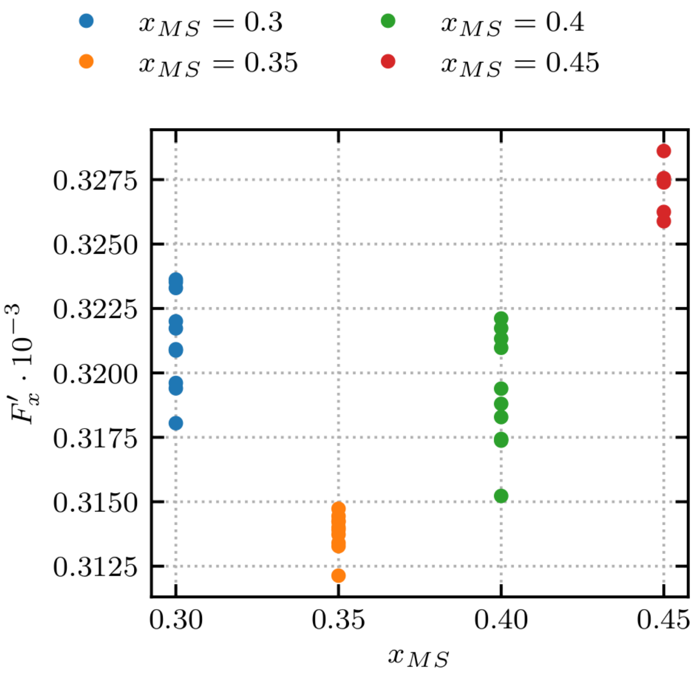


# Results: Mesh



# Results:

- Post processing script checks average y+ value on the hull and removes outliers
- Clear trends identified for parameter $x_{MS}$ and $L_{PP}$
- No trends identified for $L_{MS}$ - variation too small?



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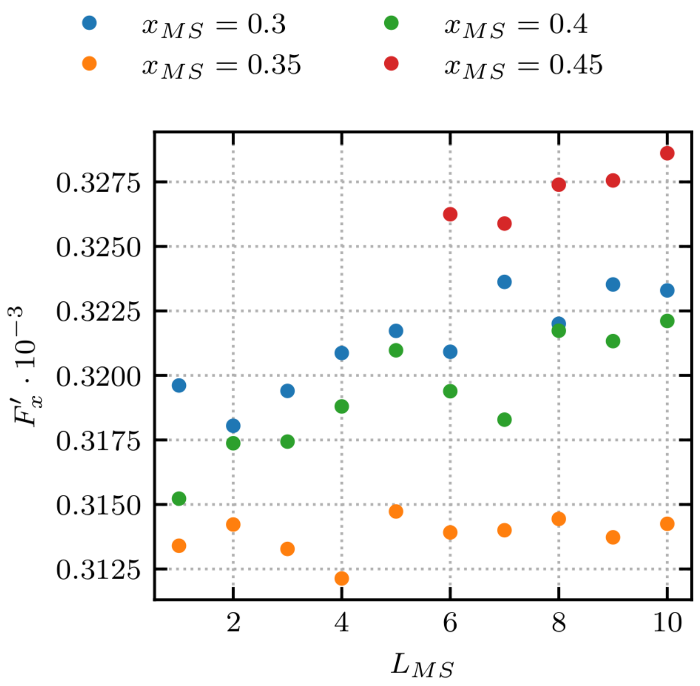

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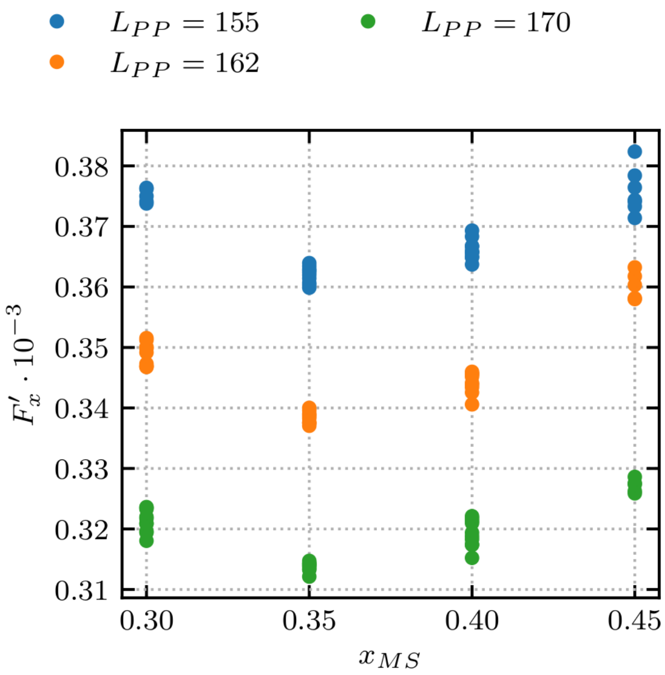
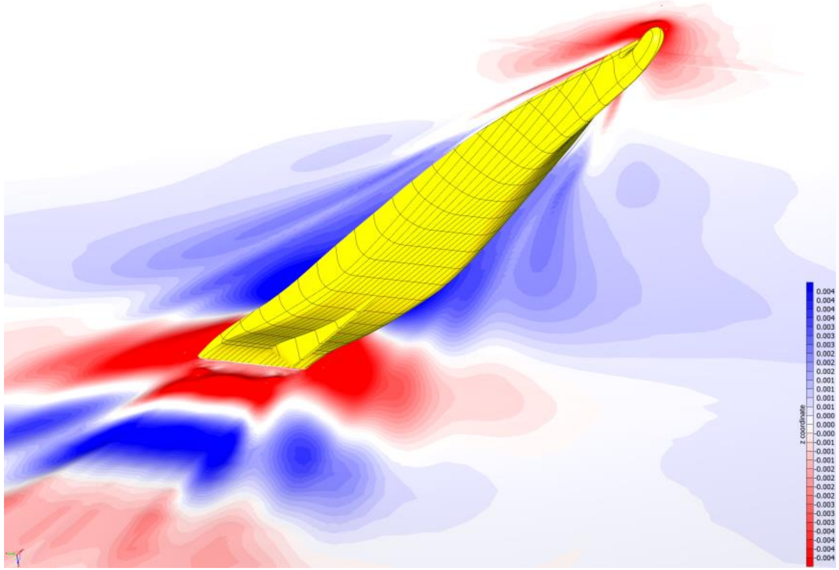
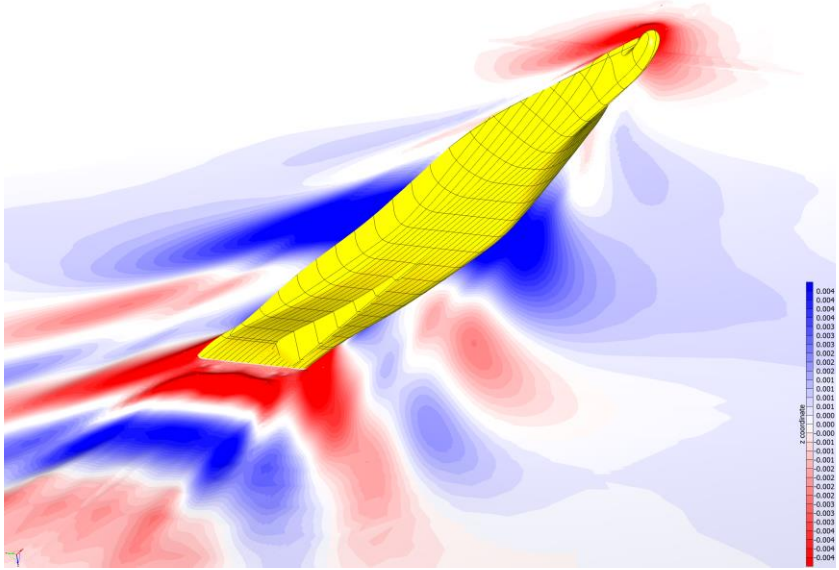


# Results:

$L_{PP}$ = 155 m, $x_{MS}$ = 0.45, $L_{MS}$ = 1



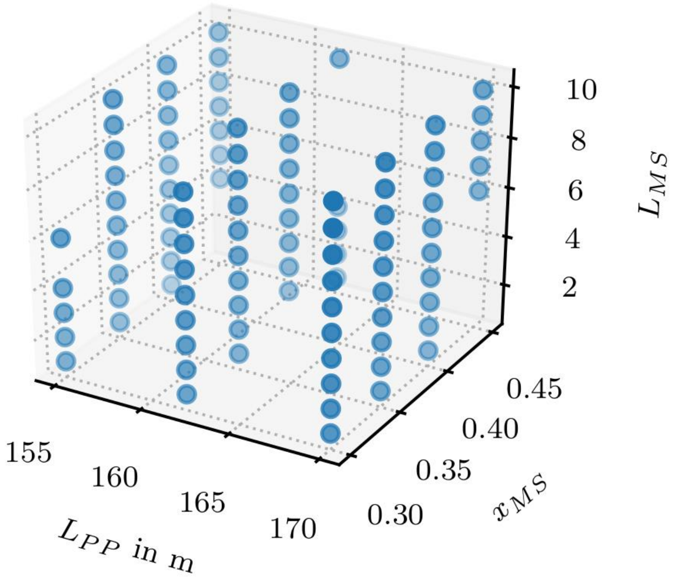
$L_{PP}$ = 155 m, $x_{MS}$ = 0.3, $L_{MS}$ = 2



Difference: 8%

# Response Surface Model

- Reduce computational time for optimisation even more by using a RSM model
- Randomly select 16 out of 100 initial design variants
- Generate a response surface model
- Recompute other 84 designs for validation



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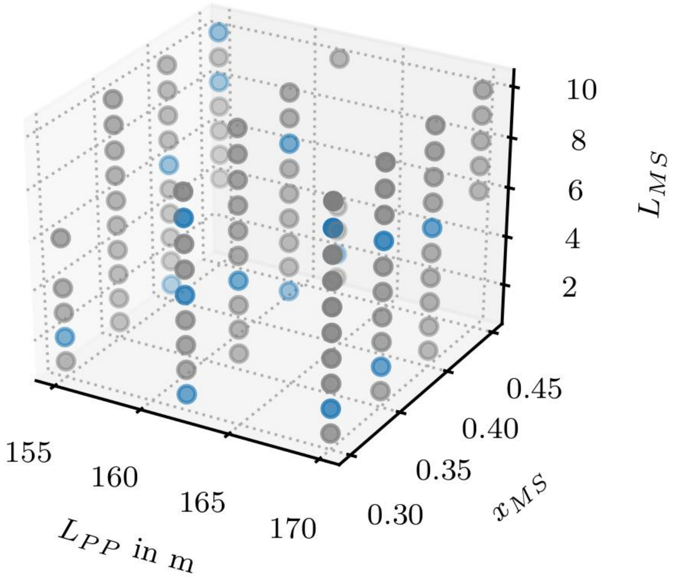

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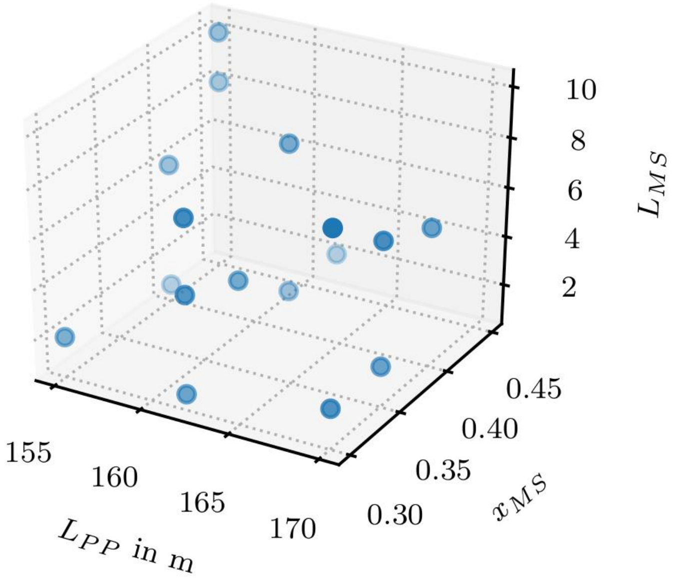

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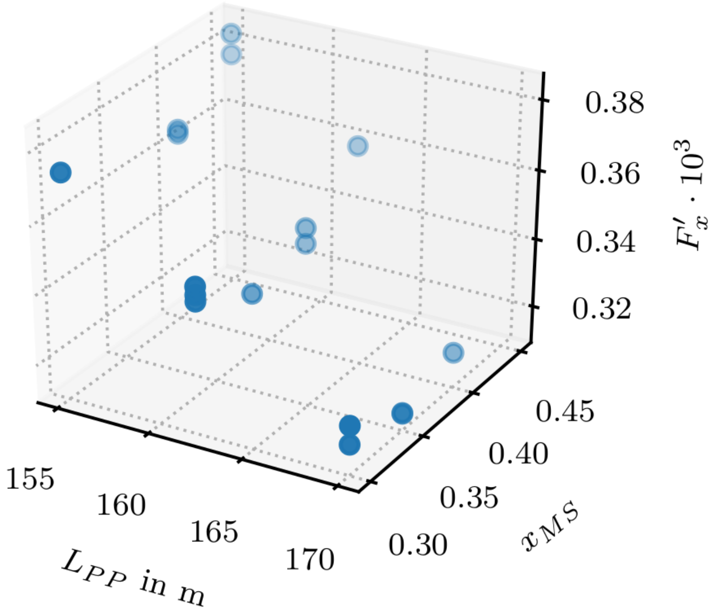


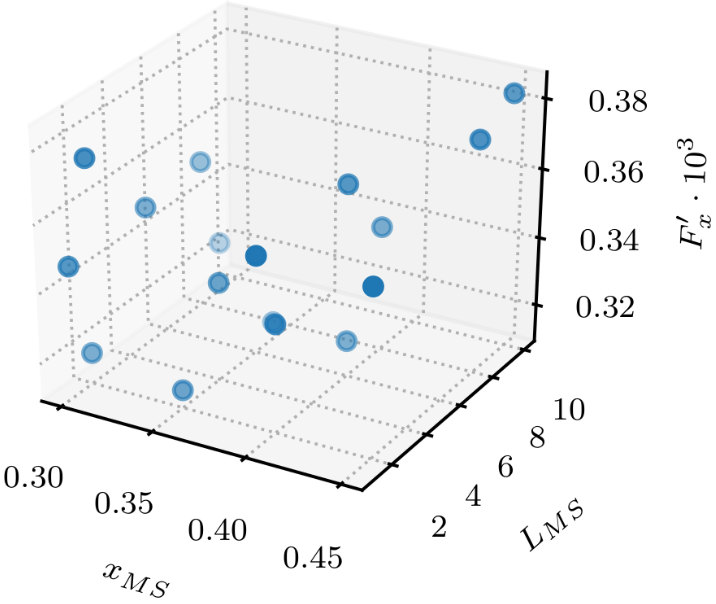

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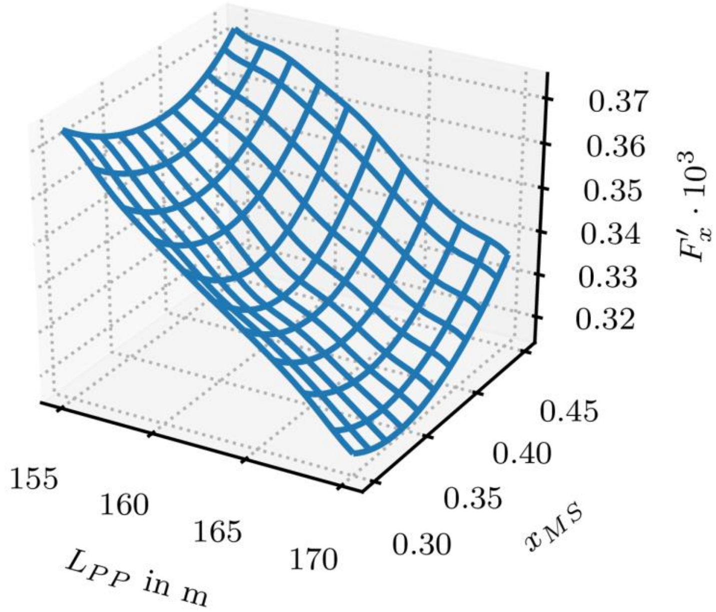
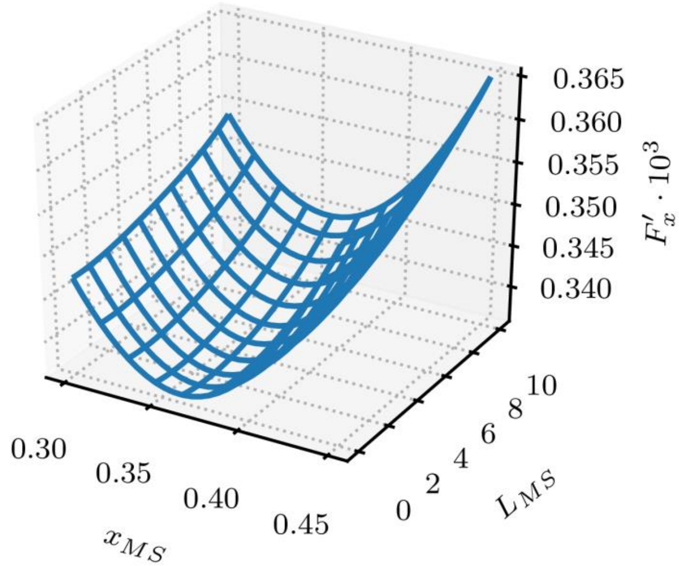
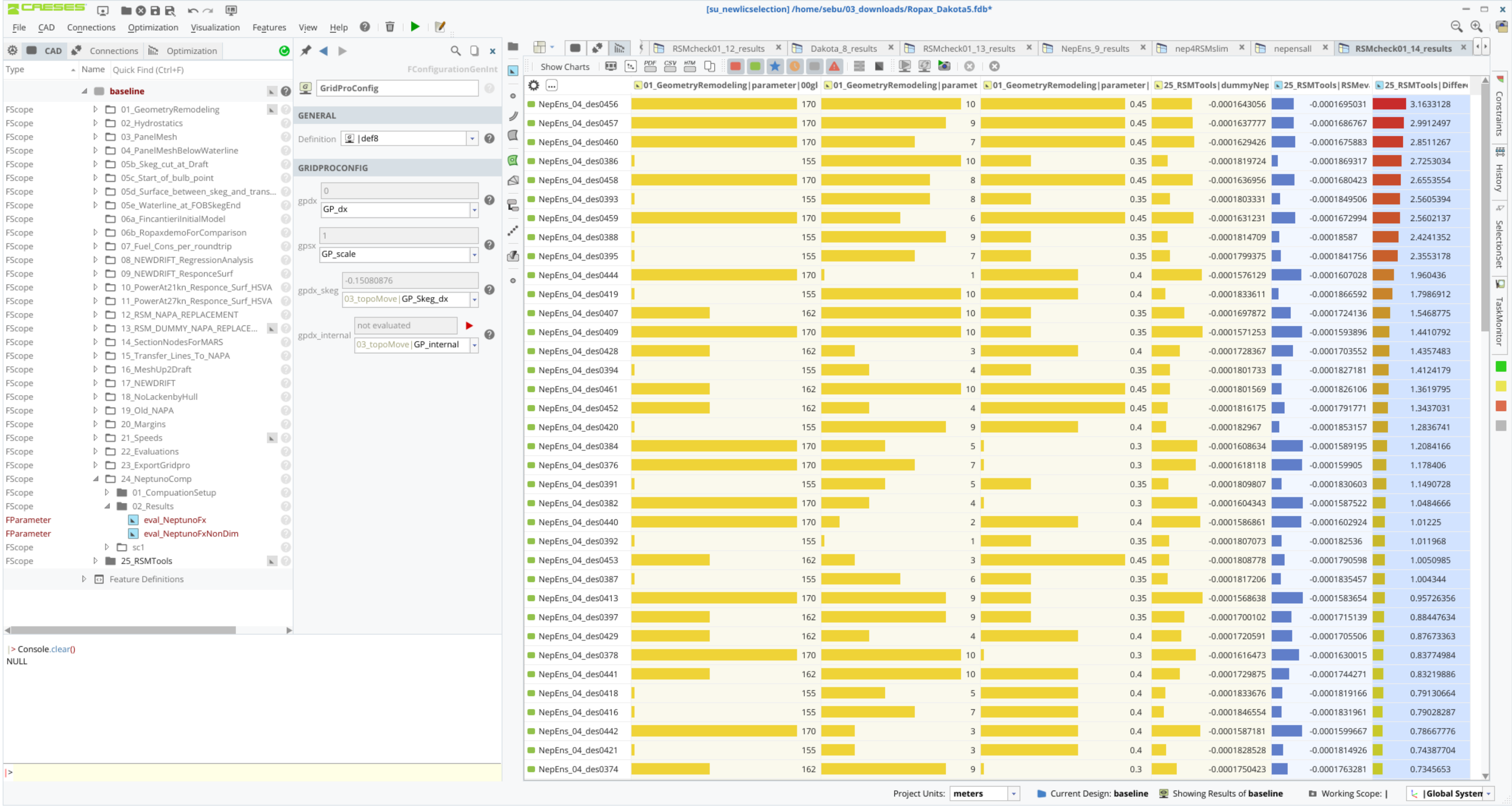


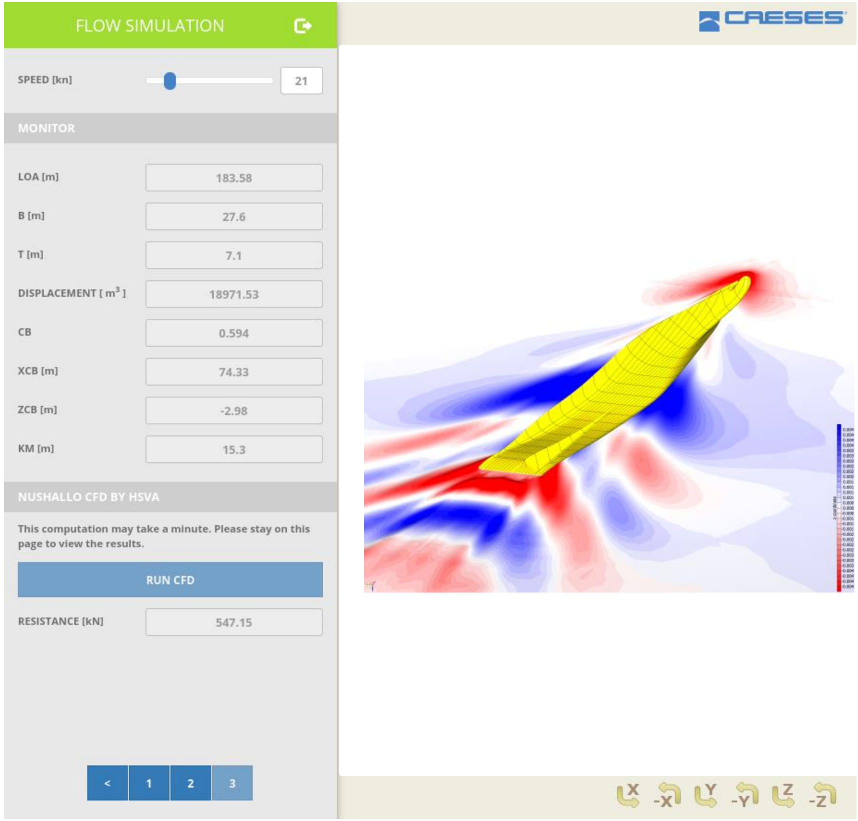



# Validation of Response Surface Model

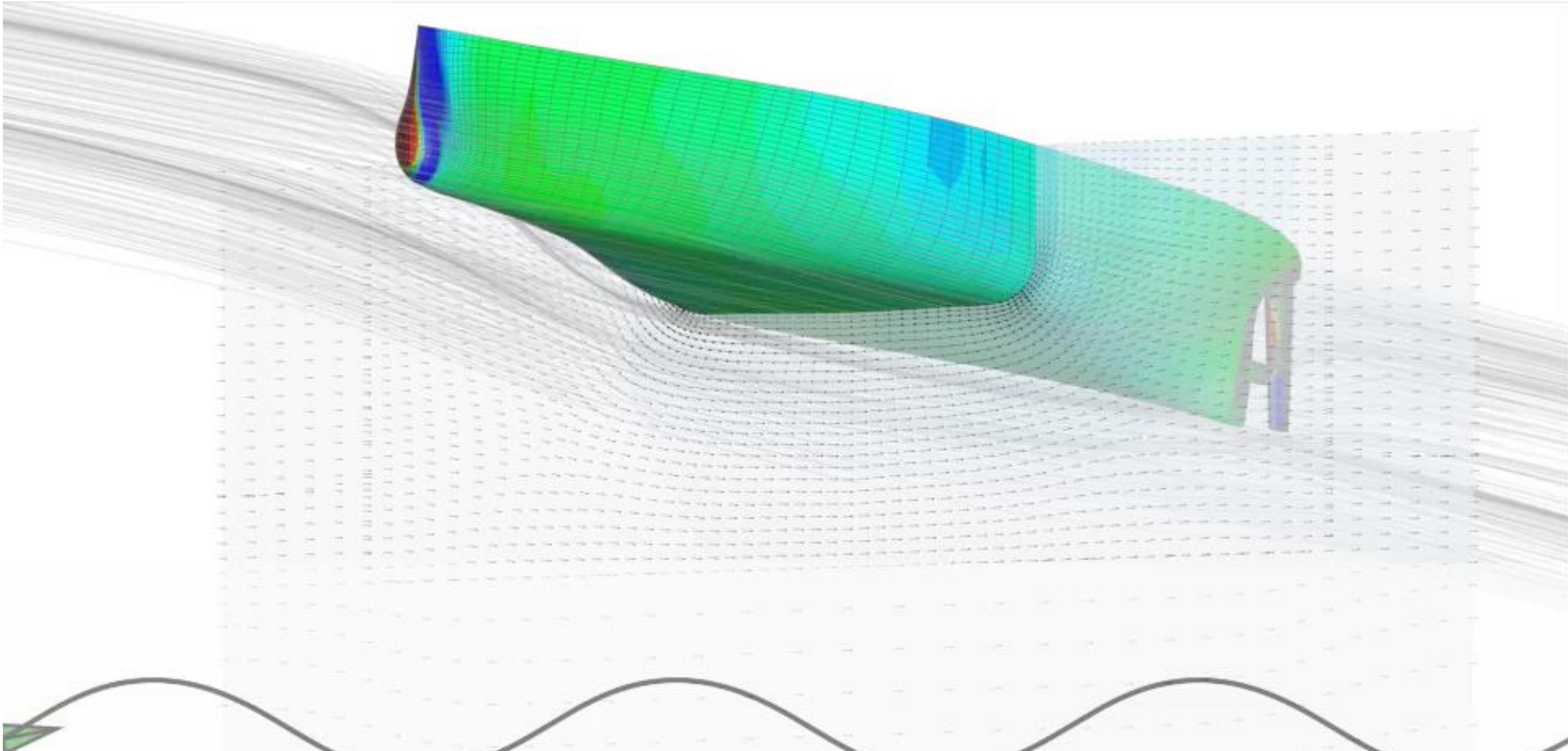


# Conclusion and Future Work

- Robust and fully automatic design space exploration
- High-quality grids, automated quality checks (grid dependence study) can be included
- RSM model shows very good results
- Employ more sophisticated design space exploration methods to reduce number of designs



# Thank you for your attention



# Thank you for your attention

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