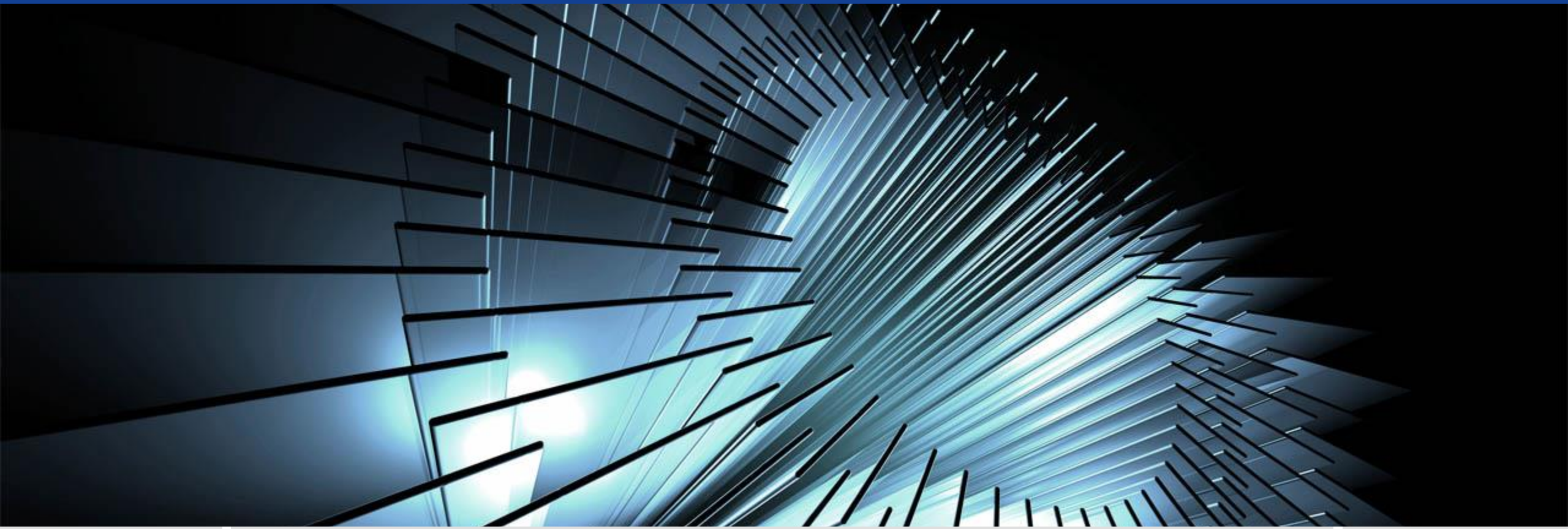


2017

European CAESES® User Meeting

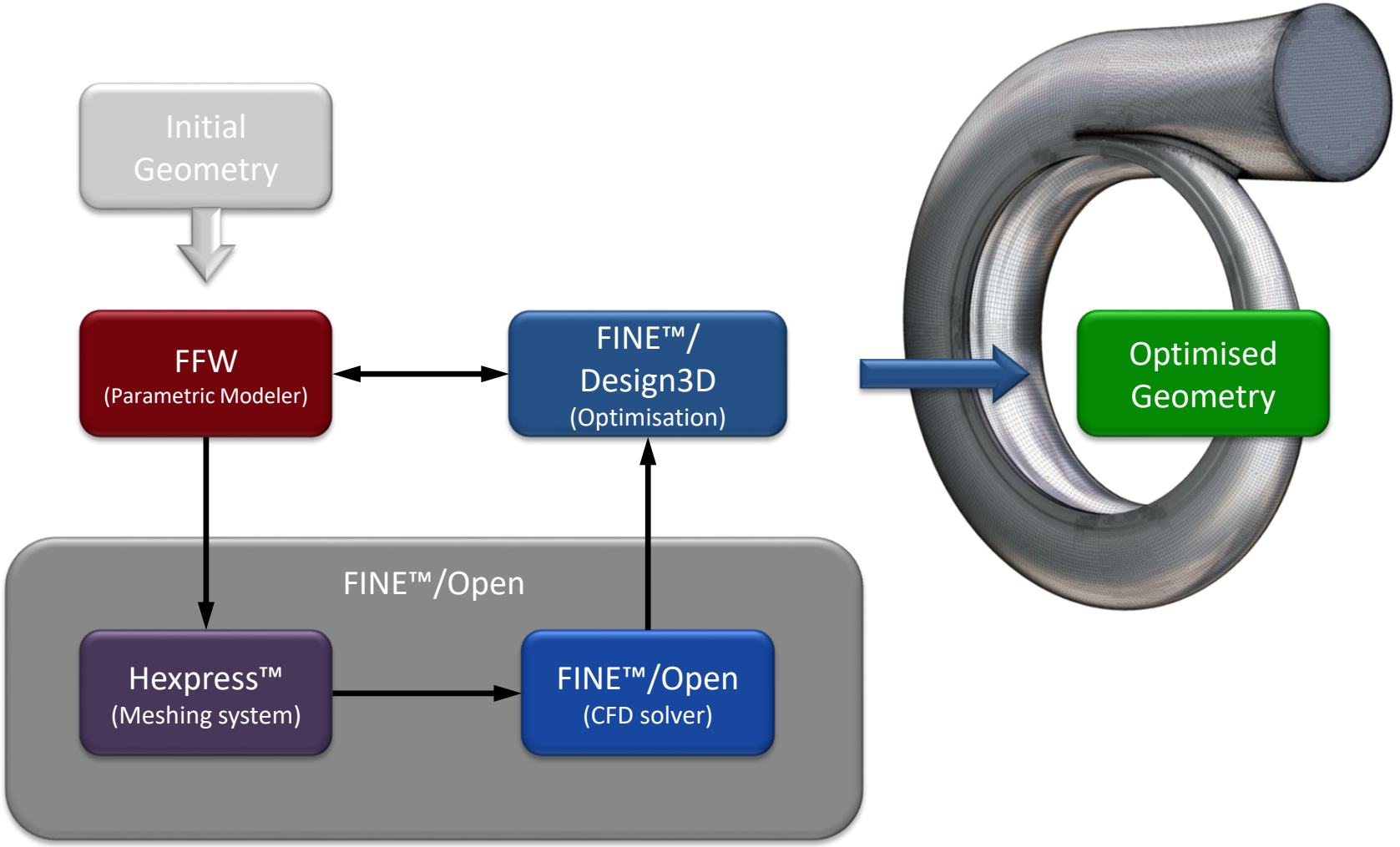
Robust Variable Geometry from CAESES® as Clean Input for FINE™

NUMECA INGENIEURBÜRO

Contents

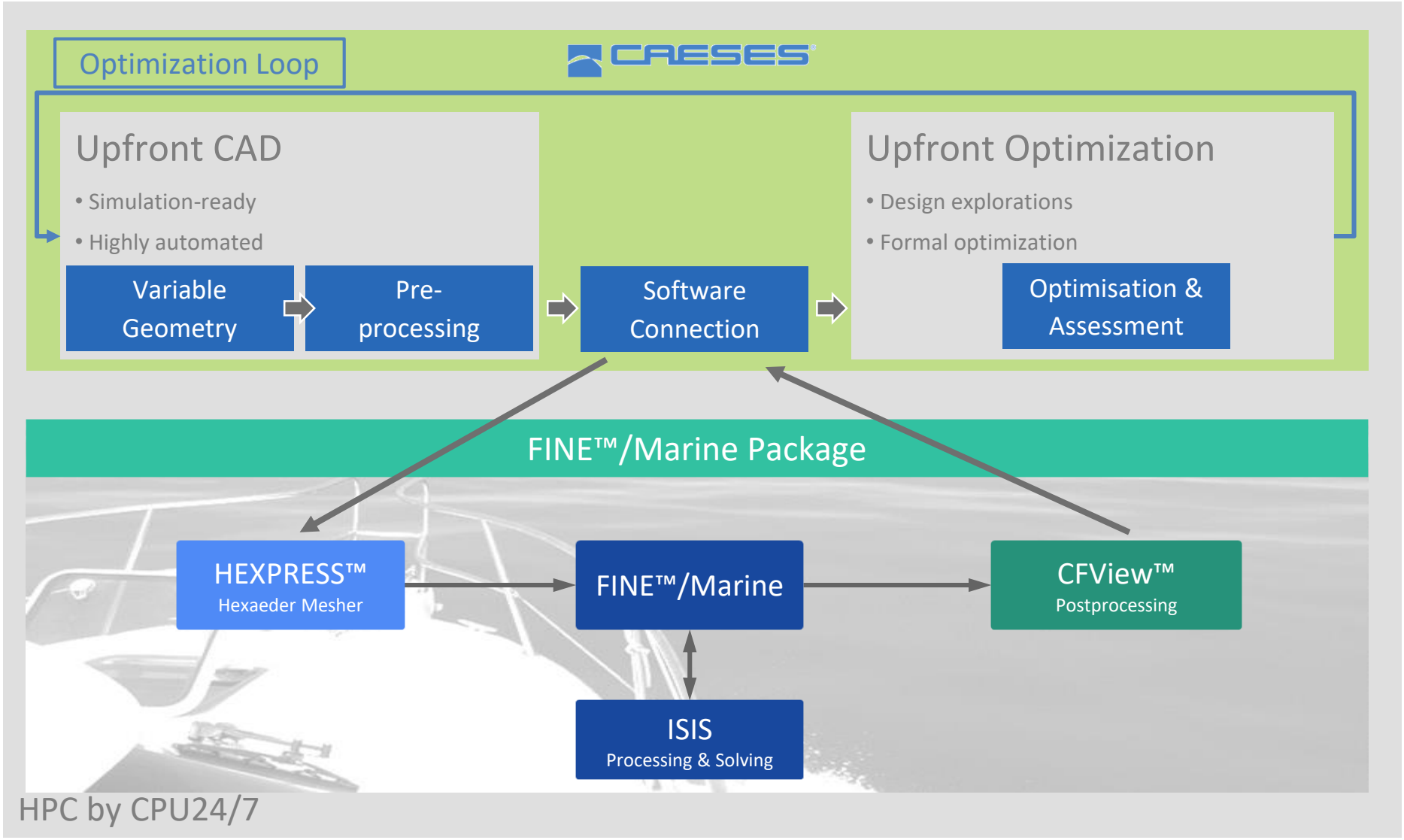
Coupling CAESES® & FINE™

Historical Coupling (2012)



Coupling CAESES® & FINE™

Coupling Today



HPC by CPU24/7

2

Cloud Based Optimization of a Powerboat

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Cloud Based Optimization of a Powerboat

Introduction & Motivation

Object of desire: RIVA Junior (1966)

- Fast & small hard chine powerboat
- Classic planning hull design by Carlo Riva

Why pick a powerboat for optimisation?

- Low Froude Number optimisation is widely used already – only little is published for high Froude Number
- Hydrodynamics of planning hulls require high-fidelity viscous calculations
- Coupling of vessel motion & fluid forces

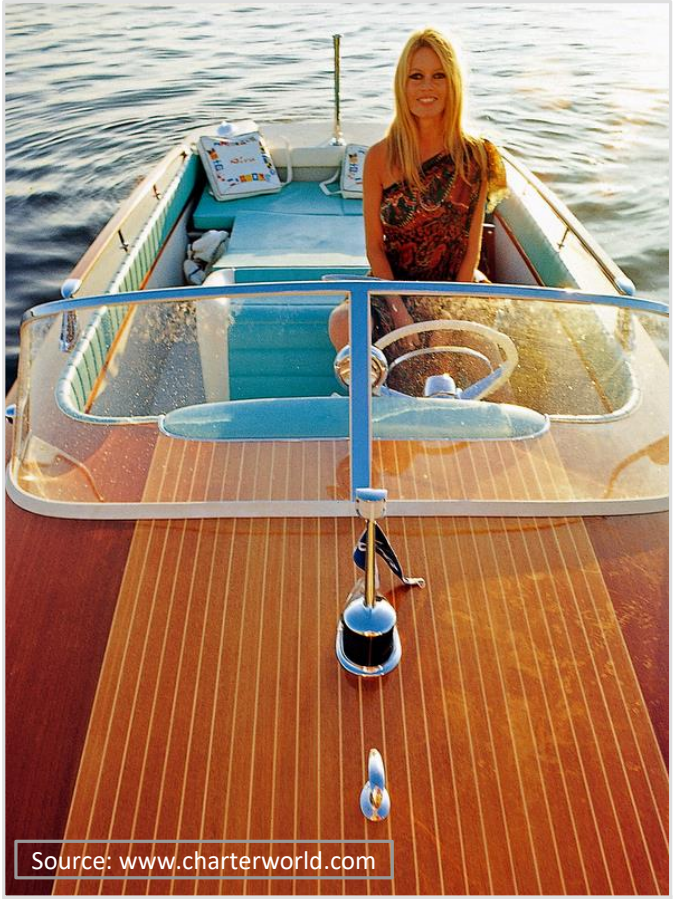
This is a challenging case – ideal to show an efficient setup for the coupling of a parametric model (CAESES®) with a free surface CFD code (FINE™/Marine) and bare-metal CPU resources (CPU24/7)

Cloud Based Optimization of a Powerboat

Riva Main Dimensions & Operating Conditions

Riva Junior		
Length over all	5.86	[m]
Lenght DWL	4.98	[m]
Draft	0.32	[m]
Beam at transom	1.6	[m]
Displacement	1.357	[m^3]
Total Resistance*	1900	[N]

CFD Operating Conditions		
Vessel Speed	18.0	[kn]
Froude Number	1.32	[-]
Speed Coefficient	2.34	[-]
Total Mass	1300	[kg]



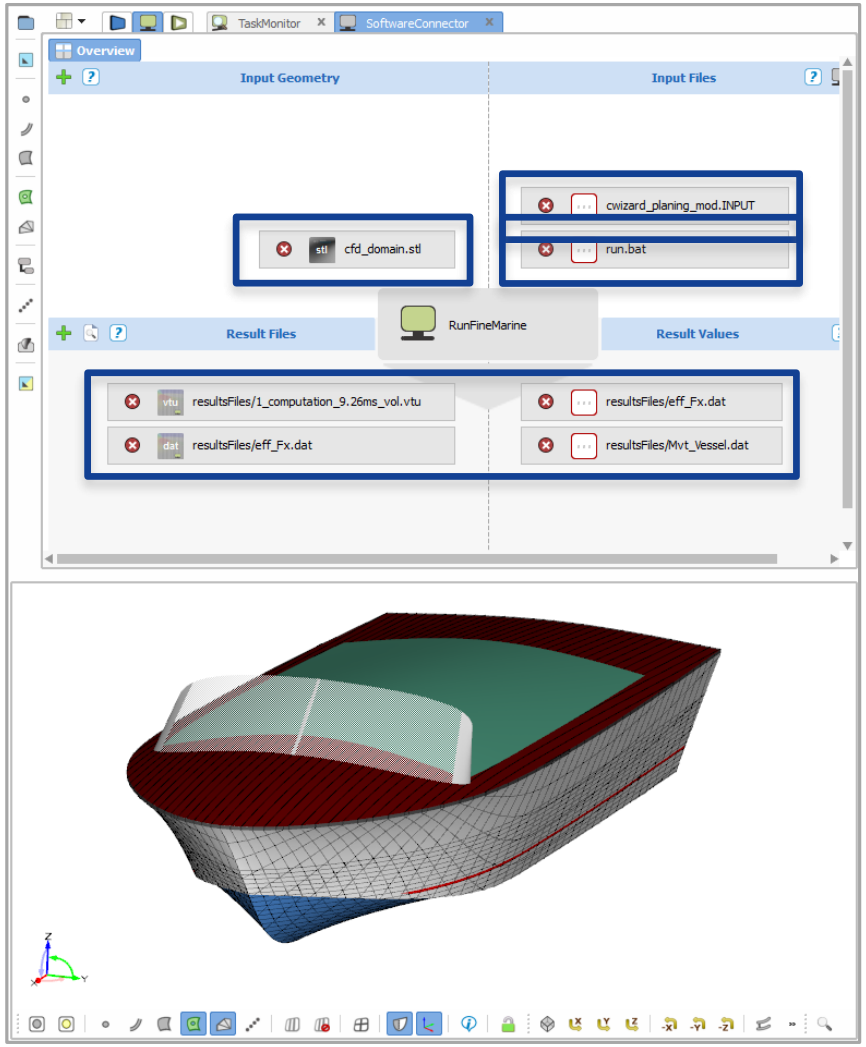
Probably the most famous RIVA fan: Brigitte Bardot

*Total Resistance according to Savitsky Theory (1964) for a trim of 5°

Cloud Based Optimization of a Powerboat

Powerboat in the Cloud – CAE Chain

- CAESES® & FINE™/Marine are batch capable
- Pre-requisite for any automated setup and otimization
- Creation of the new geometry and CFD domain, triangulation -> STL file [CAESES®]
- Complete CFD setup via the C-Wizard
- Run the simulation(s)
- Collect CFD results & import in CAESES®
- Continue with next design

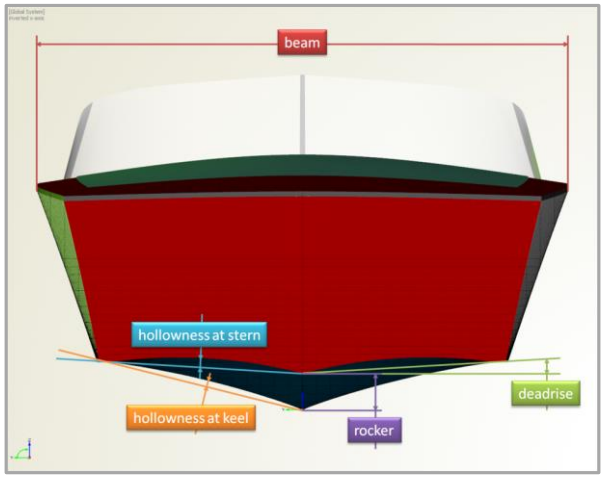


CFD simulation chain

Cloud Based Optimization of a Powerboat

Parameters, Constraints & Objectives

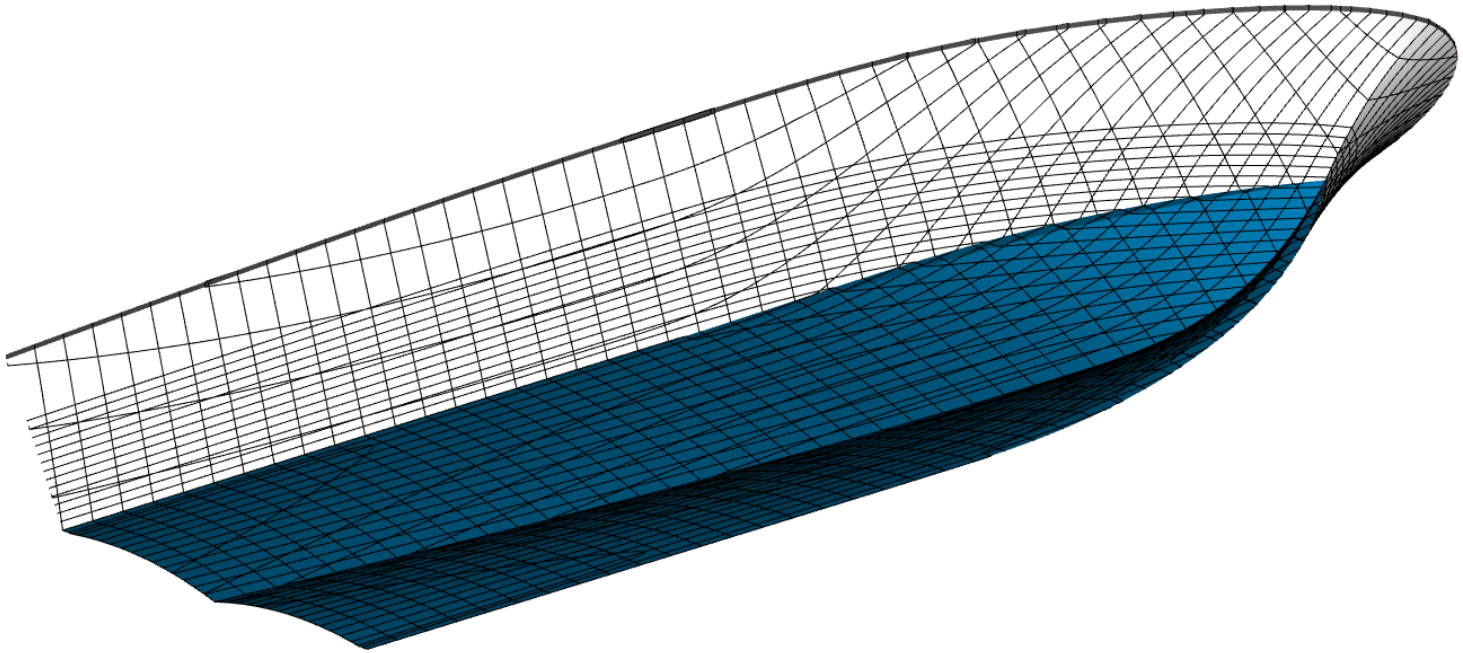
- 10 parameters selected for variation.
- Focus on the planning surface & the spray rail
- One operating point: 18kn
- Displacement kept constant 1.3m³



Parameter	Min. Value	Base Value	Max Value
Beam	2.1	2.2	2.3
Dead rise at transom	12	14	16
Rocker	0.13	0.14	0.17
Rel. hollowness at keel	0	0	0.05
Rel. hollowness at stern	0	0	0.1
Rel. hollowness in aft freeboard	0.65	0.7	0.08
4 parameters for spray rail			

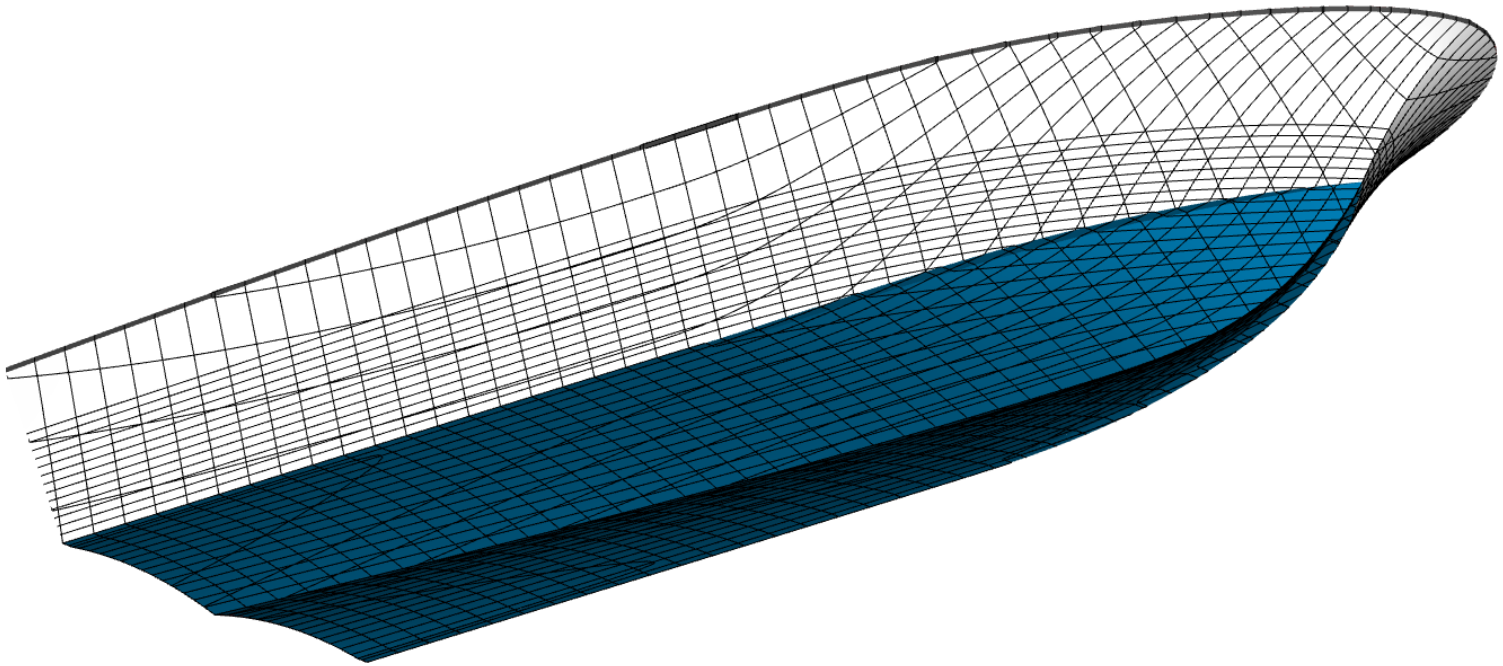
Cloud Based Optimization of a Powerboat

Powerboat in the Cloud – Parametric Model – Hull Form [FPM]



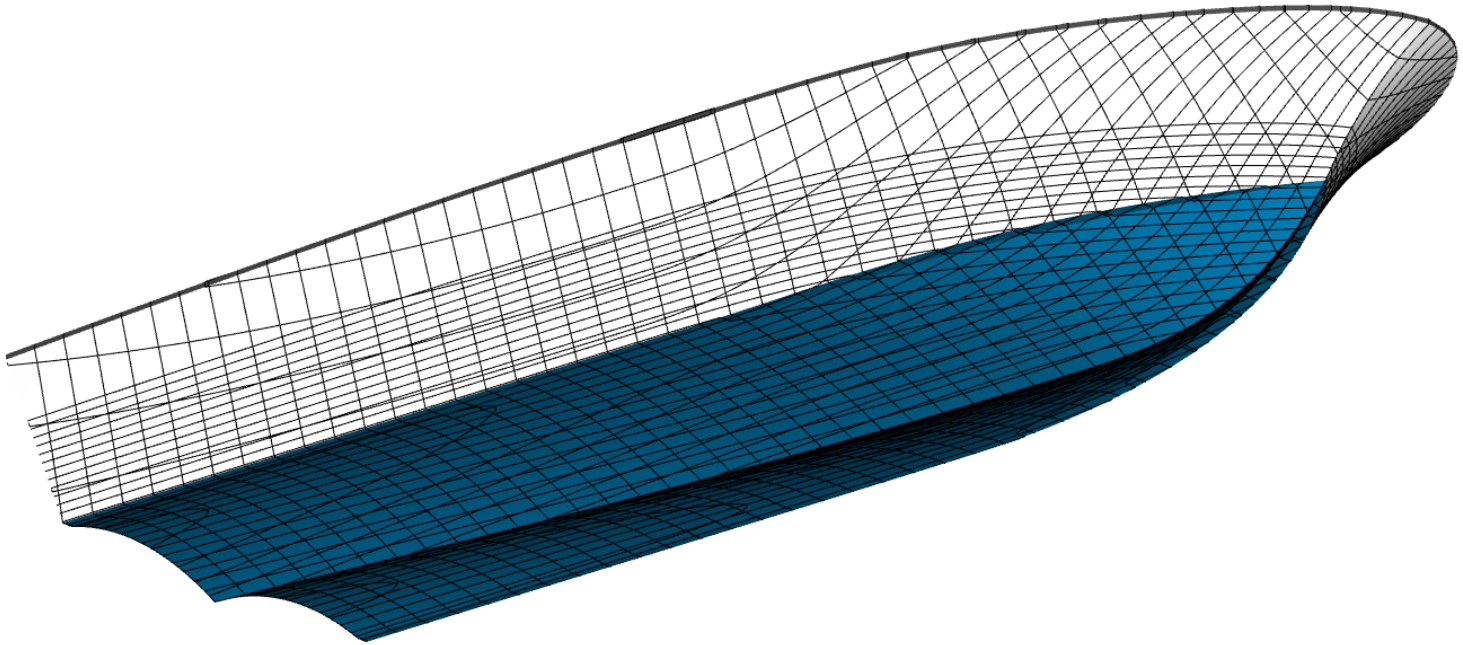
Cloud Based Optimization of a Powerboat

Powerboat in the Cloud – Parametric Model – Global Dimensions



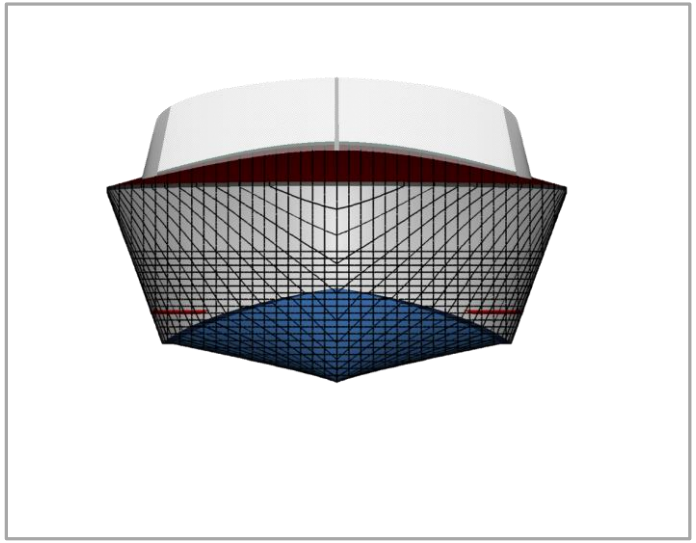
Cloud Based Optimization of a Powerboat

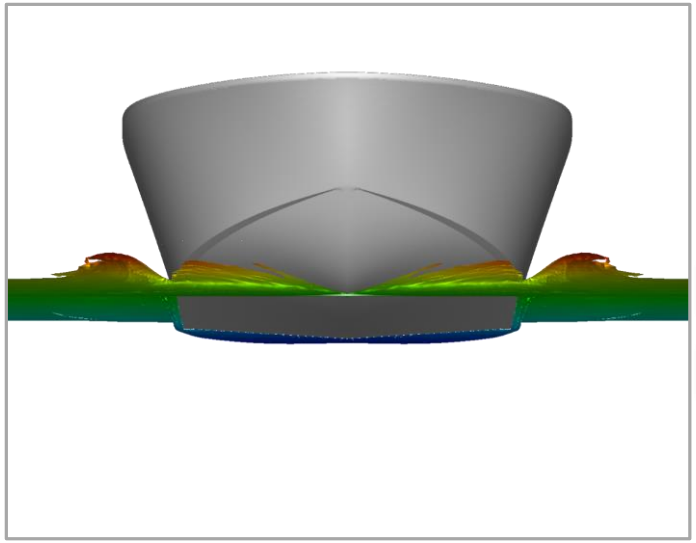
Powerboat in the Cloud – Parametric Model – Local Fine Tuning

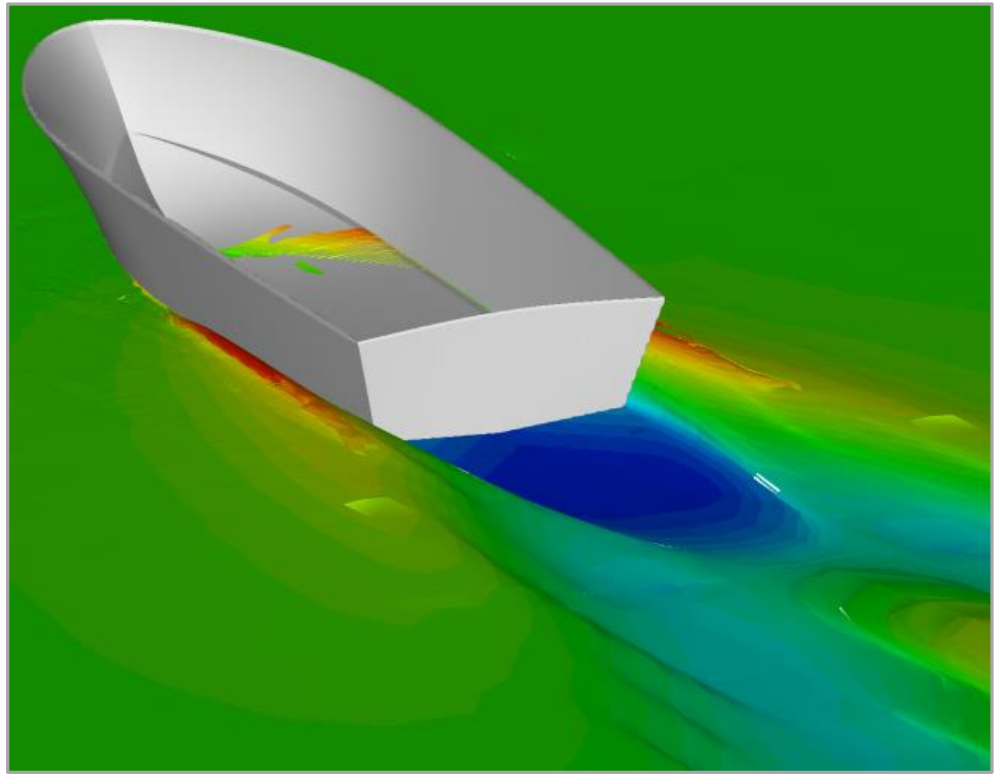


Cloud Based Optimization of a Powerboat

Baseline: Geometry & Wave Elevation





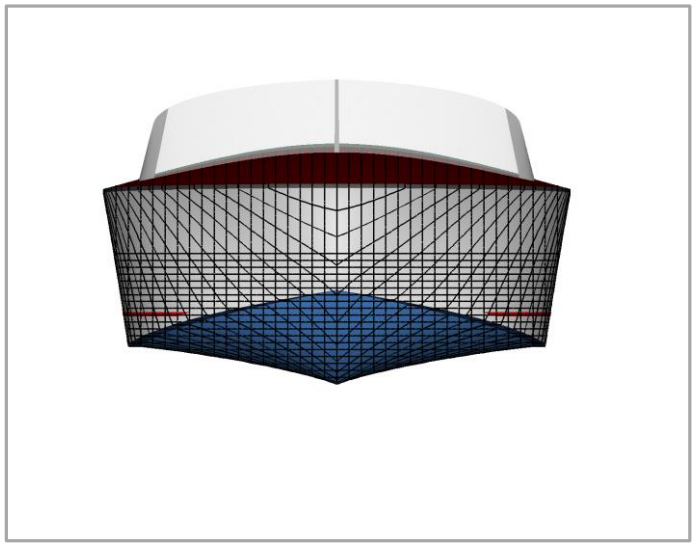


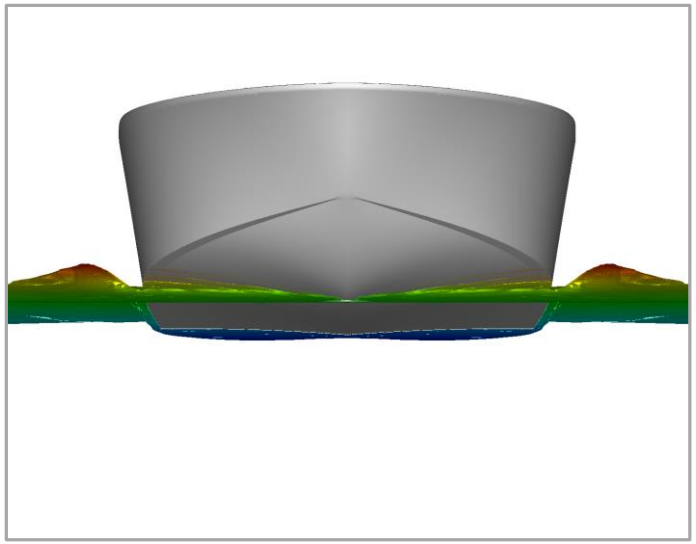
R_T = 1572N

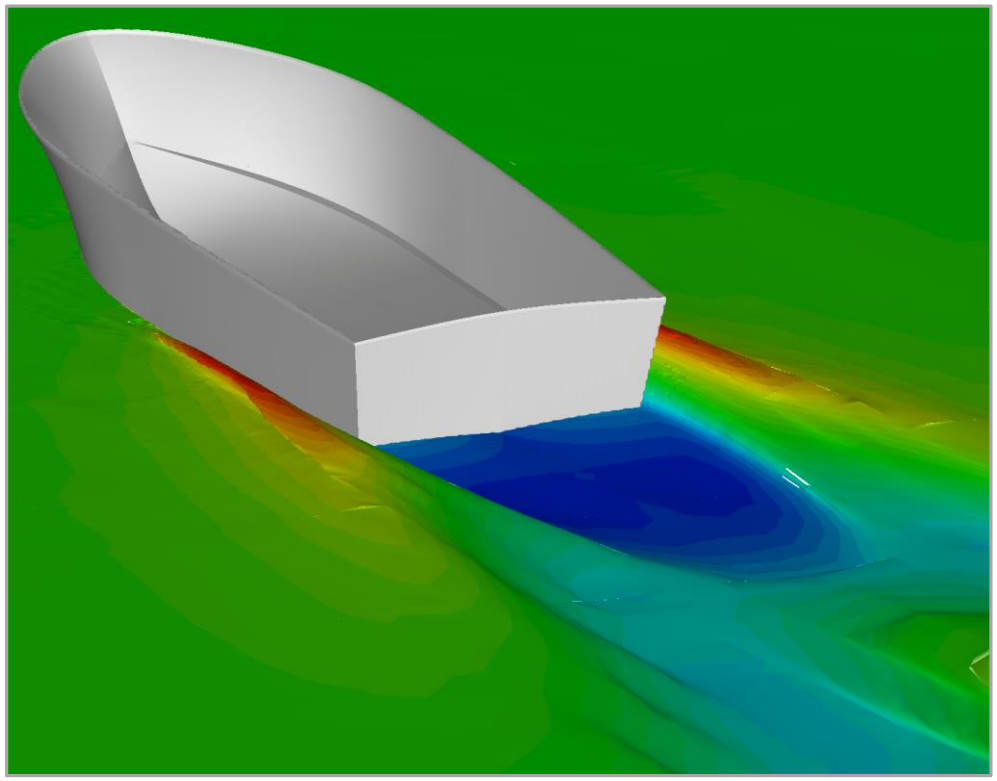
ΔR_T = 0%

Cloud Based Optimization of a Powerboat

Best DoE Design: Geometry & Wave Elevation





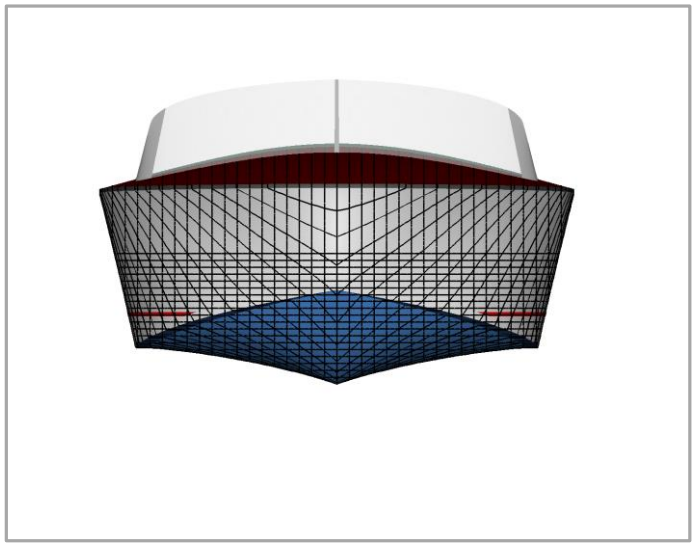


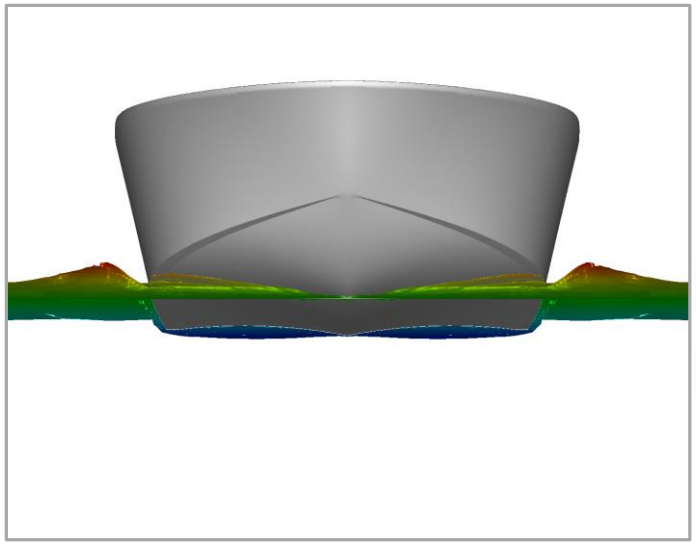
R_T = 1476N

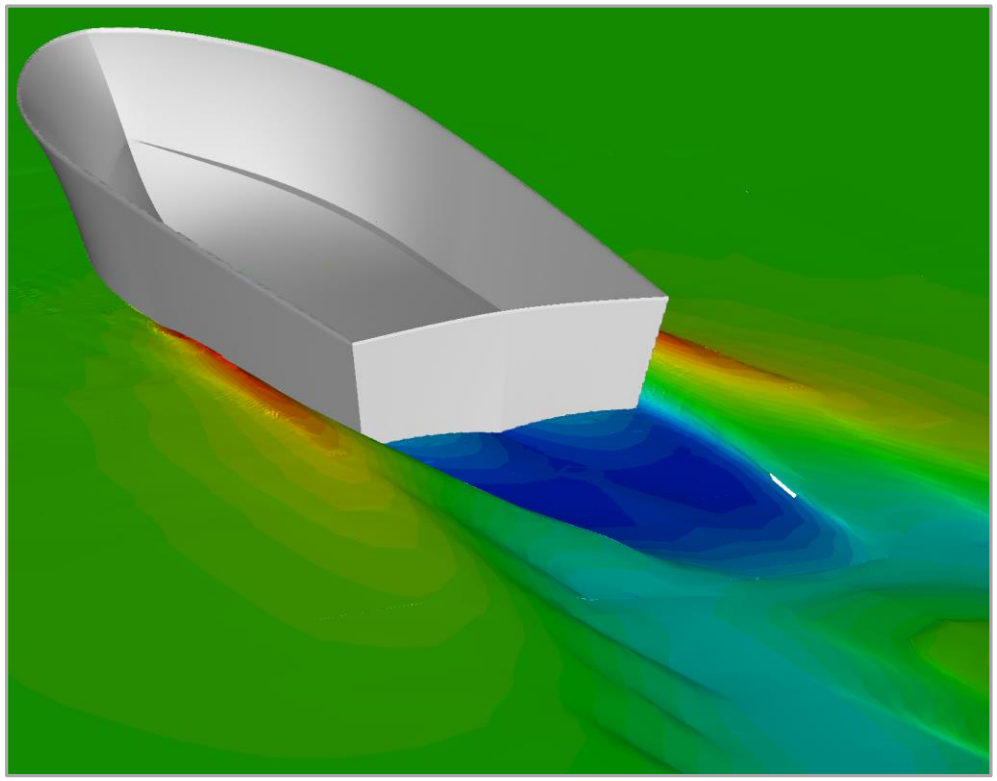
ΔR_T = -6.1%

Cloud Based Optimization of a Powerboat

Optimised Design [T-Search]: Geometry & Wave Elevation





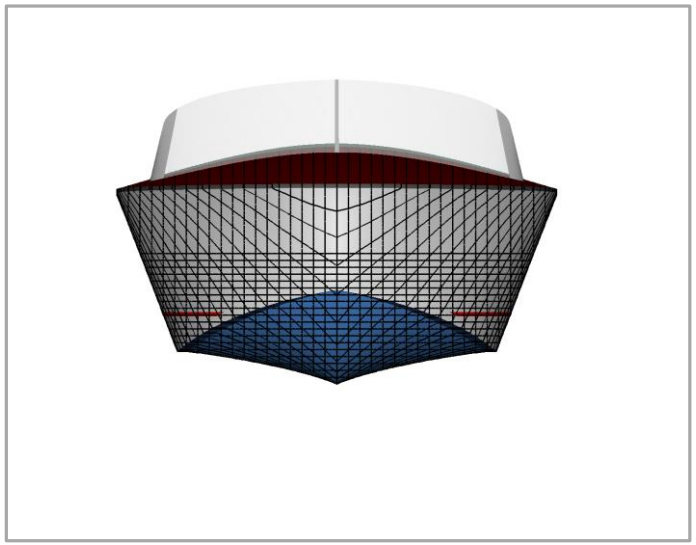


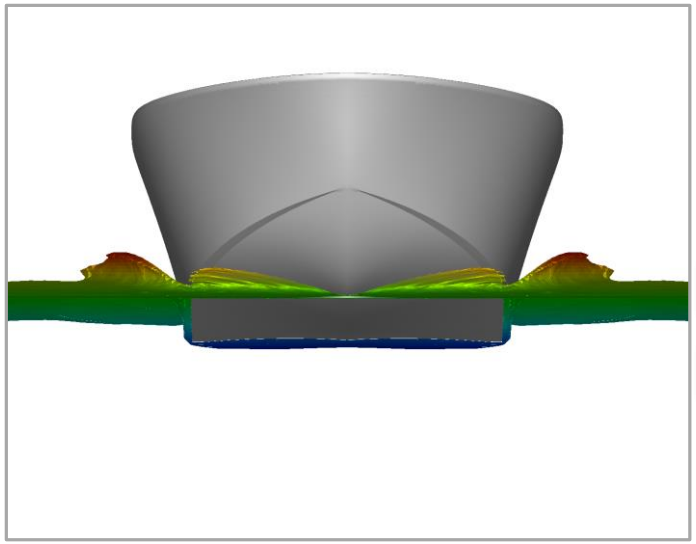
R_T = 1461N

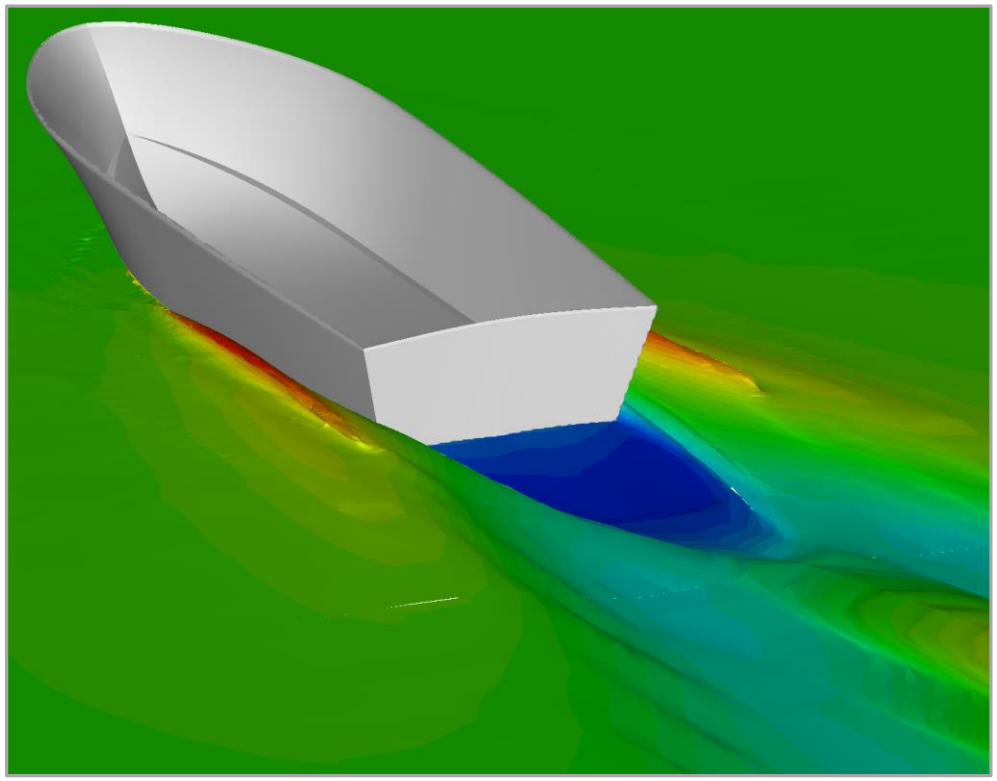
ΔR_T = -7.1%

Cloud Based Optimization of a Powerboat

Worst DoE Design: Geometry & Wave Elevation







R_T = 1645N

ΔR_T = +4.6%

Cloud Based Optimization of a Powerboat

Optimisation Successful – But Where Does the Gain Come From?

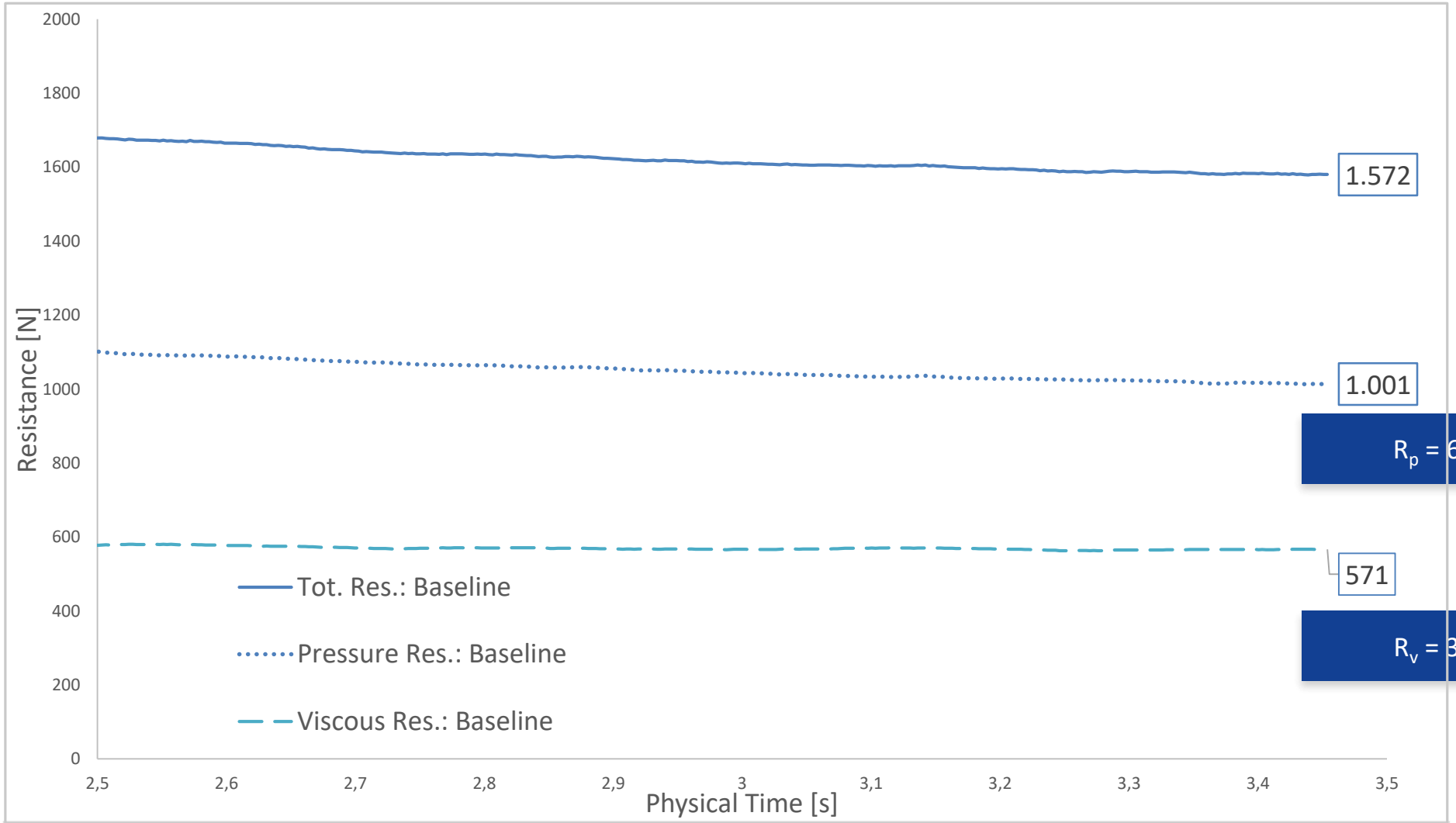
- Achivement: -7% resistance. Can be exploited:
  - less fuel consumption
  - higher end speed
  - decreased necessary engine power [probably the least preferable for a powerboat]

- But 7% also demonstrates how well designed the original Riva Junior really is!

- But since we do have computer power now – where does the decrease in resistance originate?

Cloud Based Optimization of a Powerboat

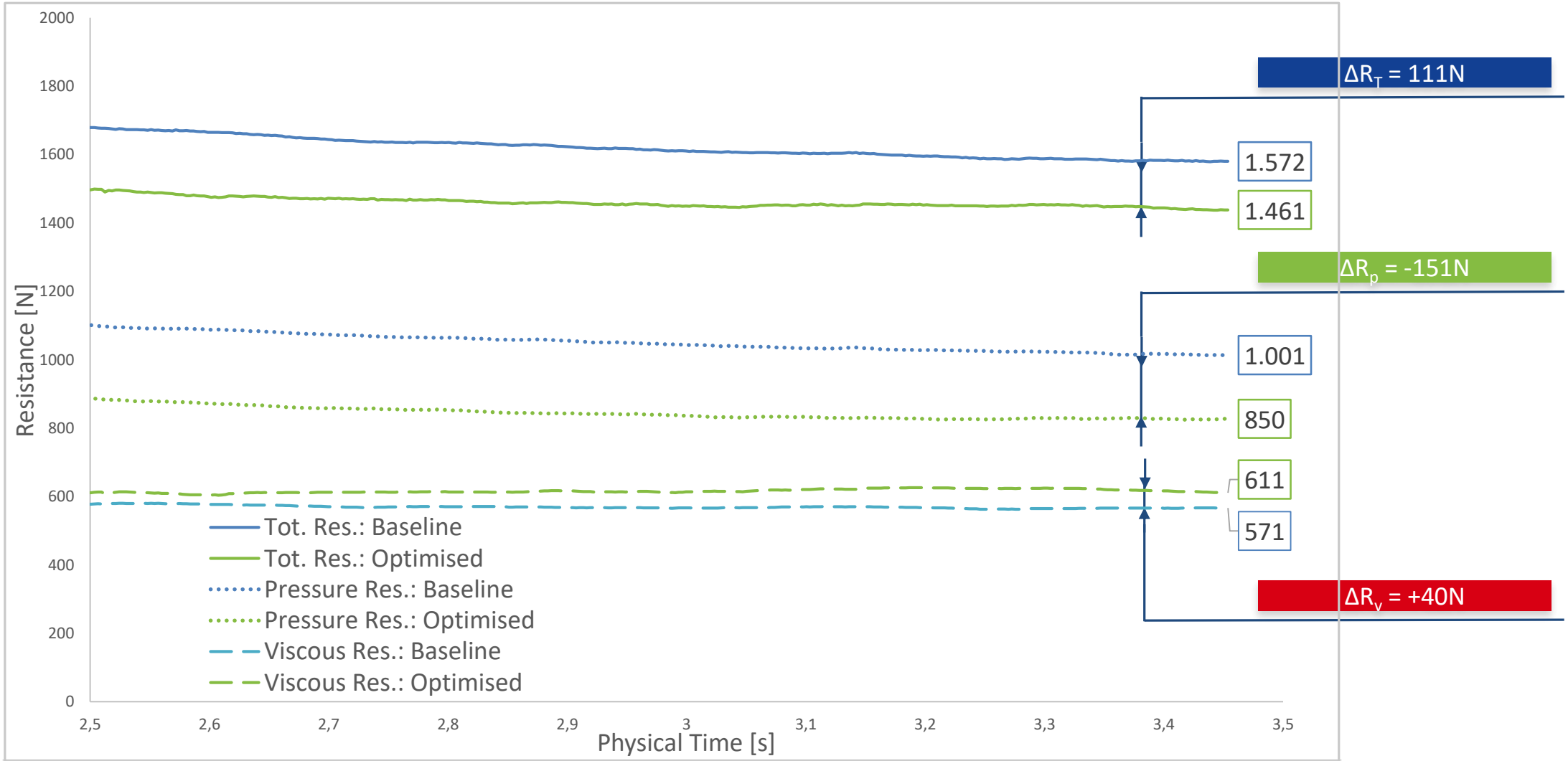
Resistance Components Breakdown – Baseline



Resistance components: Baseline

Cloud Based Optimization of a Powerboat

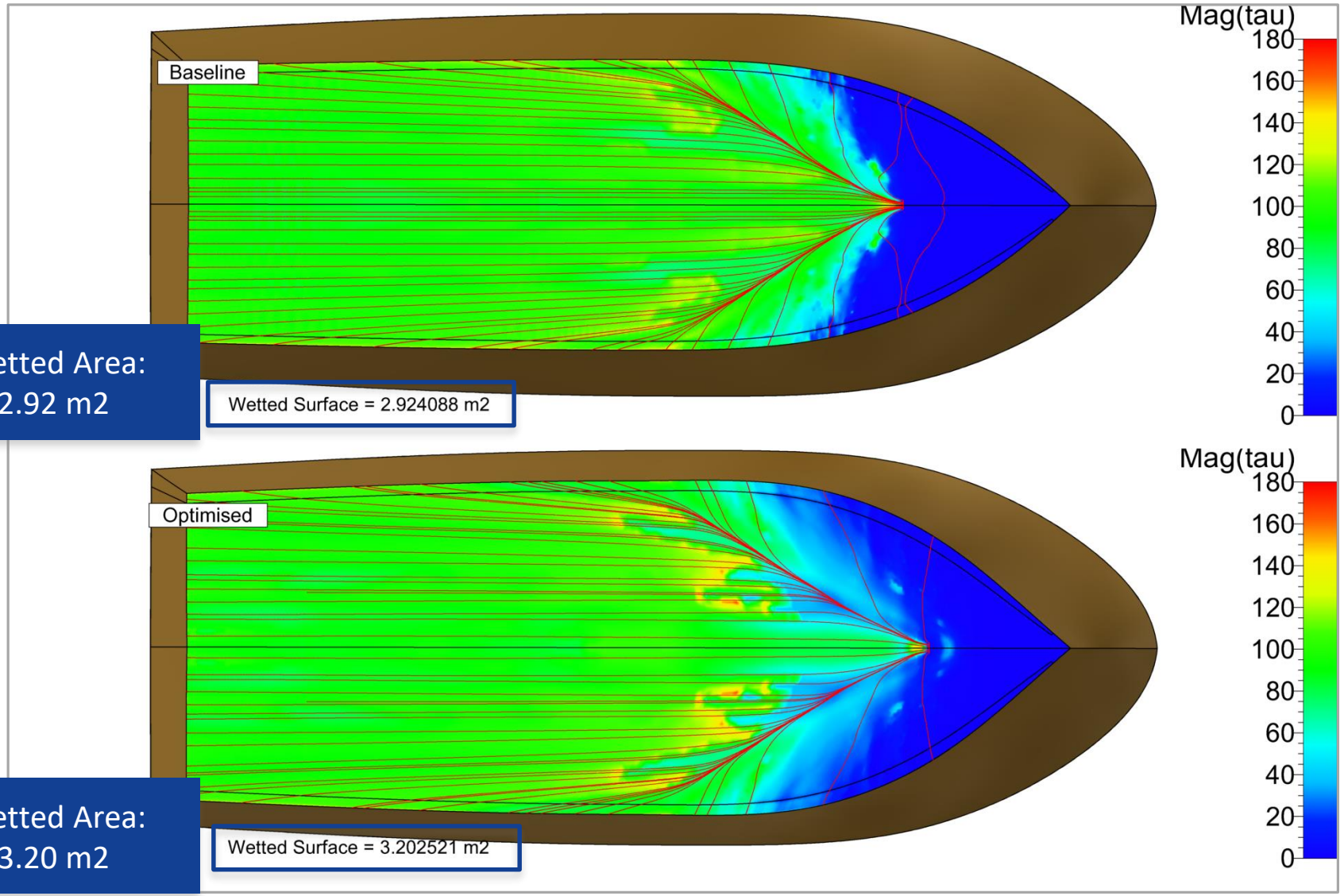
Resistance Components Breakdown – Baseline vs. Optimised



Comparison of resistance components: Baseline vs. Optimised

Cloud Based Optimization of a Powerboat

Magnitude of Viscous Stress – Baseline vs. Optimised

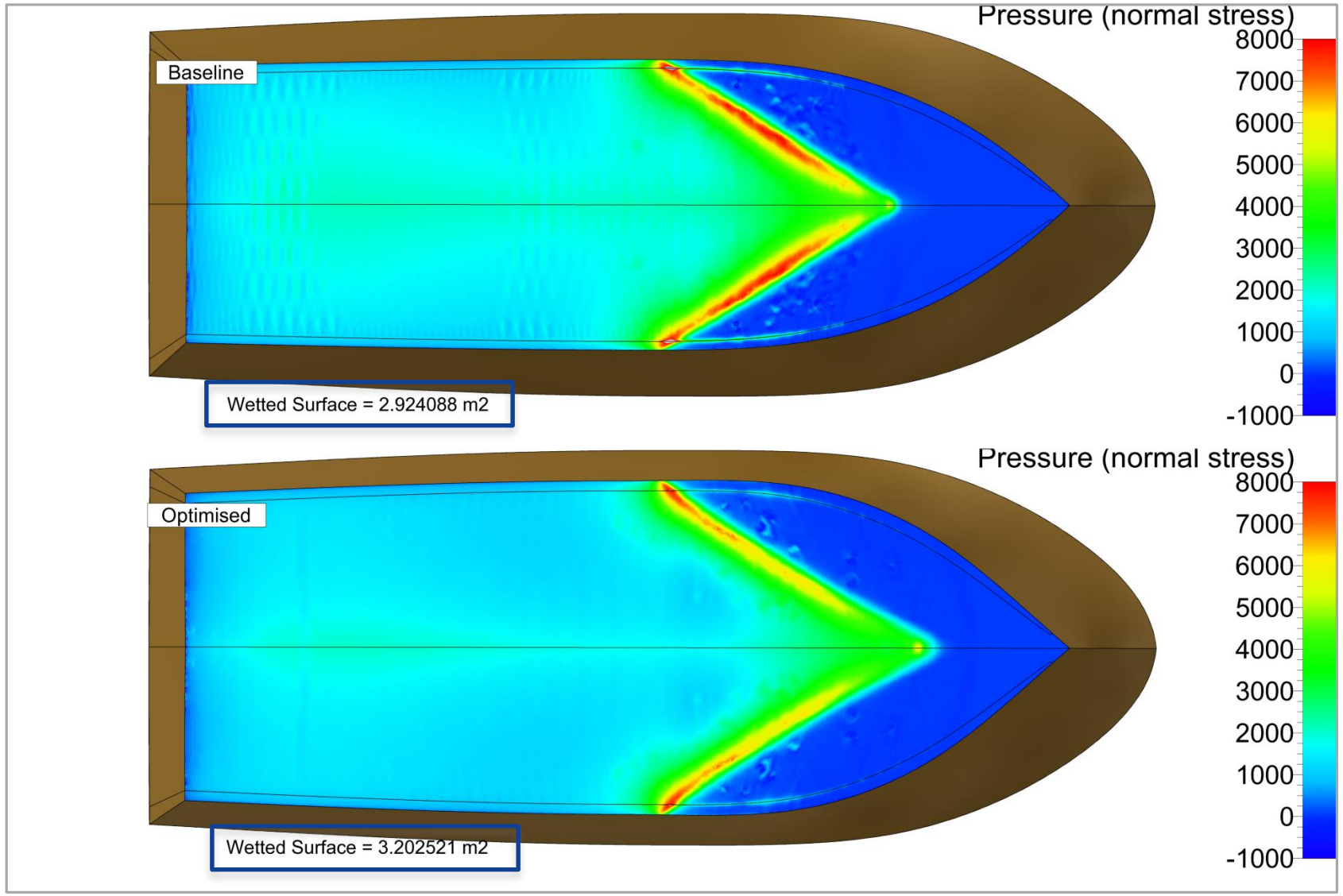


Wetted Area:
2.92 m2

Wetted Area:
3.20 m2

Cloud Based Optimization of a Powerboat

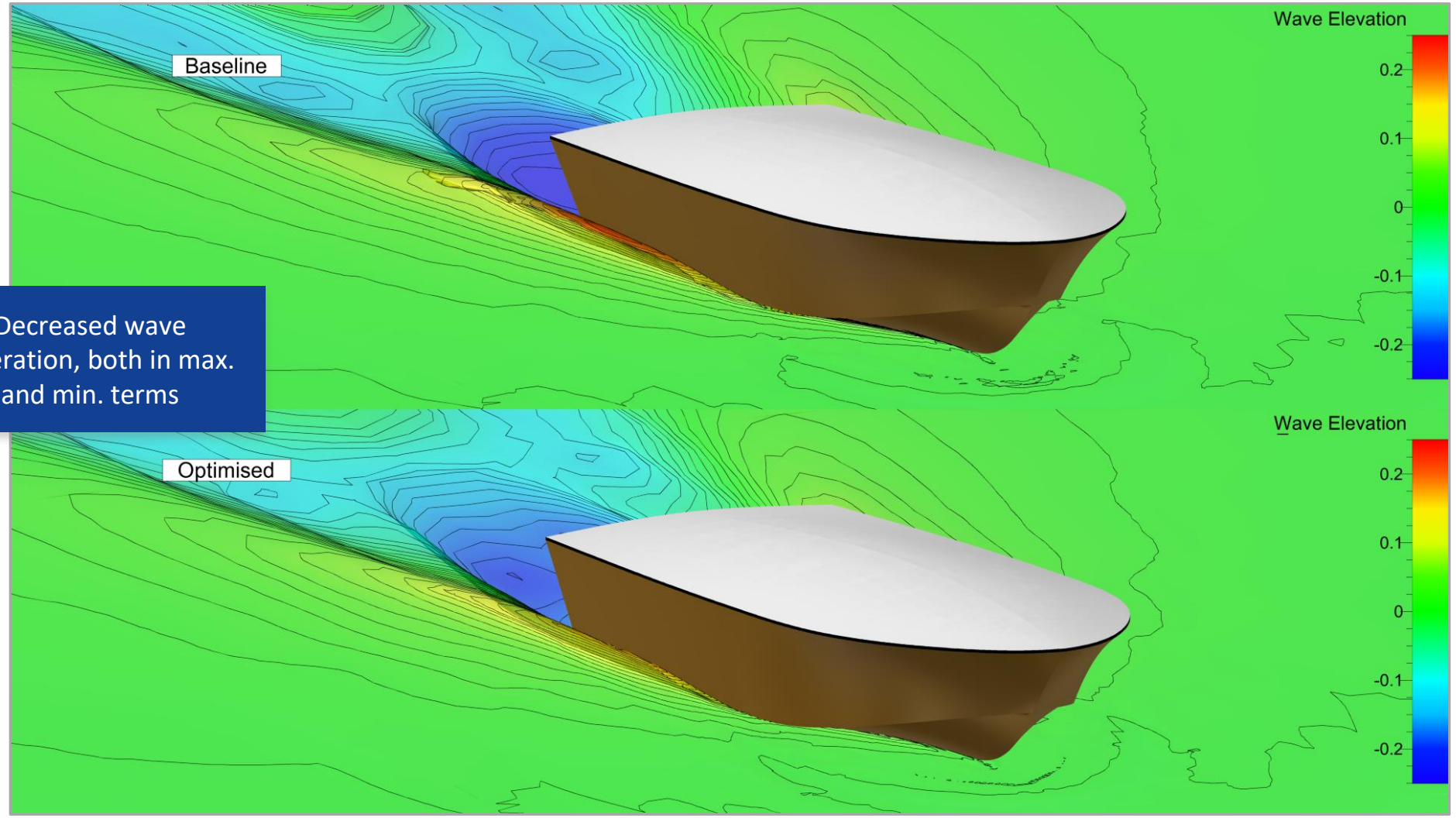
Static Pressure – Baseline vs. Optimised



Optimised design shows greatly decreased pressure along most of the stagnation line

Cloud Based Optimization of a Powerboat

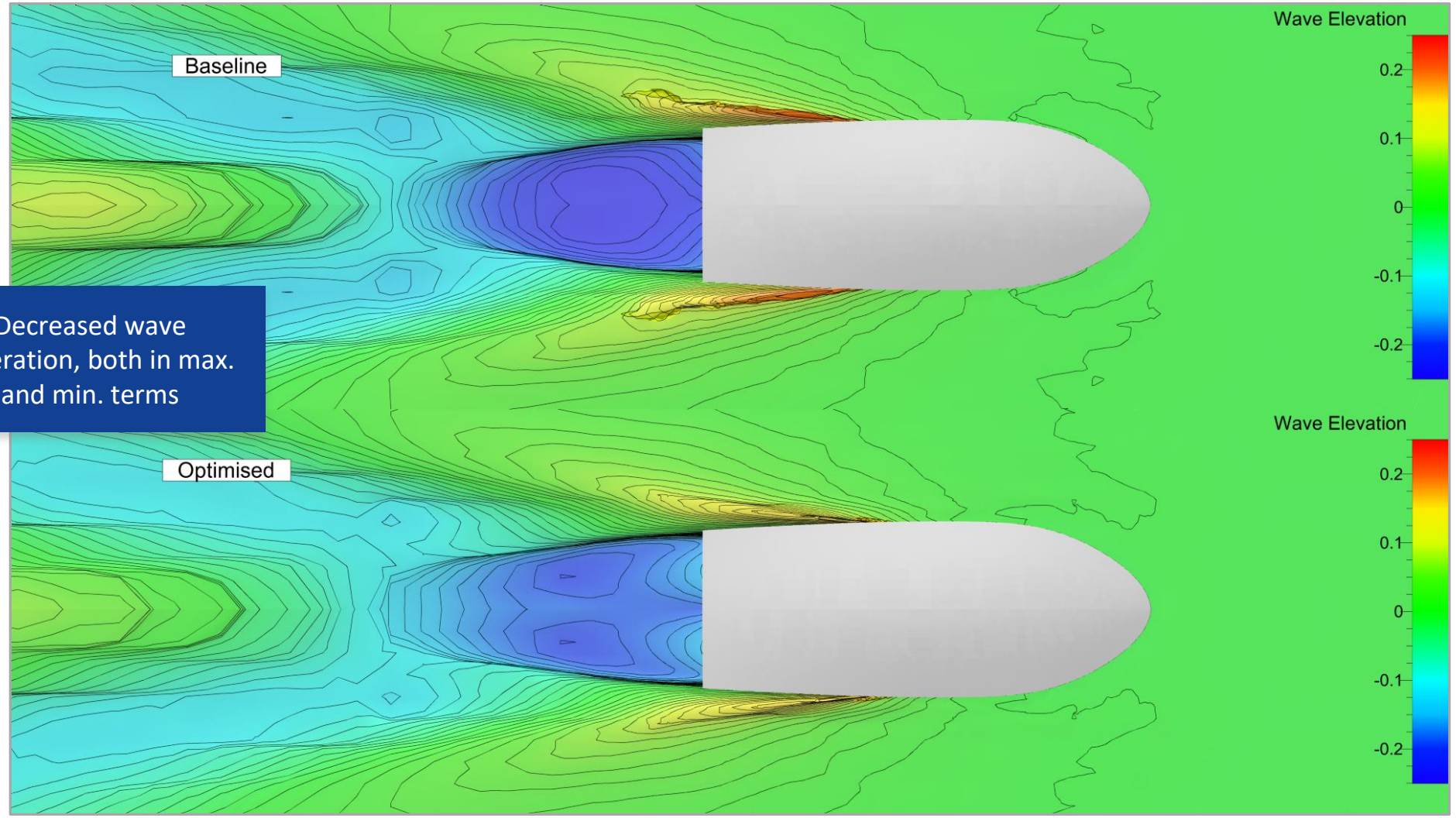
Free Surface – Baseline vs. Optimised



Decreased wave generation, both in max. and min. terms

Cloud Based Optimization of a Powerboat

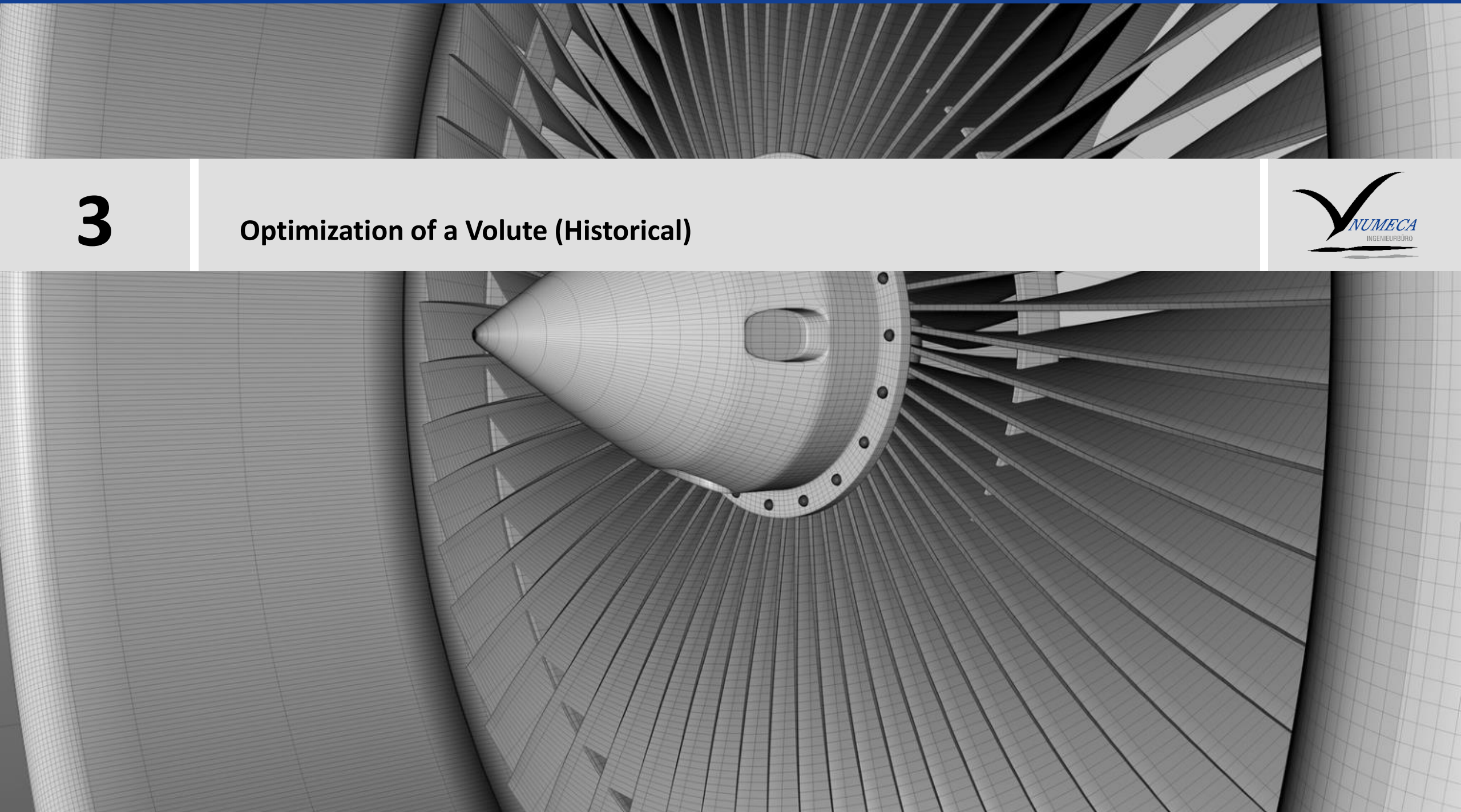
Free Surface – Baseline vs. Optimised



Decreased wave generation, both in max. and min. terms

3

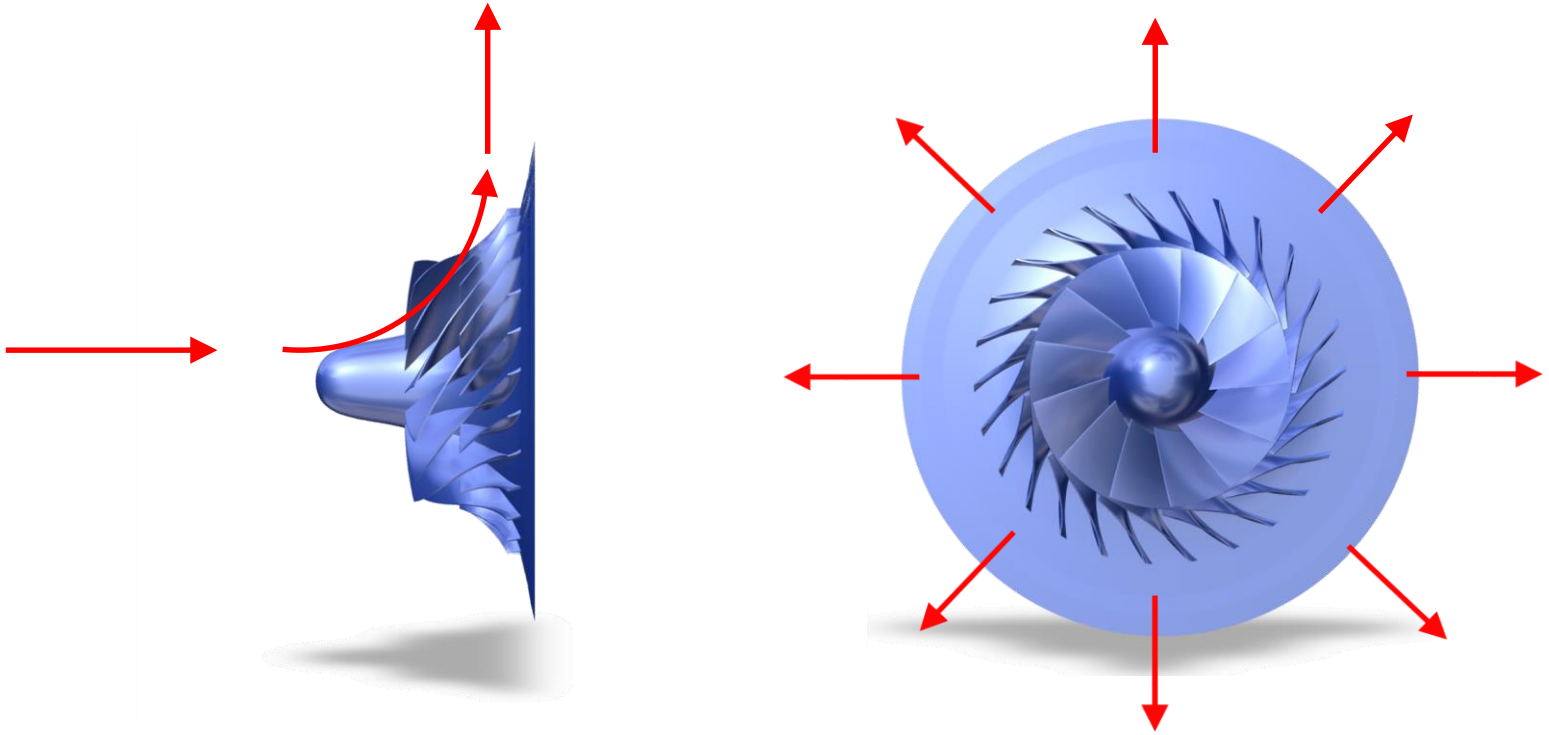
Optimization of a Volute (Historical)



Optimization of a Volute (Historical)

Definition …. For the Maritime Guys

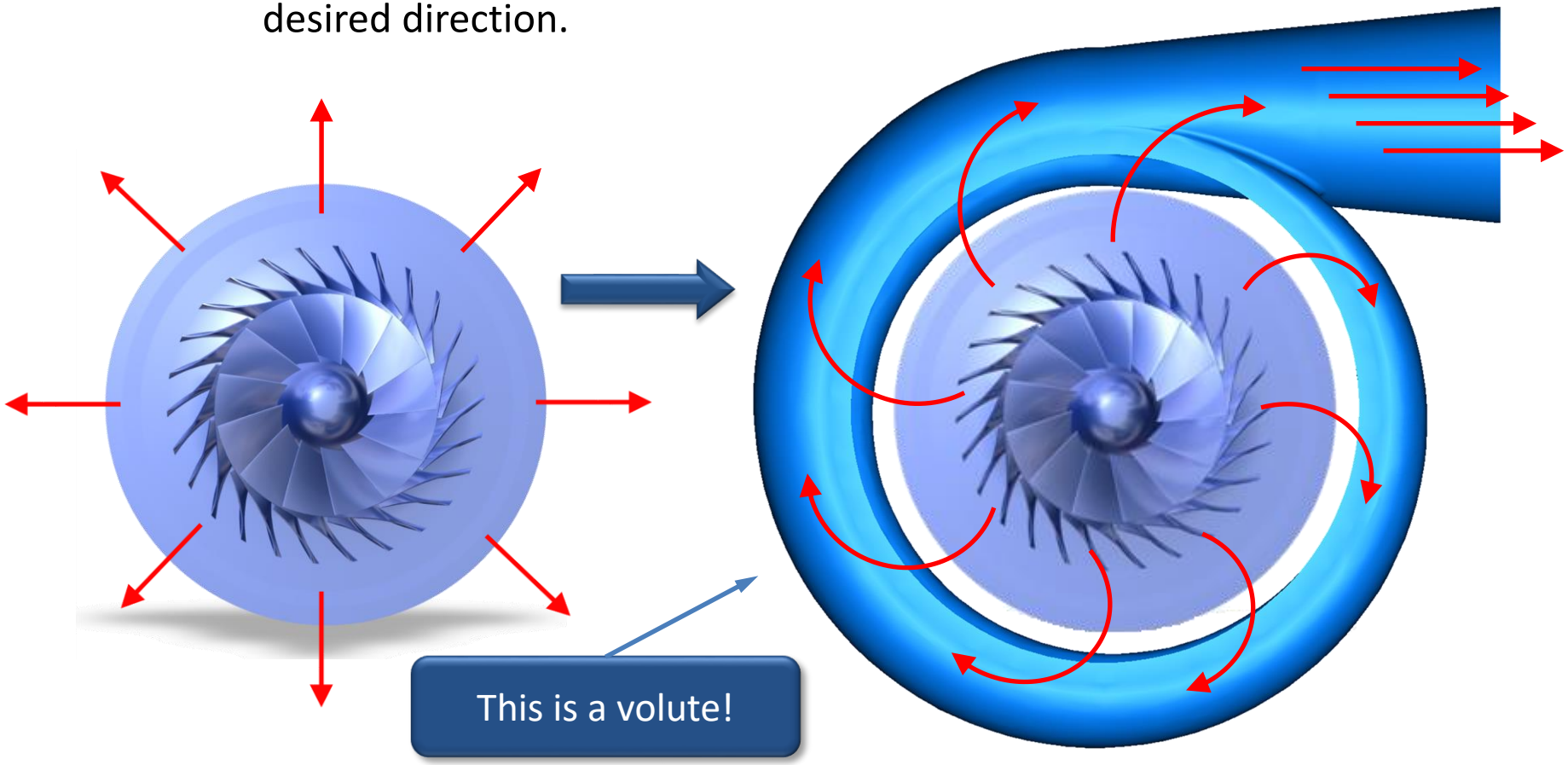
- What is a volute?
- A volute usually belongs to a radial compressor or turbine!
- A radial compressor turns at high RPM, sucks in gas from the axial direction and blows it out into the radial direction.



Optimization of a Volute (Historical)

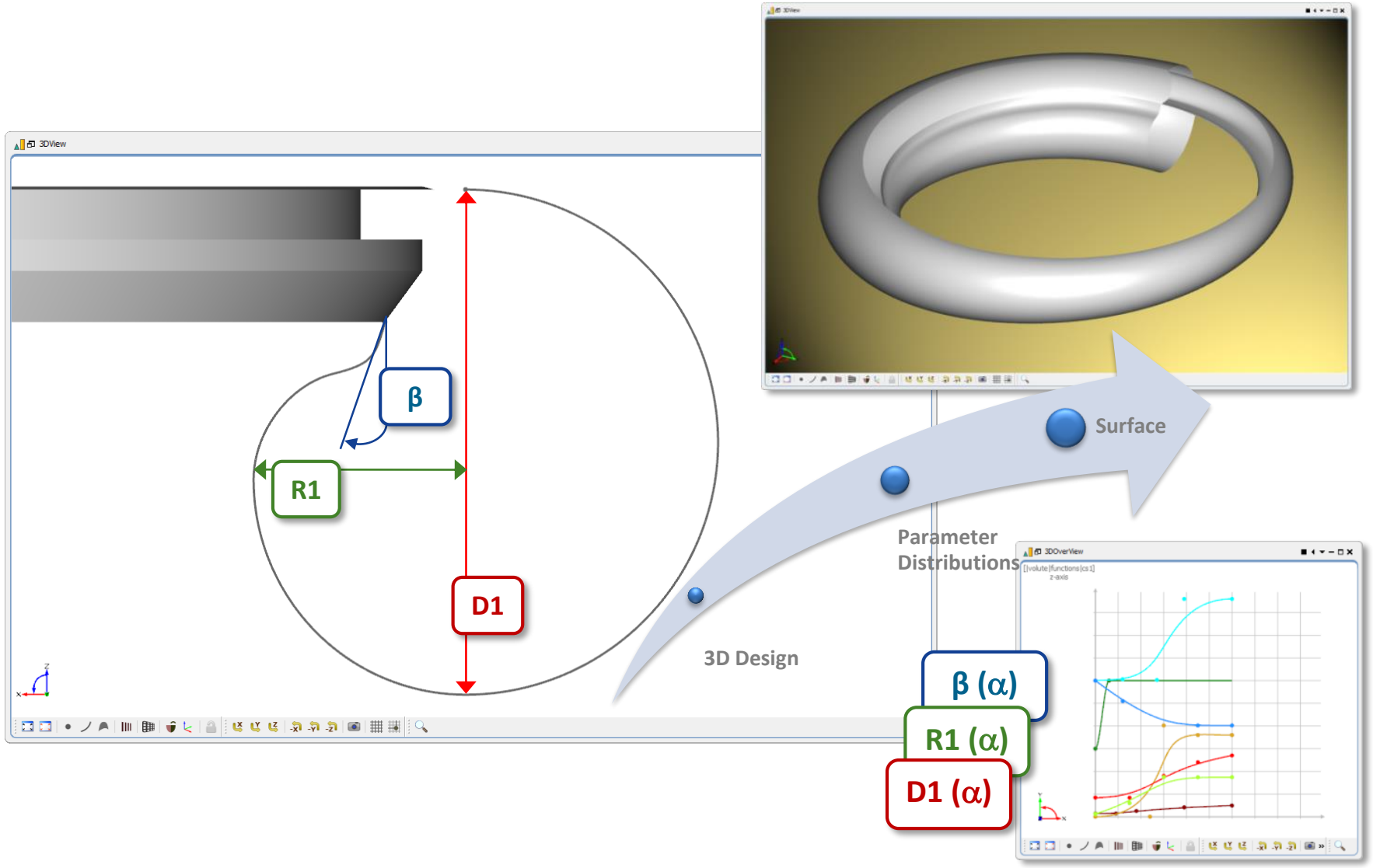
Definition …. For the Maritime Guys

- In most technical applications a radial outlet over the full circumference is hardly usable.
- A volute collects the radially exiting gas and guides into the desired direction.



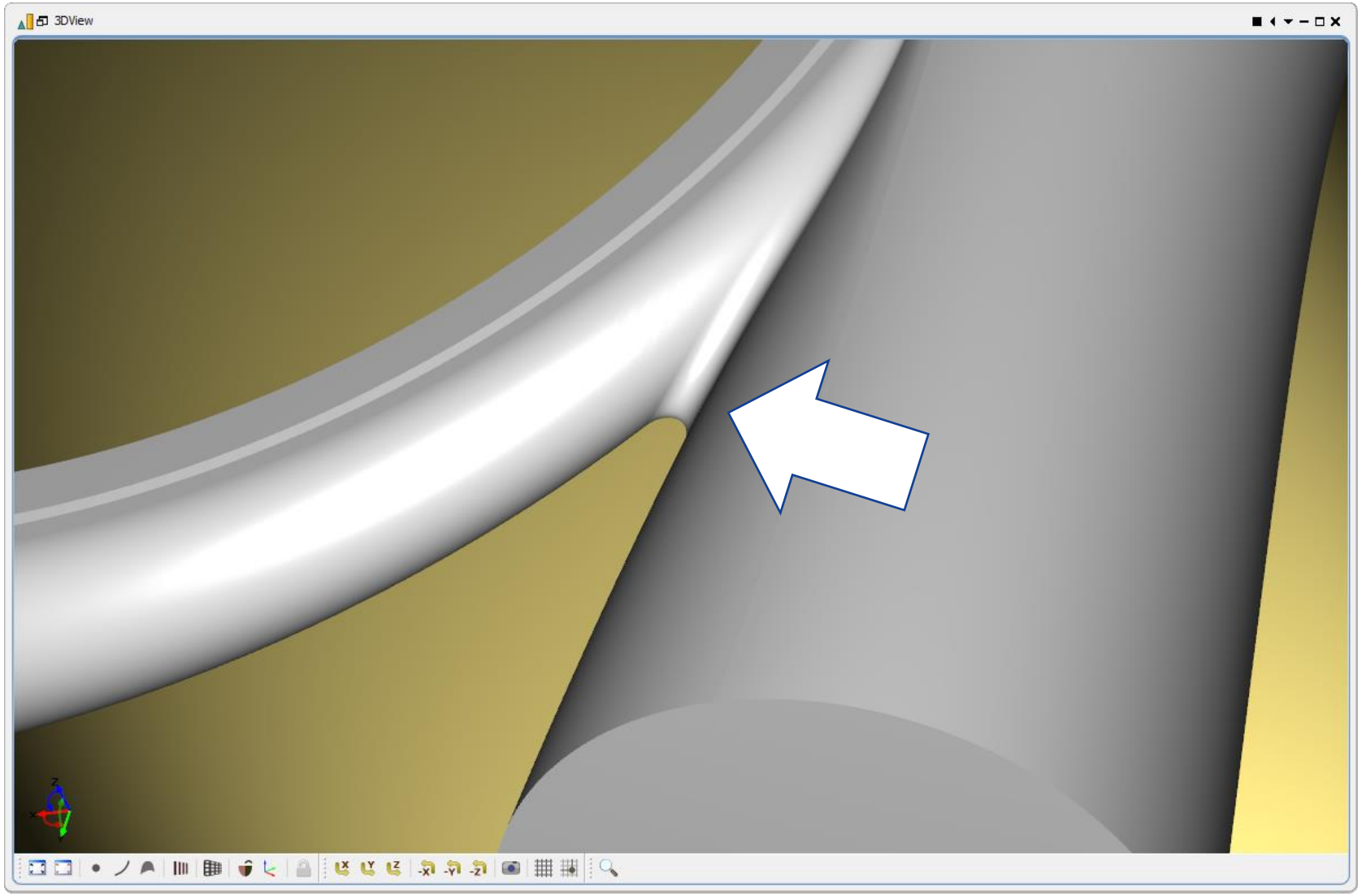
Optimization of a Volute (Historical)

Parameter Definition



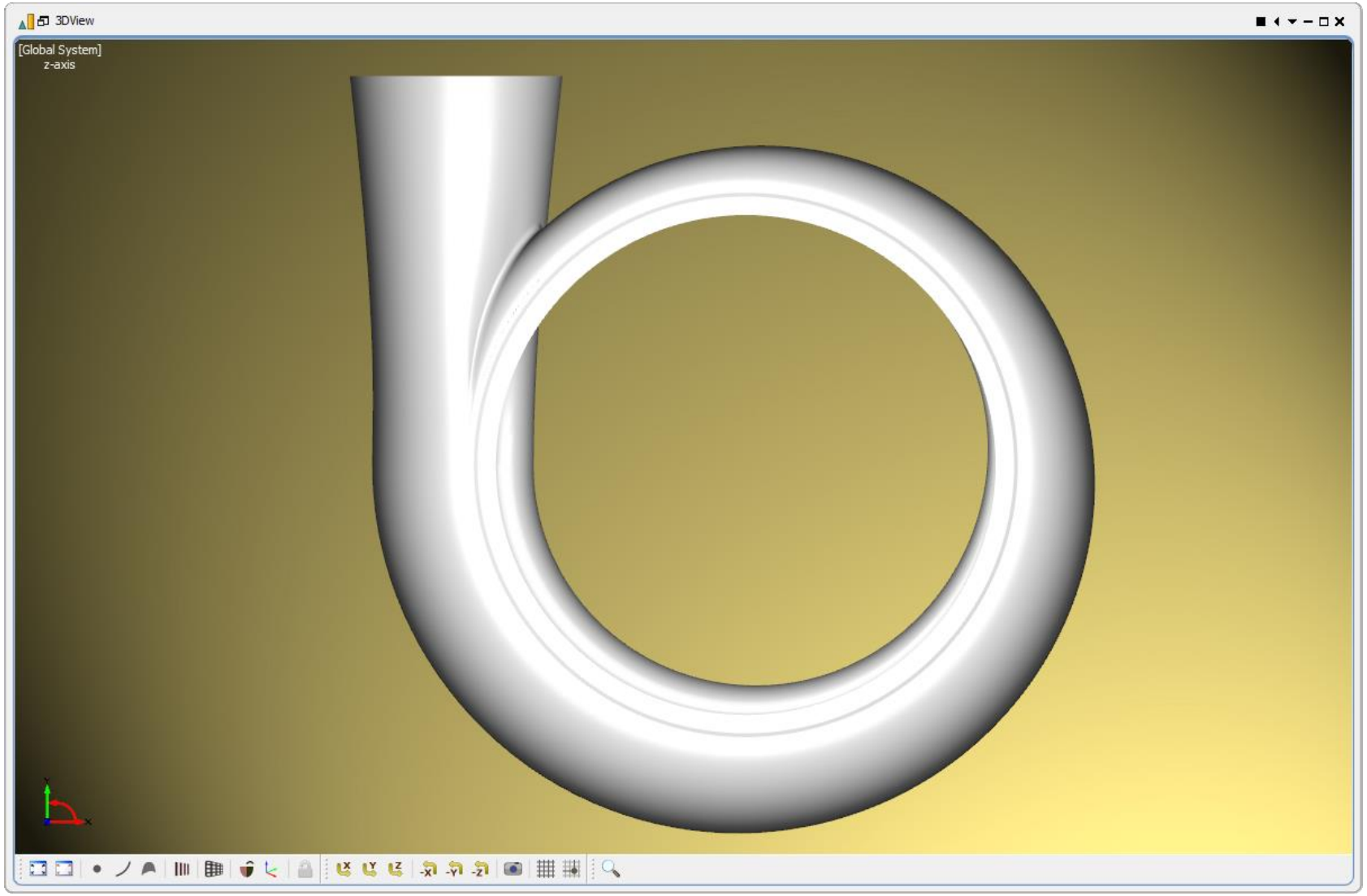
Optimization of a Volute (Historical)

Tongue Width Variation



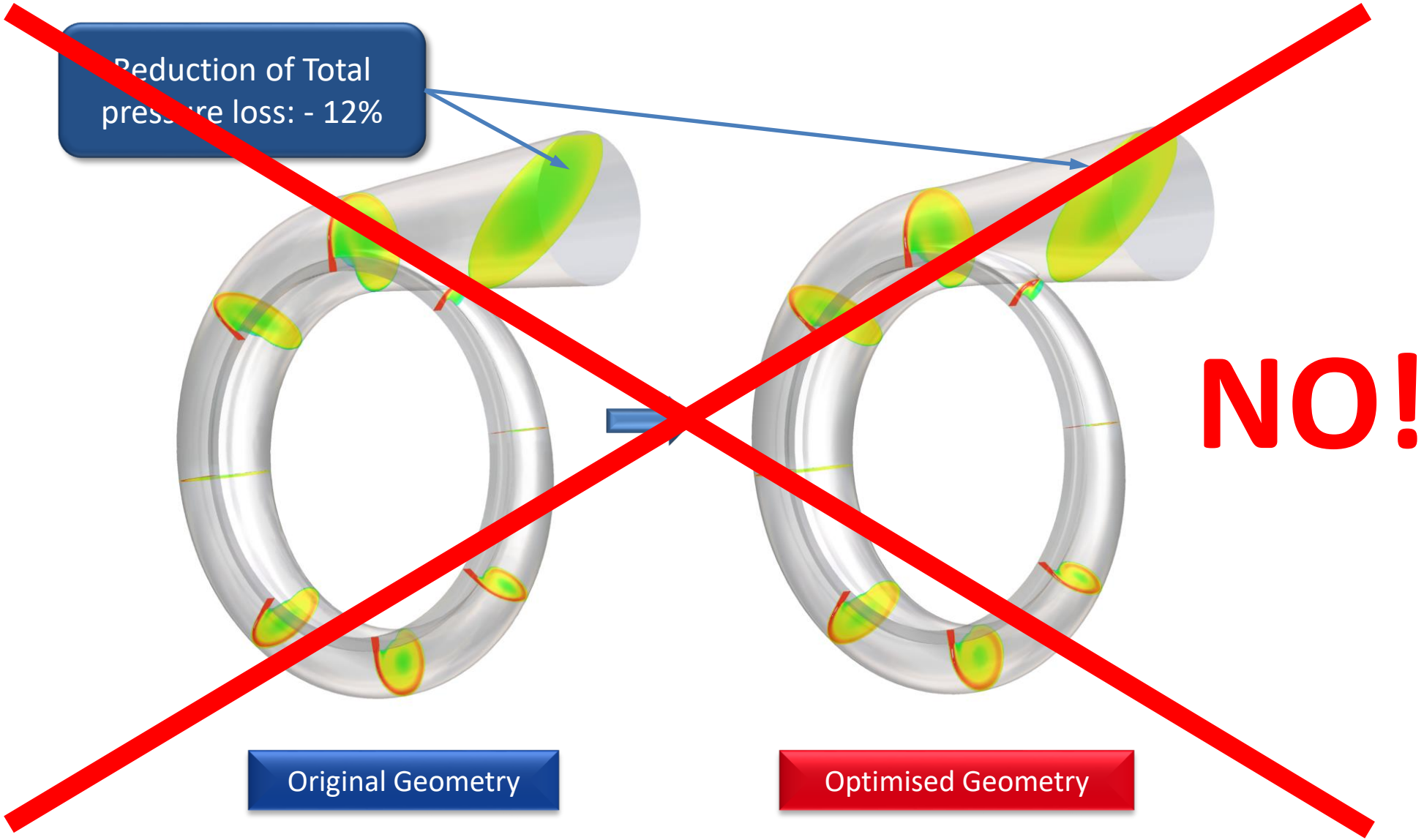
Optimization of a Volute (Historical)

Variation of Shape & Area Distribution



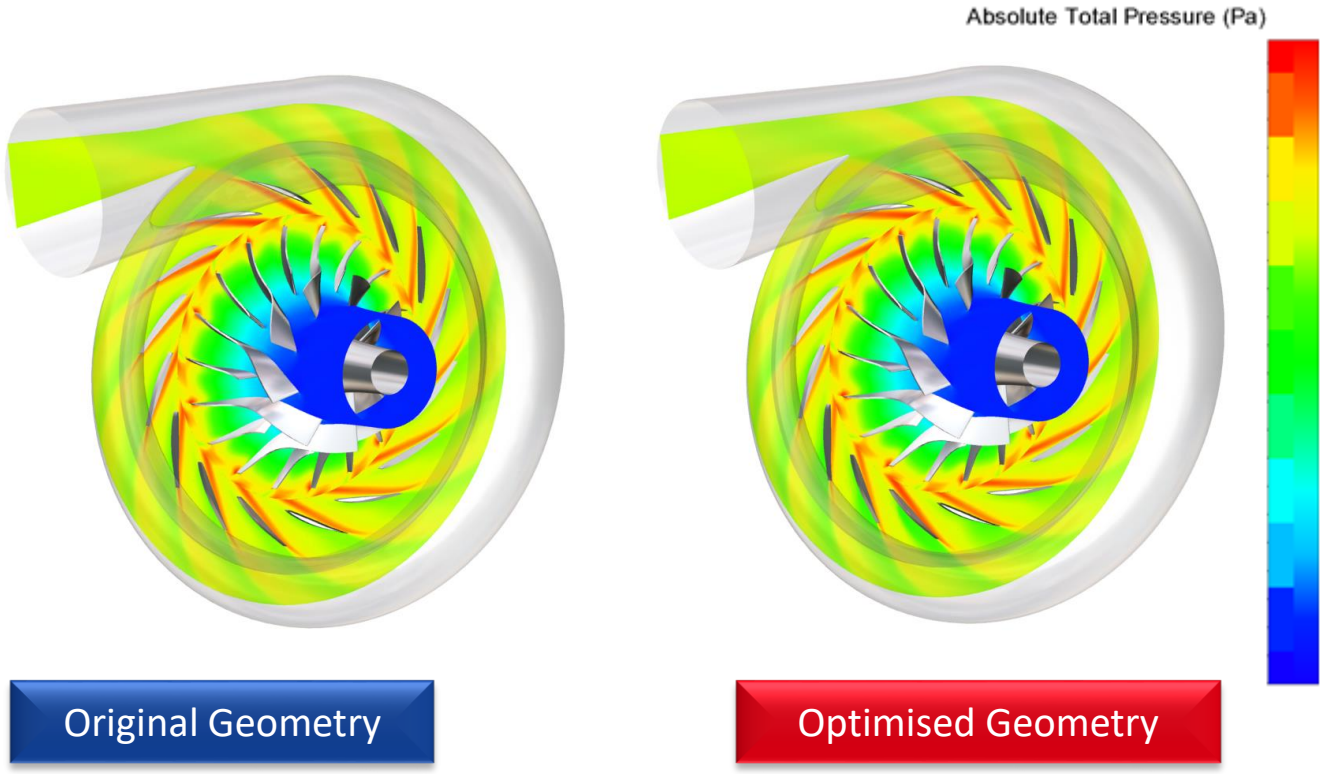
Optimization of a Volute (Historical)

Hopeful Result



Optimization of a Volute (Historical)

True Result



Increase in Efficiency: 0% !!

4

Lesson Learned: Project GAMMA-1

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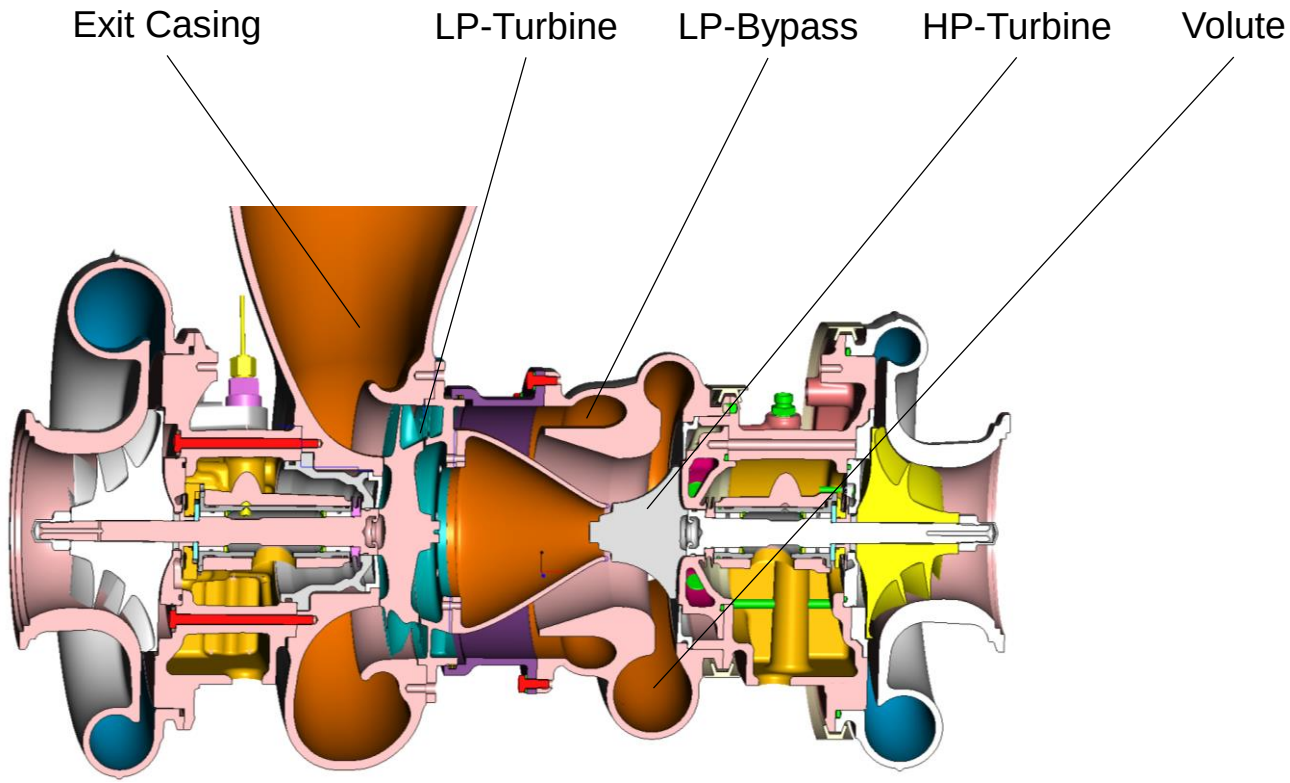
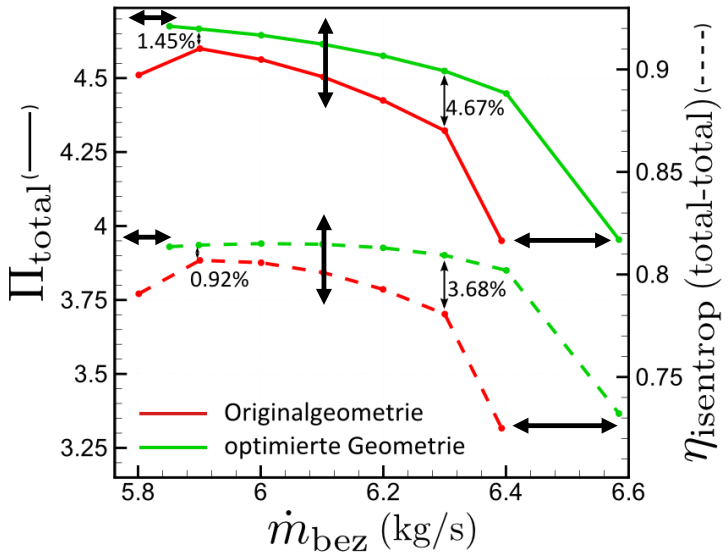
Lesson Learned: Project GAMMA-1

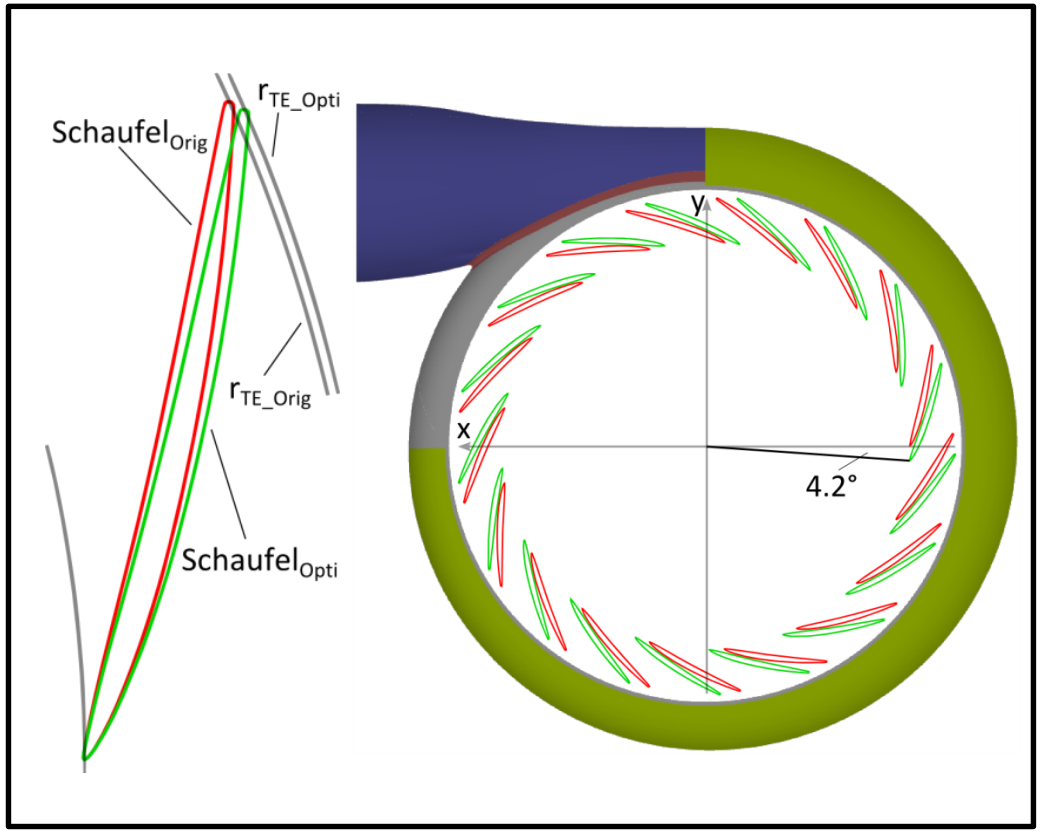
2-Stage Turbocharger of a Modern Gasmotor



Objective:
Simultaneous Optimization of Impeller, Diffuser & Volute

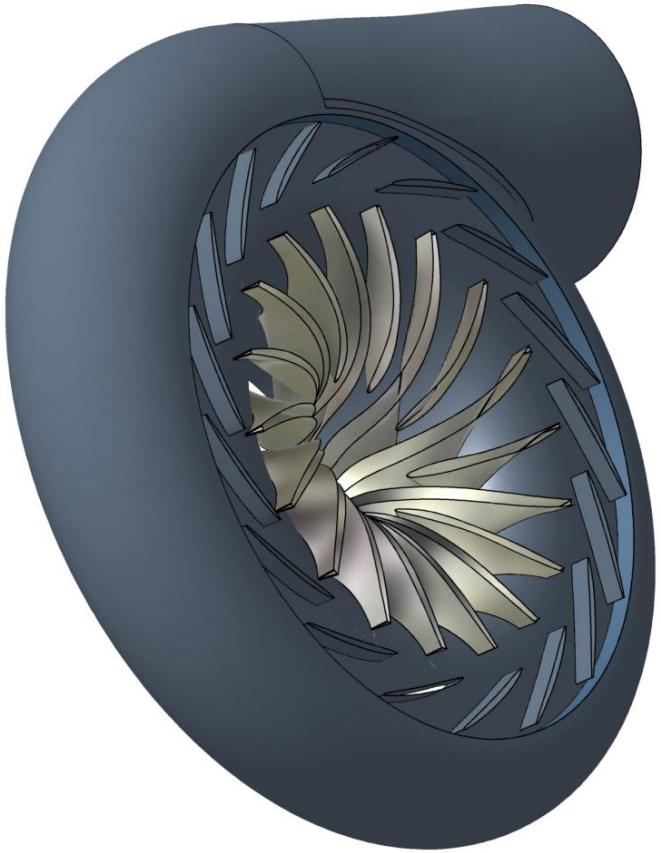


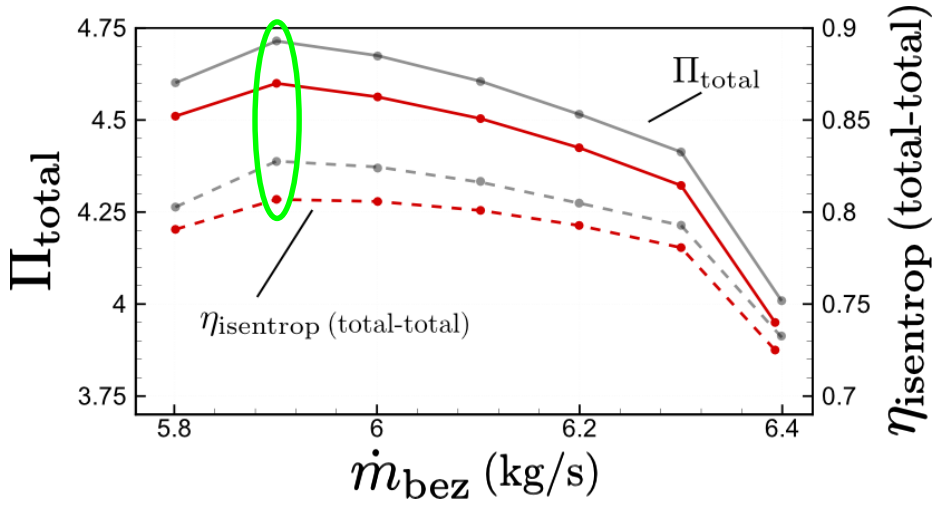
- Staffelungswinkel α
- Schaufelhinterkantenradius r_{TE}
- Rotation



Lesson Learned: Project GAMMA-1

Final Objective: Simultaneous Optimization of Impeller, Diffuser & Volute

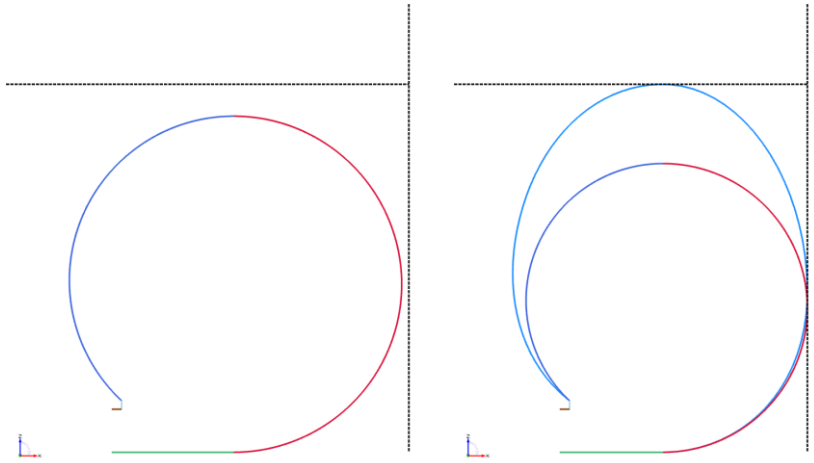


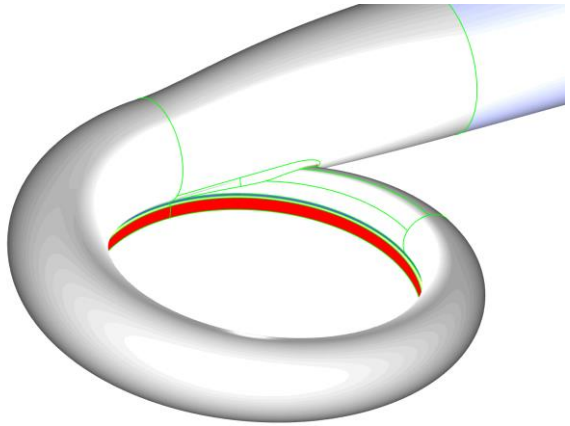


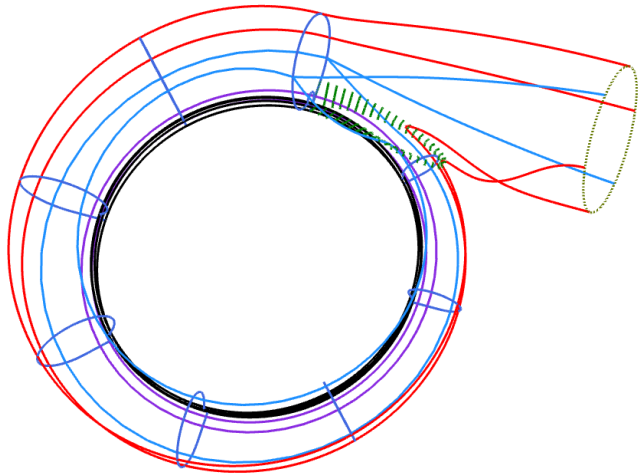
Lesson Learned: Project GAMMA-1

Base: Input from CAESES®

- Parametrisation
  - A/R Ratio
  - Incidence
  - Volume Restriction
- Robust Tongue Area
- Supporting Geometry



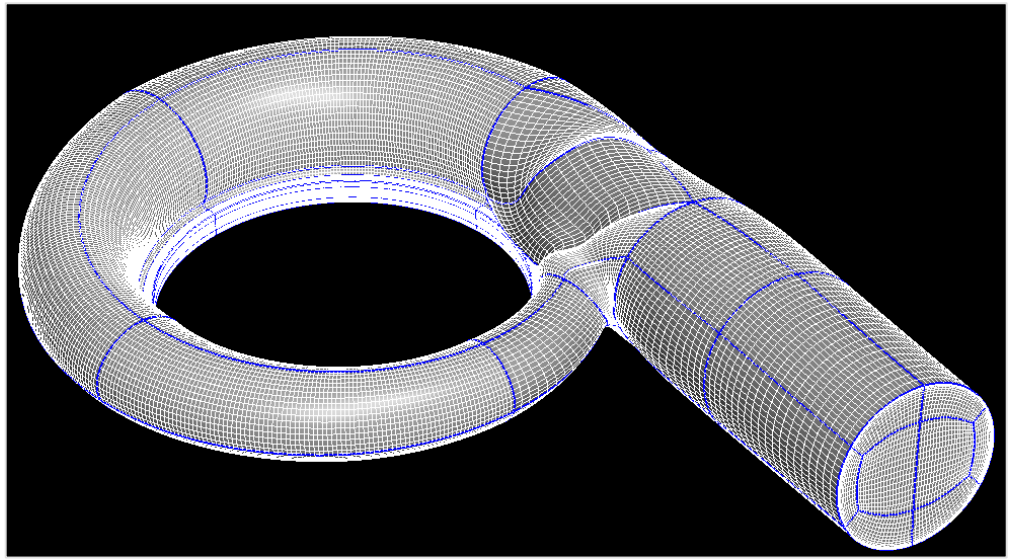




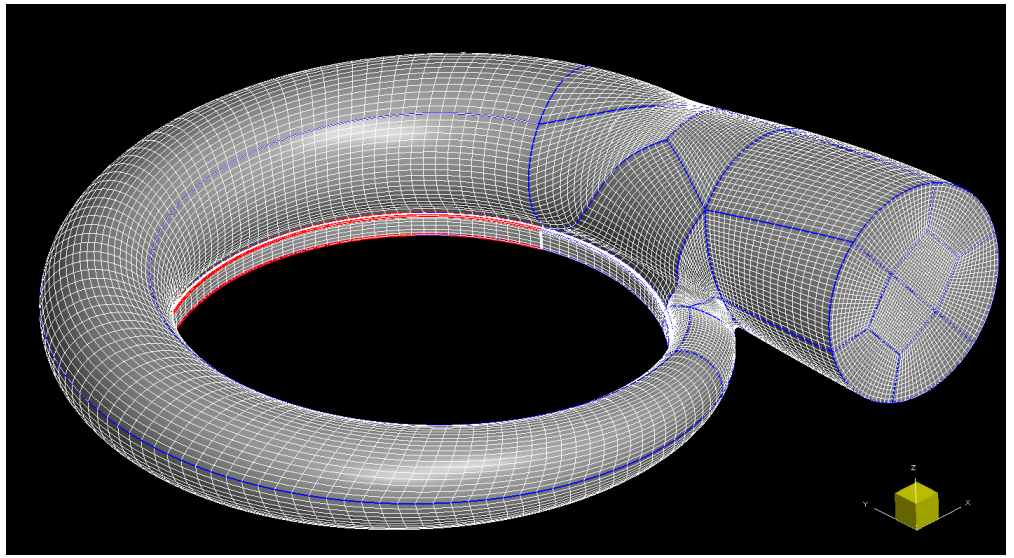
Lesson Learned: Project GAMMA-1

Key: Automatic Structured Meshing of a Volute

We are close….



29.03.2017 Working Meeting 1

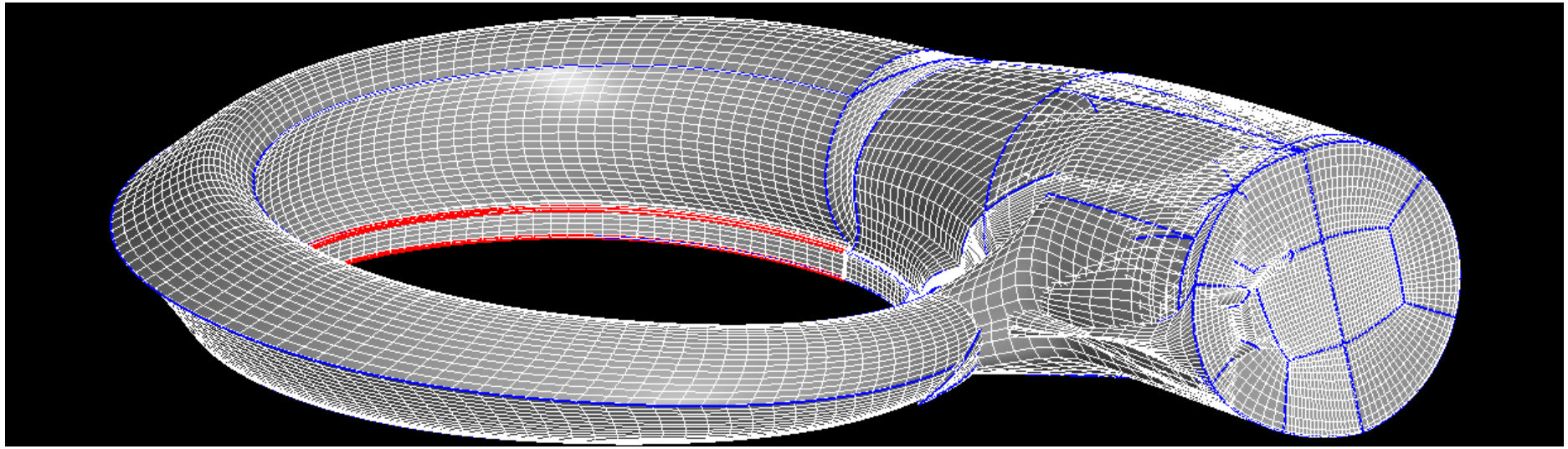


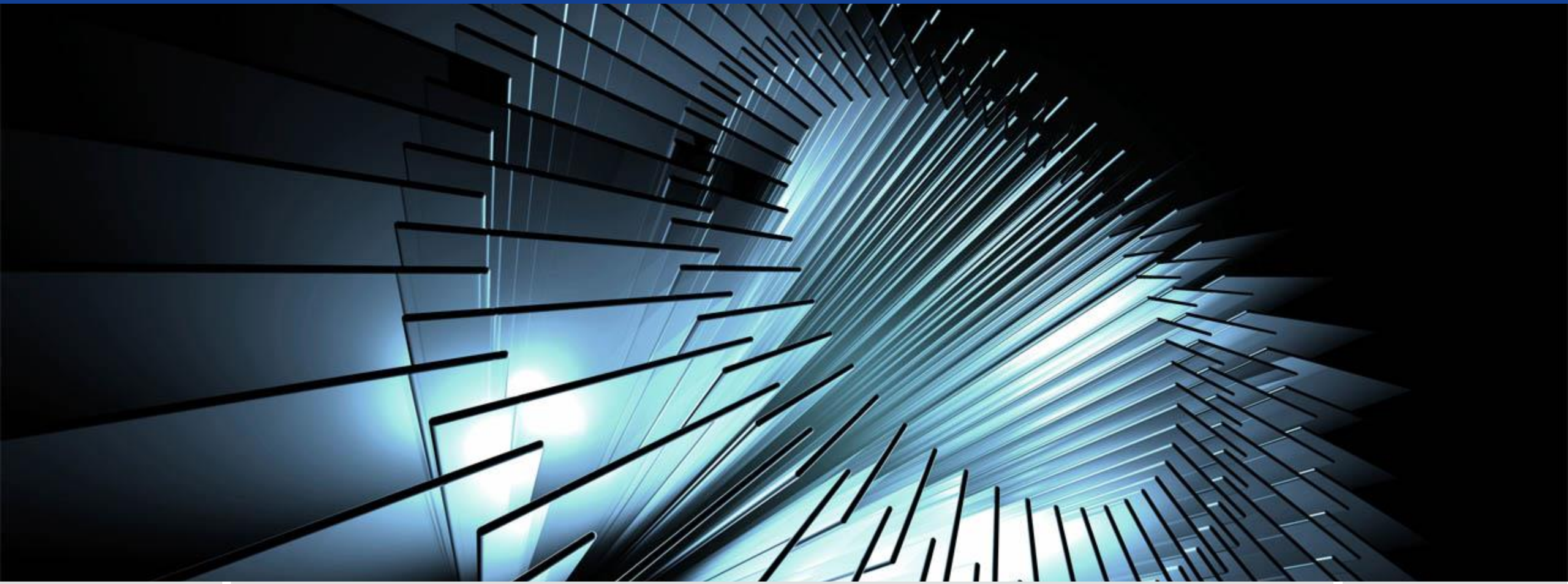
22.06.2017 Working Meeting 2

Lesson Learned: Project GAMMA-1

Key: Automatic Structured Meshing of a Volute

… but still not there!





2017

Thank you for your attention