CAESES® – Current developments and perspectives

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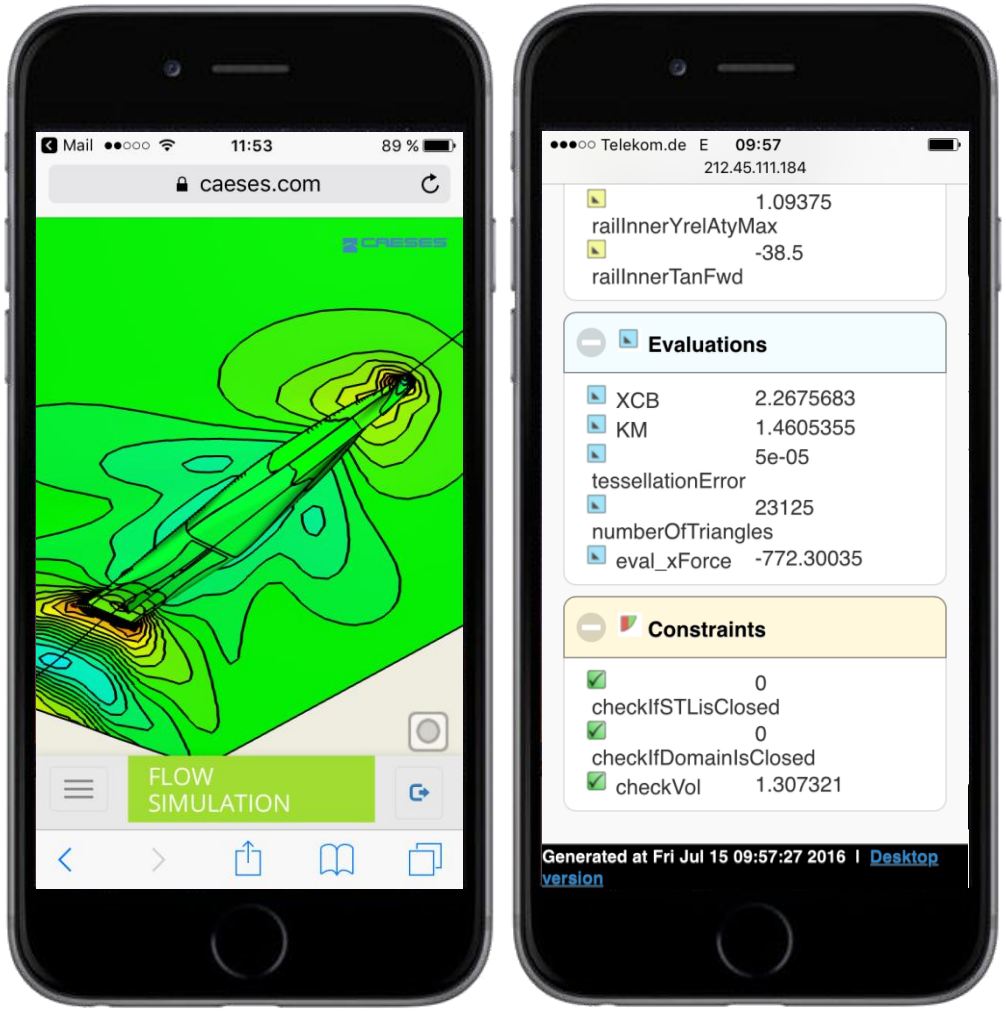
Intelligent Industrial Design Technology Seminar &
Tianfu Hipoint Software Product Users Conference

Ningbo, October 27, 2017

FRIENDSHIP SYSTEMS

Content

- State-of-the-art
- Recent and current R&D
- CAESES 5.0
- Appification and WebApps
- Sneak preview: Interactive shape variation



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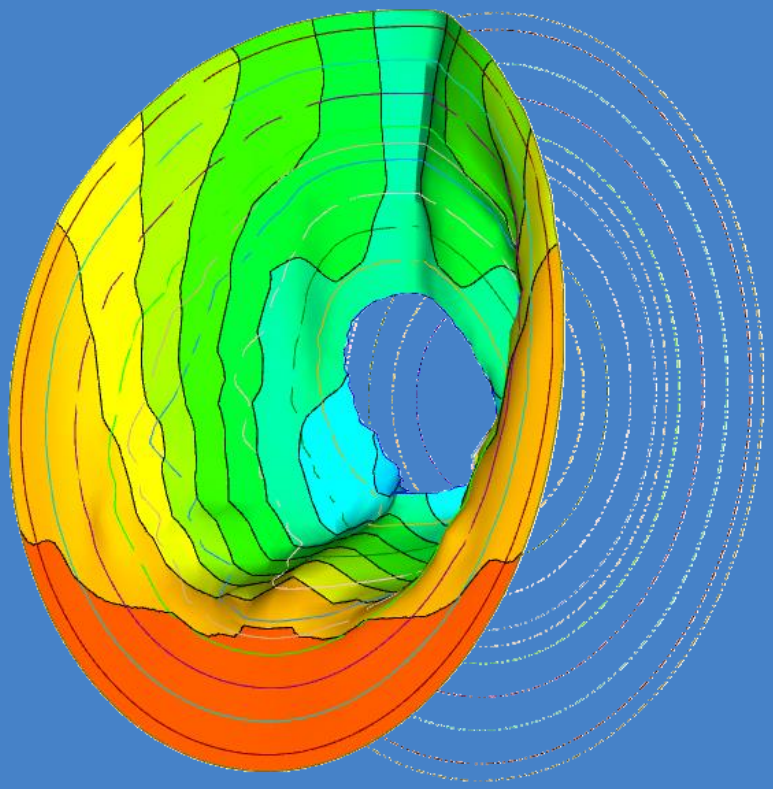
State-of-the-art



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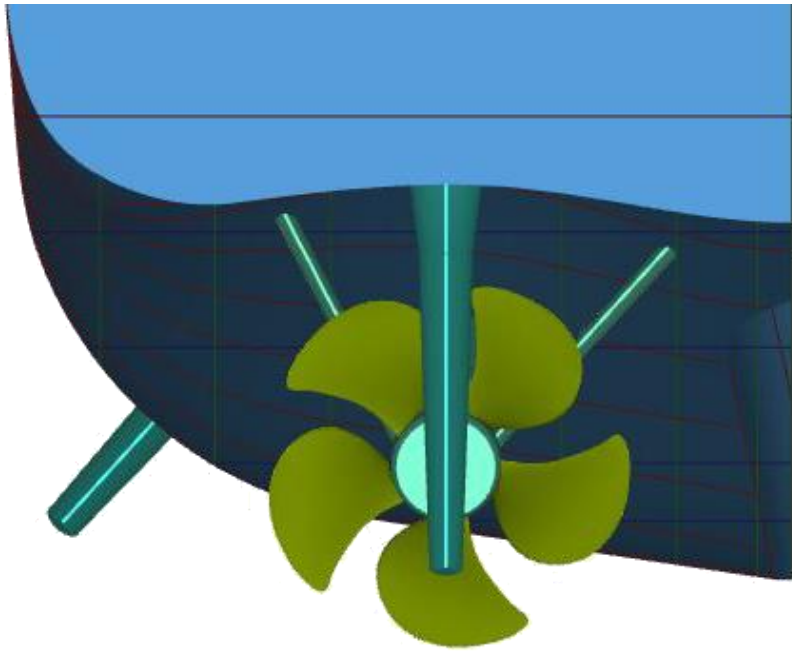
State-of-the-art: thyssenkrupp Marine Systems

- Virtual prototyping of fully-appended vessels
  - Several parametric models for fore- and aftbody
  - Parametric models for appendages
  - Coupling of CAESES with potential flow code and ANSYS CFX
- Process chain for fast and reliable studies
  - What-ifs
  - Quick checks (e.g. increased displacement)
  - Trade-offs
  - Formal optimization (e.g. interceptor)

thyssenkrupp



Source: Tanja Richardt, thyssenkrupp Marine Systems, CAESES Users' Meeting 2017

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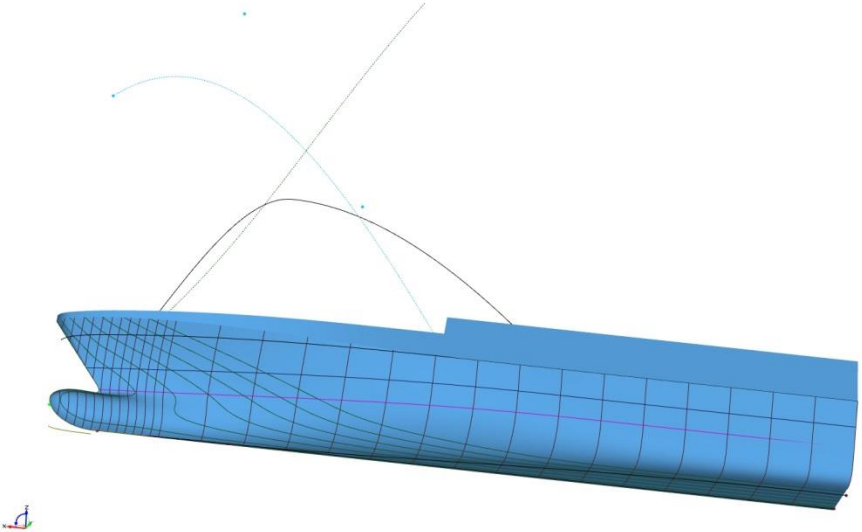
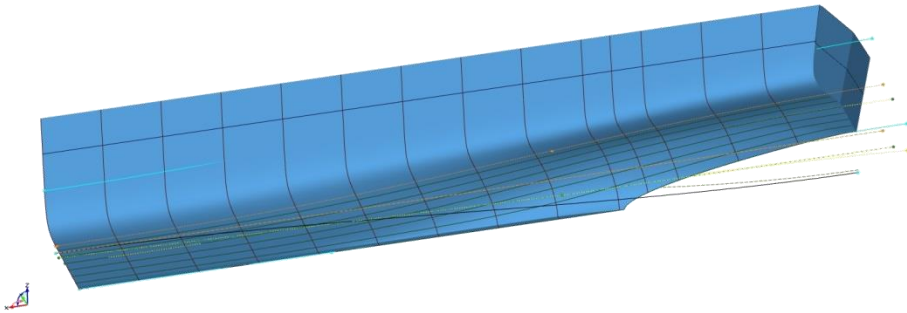
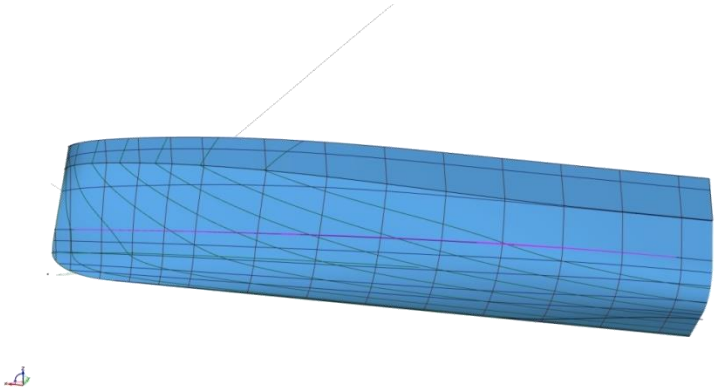
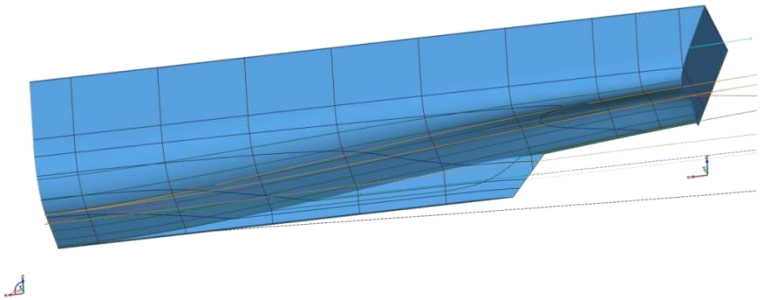
State-of-the-art: Standard models for combination









Source: Tanja Richardt, thyssenkrupp Marine Systems, CAESES Users' Meeting 2017

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State-of-the-art: thyssenkrupp Marine Systems

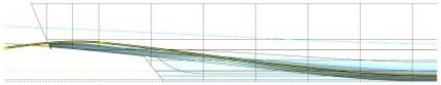
1 Parametric modeling

2 Optimization (potential flow)

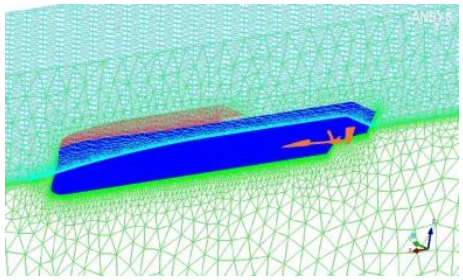
3 RANSE simulations

4 Optimization

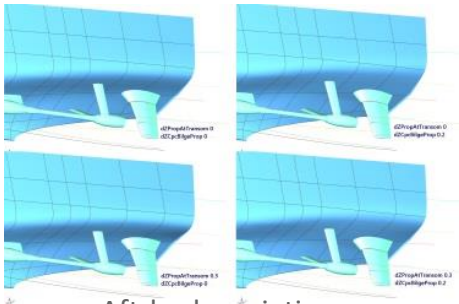
Basic curves



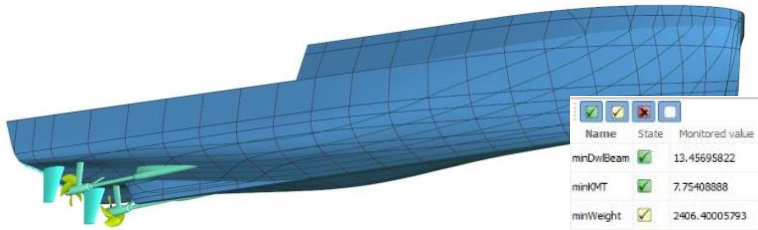
Free variables



Automatic mesh generation



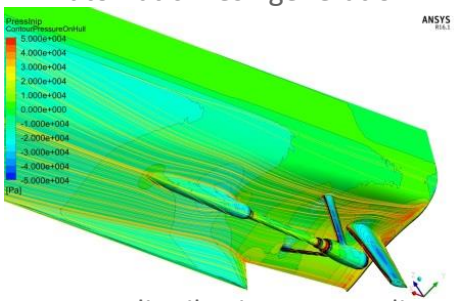
Aft-body variations



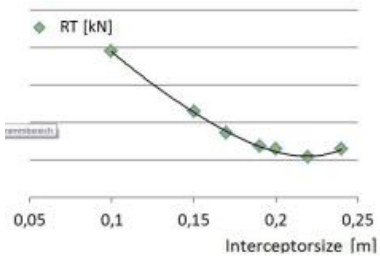
Generated smooth hull form

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

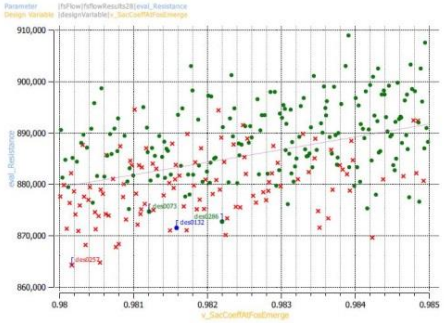
Constraints



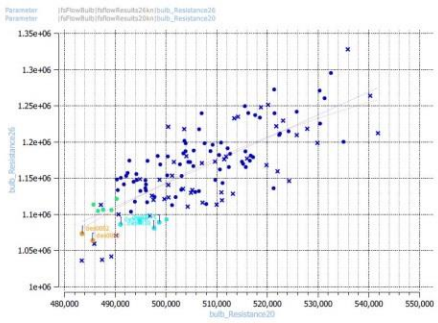
Pressure distribution, streamlines



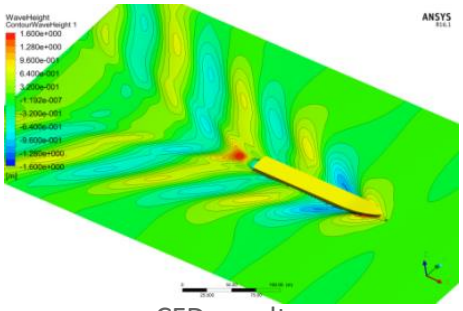
Interceptor optimization



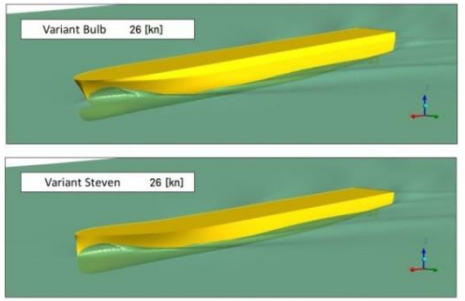
Parameter evaluation



Multi-objective optimization



CFD results



Comparison of different bow types

Source: Tanja Richardt, thyssenkrupp Marine Systems, CAESES Users' Meeting 2017

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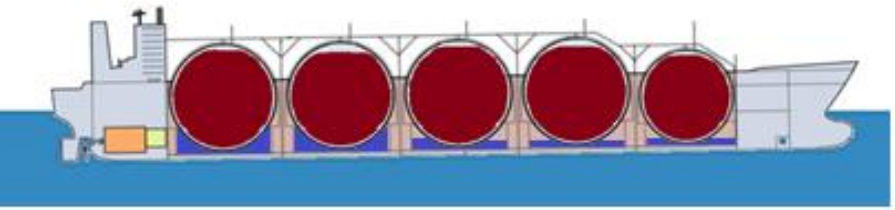
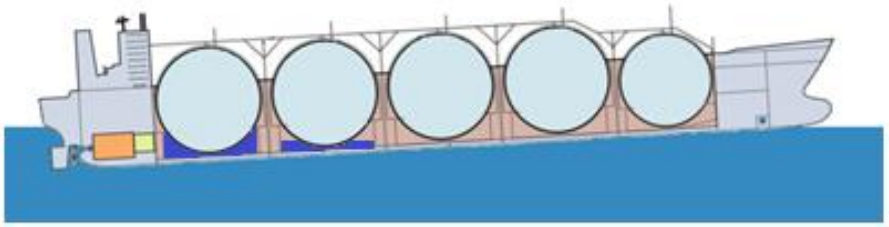
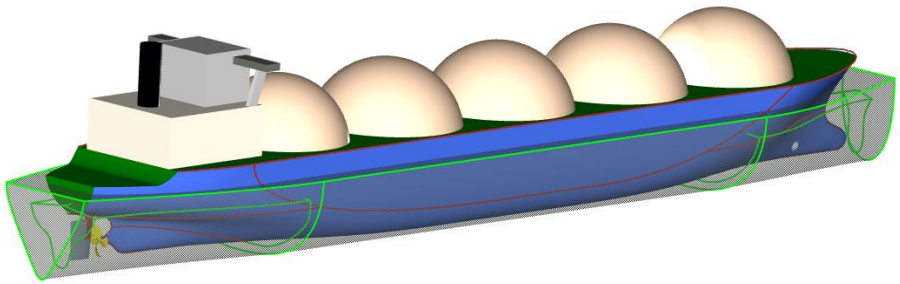
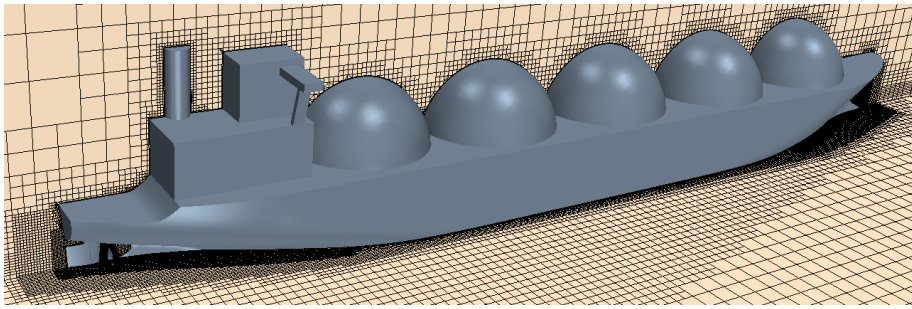
State-of-the-art: University of Strathclyde

- Concept studies
- Pre- and post-processing of CFD for extreme conditions









Support grid generation

Auxiliary geometry for refinements and better quality

Source: Matthias Maasch, University of Strathclyde, CAESES Users' Meeting 2017

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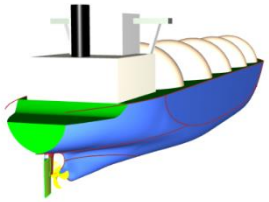
State-of-the-art: Streamlined process



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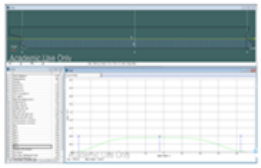
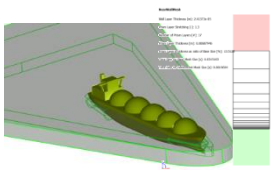


MAXSURF Stability



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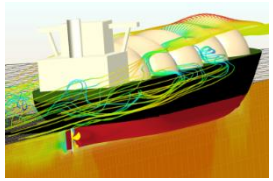
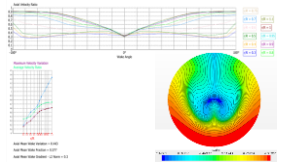


STAR-CCM+®



CAESES

CAD geometry → Hydrostatics → CFD pre-processing → CFD simulation → CFD post-processing

1 2 3 4 5

Source: Matthias Maasch, University of Strathclyde, CAESES Users' Meeting 2017

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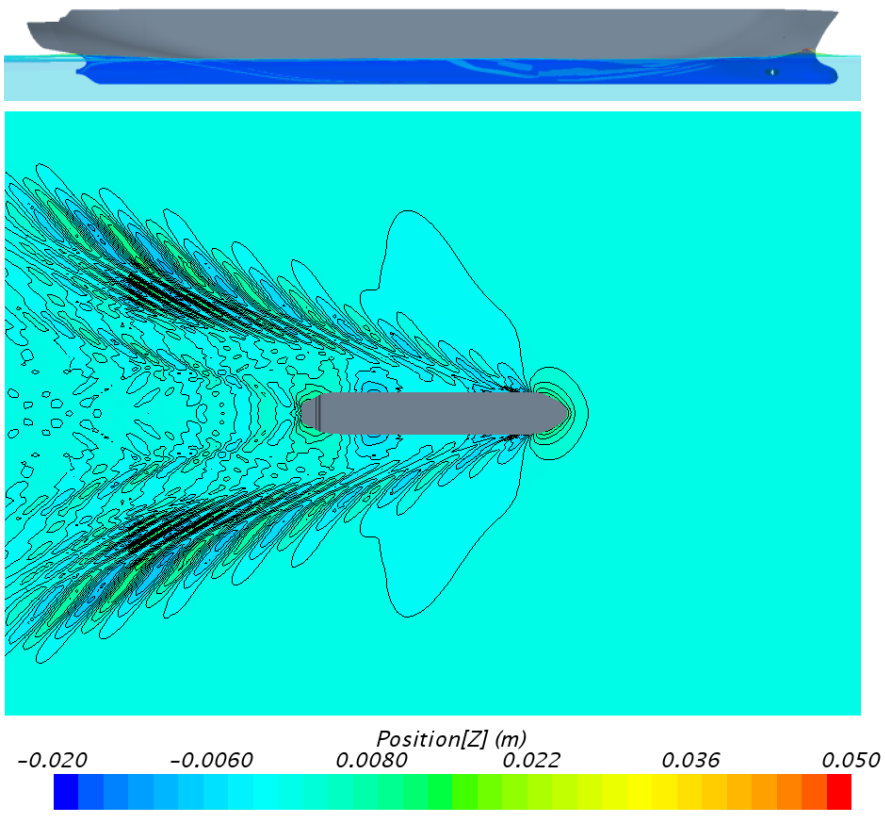
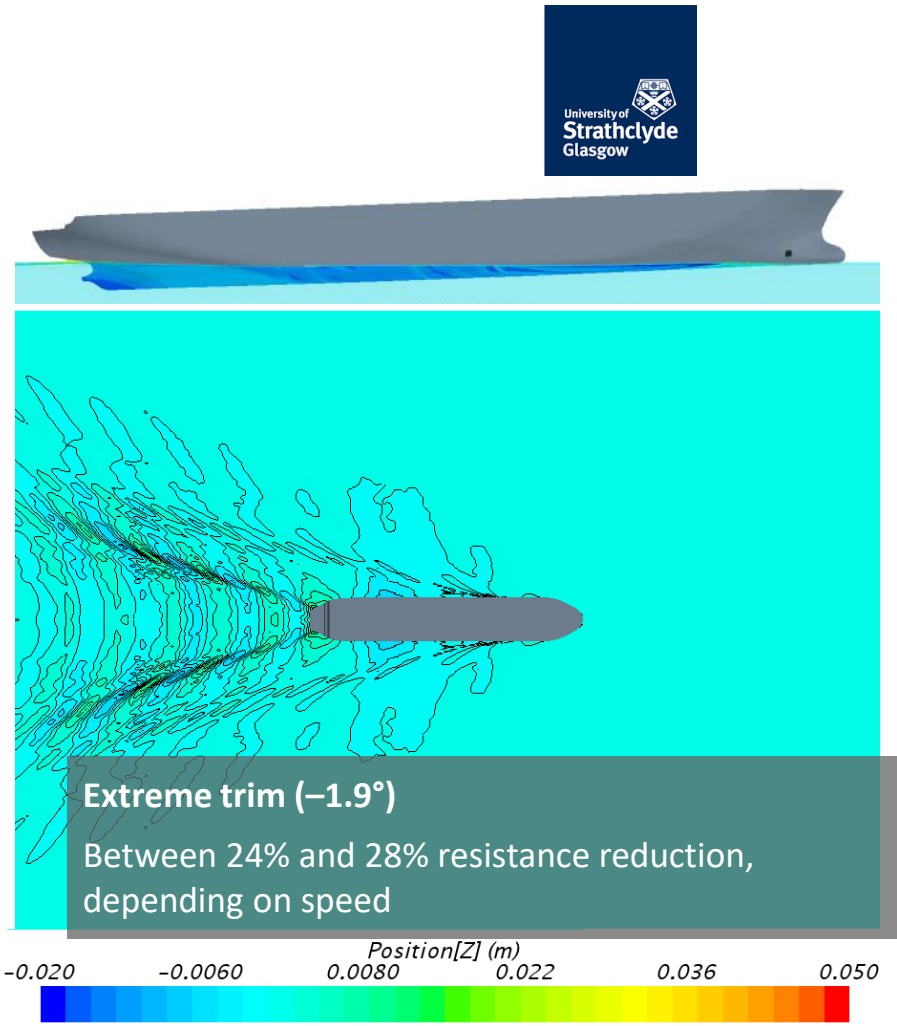
State-of-the-art: Study for extreme conditions





Extreme trim (–1.9°)

Between 24% and 28% resistance reduction, depending on speed

Source: Matthias Maasch, University of Strathclyde, CAESES Users' Meeting 2017

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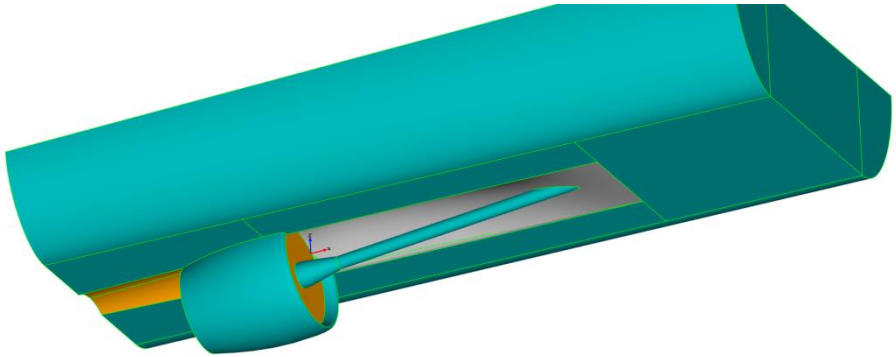
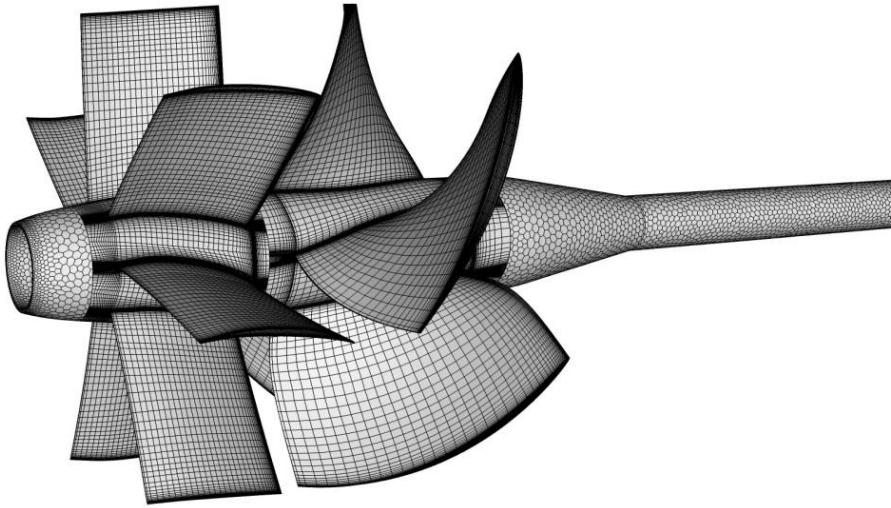
State-of-the-art: Voith

- Advanced parametric modeling of ship hulls and propulsion systems
- Auxiliary geometry to support grid generation

VOITH





Source: David Bendl, Voith, CAESES Users' Meeting 2017

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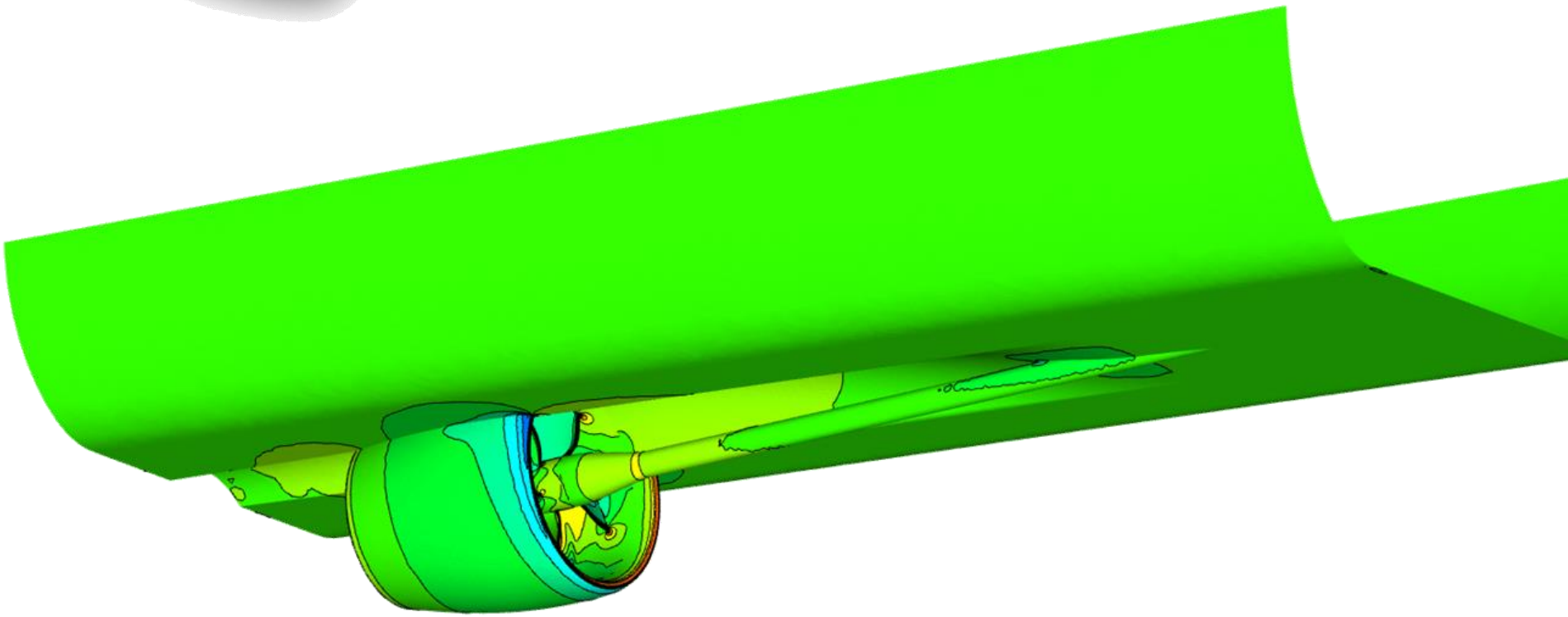
State-of-the-art: Voith Linear Jet (VLJ)

VOITH



Source: David Bendl, Voith, CAESES Users' Meeting 2017

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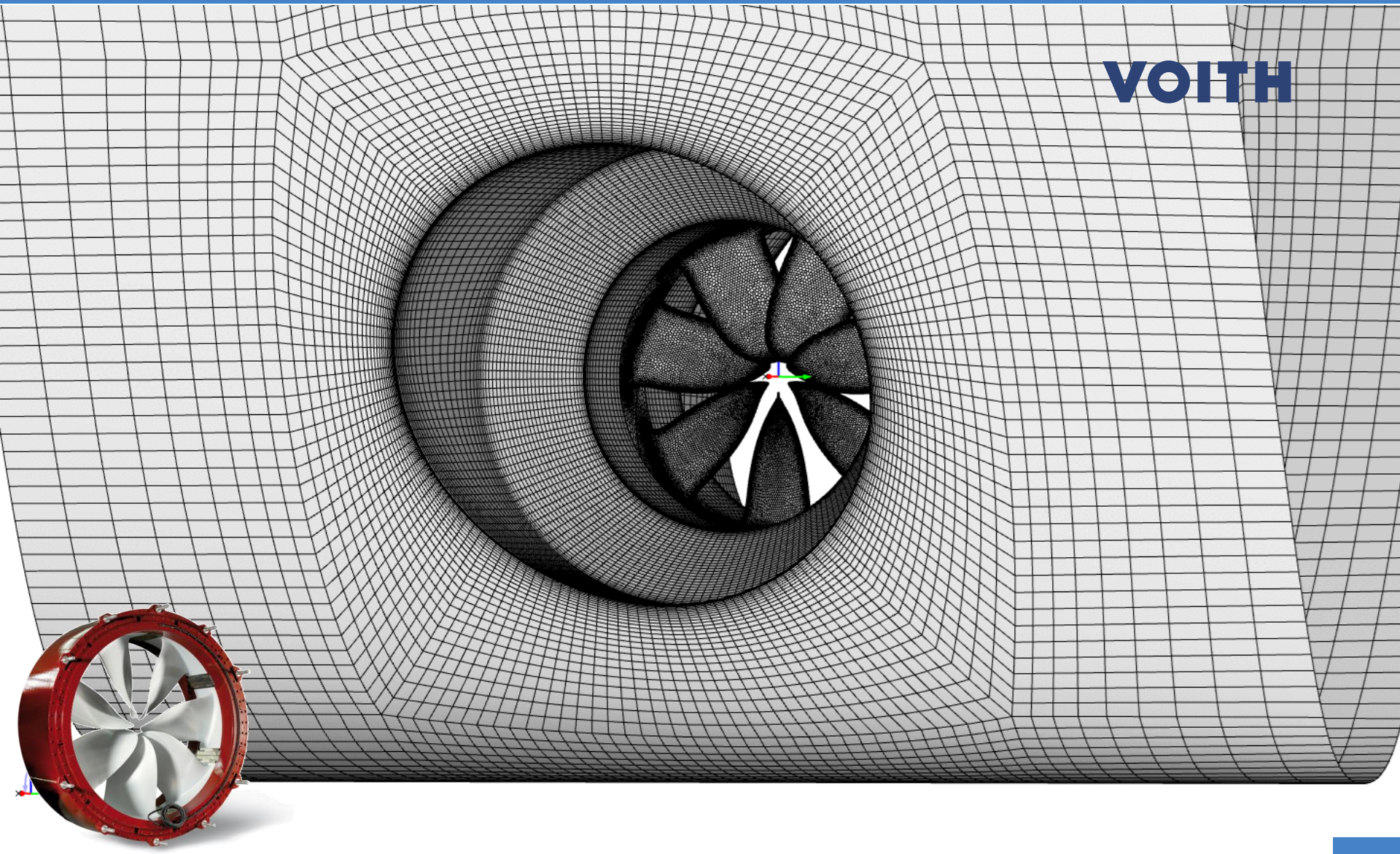
State-of-the-art: Voith Inline Thruster (VIT)



Source: David Bendl, Voith, CAESES Users' Meeting 2017

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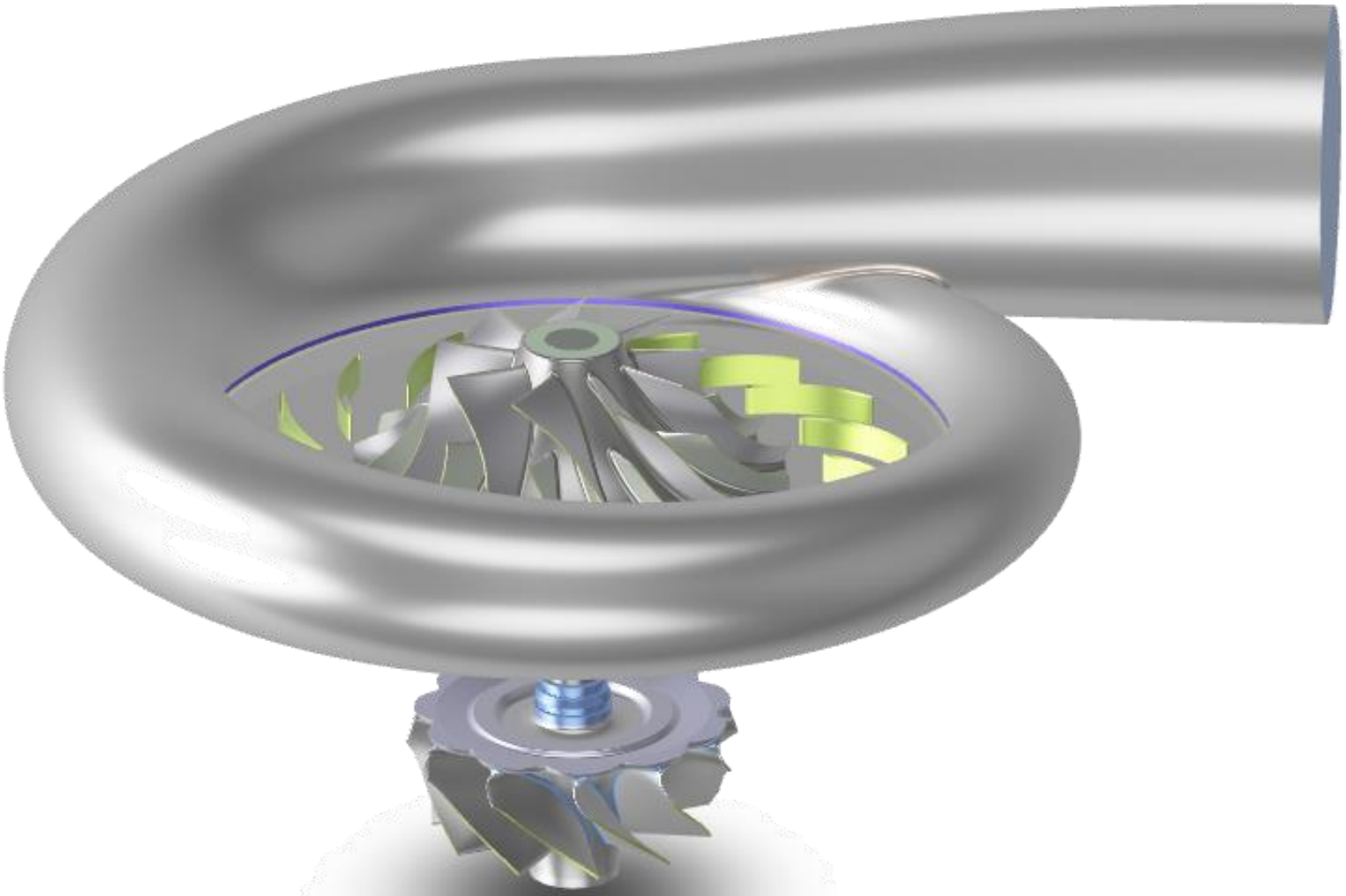
Recent and current R&D



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Recent and current R&D (highlights)

- PerSee
  - Hydrodynamic design of ships in sea-states
- No-Welle and FormPro
  - Parametric adjoint optimization
- HYKOPS
  - Appificiation
  - Geometric modeling
- HOLISHIP
  - Holistic design and process integration (platform)
  - Wrapping of functionality (dominos)
- GAMMA-1
  - Parameter reduction (Karhunen-Loève expansion)
  - Ease-of-use and GUI

Acknowledgement

Parts of the work presented here were realized within projects funded by the Federal Ministry of Economics and Technology (BMWi) on the orders of the German Bundestag and PtJ as the conducting agency.

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Funded by the European Union

Projektträger Jülich Forschungszentrum Jülich

Bundesministerium für Wirtschaft und Technologie

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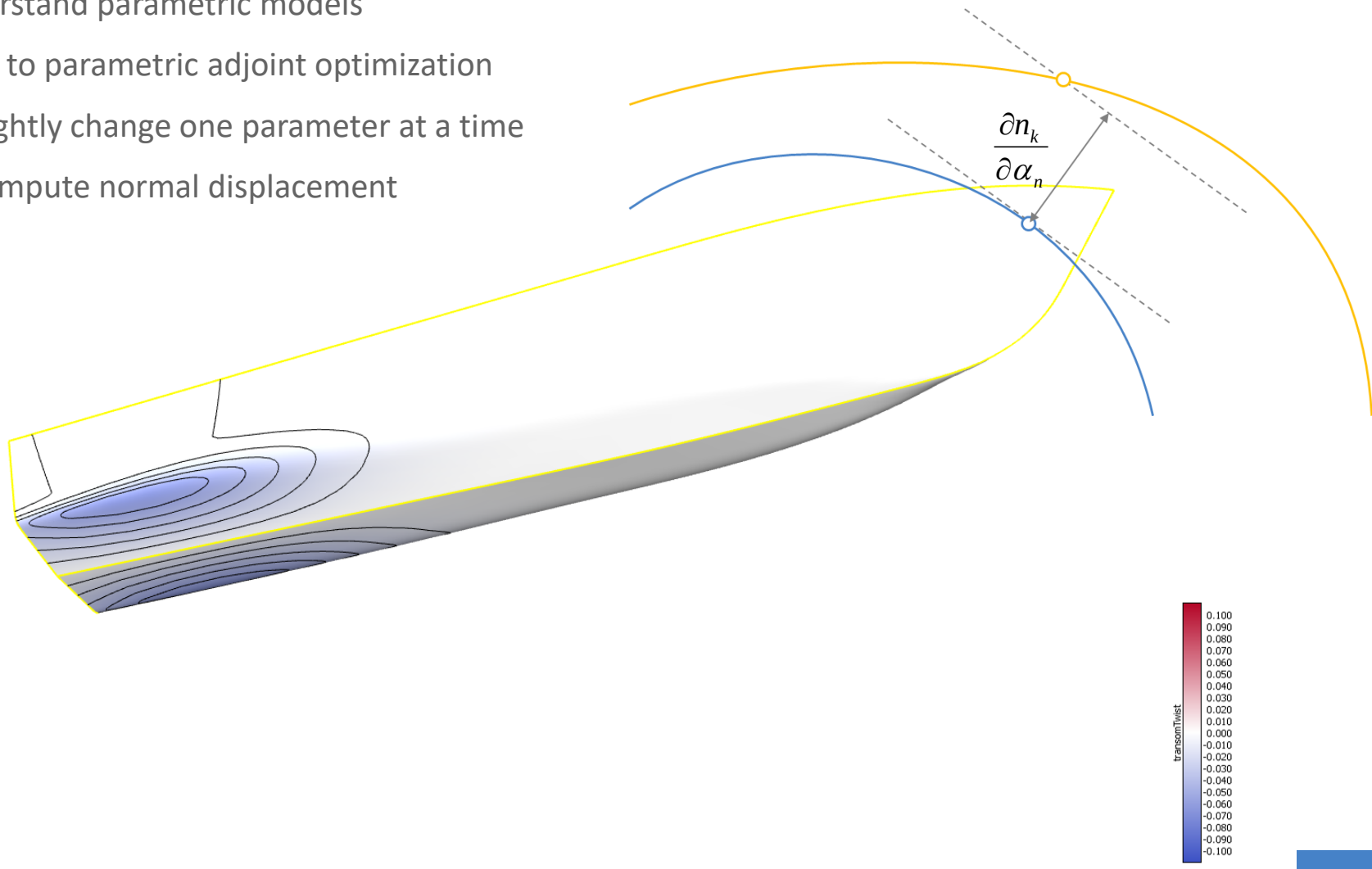
Parametric adjoint optimization: Design velocity

- Understand parametric models
- Input to parametric adjoint optimization
  - Slightly change one parameter at a time
  - Compute normal displacement



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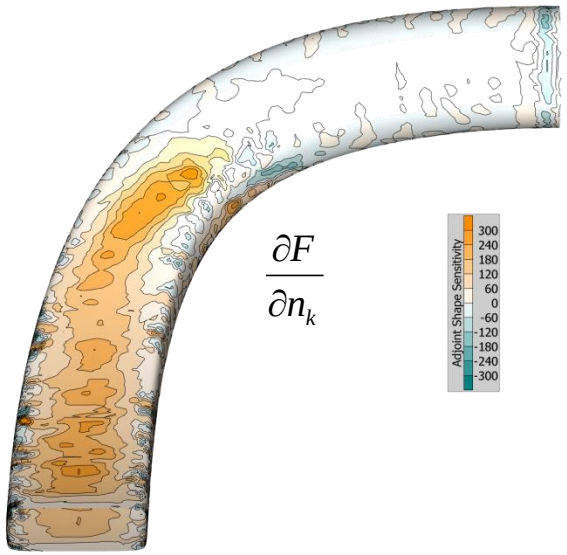
Parametric adjoint optimization

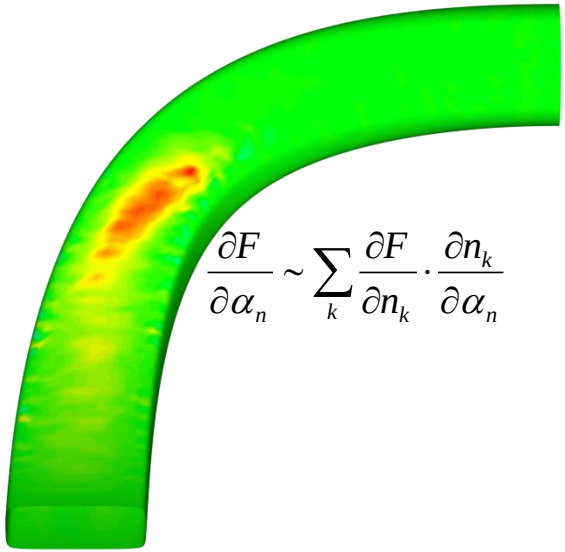
- Results from adjoint CFD computation specify areas of the geometry that have the biggest impact on the objective
- Connecting to information about parameter influence on shape leads to sensitivities for all design parameters

pictures: Sensitivities

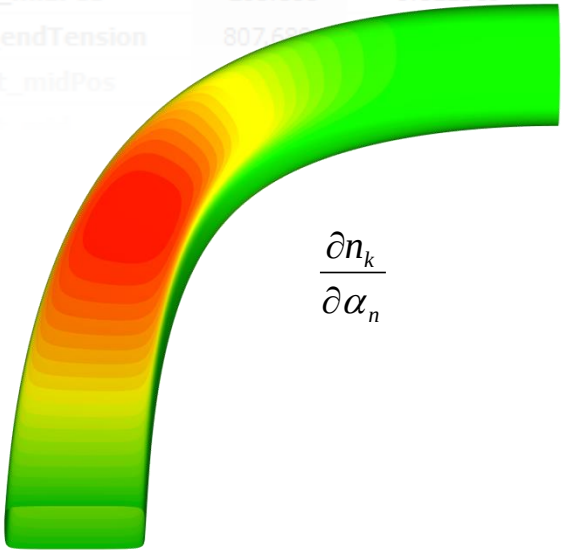
	Sensitivity	Variation Delta
width_mid	-41.2465	3.99853
path_midfactorZ	1388.89	0.0208482
path_startTension	562.865	0.0419241
height_startTension	3119.02	0.242158
path_midfactorY	233.01	0.0402543
width_endTension	115.733	0.587913
path_midfactorX	-619.726	0.0205169
width_midPos	-265.585	0.522516



$$\frac{\partial F}{\partial n_k}$$



$$\frac{\partial F}{\partial \alpha_n} \sim \sum_k \frac{\partial F}{\partial n_k} \cdot \frac{\partial n_k}{\partial \alpha_n}$$



$$\frac{\partial n_k}{\partial \alpha_n}$$

adjoint shape sensitivity → product ← design velocity

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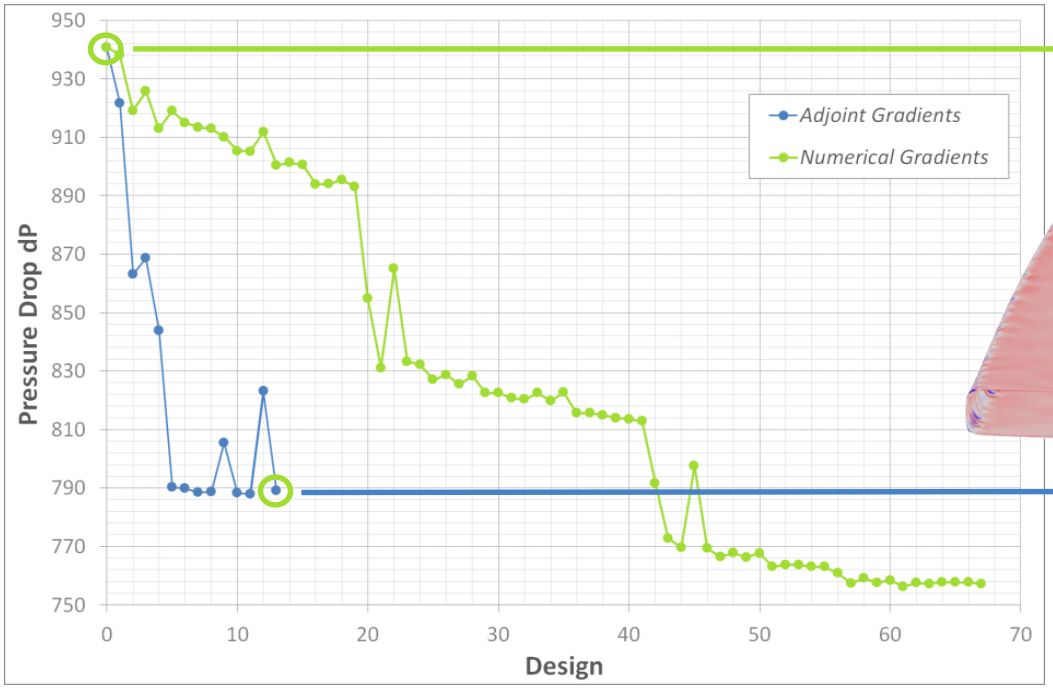
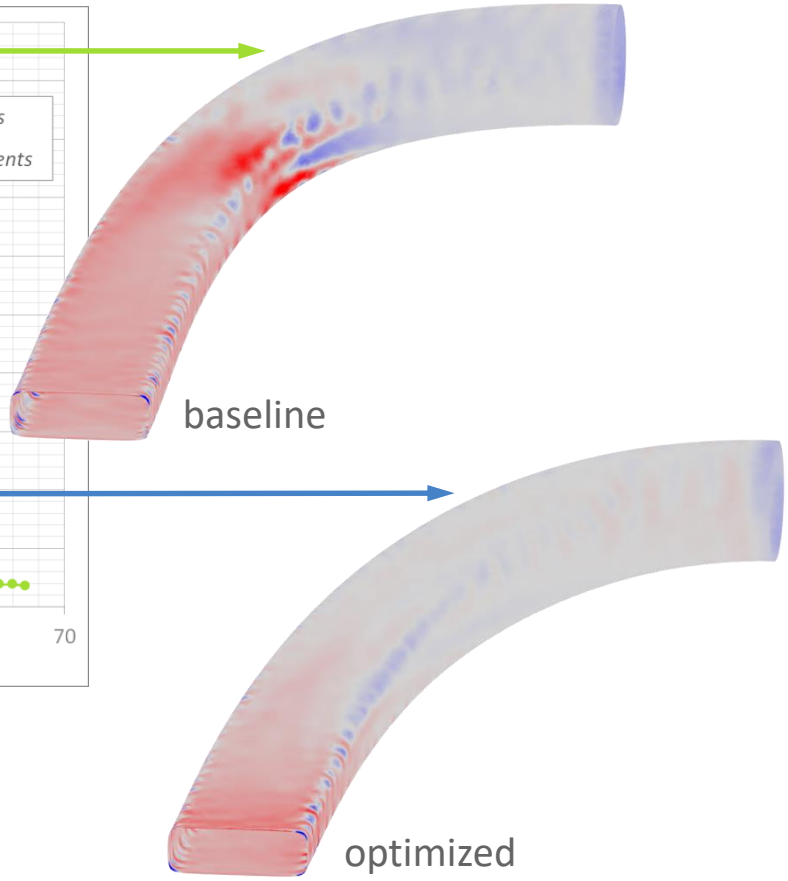
Parametric adjoint optimization





- Using the gradient information from the adjoint CFD leads to a much faster convergence towards a local optimum

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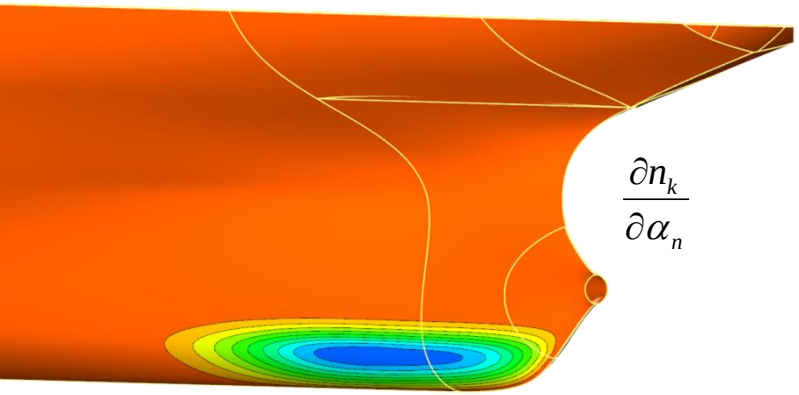
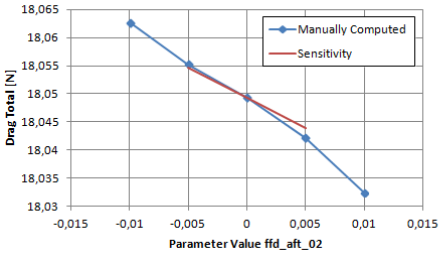
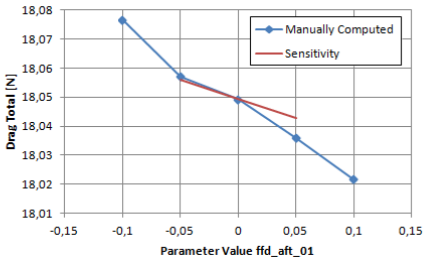
Parametric adjoint optimization



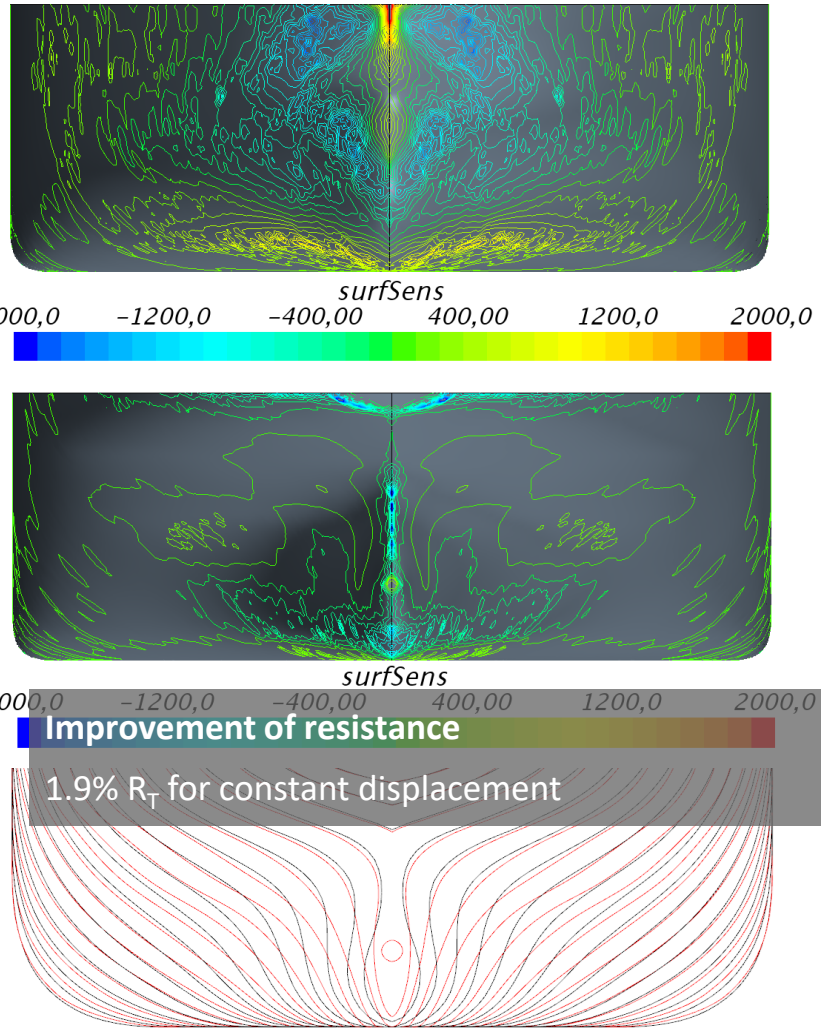
$$\frac{\partial n_k}{\partial \alpha_n}$$

$$\frac{\partial F}{\partial \alpha_n} \sim \sum_k \frac{\partial F}{\partial n_k} \cdot \frac{\partial n_k}{\partial \alpha_n}$$





$$\frac{\partial F}{\partial n_k}$$



Improvement of resistance

1.9% R_T for constant displacement

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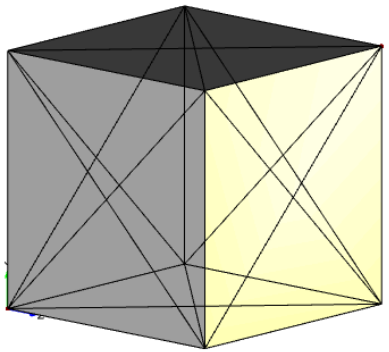
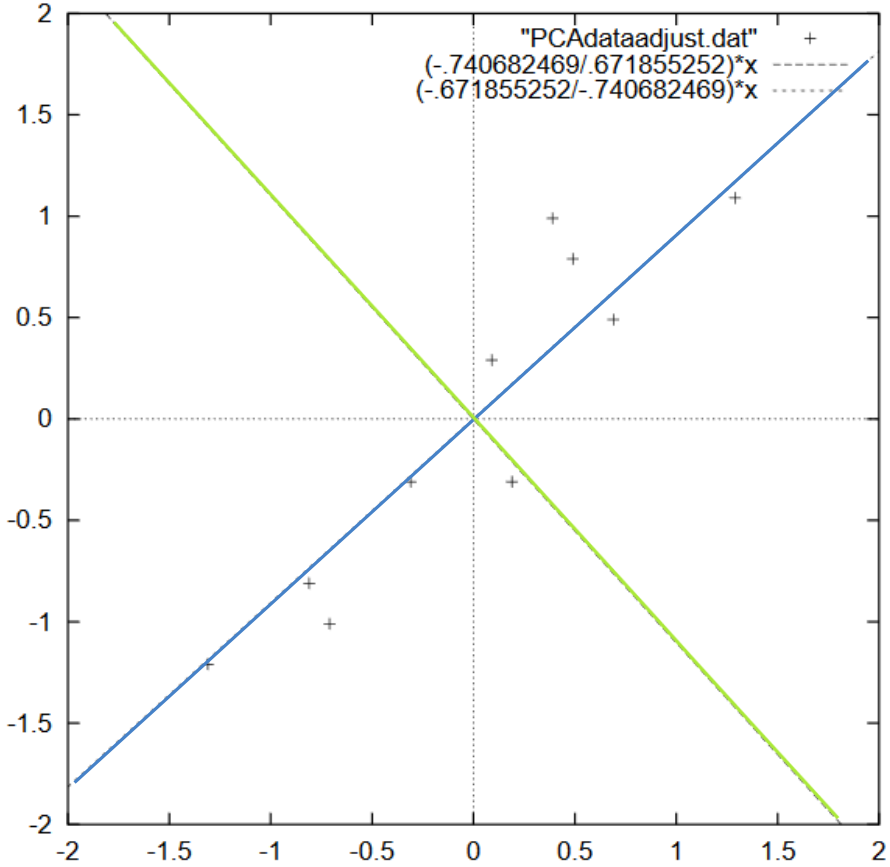
Karhunen-Loève Expansion (KLE)

- Aims
  - Check quality of a parametric model
  - If needed and possible reduce number of free variables (further)
- Principle components analysis
  - A large number of statistical variable are being replaced by an approximation with a reduced number of linear combinations of orthogonal basis functions
  - Decorrelation of data (as far as possible)





Source: Lindsay I. Smith (2002) A Tutorial on Principal Components Analysis

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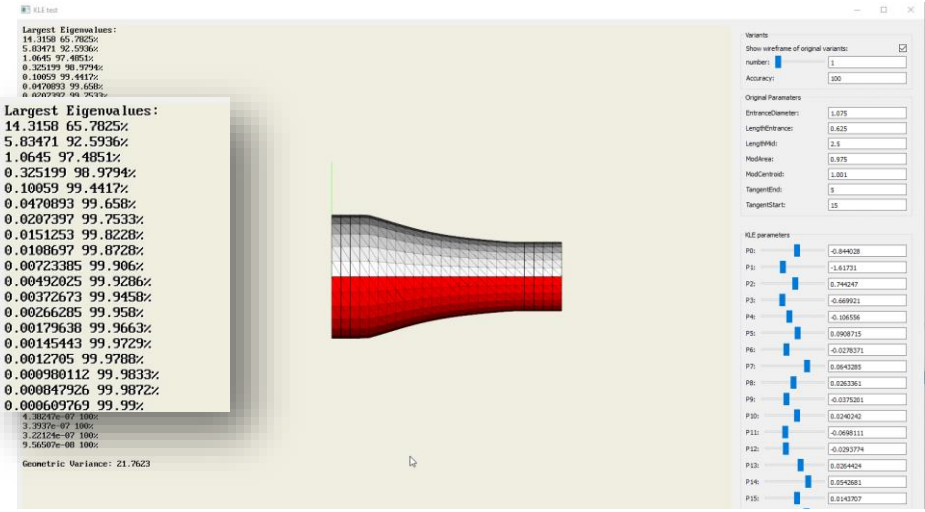
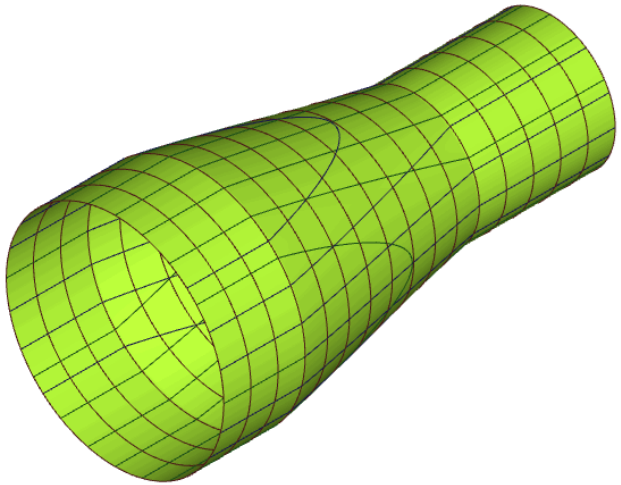
Karhunen-Loève Expansion (KLE)

- Inlet geometry with 7 free variables
- Variability achieved
  - 1. “super parameter” 65,78%
  - 1. + 2. “super parameter” 92,59%
  - 1. + 2. + 3. parameter 97,49%
  - 1. + 2. + 3. + 4. parameter 98,98%
  - 1. + 2. + 3. + 4. + 5. 99,44%





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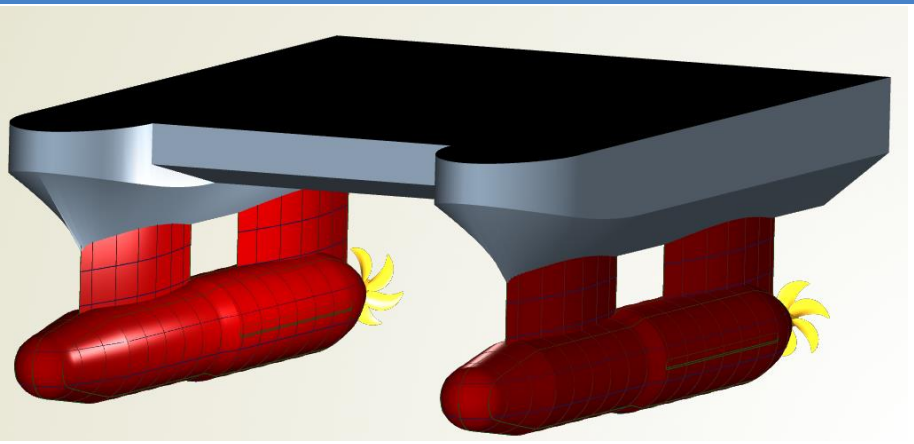
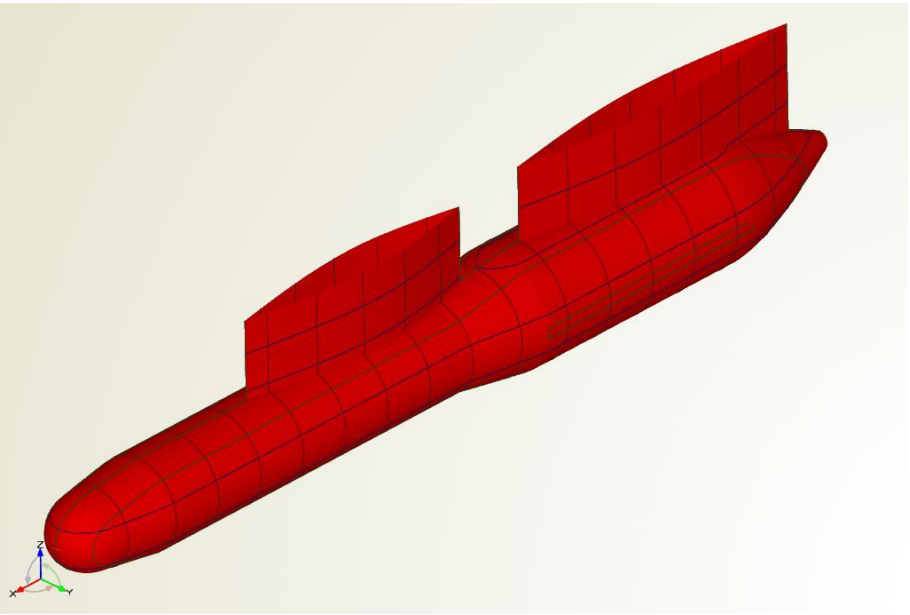
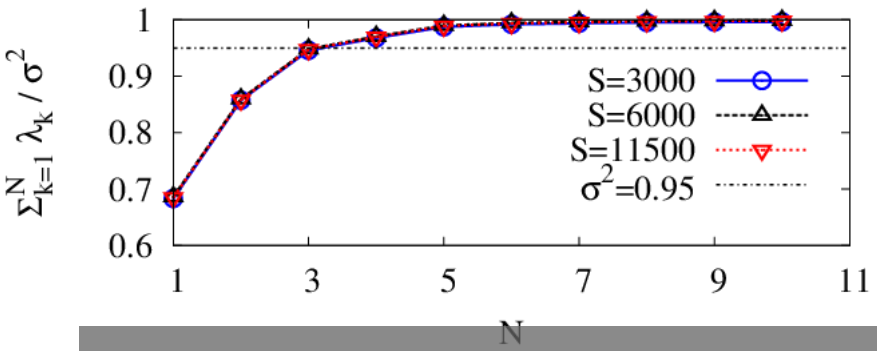
Parameter reduction







Parameter reduction from 27 to 4

Already 4 modes are sufficient to retain more than 95% of the original variance

From 27 original parameter to 4 KLE variables reduces the dimensionality by more than 85%

Source: Riccardo Pellegrini, CNR-INSEAN, CAESES Users' Meeting 2017

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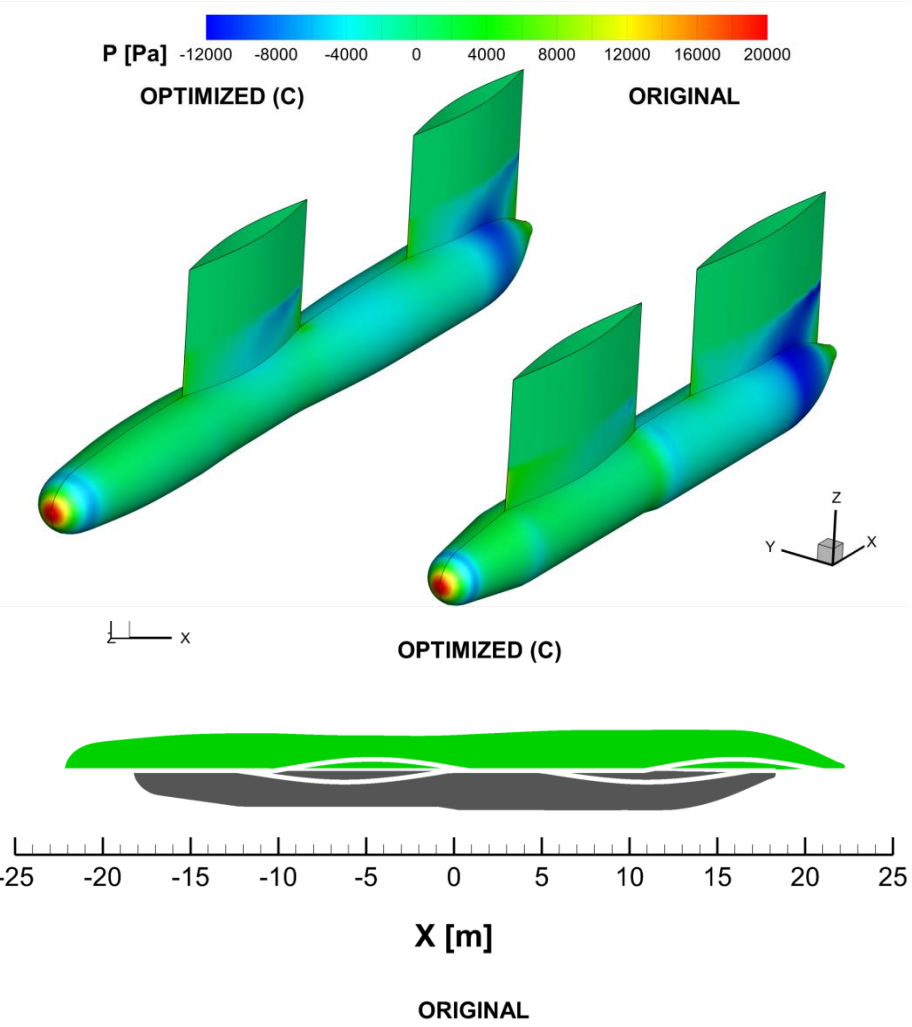
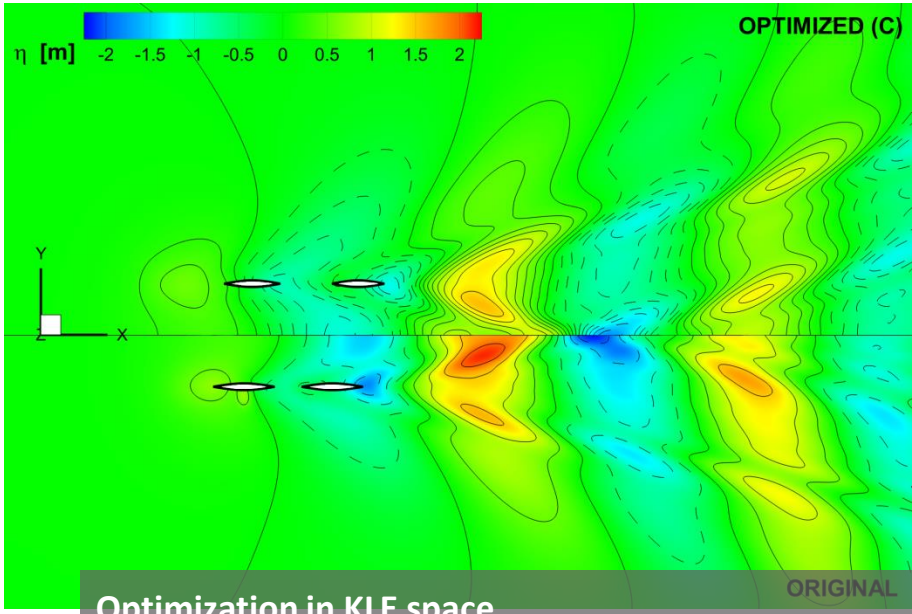
Parameter reduction



Marine Technology Research Institute
INSEAN



Optimization in KLE space

Chosen design shows a reduction of total resistance by about 25% while, at the same time, increasing displacement by around 25%

HOLISHIP

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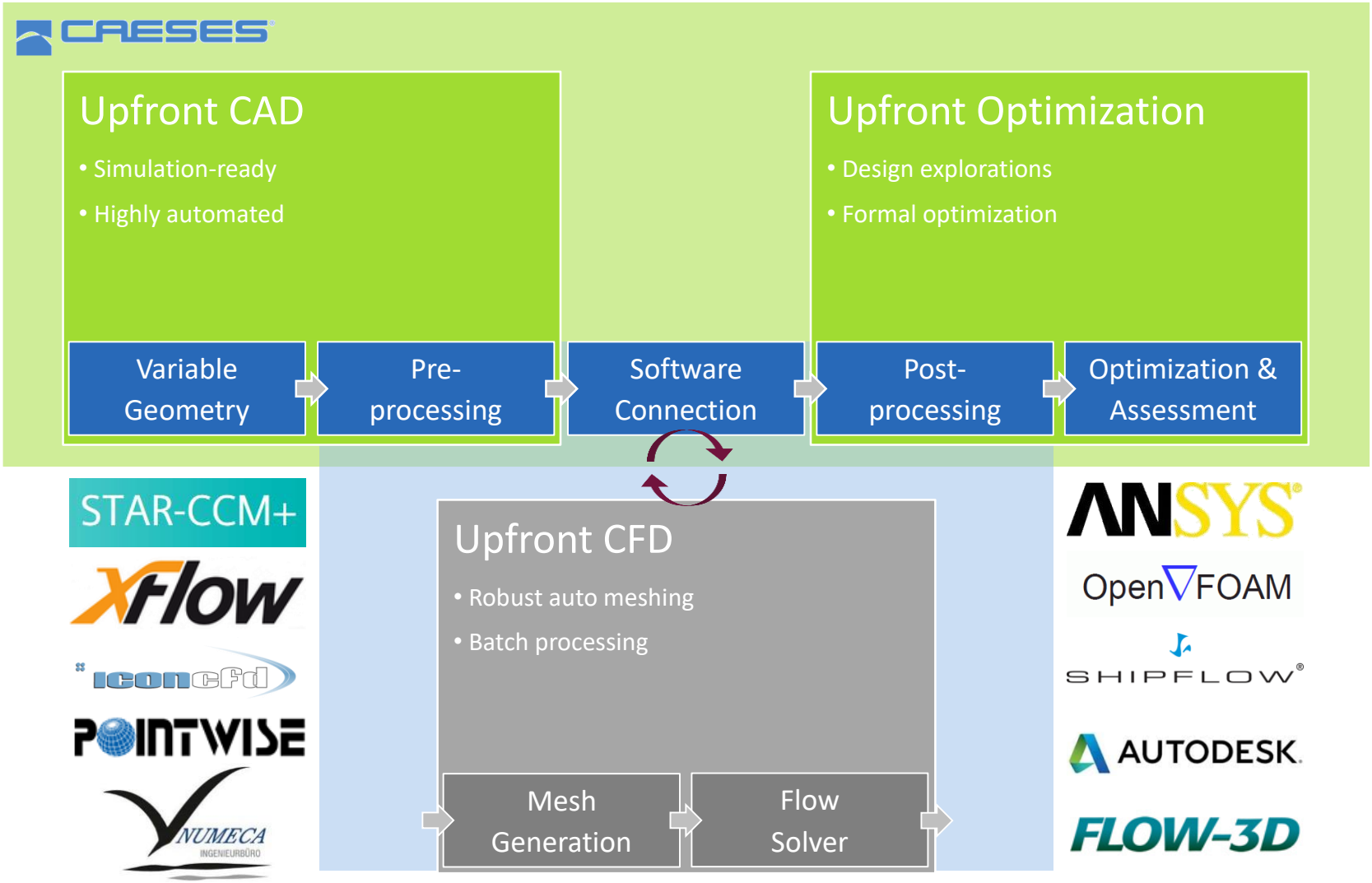
Available integrations



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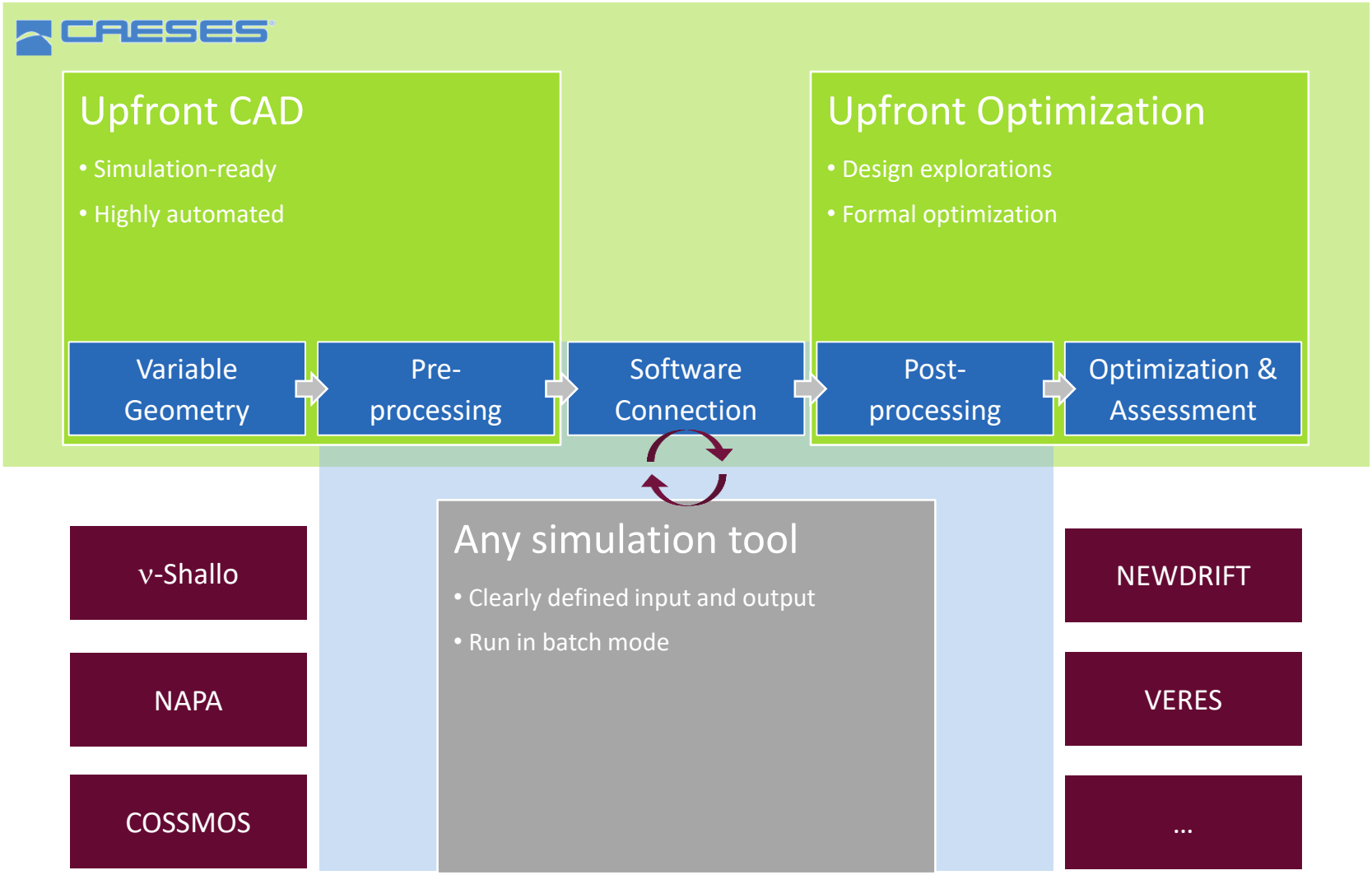
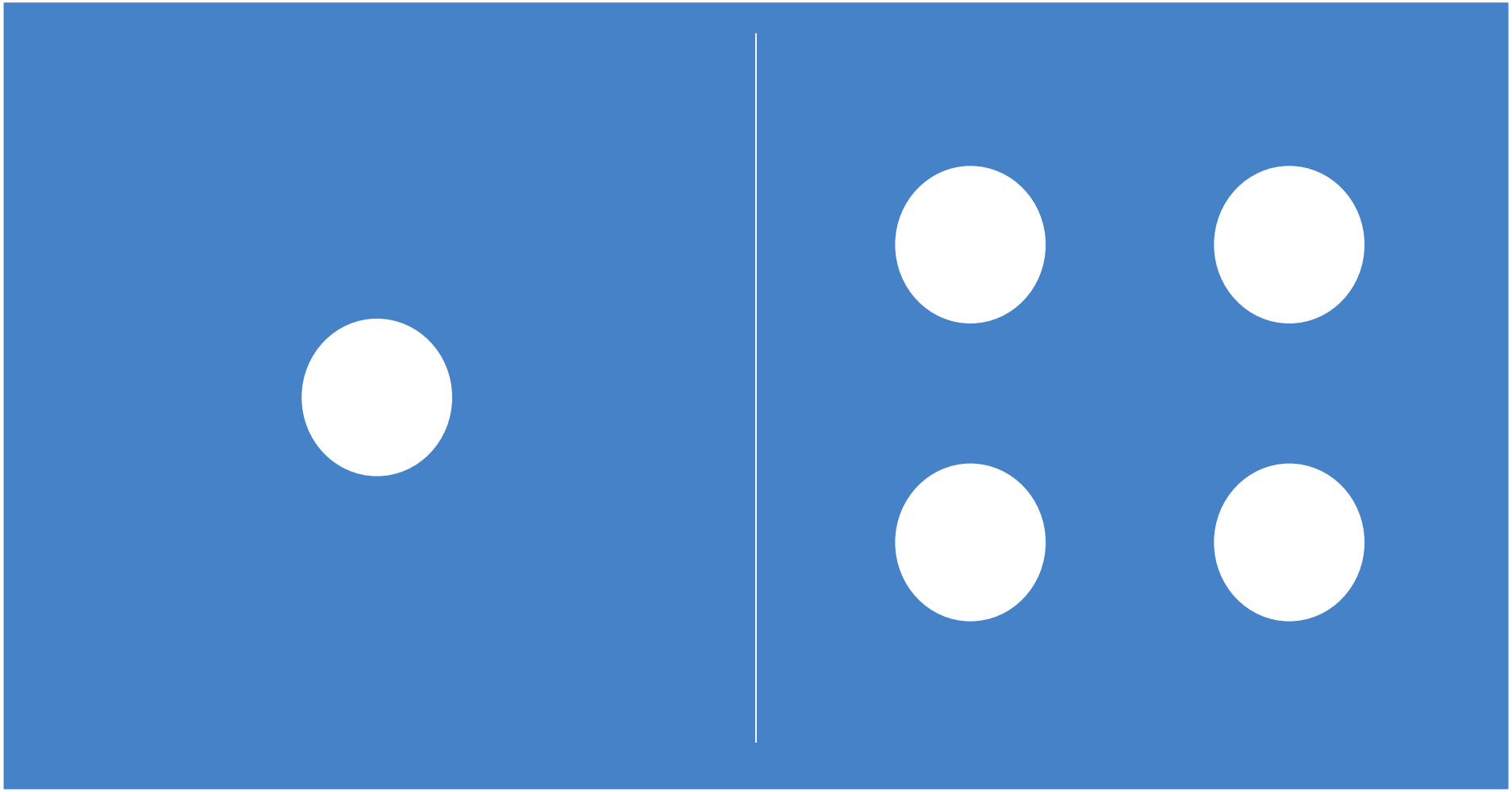
HOLISHIP



FRIENDSHIP SYSTEMS © 2017

HOLISHIP



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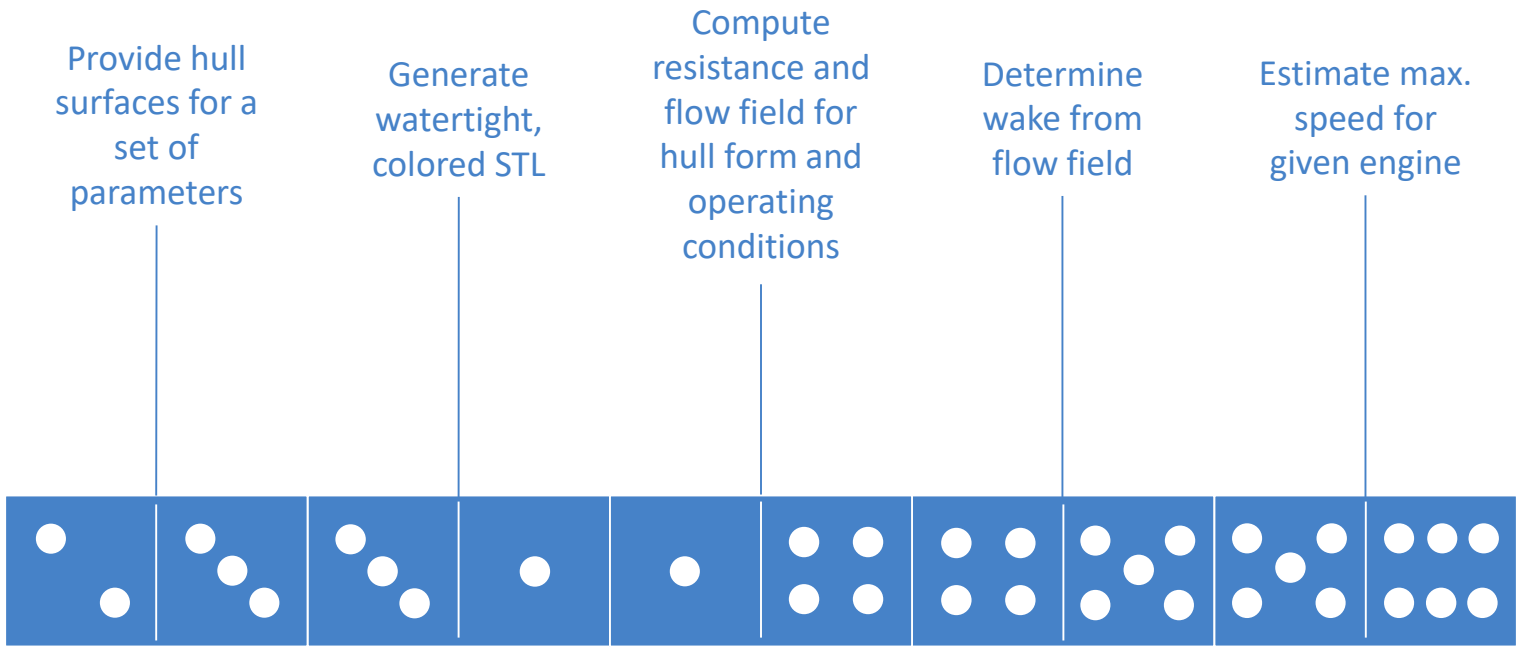
HOLISHIP



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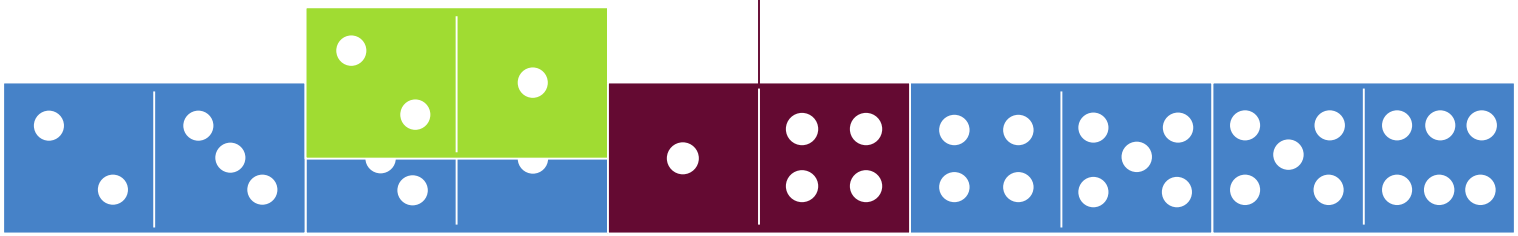
HOLISHIP

- Wrap functionality to make it more easily accessible
- Provide wrapped tools that can be flexibly combined within comprehensive projects

Rolls-Royce

Compute resistance and flow field for hull form and operating conditions via a WebApp



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HOLISHIP – Application case Rolls-Royce OSV

Rolls-Royce

Hull verification

Input:
Hull geometry
CoG
Draft
Displacement
Crane info
Lifting weight

Output:
Go/No-go

NAPA

Hull design

Input:
Baseline and transformation

Output:
Hull design
VcG, LcG
Displacement

CAESES feature

Motions

Input:
Crane motion limits

Output:
Limiting Hs, Tp

VERES

Steel w. / light weight

Input:
Dimensions
Coefficients

Output:
Steel weight
Lightship weight

CAESES feature

DP

Input:
Thruster config. fixed
Thruster location
Windage area
Waterplane shape
Seastate

Output:
Thrust for and aft

SHIPX

Cost (CAPEX)

Input:
Power requirement
Thruster sizes
Steelweight
Crane cost

Output:
Cost level

CAESES feature

Manoev. / Propulsion

Input:
Thrust aft (ShipX)
Propulsion thrust (Shipflow)

Output:
Power fore
Power aft

CAESES feature

Resistance

Input:
Hull model
Speed

Output:
Resistance
(Required thrust)

SHIPFLOW

HOLISHIP

CAESES

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HOLISHIP – Application case FINCANTIERI RoPax

Hull design

Input:
Main dimensions

Output:
Hull shape
Hydrostatics

FRIENDSHIP SYSTEMS

CAESES model

Damage stability

Input:
Hull shape
Topology

Output:
Attained index

NAPA

CETENA
FINCANTIERI

Wave resistance

Input:
Hull shape
Operational profile

Output:
Wave resistance

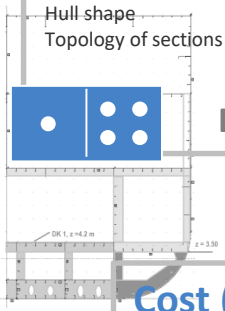
HSVA

Steel w. / light weight

Input:
Hull shape
Topology of sections

Output:
Steel weight
Lightship weight

BV Mars / Steel



Viscous flow

Input:
Hull shape
Operational profile
Assumptions about propeller

Output:
Resistance and propulsion at full scale

HSVA

FreSco

CAESES

1 2 3 4 5 6 7 8

Cost (CAPEX)

Input:
Ship type
Hull shape
Scantlings
Yard specific data

Output:
Cost

e.g. CAESES feature

...

Input:
...

Output:
...

Any external tool

Added resistance

Input:
Hull shape
Operational profile
Sea states

Output:
Added resistance in waves

Newdrift

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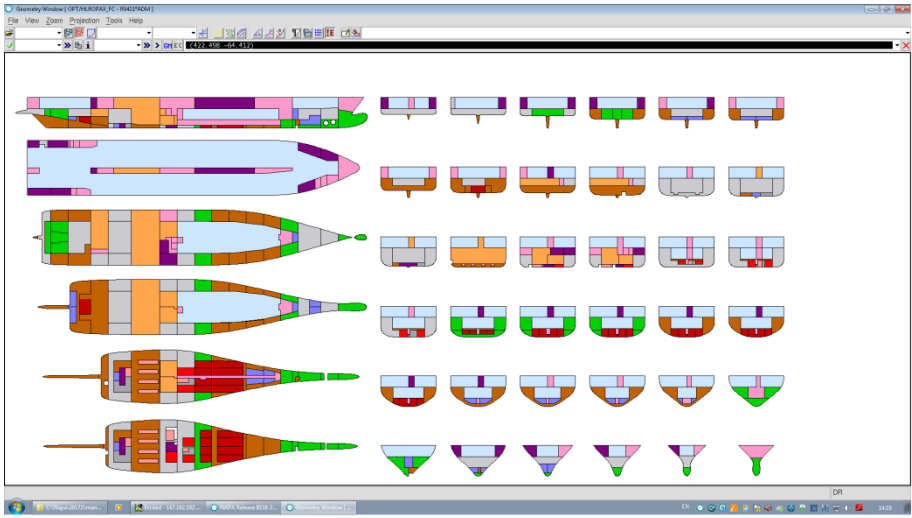
Coupling of CAESES and NAPA

- Hull forms are created in CAESES and surfaces are transferred to NAPA via an IGES file
- A detailed watertight subdivision is created using a series of NAPA macros
- The Attained subdivision index is calculated according to SOLAS 2009 Reg.7
- The above procedure is repeated for a large number of variants via a Sobol



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Running NAPA batch file

NAPA-CAESES batch file v1 - Copy - Notepad

File Edit Format View Help

```
:: Copying INPUT files to the directory where NAPA reads them
copy "%CD%\Hull.iges"  "C:\napa\pr\HLROPAX_FC\Hull.iges"
copy "%CD%\variables00.txt"  "C:\napa\pr\HLROPAX_FC\variables00.txt"
```

COPYING INPUT FROM CAESES DIRECTORY TO NAPA DIRECTORY

```
::-----------------------------------------------------
::  THE BELOW SCRIPT CAN BE FOUND IN THE NAPA MANUAL
::-----------------------------------------------------
@echo off
setlocal

:: Please enter your details here
set USER=ADMI
set PROJECT=C:\NAPA\pr\hlropax_fc.db64
set MACRO=01_EXECUTE

:: General setup
set INSTALLATION_FOLDER=c:\napa\
set PATH=C:\Program Files\Hummingbird\Connectivity\14.00\Exceed

:: NAPA specific configuration
set NAPADB=c:\napa\20172\database\napadb.db
set SYSDB=C:\NAPA\pr\sysdb.db
set NAPALIC=C:\NAPA\pr\napalic.txt
set NAPAIOF=C:\NAPA\pr\IOF_X64.dat
set NAPADIR=C:\NAPA\pr\

c:\napa\20172\bin64\NapaRunMacro.exe -u %USER% -f %NAPADIR%
                                    -l %NAPALIC% -n %NAPADB%
                                    -s %SYSDB% -i %NAPAIOF%
                                    -p %PROJECT% -m %MACRO%

::-----------------------------------------------------
::  END OF NAPA MANUAL SCRIPT
::-----------------------------------------------------
```

RUNNING NAPA*

*script can be found in NAPA manual

Batch file

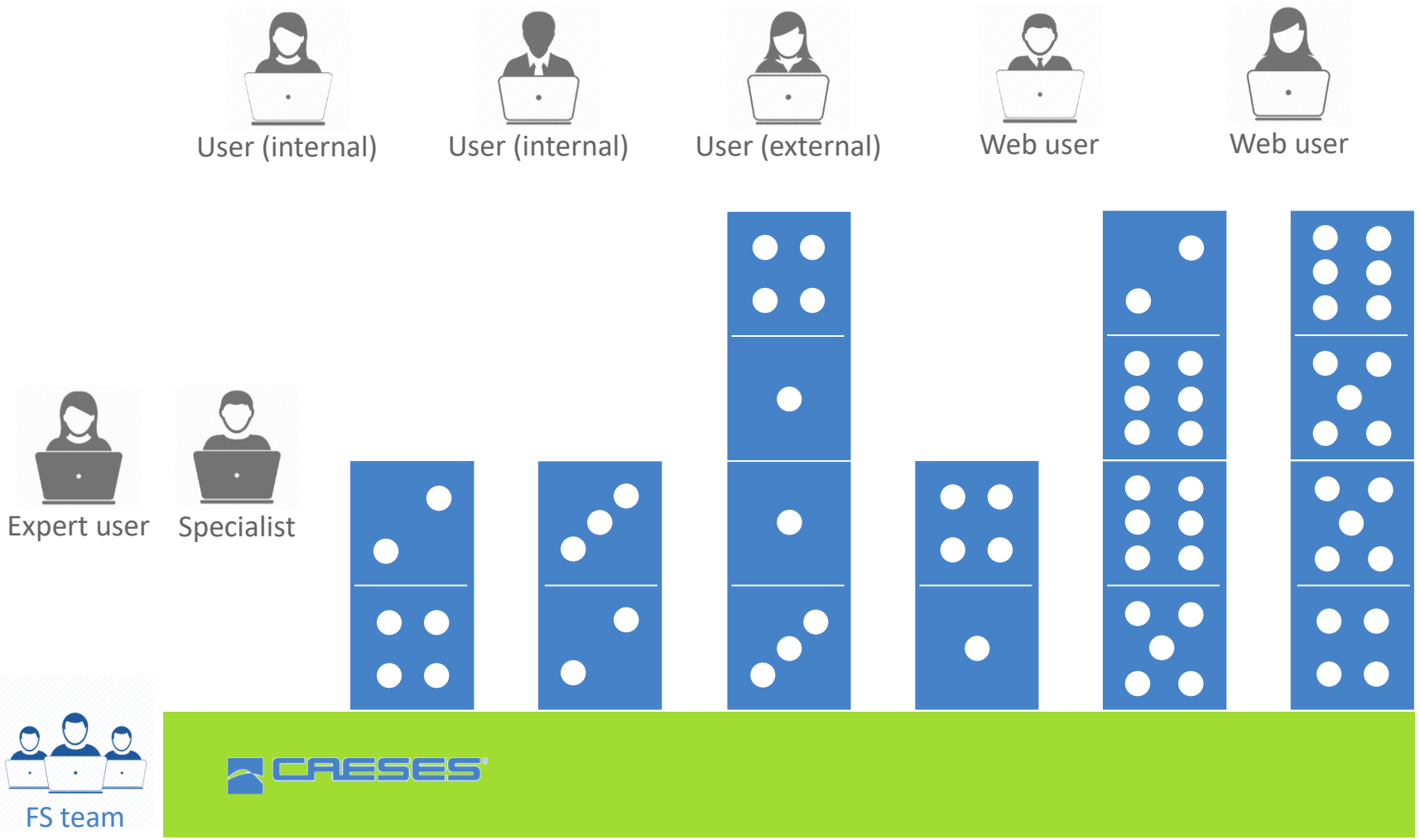
Needs to be adjusted to working environment

```
:: Copying the OUTPUT files in the directory where CAESES saves them
copy "C:\napa\pr\HLROPAX_FC\output.txt"  "%CD%\output.txt"
copy "C:\napa\pr\HLROPAX_FC\damstabres.txt"  "%CD%\damstabres.txt"
```

COPYING OUTPUT FROM NAPA DIRECTORY TO CAESES DIRECTORY

FRIENDSHIP SYSTEMS © 2017

CAESES as a platform (and “operating system”)



Source: iconfinder.com

FRIENDSHIP SYSTEMS © 2017

CAESES 5.0

FRIENDSHIP SYSTEMS © 2017

CAESES 5.0

- Parallelized
  - CAESES 5.0 exploits all cores of multi-core machines (while 4.x uses only one core)
  - Speeds up project loading and model update (depending on the project, up to a linear scaling with regards to number of cores)
- New rendering engine
  - Handling of larger objects
  - Better user experience
  - Nicer pictures
- Base for appification

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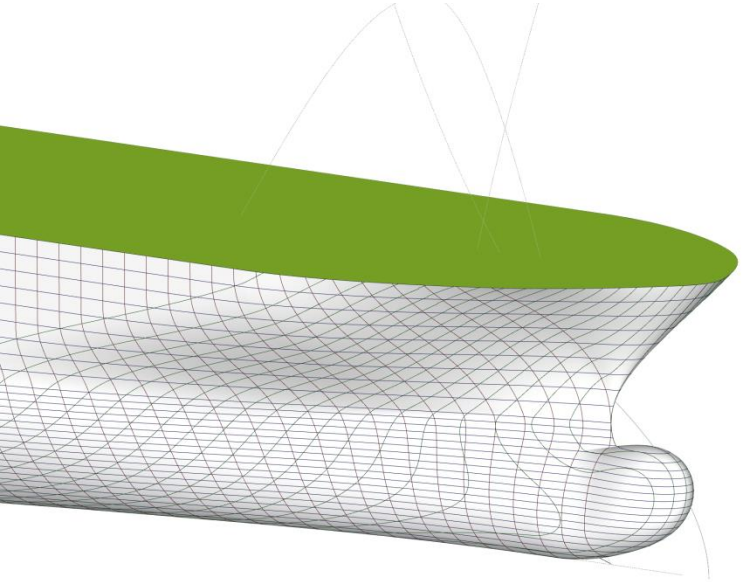
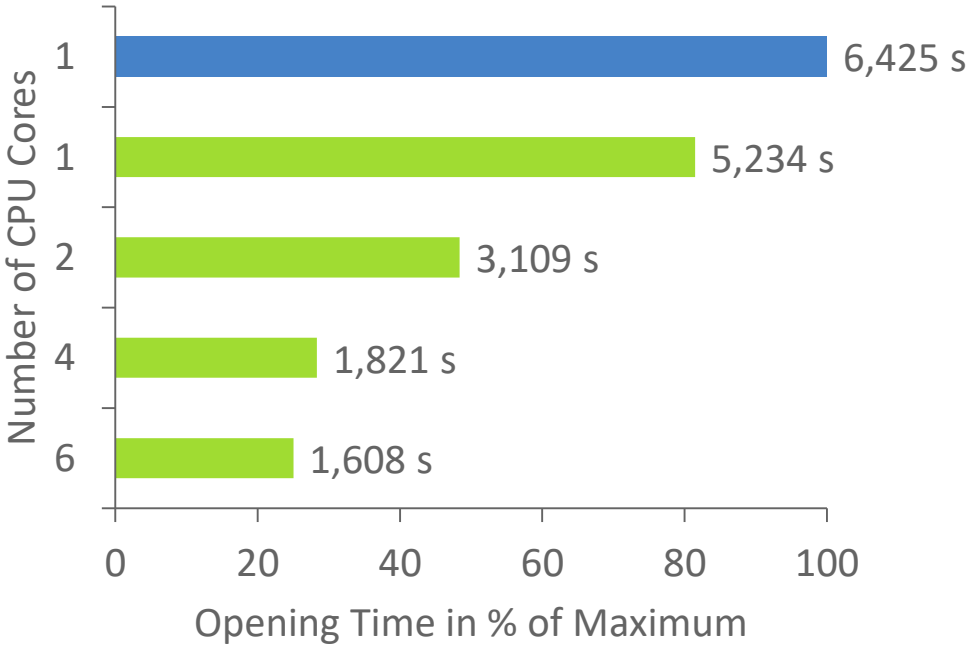
Speed up in CAESES 5.0

- Parametric CAESES model of a container vessel
- Good scaling on multiple CPUs

Up to 4 x faster

Using 6 cores instead of one





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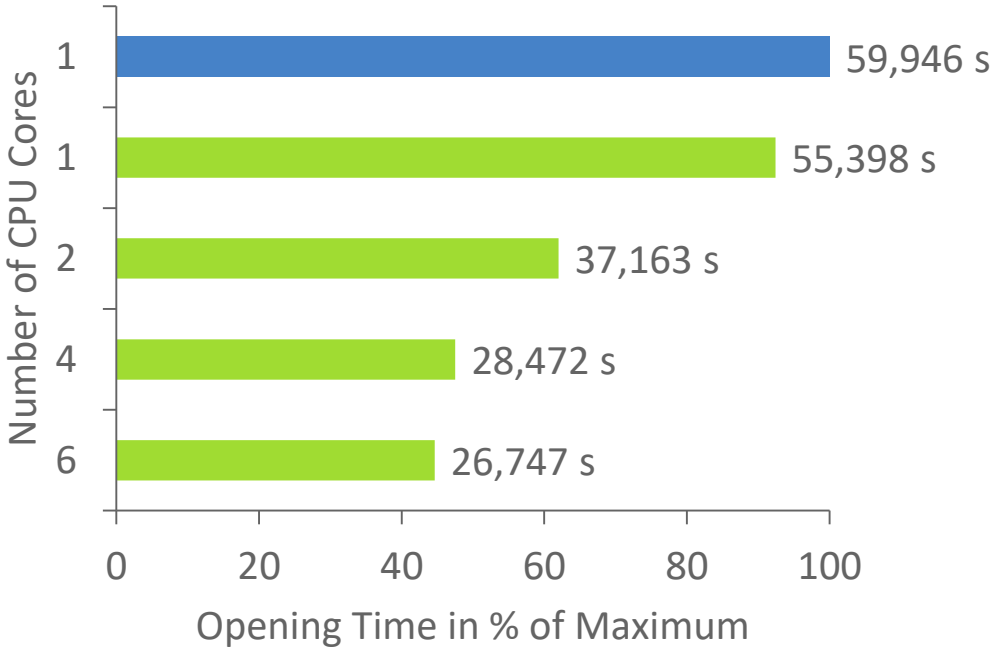
Speed up in CAESES 5.0

- Turbine example modeled in CAESES
- Scaling depends on hierarchical model

Opening time reduced by more than 30 seconds

Using 6 cores instead of one



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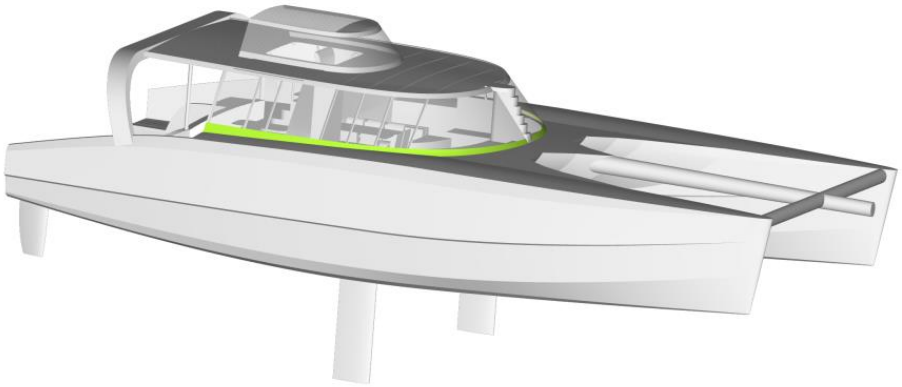
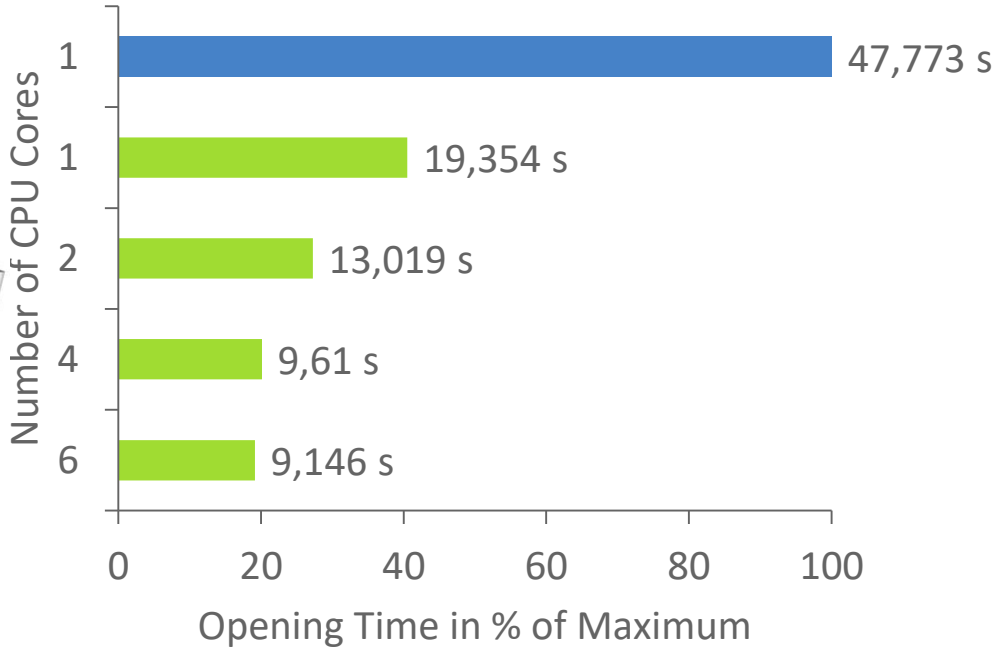
Speed up in CAESES 5.0

- Complex model of a catamaran
- Created in 4.2 runs flawless in CAESES 5.0

Better performance already in serial mode

Opening time reduced by 60%





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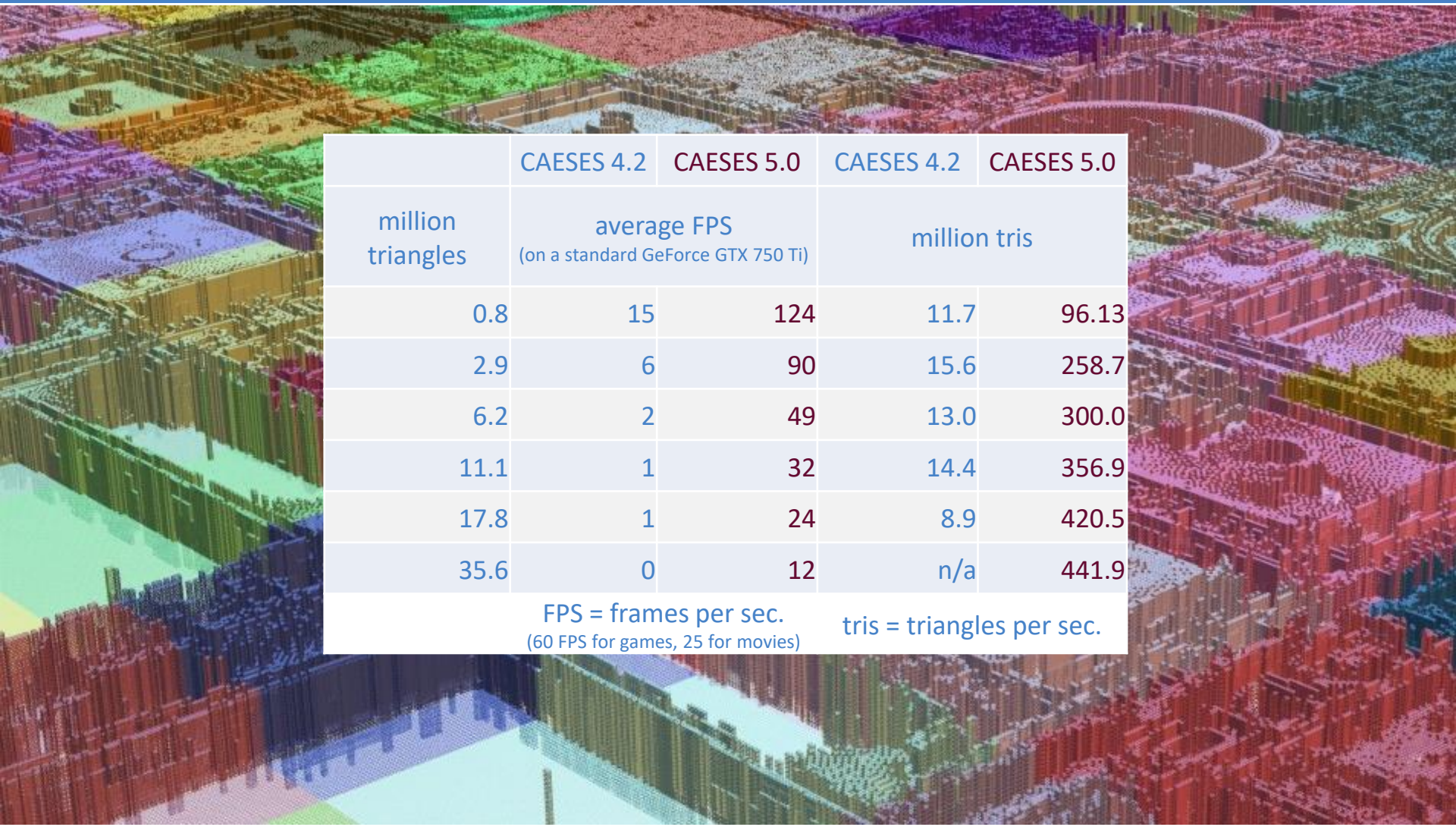
Rendering engine



	CAESES 4.2	CAESES 5.0	CAESES 4.2	CAESES 5.0
million triangles	average FPS (on a standard GeForce GTX 750 Ti)		million tris	
0.8	15	124	11.7	96.13
2.9	6	90	15.6	258.7
6.2	2	49	13.0	300.0
11.1	1	32	14.4	356.9
17.8	1	24	8.9	420.5
35.6	0	12	n/a	441.9
	FPS = frames per sec. (60 FPS for games, 25 for movies)		tris = triangles per sec.	

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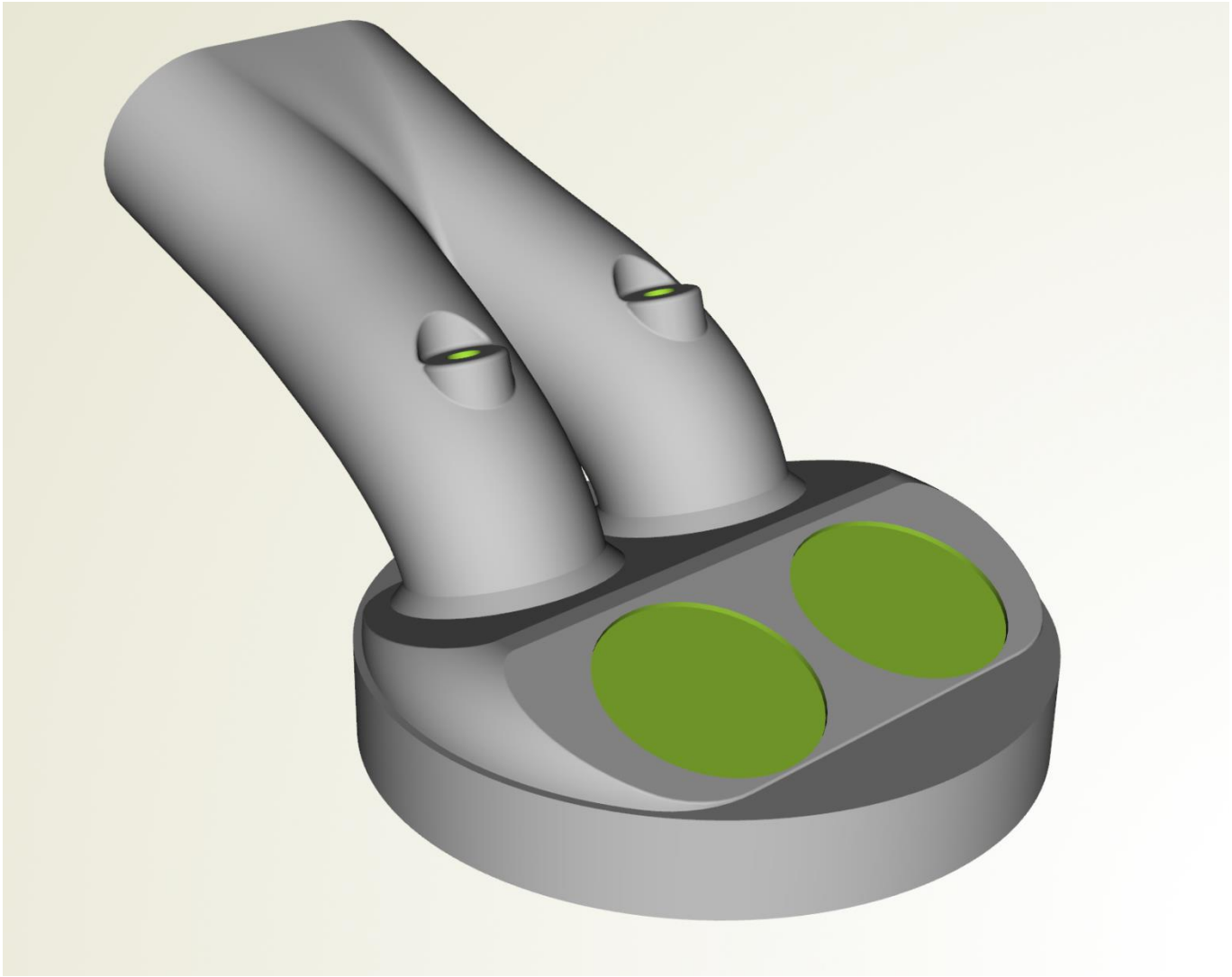
Rendering engine 4.x



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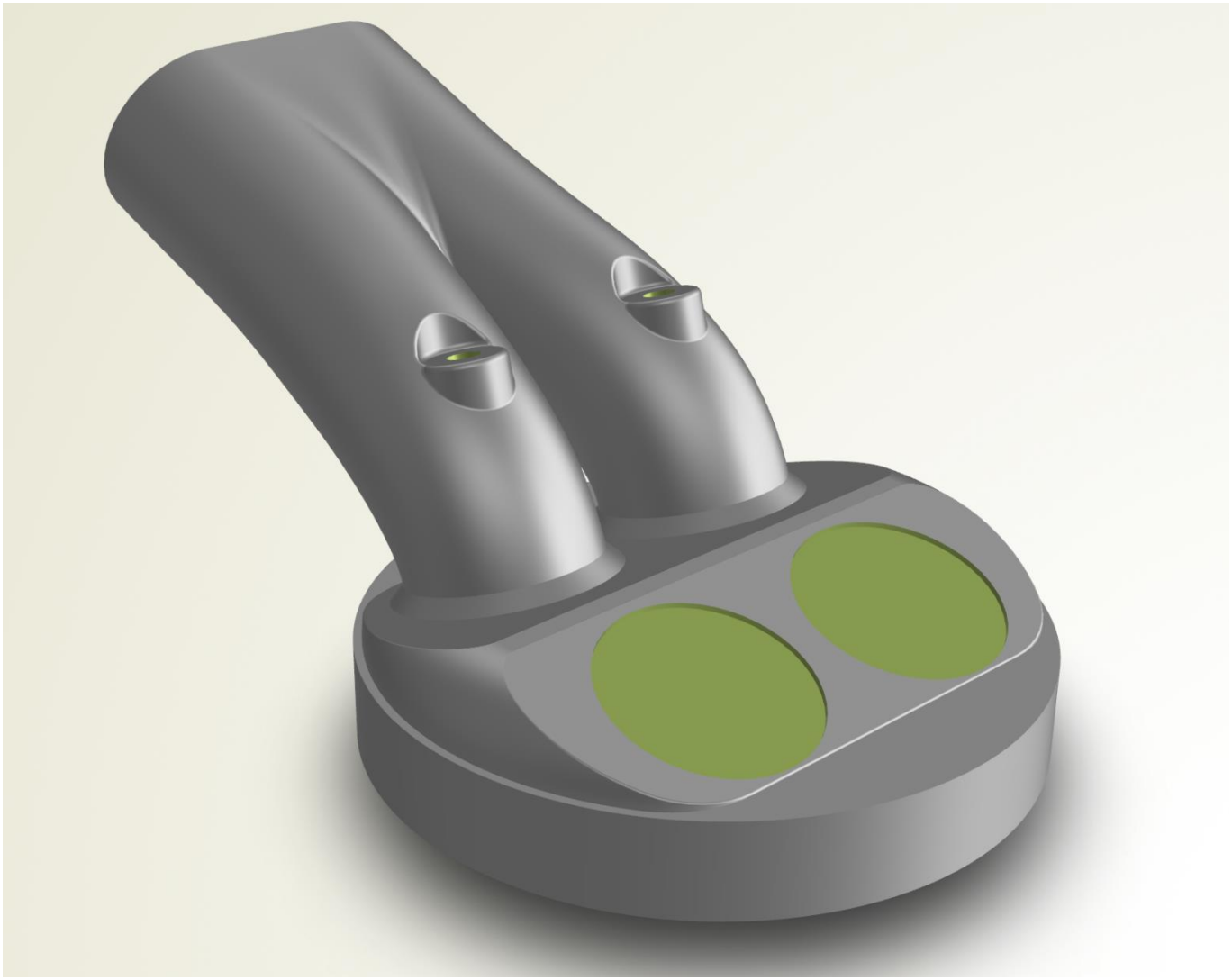
Rendering engine 5.0



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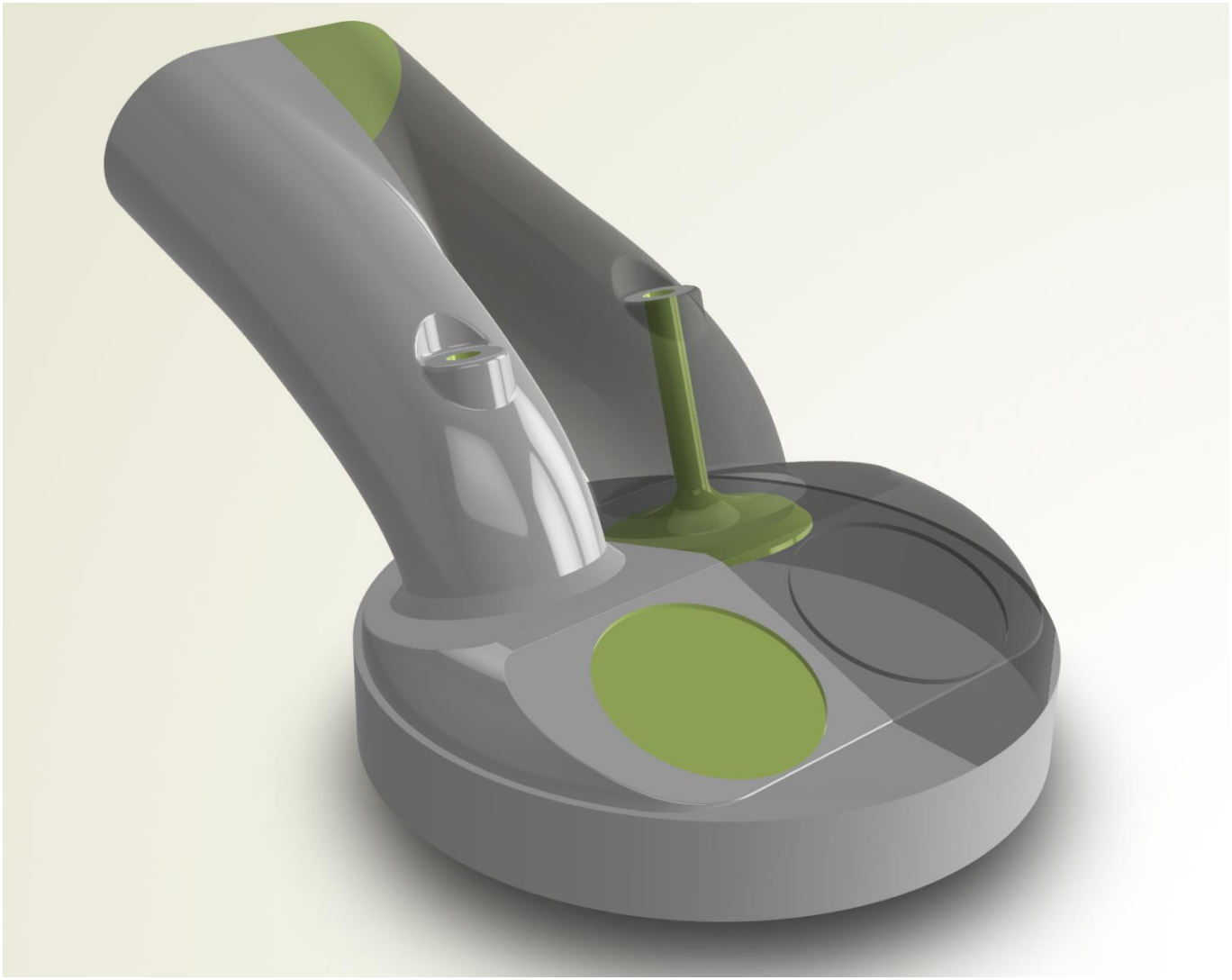
Rendering engine 5.0



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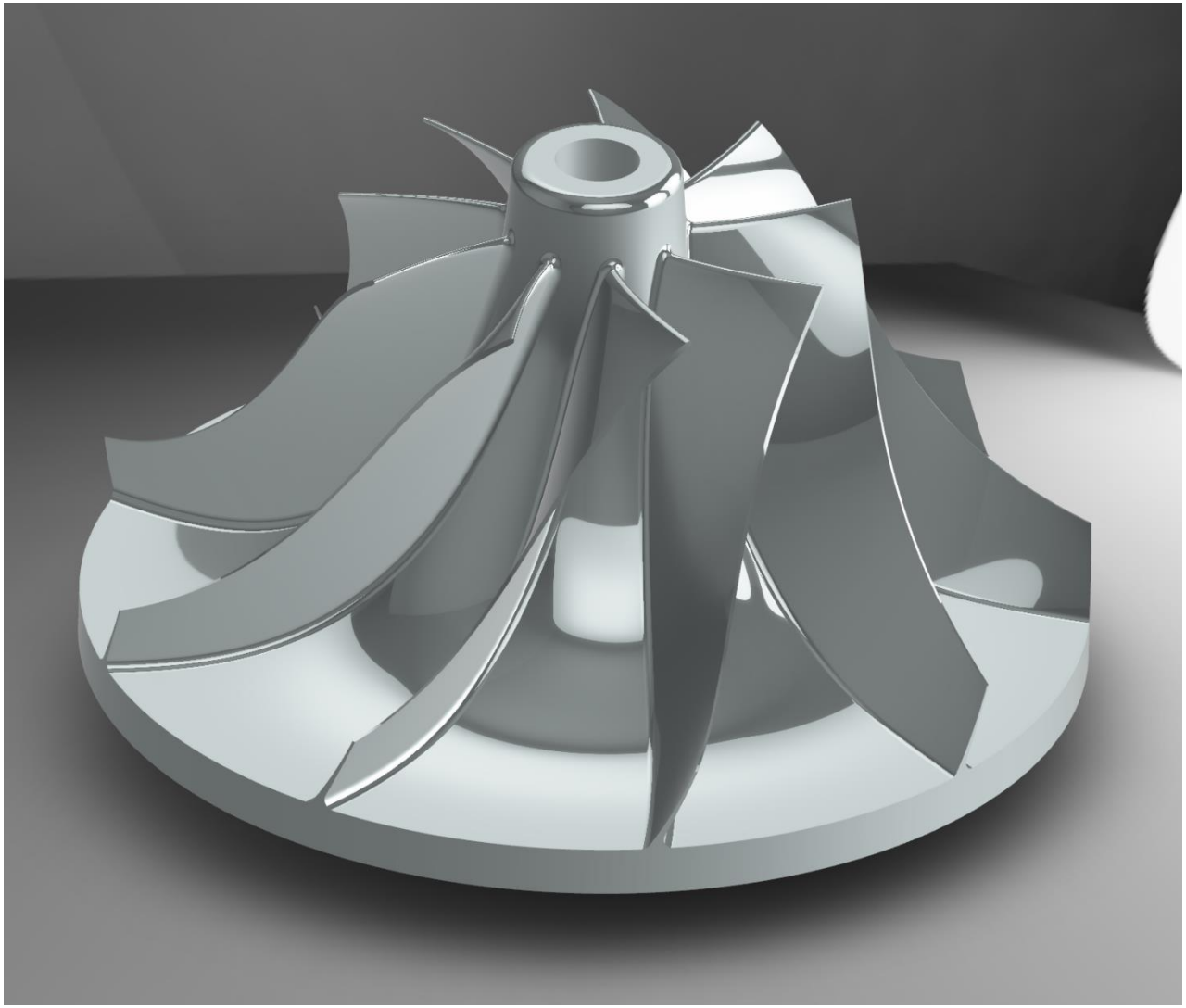
Rendering engine 4.x

FRIENDSHIP SYSTEMS © 2017

Rendering engine 5.0



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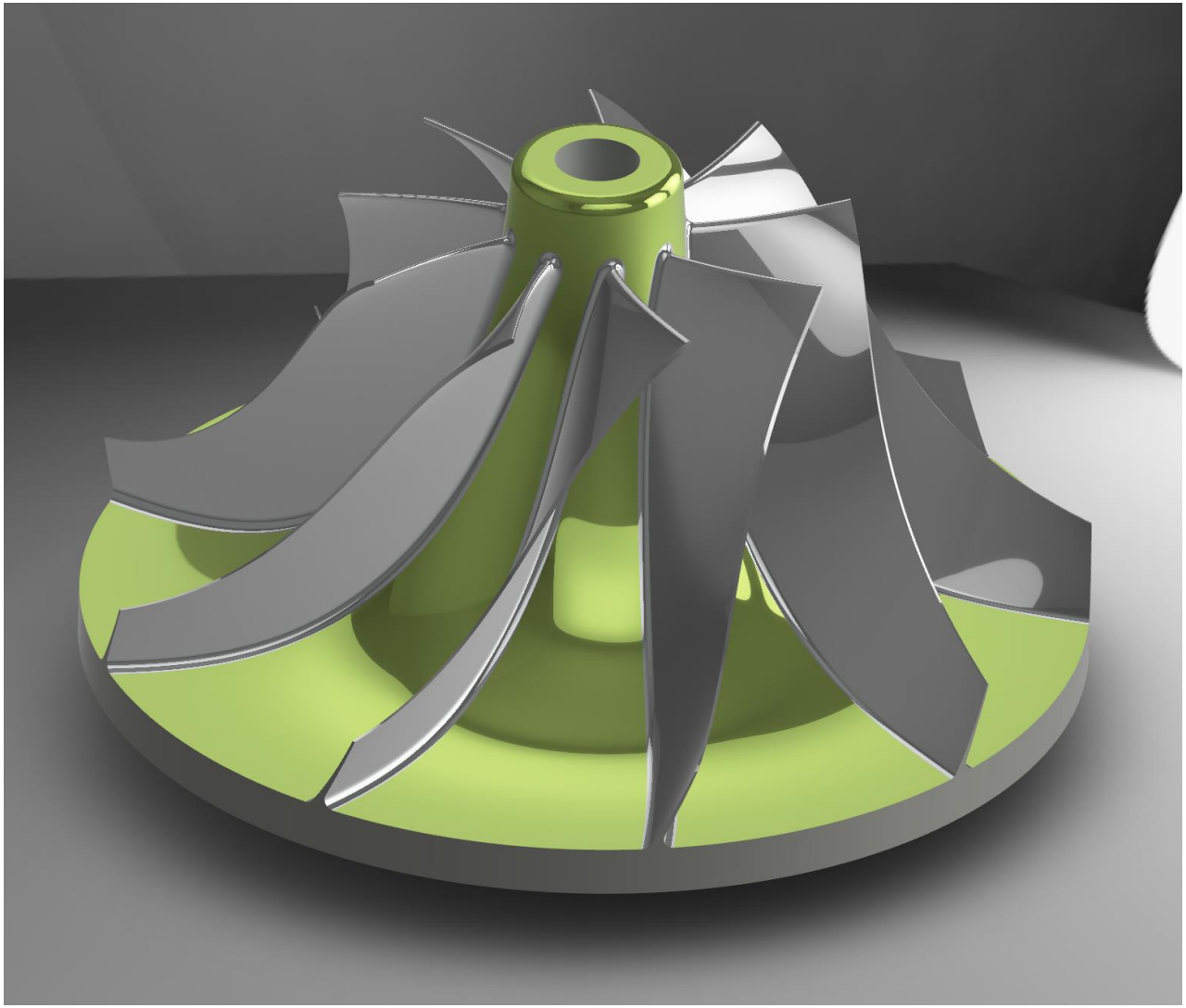
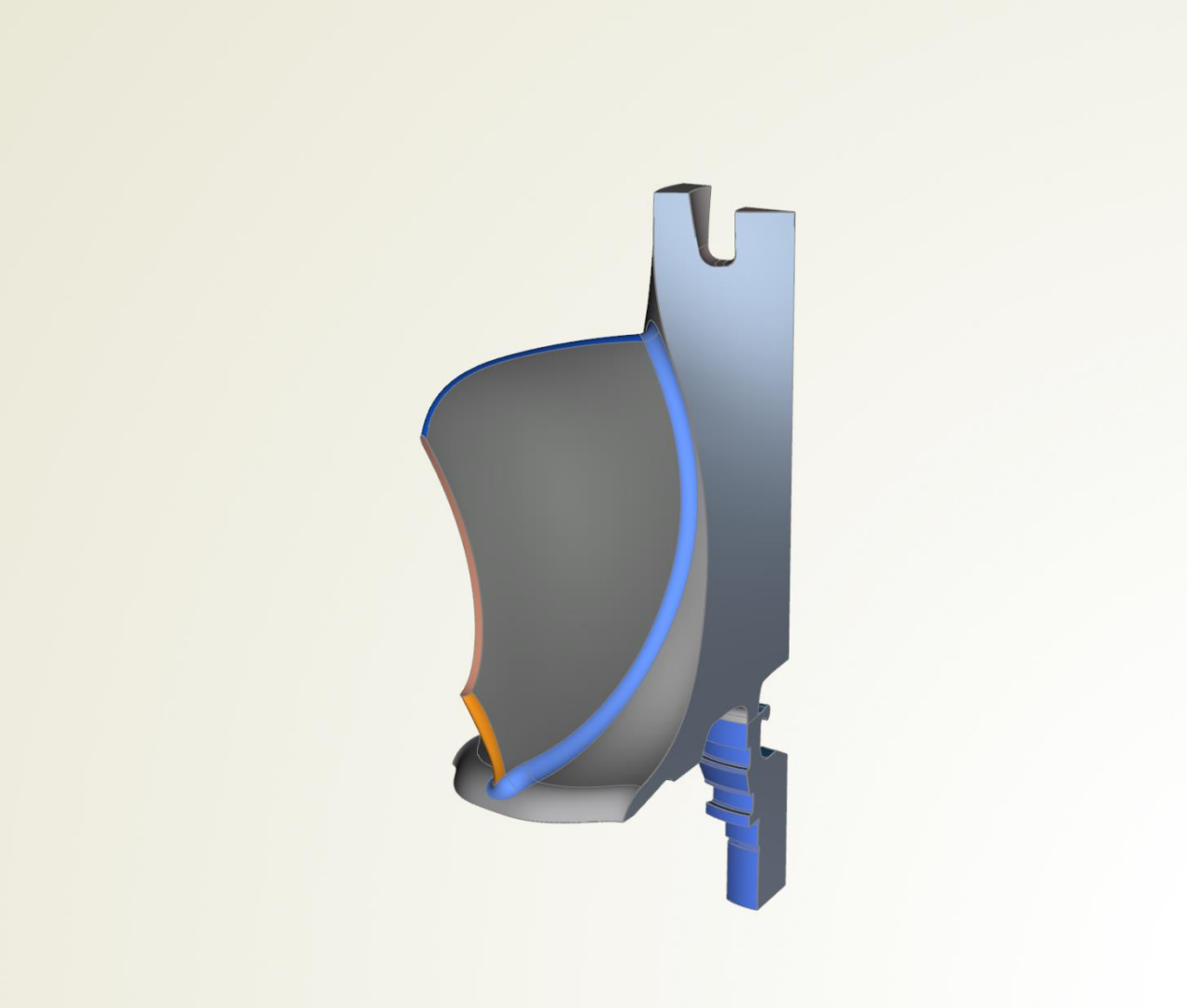
Rendering engine 5.0



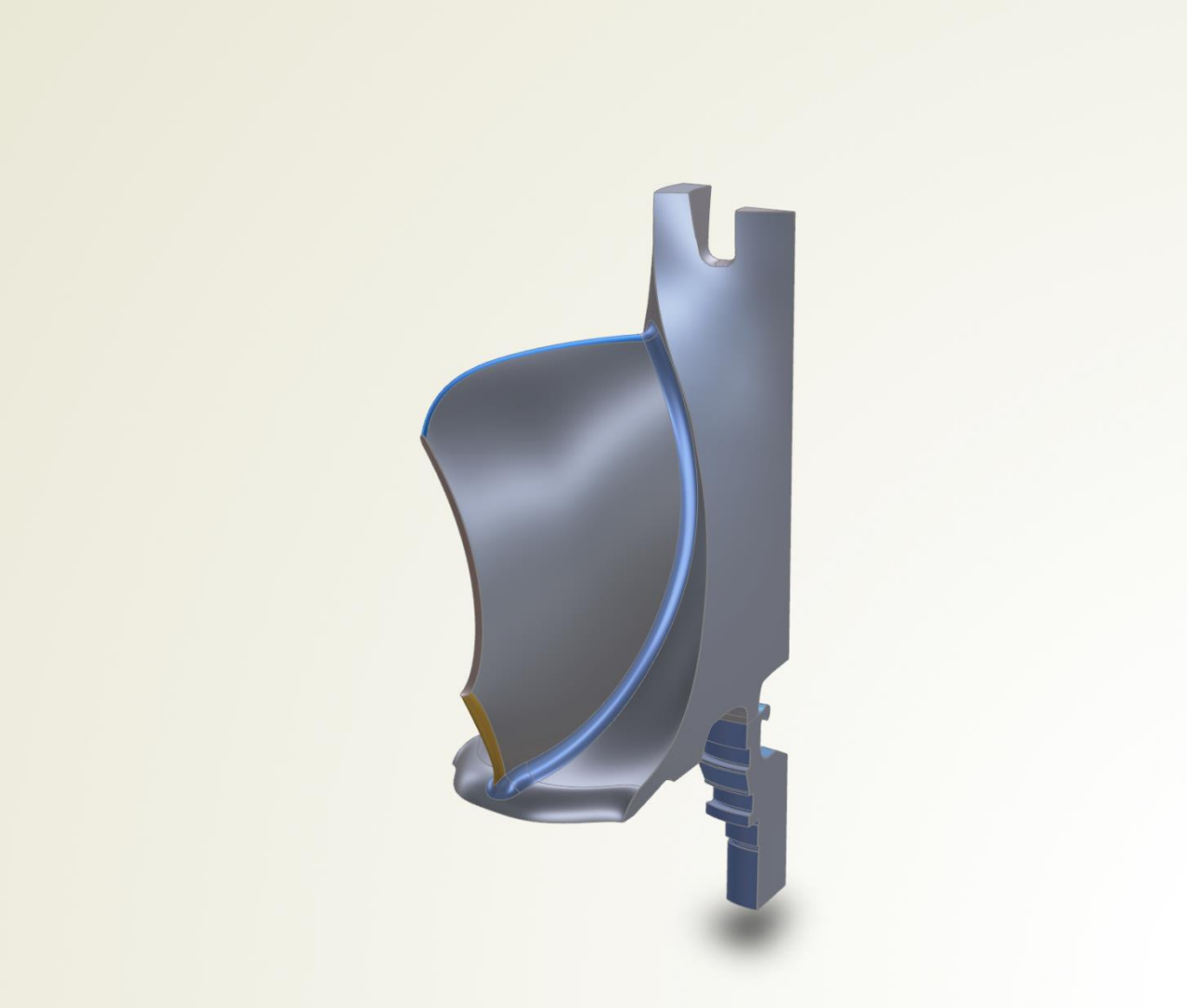
FRIENDSHIP SYSTEMS © 2017

Rendering engine 4.x



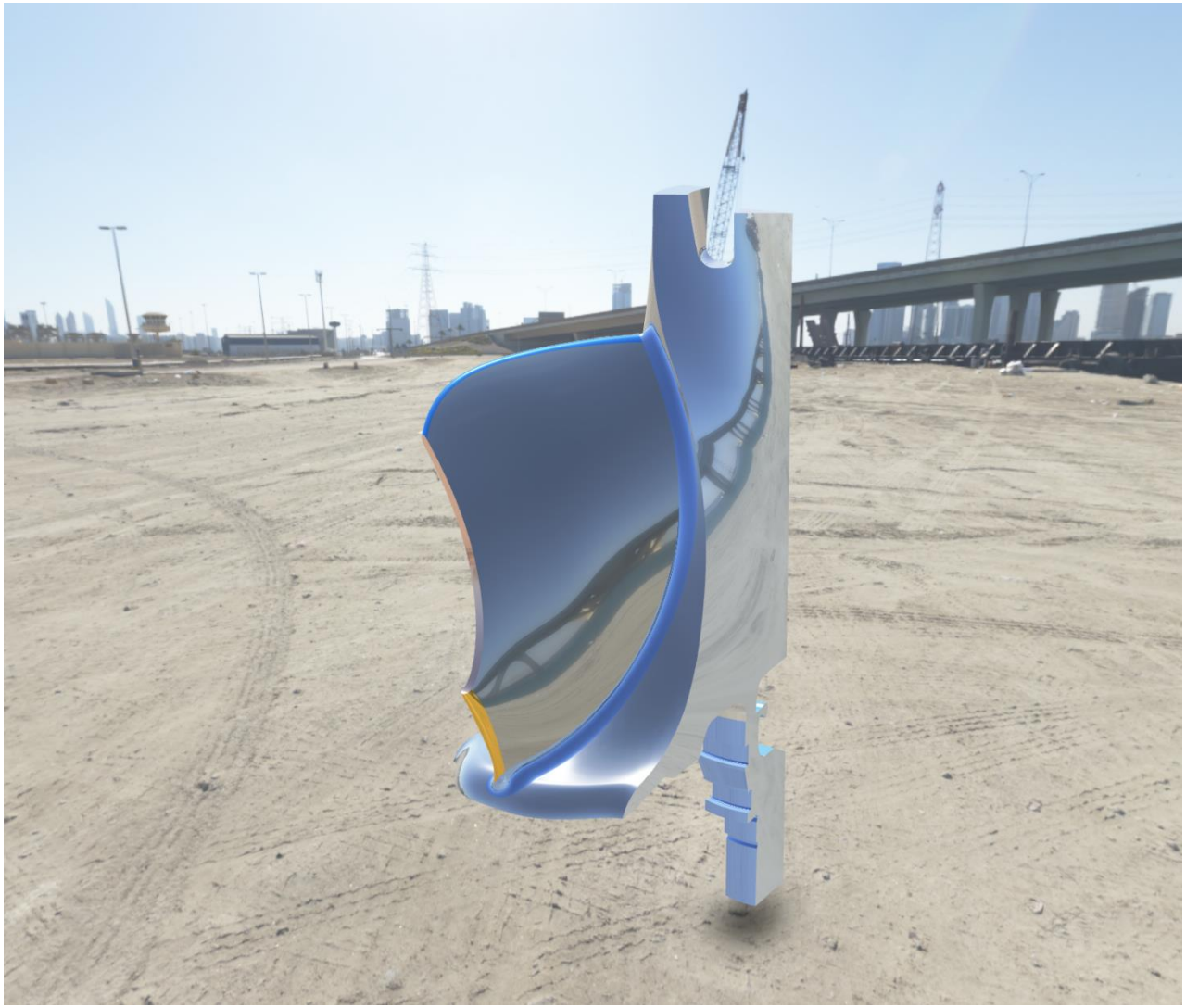
FRIENDSHIP SYSTEMS © 2017

Rendering engine 5.0



FRIENDSHIP SYSTEMS © 2017

Rendering engine 5.0



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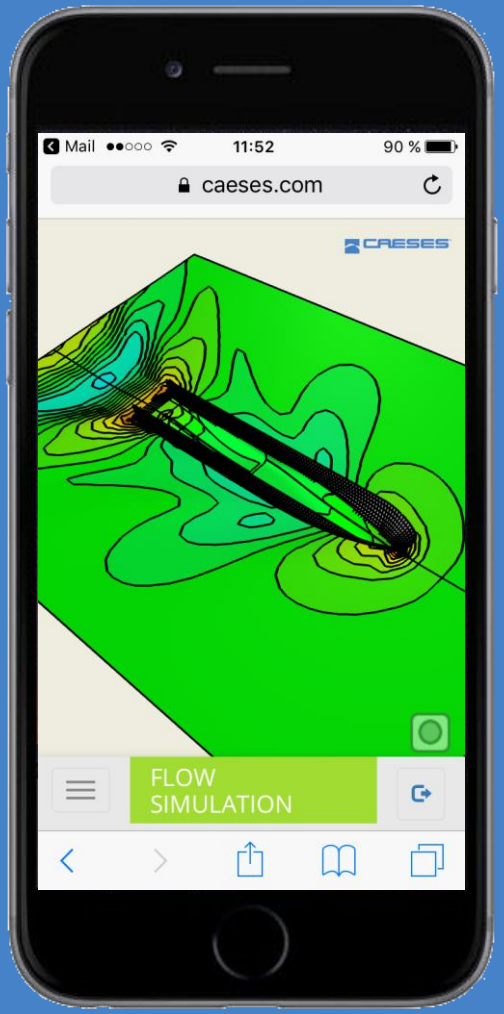
Appification and WebApps



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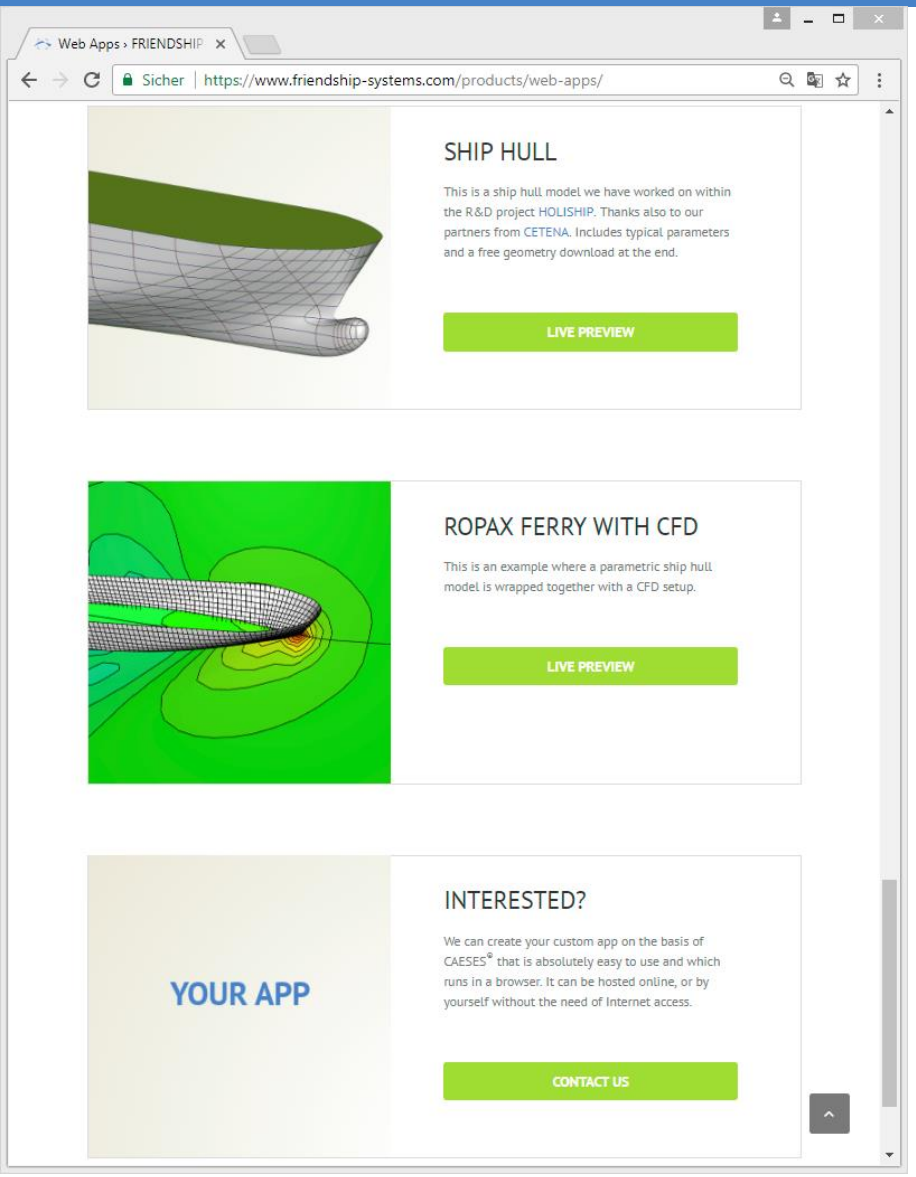
Appification



Website

https://www.friendship-systems.com/products/web-apps

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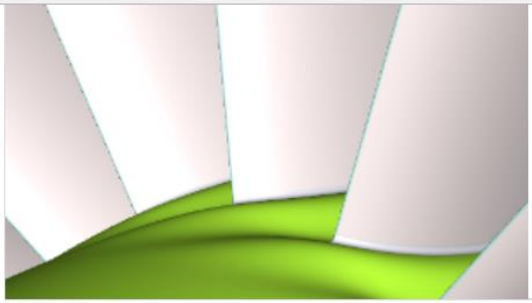
Example WebApp

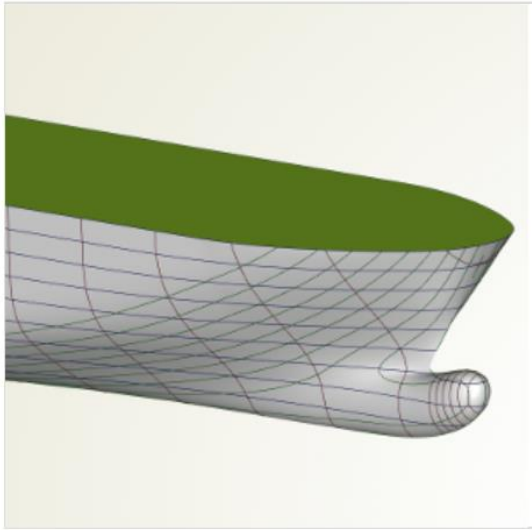
Showroom › CAESES

Sicher | https://www.caeses.com/products/caeses/showroom/



download the final geometry.

LIVE PREVIEW



SHIP HULL

This is a ship hull model we have worked on within the R&D project HOLISHIP. Thanks also to our partners from CETENA. Includes typical parameters and a free geometry download at the end.

LIVE PREVIEW

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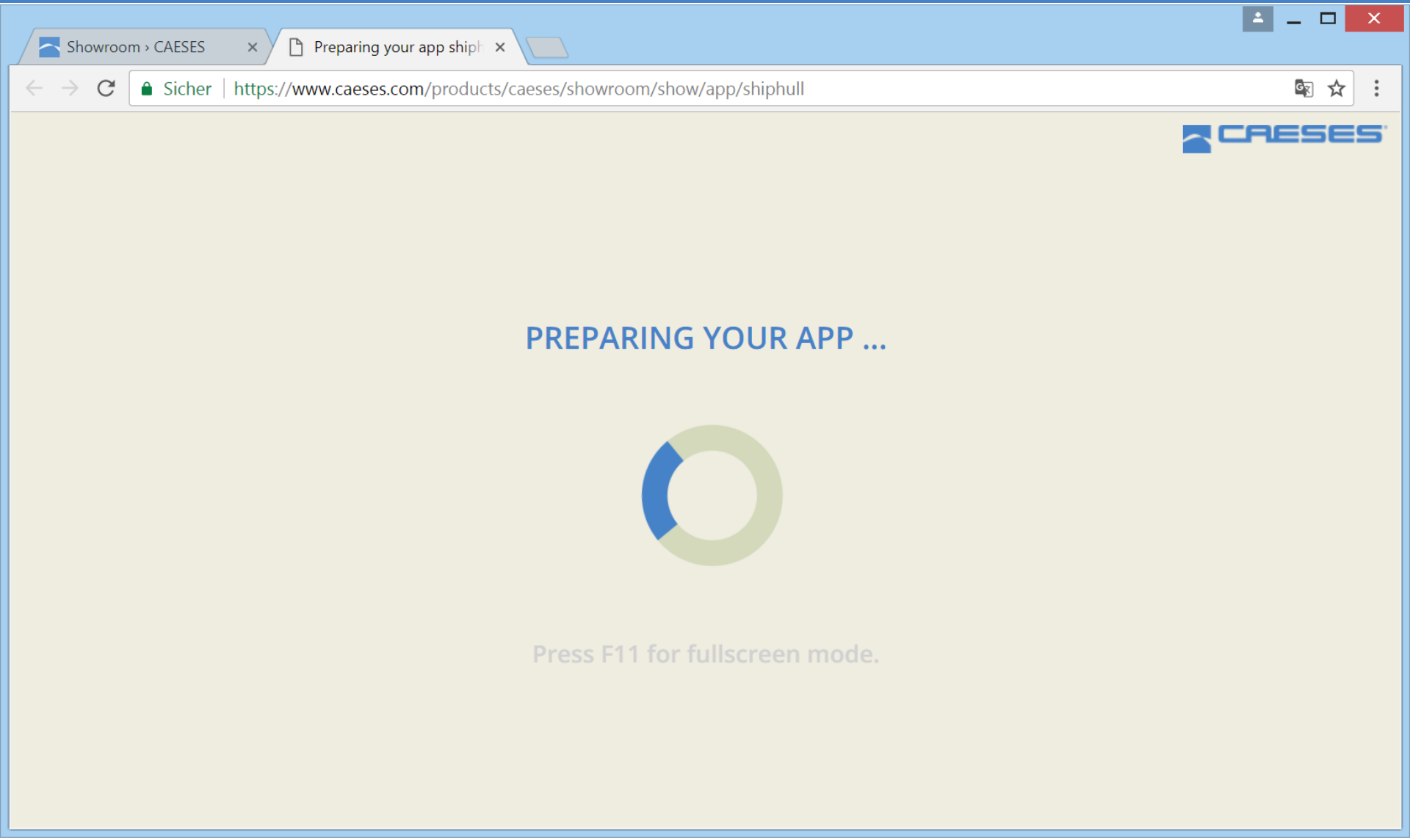
Example WebApp



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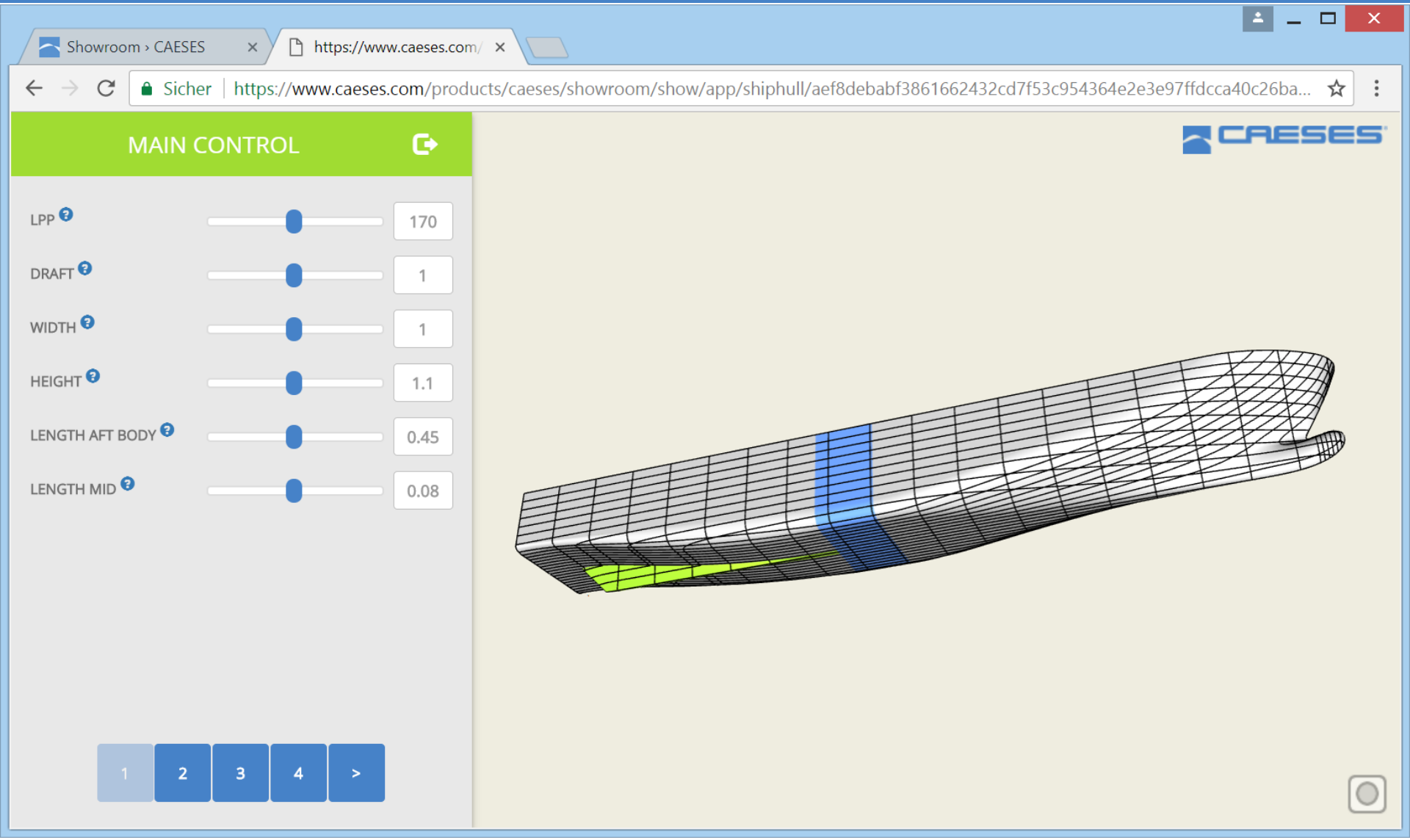
Example WebApp



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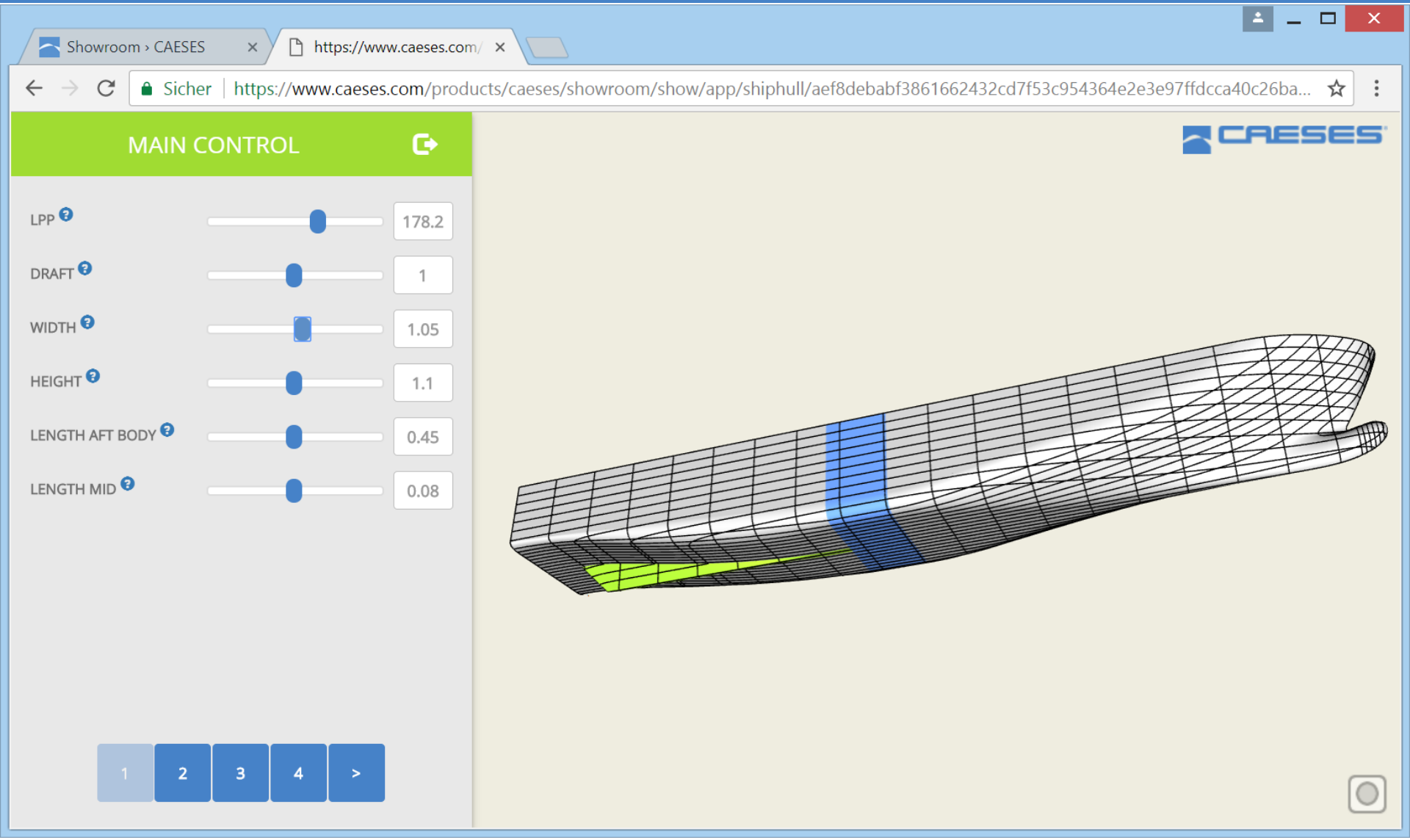
Example WebApp



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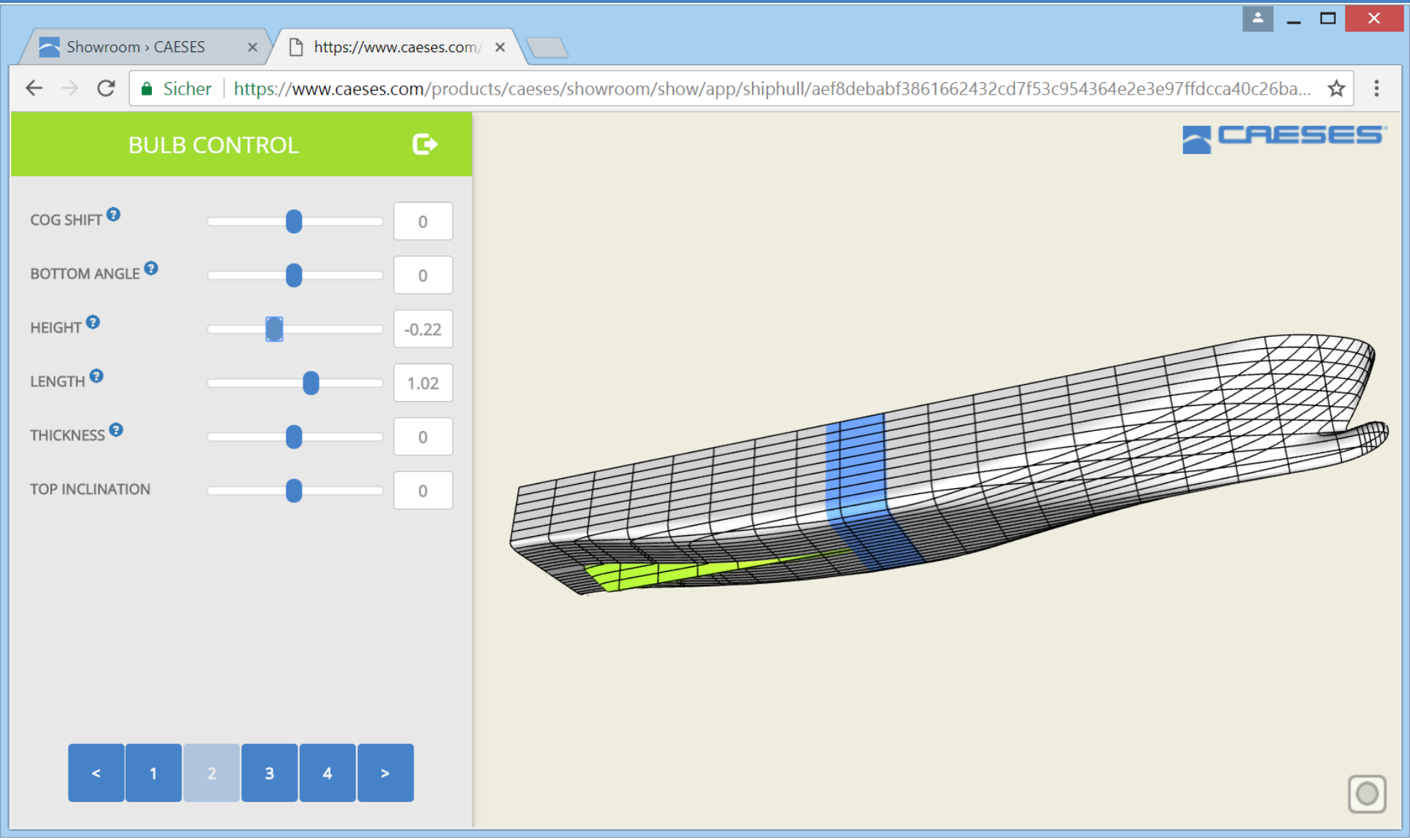
Example WebApp



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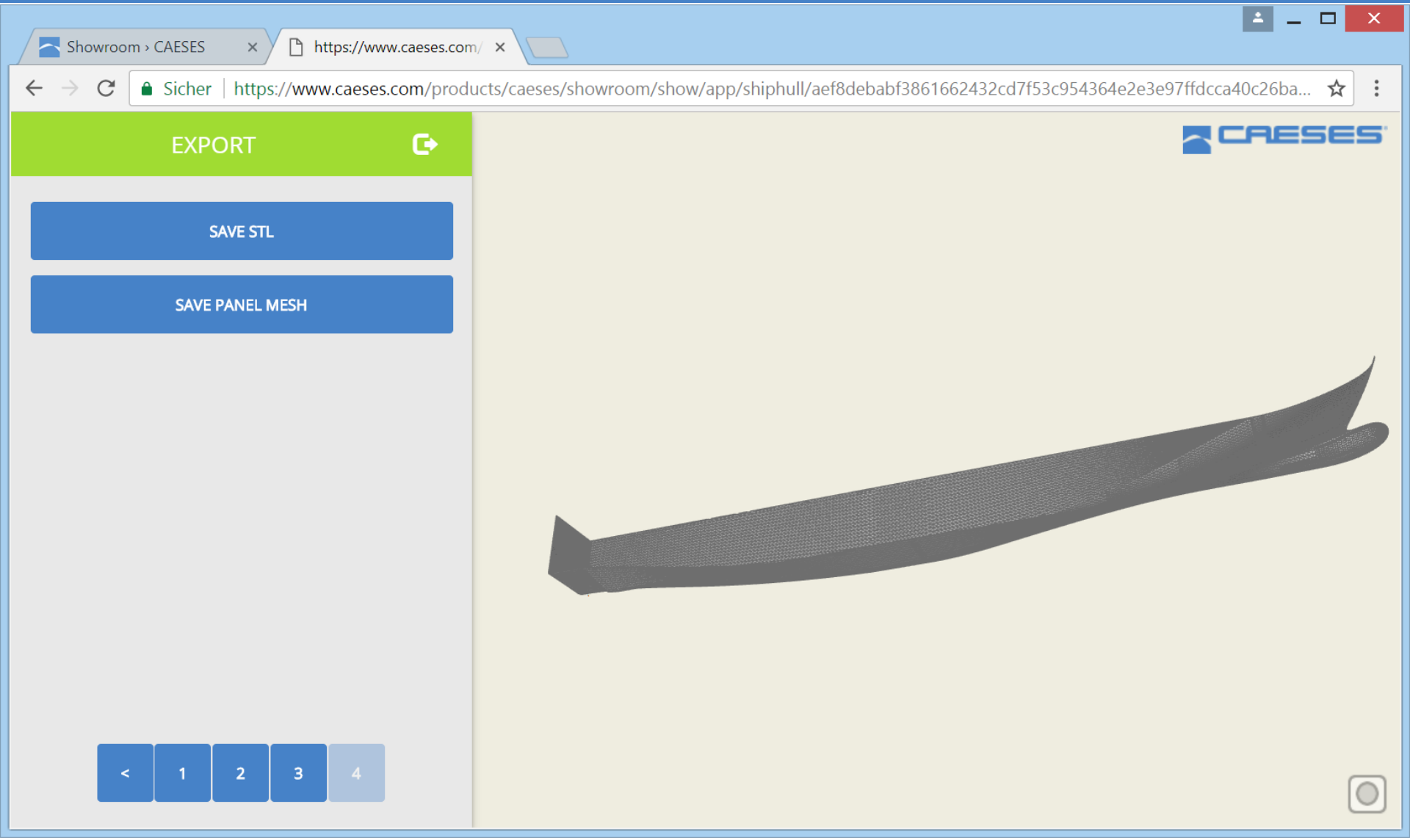
Example WebApp



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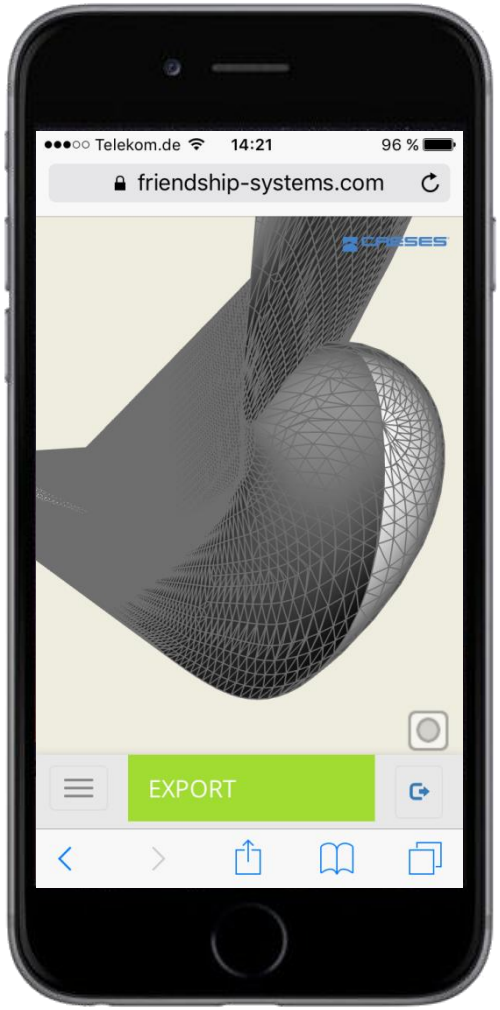
Example WebApp



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Sneak preview: Interactive shape variation

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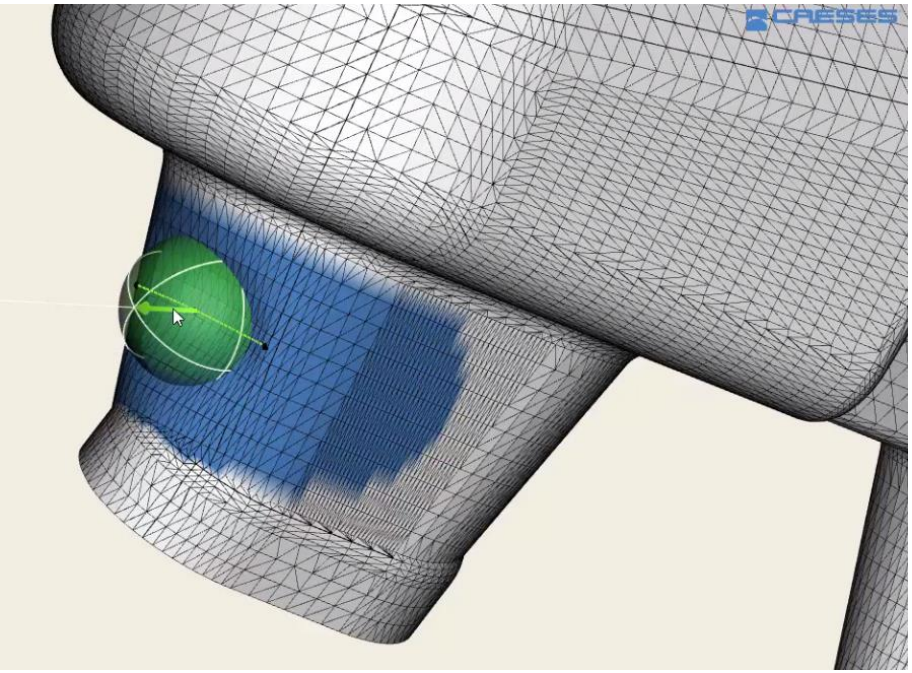
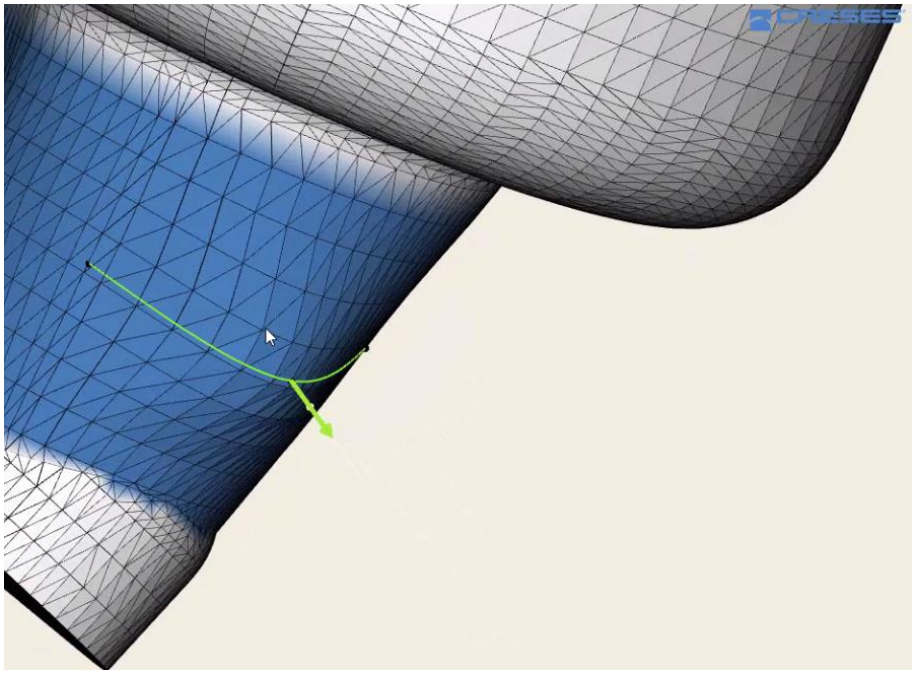
Sneak preview: Interactive shape variation





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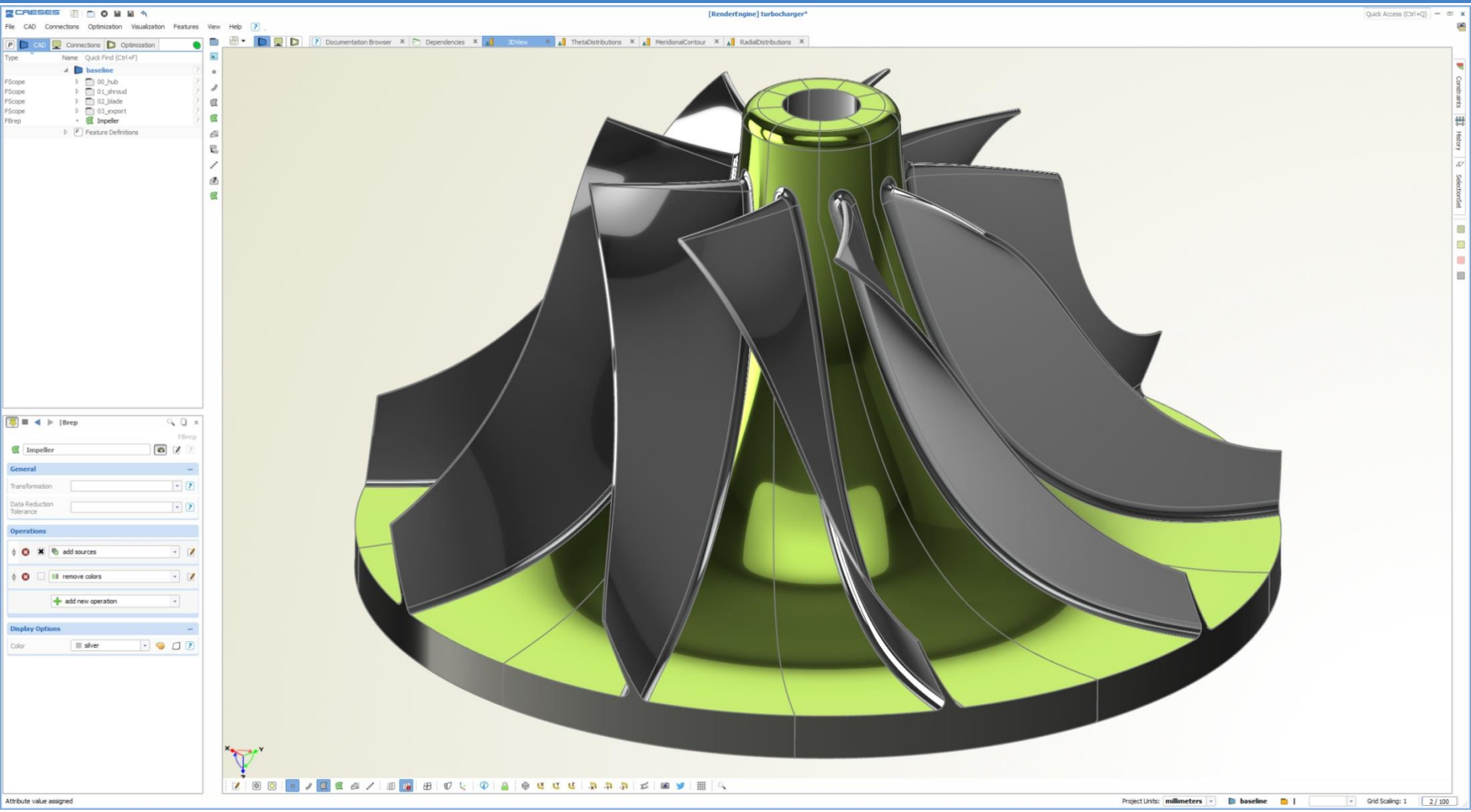
Thank you very much



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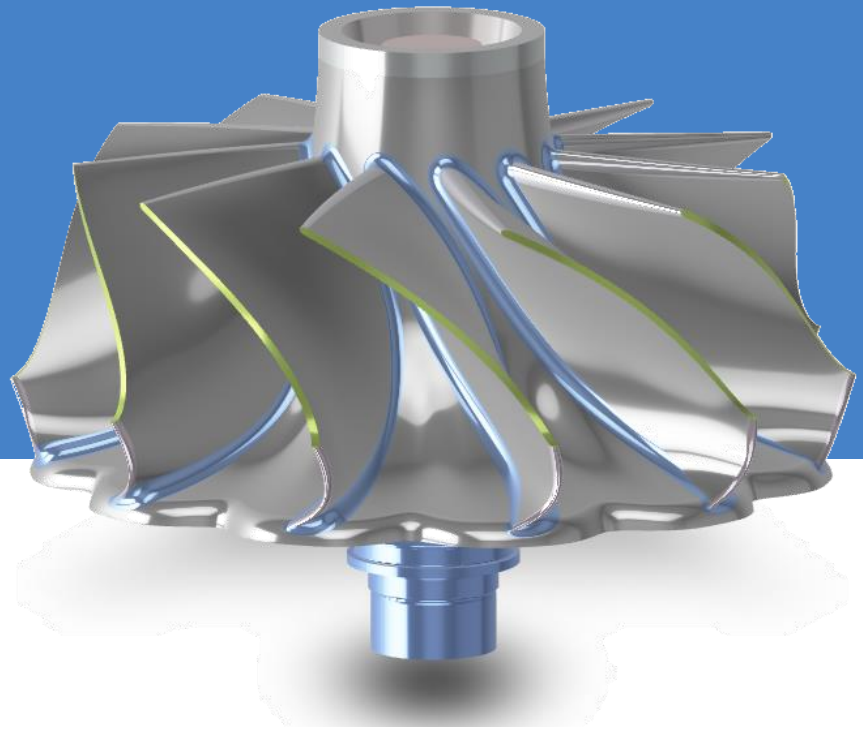

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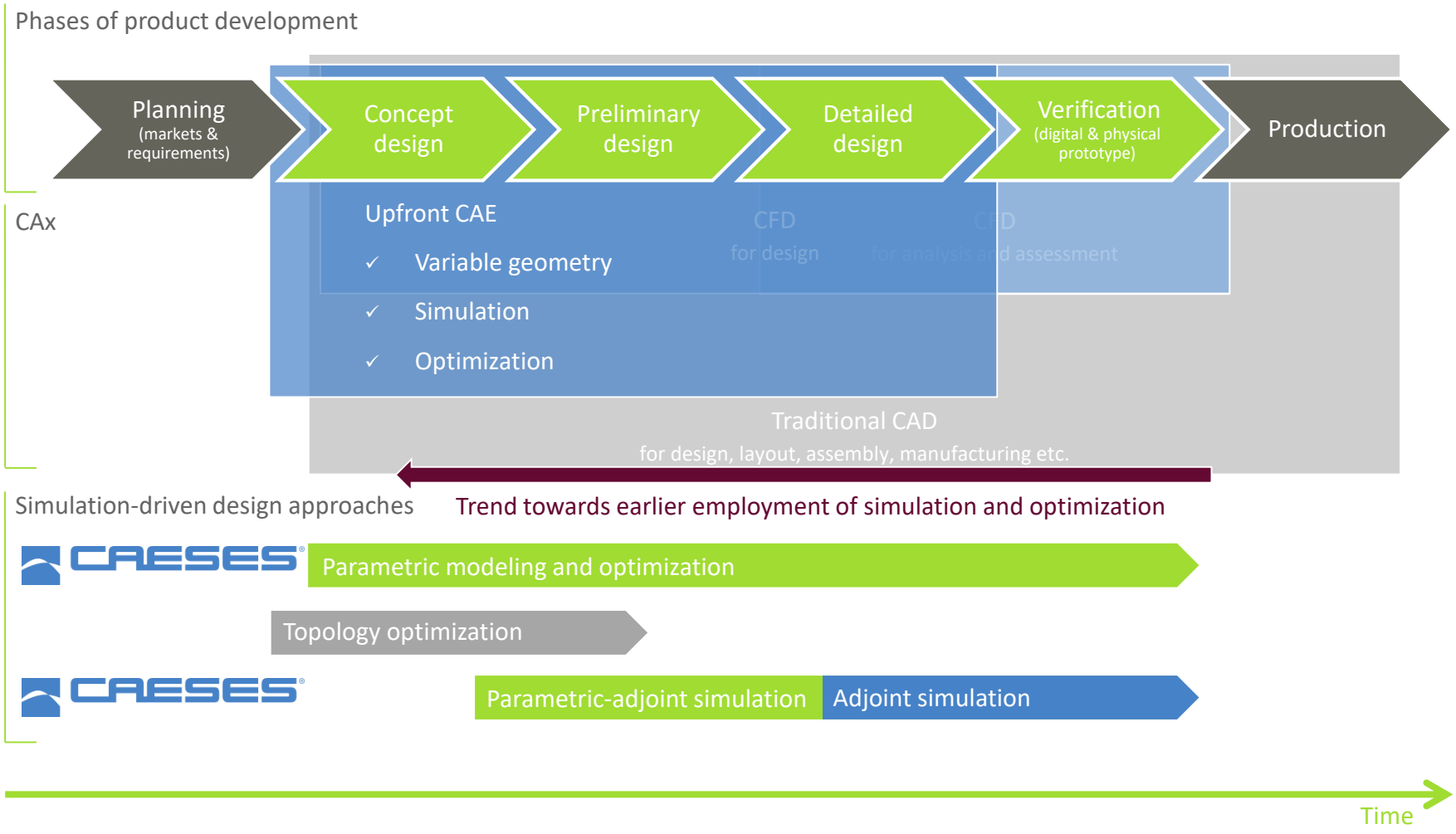
Simulation-driven design with CAESES



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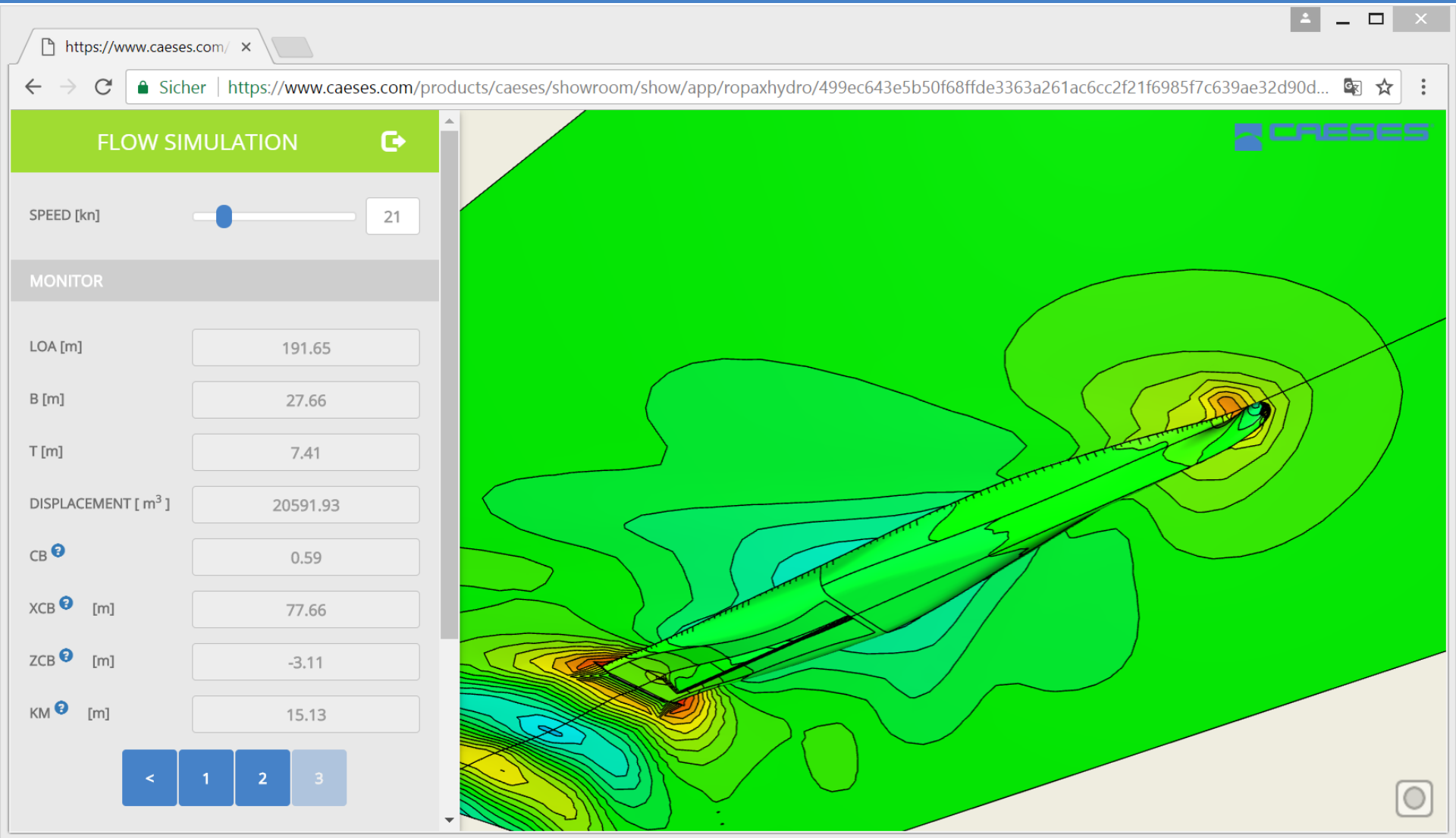
Example webApp



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Example webApp

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Encapsulate functionality and make them accessible

about the Wageningen B-Series propeller.

THIS IS HOW IT WORKS

- Enter your information about the ship vessel and the propulsion system
- We do the calculation for you to find the right dimensions and propeller shape
- Check the visualization of the propeller
- Download a demo STL of the propeller for a check on your computer
- Download the final STEP/STL file of the propeller

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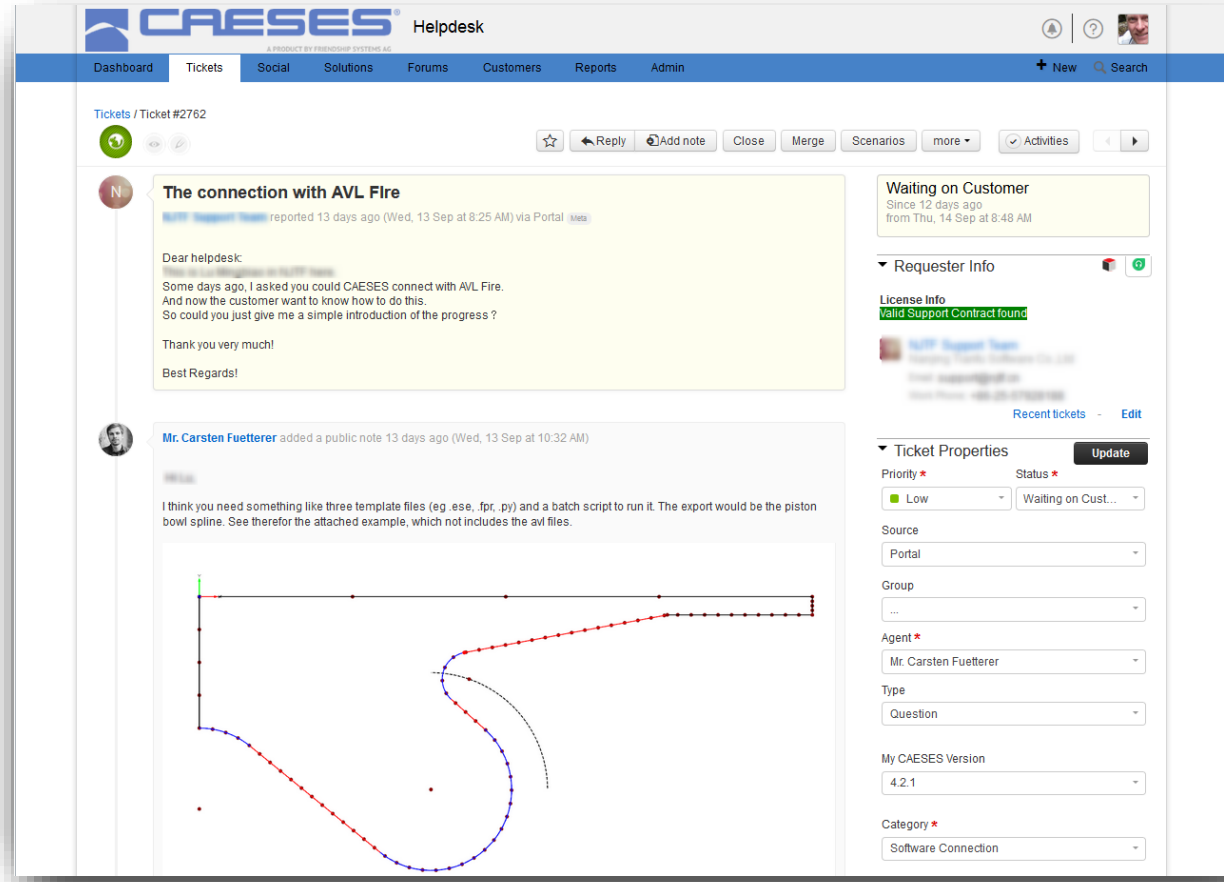
Documentation and support

- YouTube
- Blog
- Forum
- Documentation browser
- Helpdesk



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