Perfect shape – perfect flow

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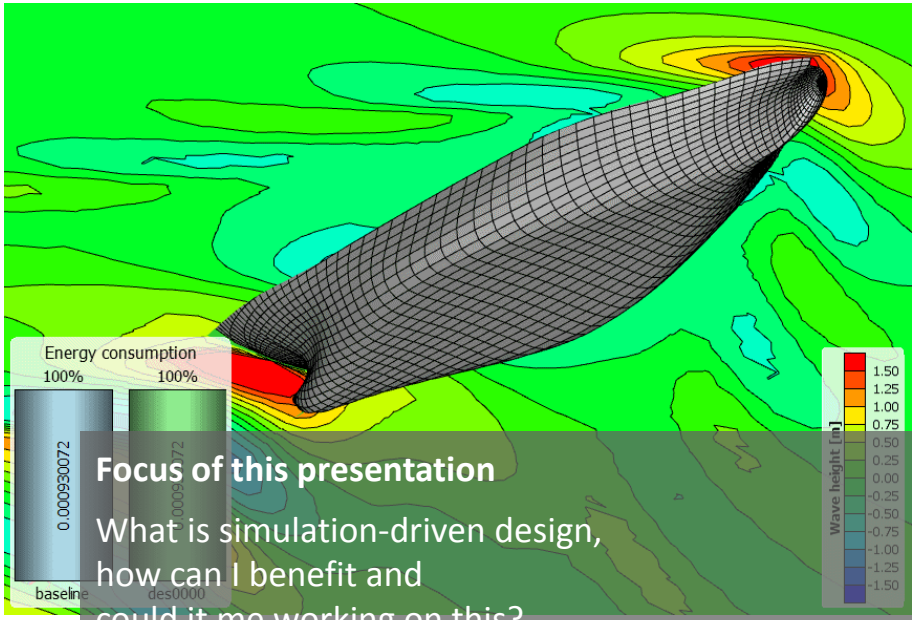
EMship

La Spezia, February 14, 2018

FRIENDSHIP SYSTEMS

Content

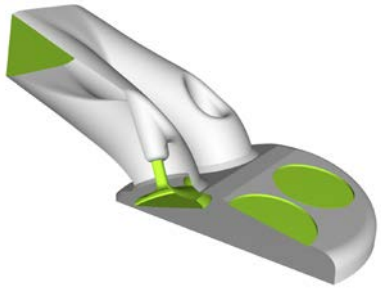
- Simulation-driven design (SDD)
  - Fields of applications
  - CAESES®
  - State-of-the-art applications
- Thesis proposition for EMship student



Focus of this presentation

What is simulation-driven design,
how can I benefit and
could it me working on this?

Fields of application



TOYOTA

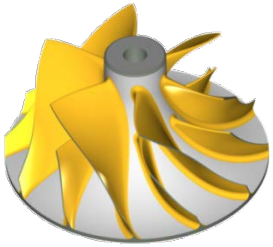
FCA
FIAT CHRYSLER AUTOMOBILES

MAN

BOSCH

MASERATI

mtu



SIEMENS

HITACHI
Inspire the Next

MITSUBISHI HITACHI
POWER SYSTEMS

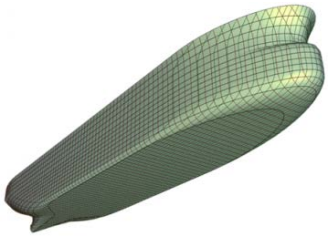
KSB

IHI CHARGING SYSTEMS INTERNATIONAL

Rolls-Royce

VOITH

EBARA



Sumitomo

SAMSUNG

DSME DAEWOO SHIPBUILDING & MARINE ENGINEERING CO.,LTD.

Artemis Racing

Kawasaki

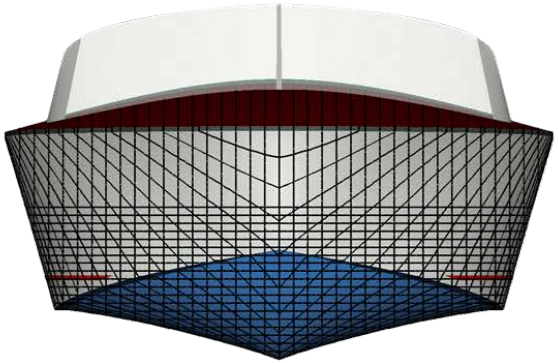
HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

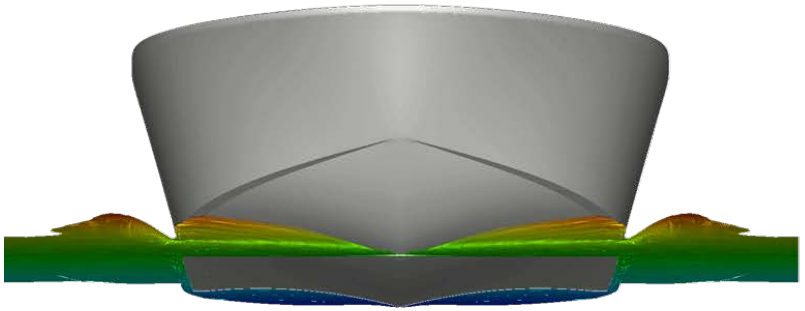
TRANSPORTATION

TURBOMACHINERY

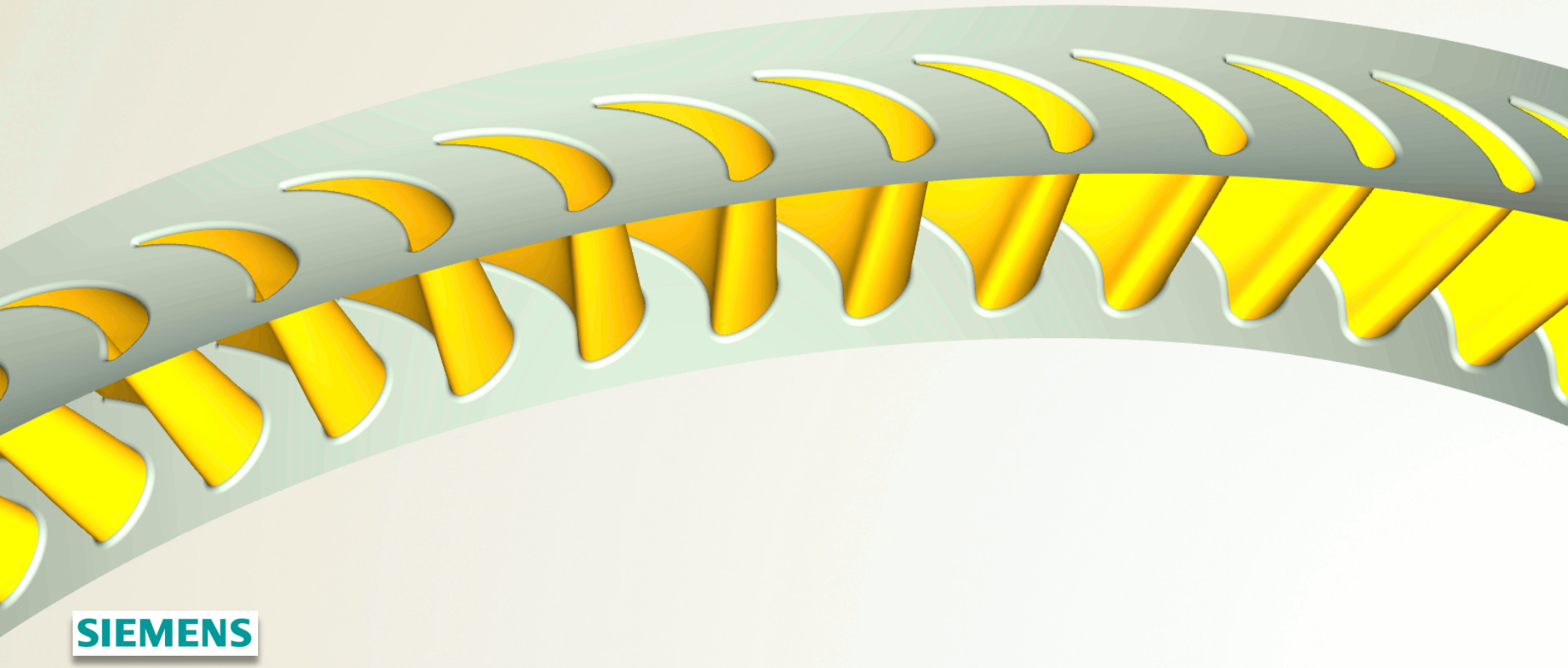
SHIPBUILDING

SDD in naval architecture



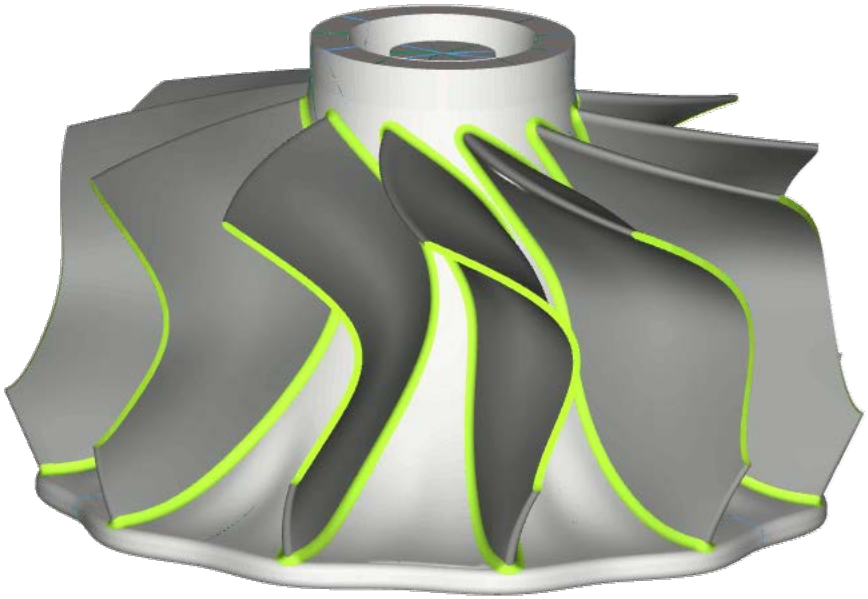


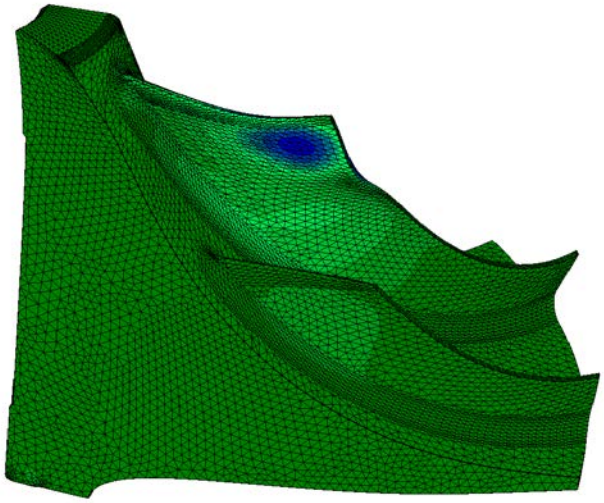
SDD in turbomachinery



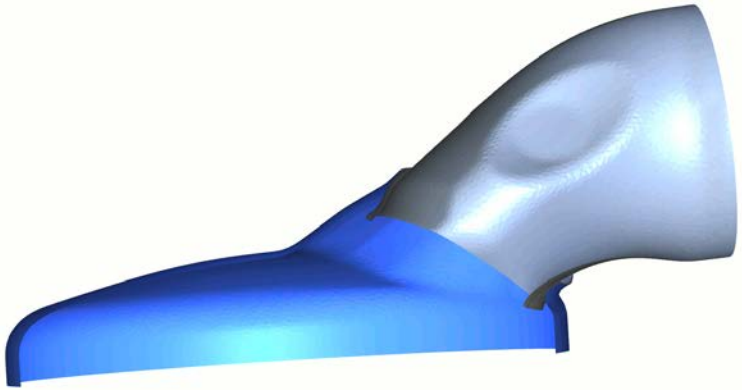
SIEMENS

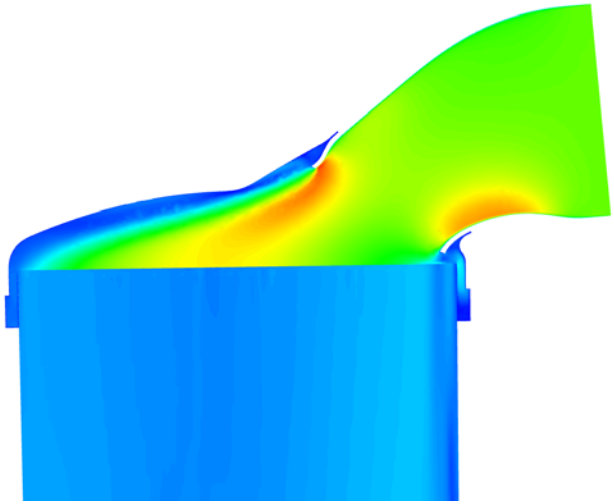
SDD in turbomachinery

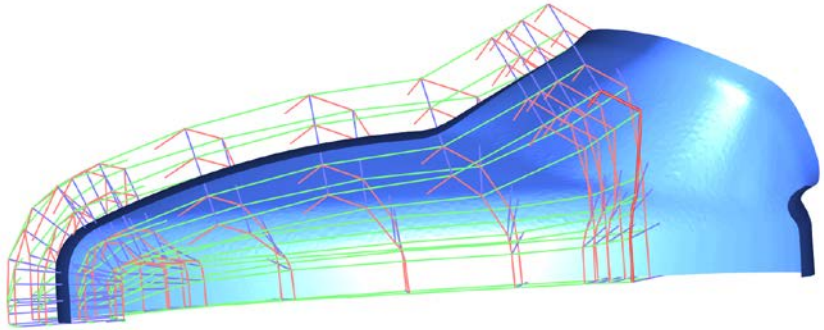


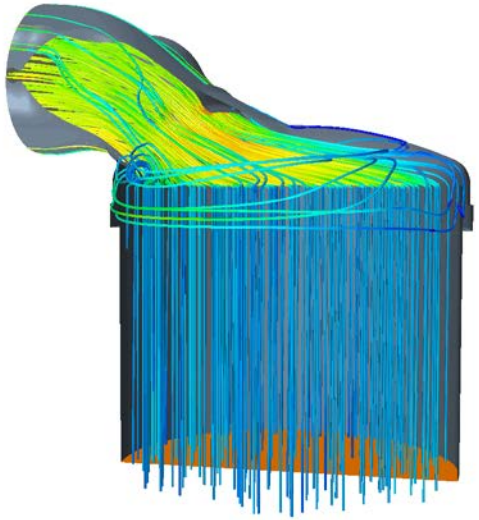


SDD in the automotive industry

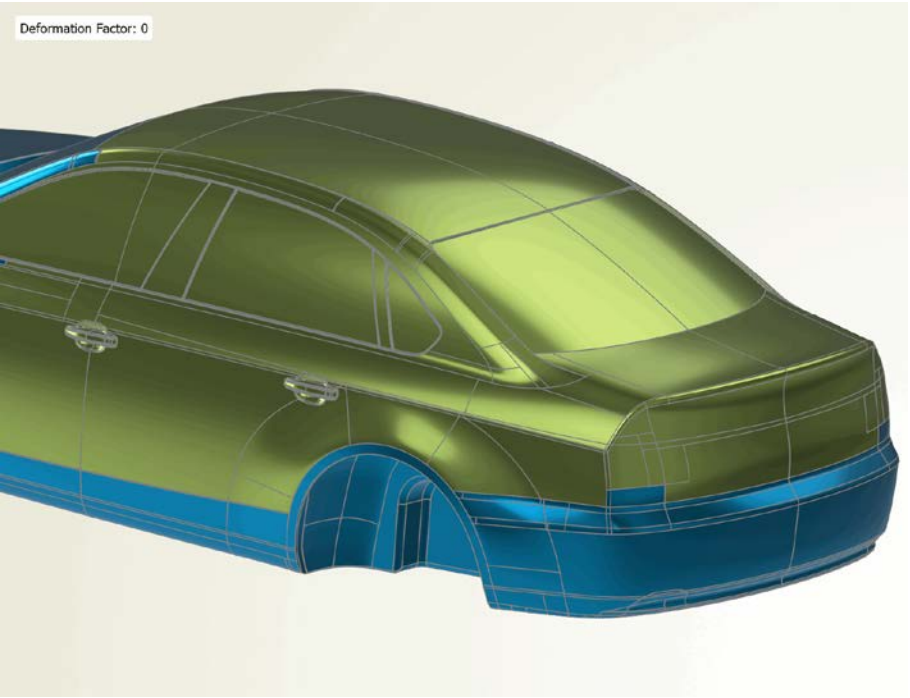


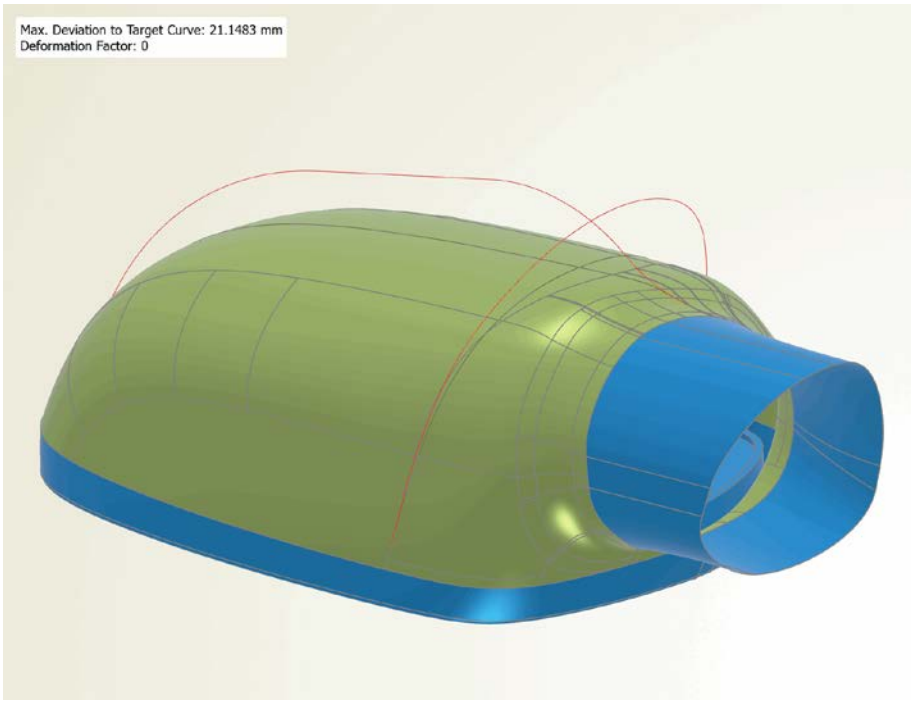




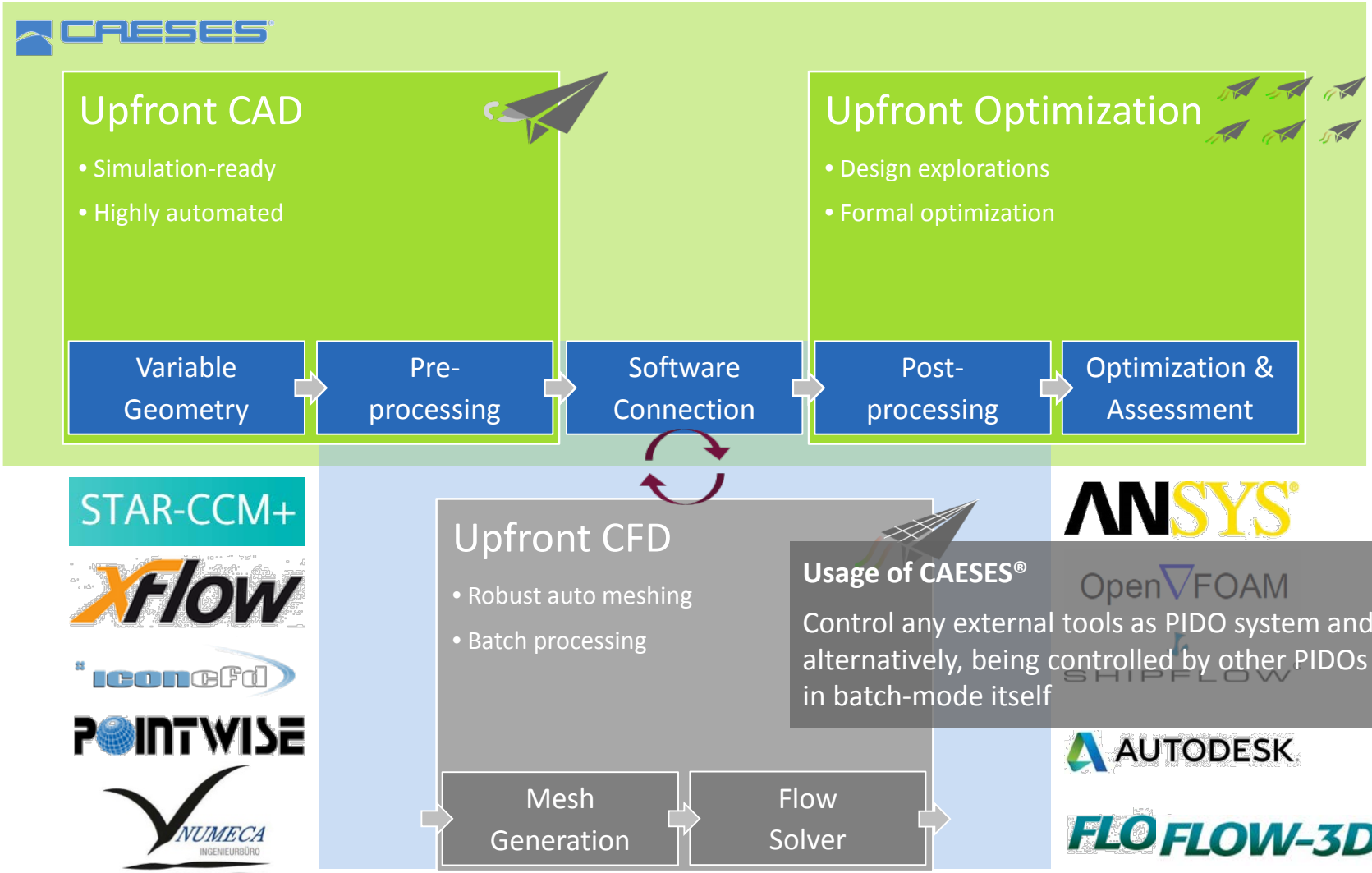


SDD in the automotive industry





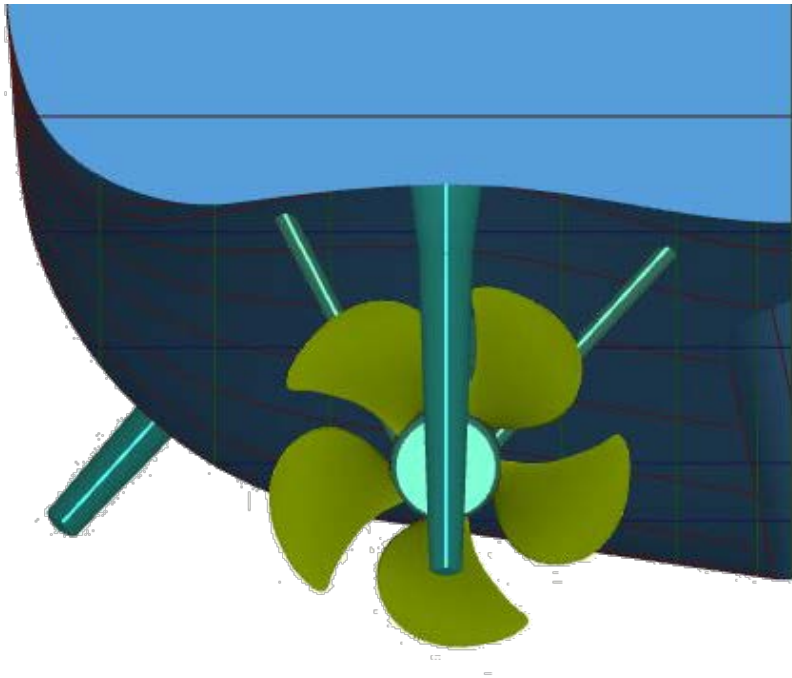
Process Integration and Design Optimization (PIDO)



State-of-the-art: thyssenkrupp Marine Systems

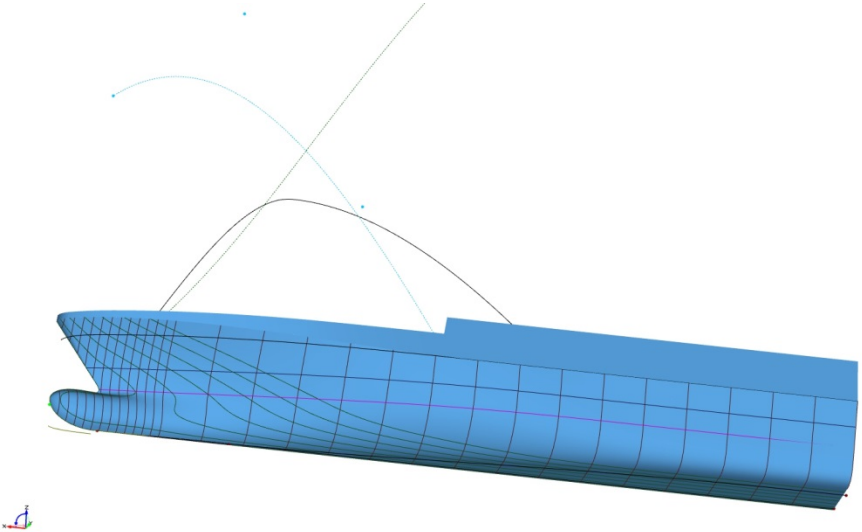
- Virtual prototyping of fully-appended vessels
  - Several parametric models for fore- and aftbody
  - Parametric models for appendages
  - Coupling of CAESES with potential flow code and ANSYS CFX
- Process chain for fast and reliable studies
  - What-ifs
  - Quick checks (e.g. increased displacement)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

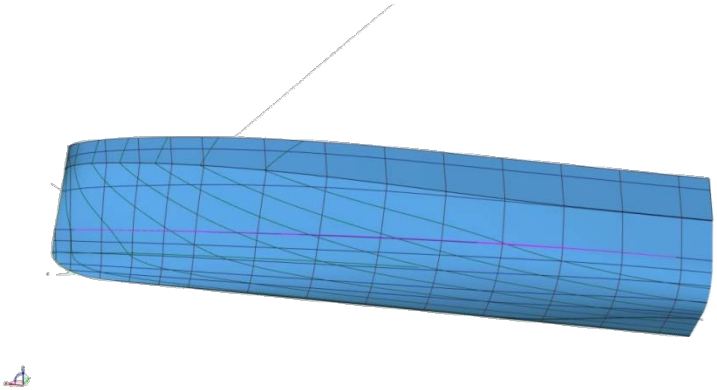
thyssenkrupp



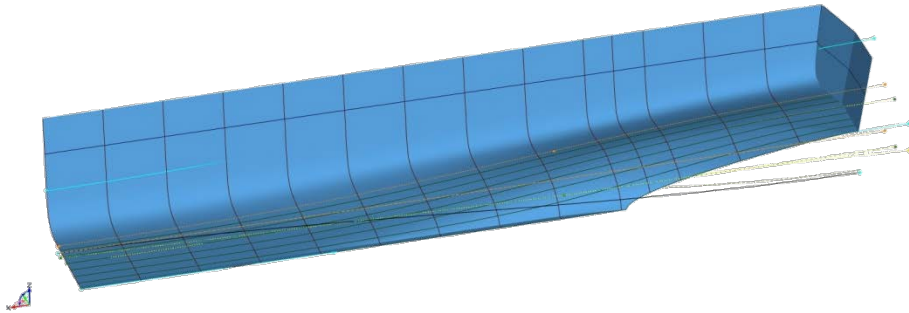
Source: Tanja Richardt, thyssenkrupp Marine Systems, CAESES Users' Meeting 2017

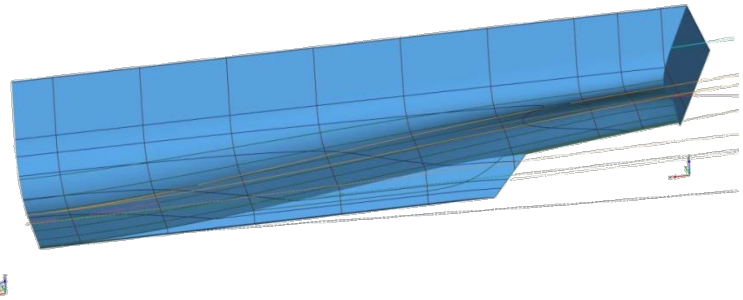
State-of-the-art: Standard models for combination





thyssenkrupp





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

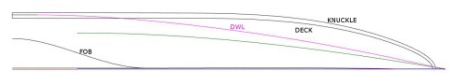
State-of-the-art: thyssenkrupp Marine Systems

1 Parametric modeling

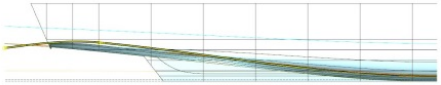
2 Optimization (potential flow)

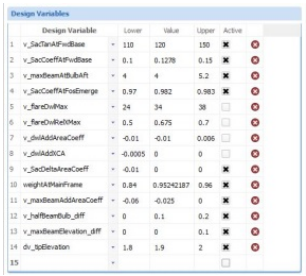
3 RANSE simulations

4 Optimization

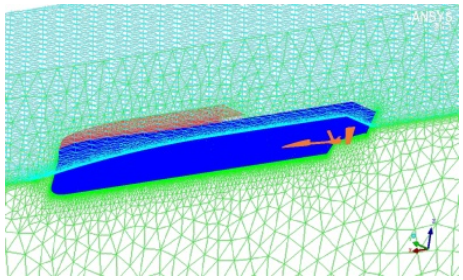


Basic curves

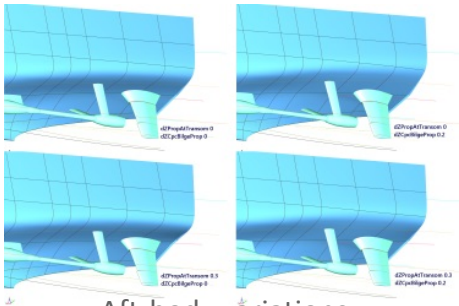




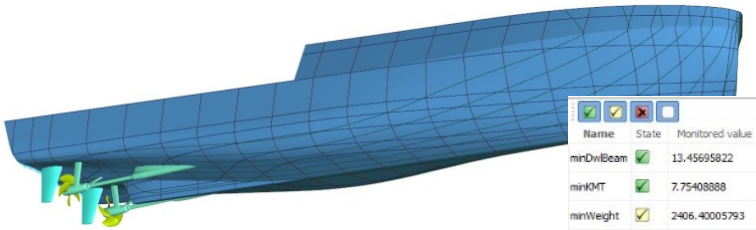
Free variables



Automatic mesh generation



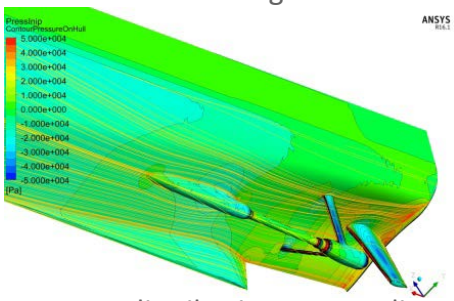
Aft-body variations



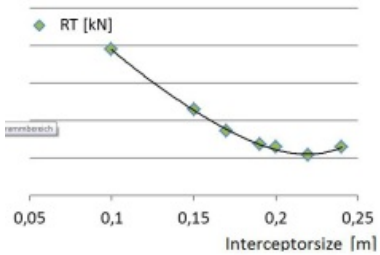
Generated smooth hull form

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

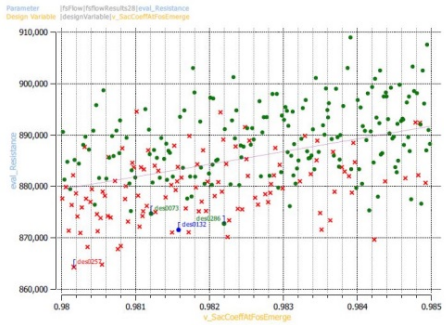
Constraints



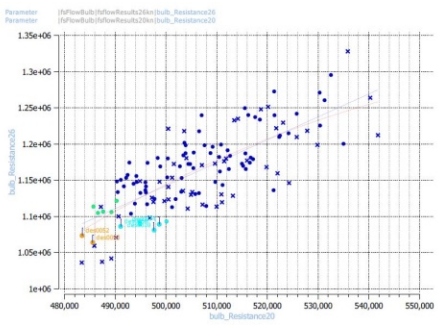
Pressure distribution, streamlines



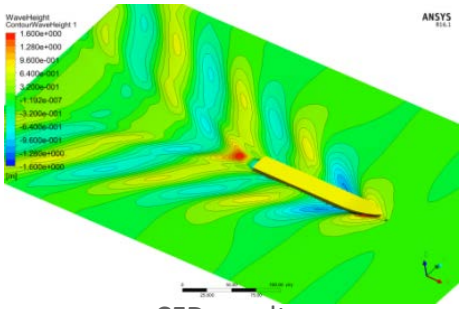
Interceptor optimization



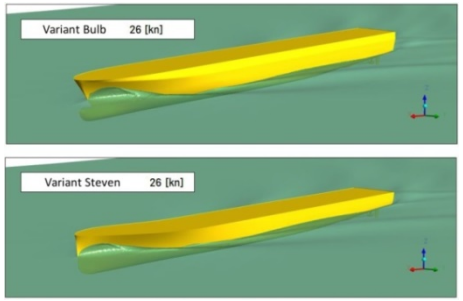
Parameter evaluation



Multi-objective optimization



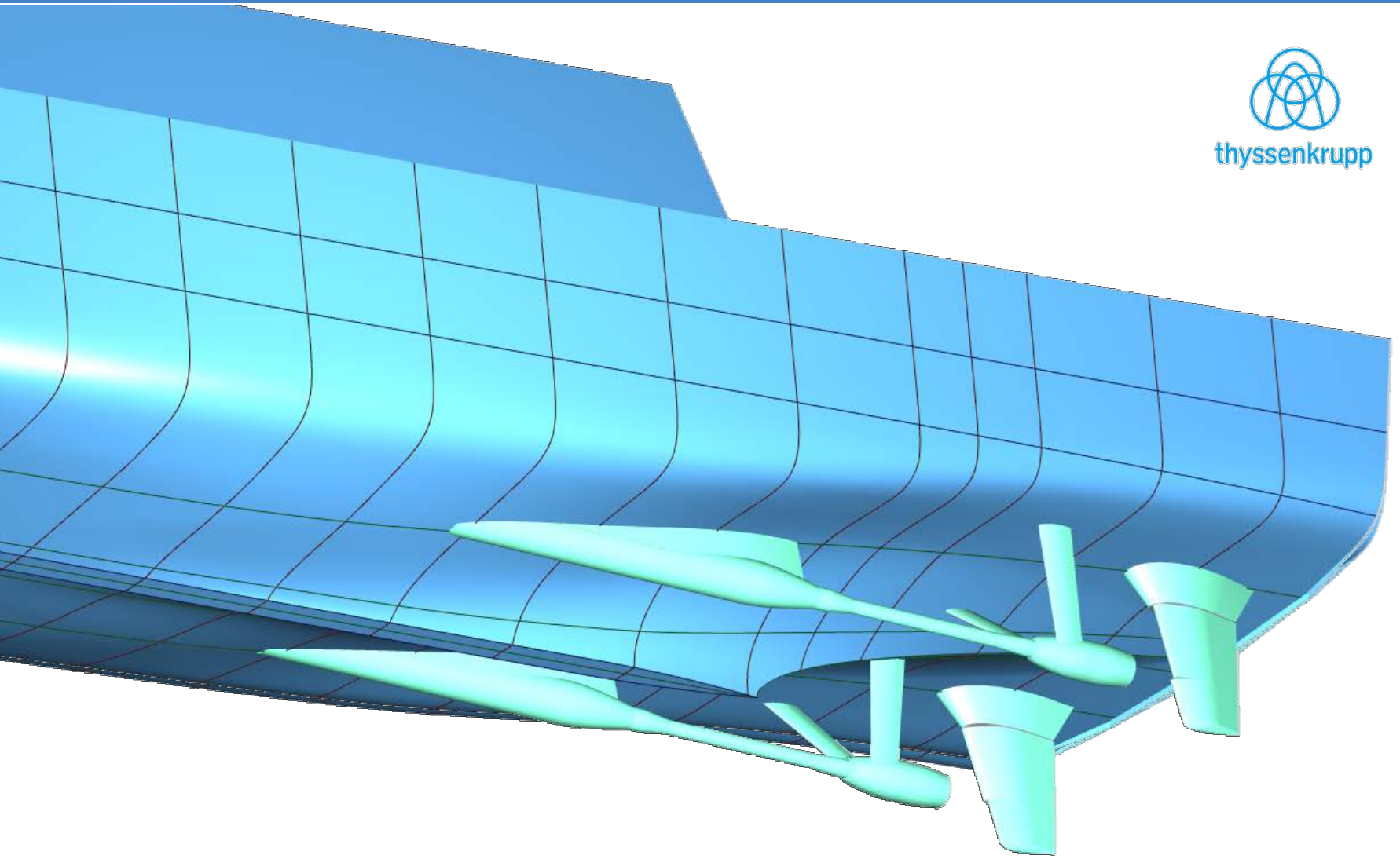
CFD results



Comparison of different bow types

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

State-of-the-art: Interceptor optimization



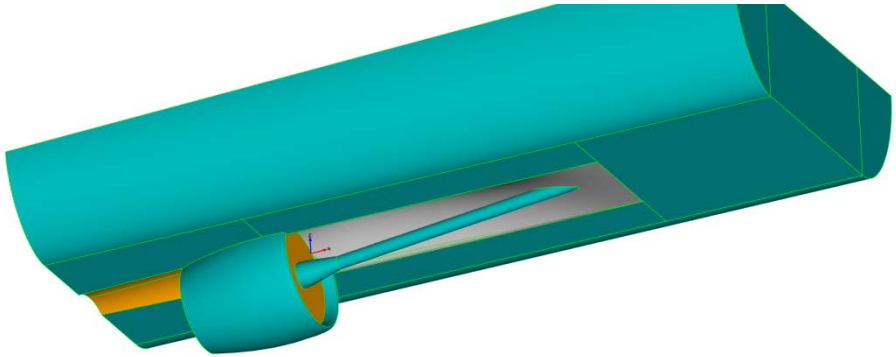
thyssenkrupp

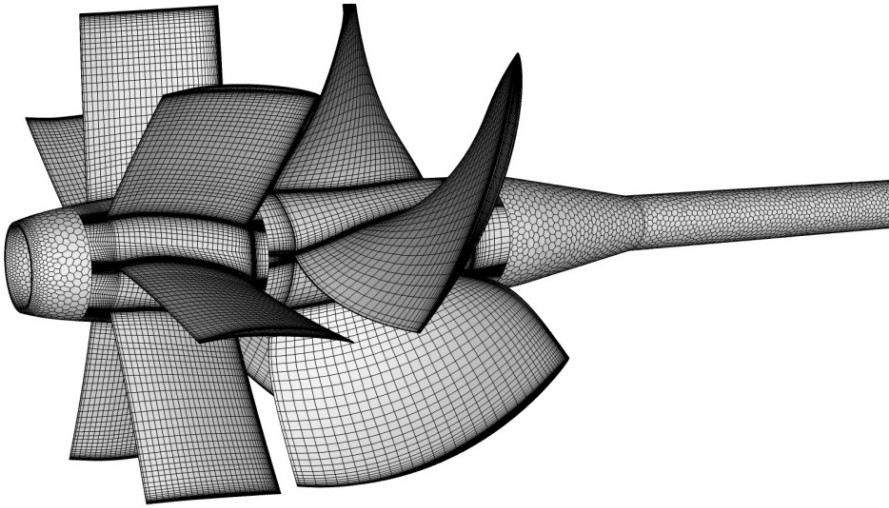
Source: Tanja Richardt, thyssenkrupp Marine Systems, CAESES Users' Meeting 2017

State-of-the-art: Voith

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

VOITH

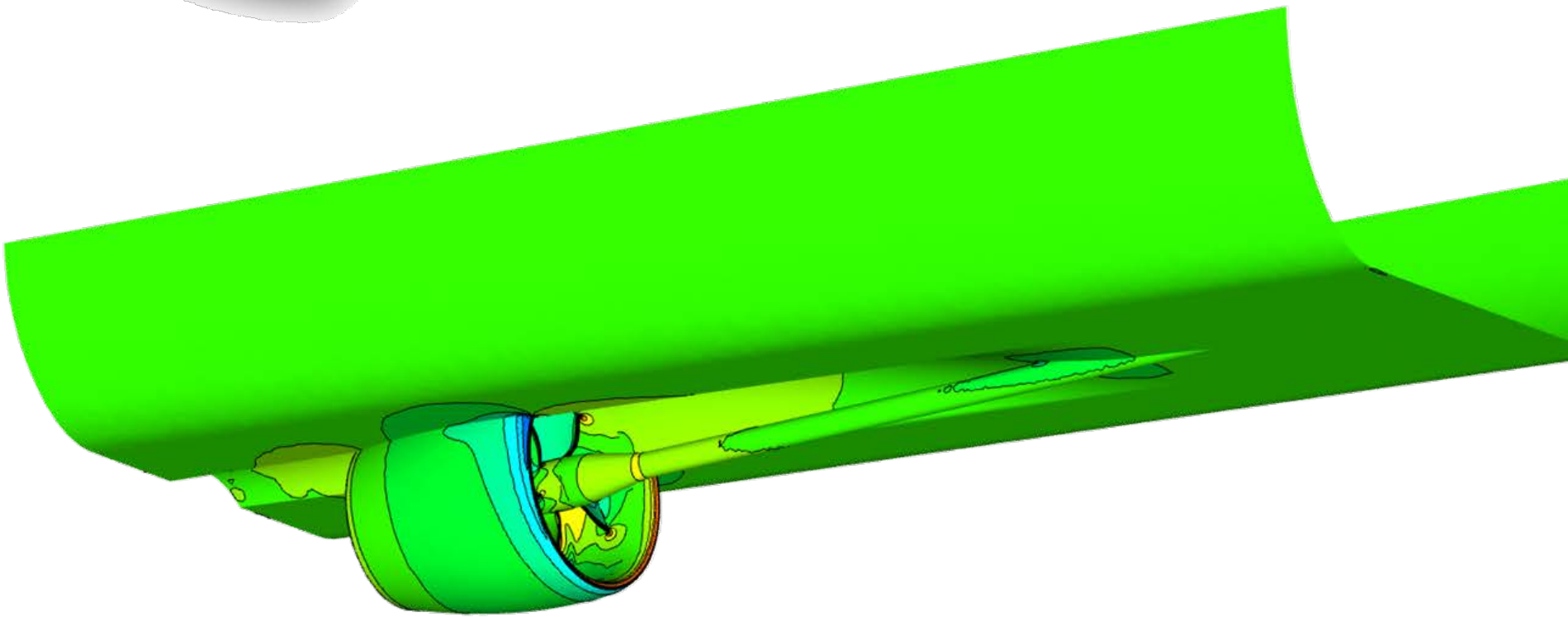




Source: David Bendl, Voith, CAESES Users' Meeting 2017

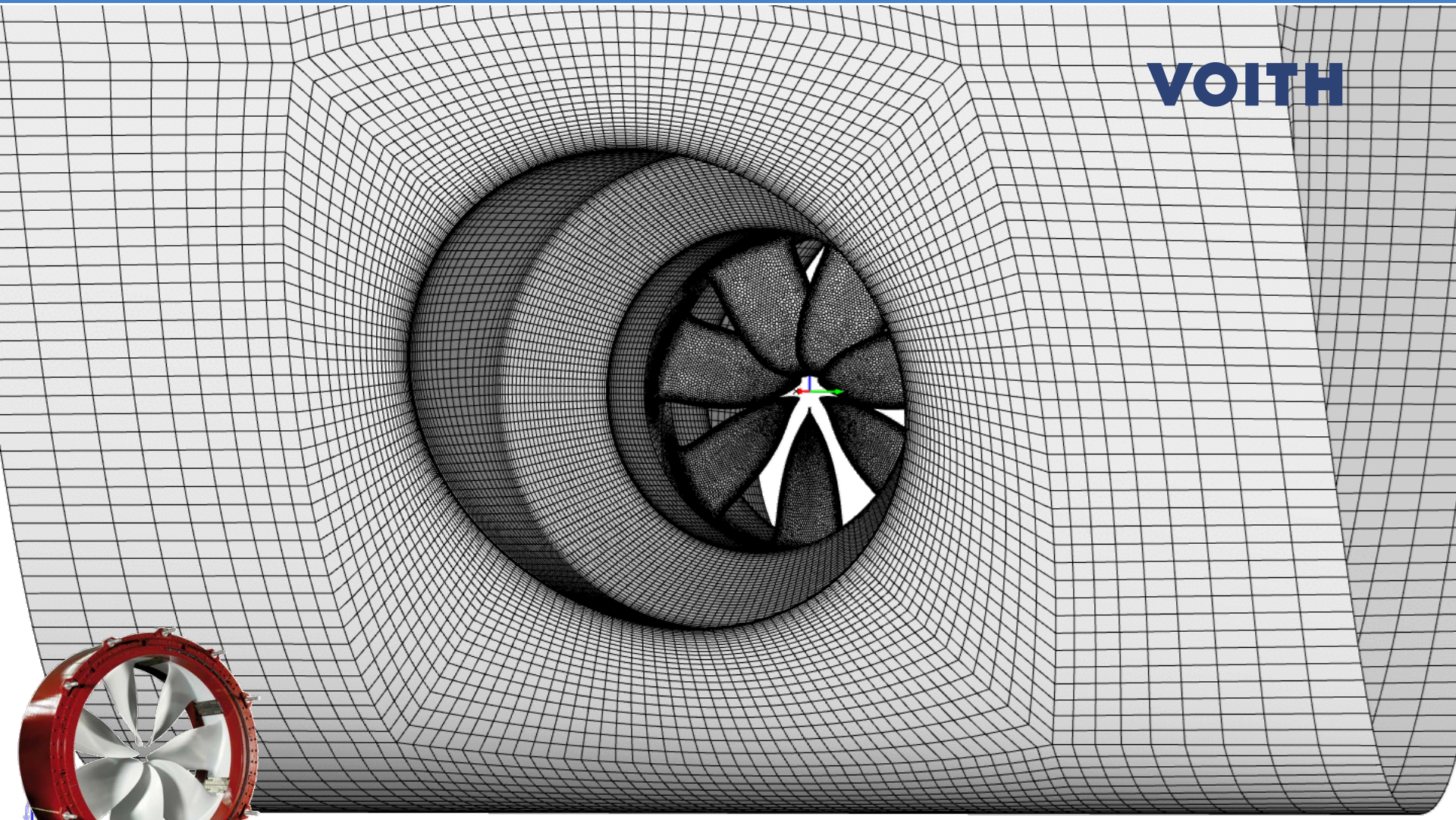
State-of-the-art: Voith Linear Jet (VLJ)

VOITH



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

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



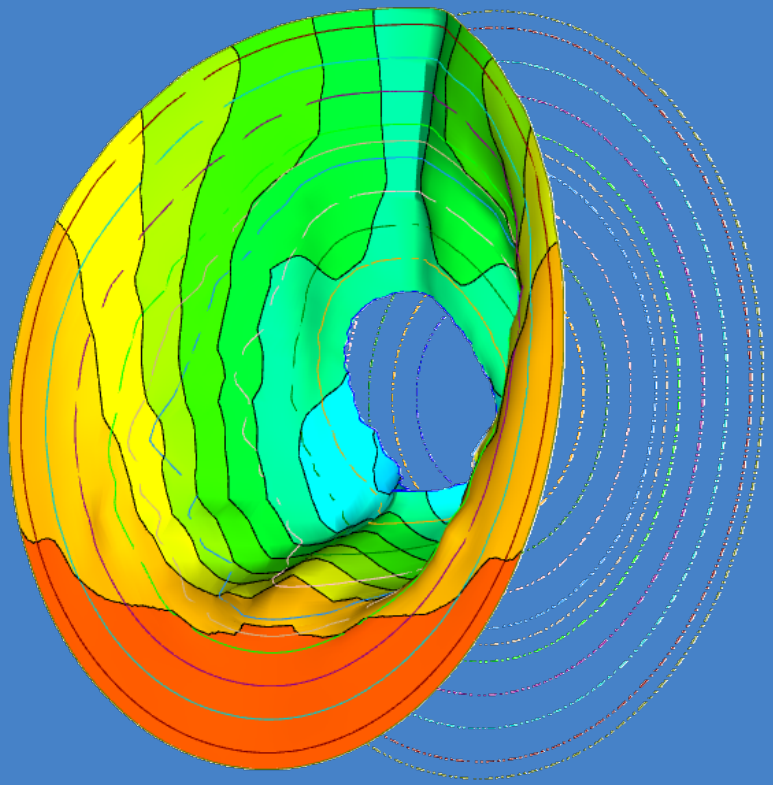
Source: David Bendl, Voith, CAESES Users' Meeting 2017

State-of-the-art: Final results

VOITH

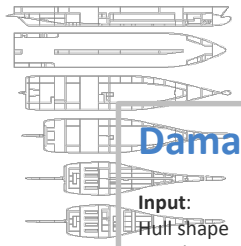
Source: David Bendl, Voith, CAESES Users' Meeting 2017

Thesis proposition



HOLISHIP

Thesis proposition



Damage stability

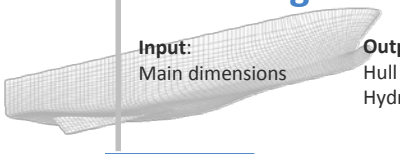
Input:
Hull shape
Topology

Output:
Attained index

NAPA

Hull design

FRIENDSHIP SYSTEMS



Input:
Main dimensions

Output:
Hull shape
Hydrostatics

CAESES model

Wave res.

HSVA

Input:
Hull shape
Operational profile

Output:
Wave resistance

ν-Shallo

1 2 3 4 5 6 7 8

HOLISHIP

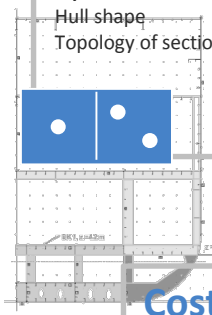
CAESES

Steel w. / light weight

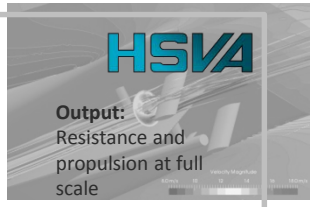
Input:
Hull shape
Topology of sections

Output:
Steel weight
Lightship weight

BV Mars / Steel



RANSE

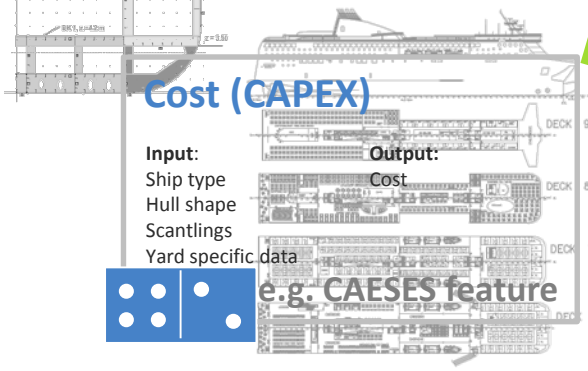


HSVA

Input:
Hull shape
Operational profile
Propeller

Output:
Resistance and propulsion at full scale

FreSco+

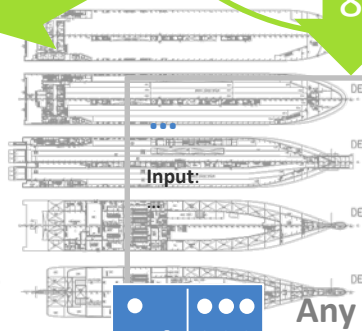


Cost (CAPEX)

Input:
Ship type
Hull shape
Scantlings
Yard specific data

Output:
Cost

e.g. CAESES feature



CETENA
FINCANTIERI

Input:
...

Output:
...

Any external tool

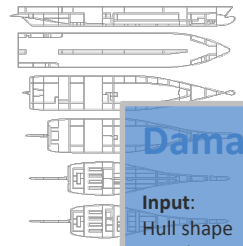
Added resistance

Input:
Hull shape
Operational profile
Sea states

Output:
Added resistance in waves

NEWDRIFT+

Thesis proposition



Damage stability

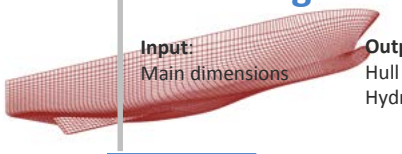
Input:
Hull shape
Topology

Output:
Attained index

NAPA

Hull design

FRIENDSHIP SYSTEMS



Input:
Main dimensions

Output:
Hull shape
Hydrostatics

CAESES model

Wave res.

HSVA

Input:
Hull shape
Operational profile

Output:
Wave resistance

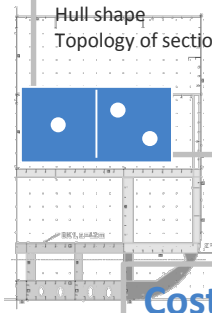
ν-Shallo

Steel w. / light weight

Input:
Hull shape
Topology of sections

Output:
Steel weight
Lightship weight

BV Mars / Steel



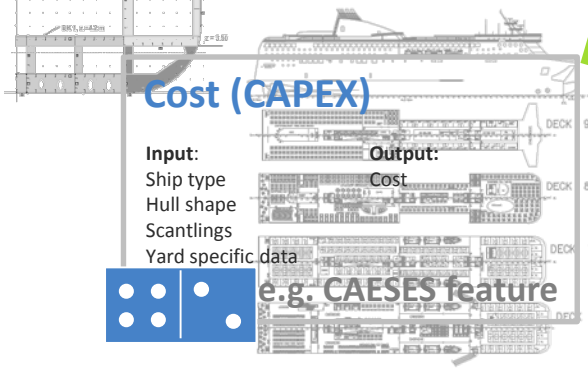
RANSE

HSVA

Input:
Hull shape
Operational profile
Propeller

Output:
Resistance and propulsion at full scale

FreSco+

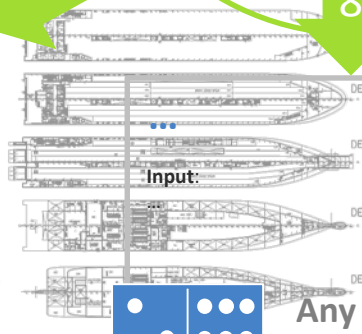


Cost (CAPEX)

Input:
Ship type
Hull shape
Scantlings
Yard specific data

Output:
Cost

e.g. CAESES feature



CETENA
FINCANTIERI

Input:
...

Output:
...

Any external tool

Added resistance

Input:
Hull shape
Operational profile
Sea states

Output:
Added resistance in waves

NEWDRIFT+

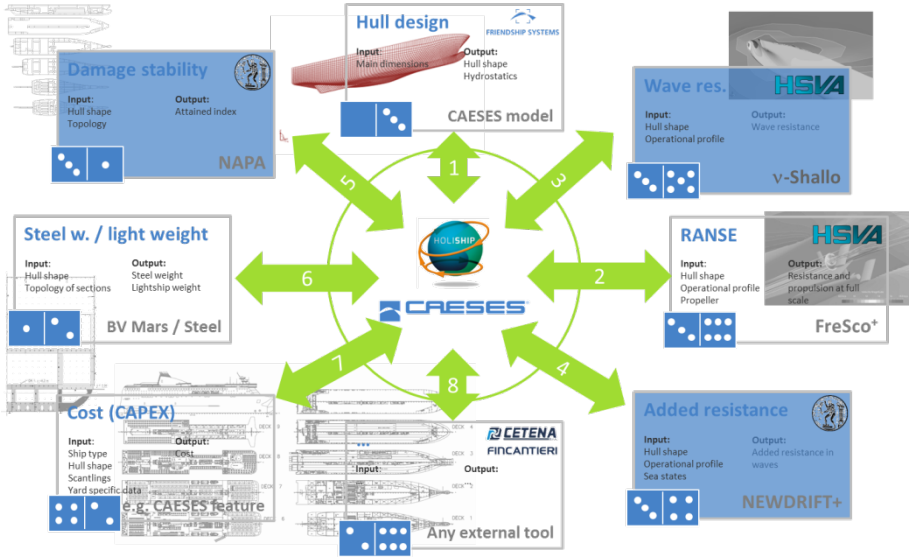
HOLISHIP

CAESES

1 2 3 4 5 6 7 8

Thesis proposition

- Tentative title
  "Potentials and Limits of Surrogate Models for the Design and Optimization of Ships"
- Idea
  - Ship design is complex
  - Many different disciplines to be considered
  - Many important aspects need extensive simulations to adequately capture relationships and dependencies
  - At the early design stages not all simulations can be run concurrently or take too much time, for instance due to high resource demands for CFD or damage stability analysis



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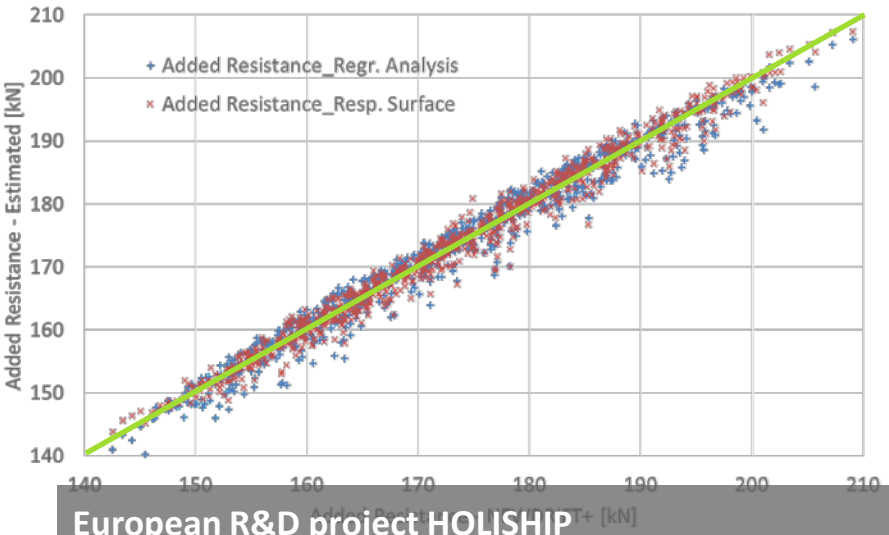
Use CAESES® in the context of the design of a modern RoPAX ferry

Thesis proposition

- Idea (cont.)
  - Run extensive sets of designs beforehand
  - Capture the essence of system behavior in surrogate models (also known as meta-models and response surfaces), e.g.
    - Artificial Neural Networks
    - Kriging
    - Polynomial regression
    - …
  - Investigate which models can be utilized



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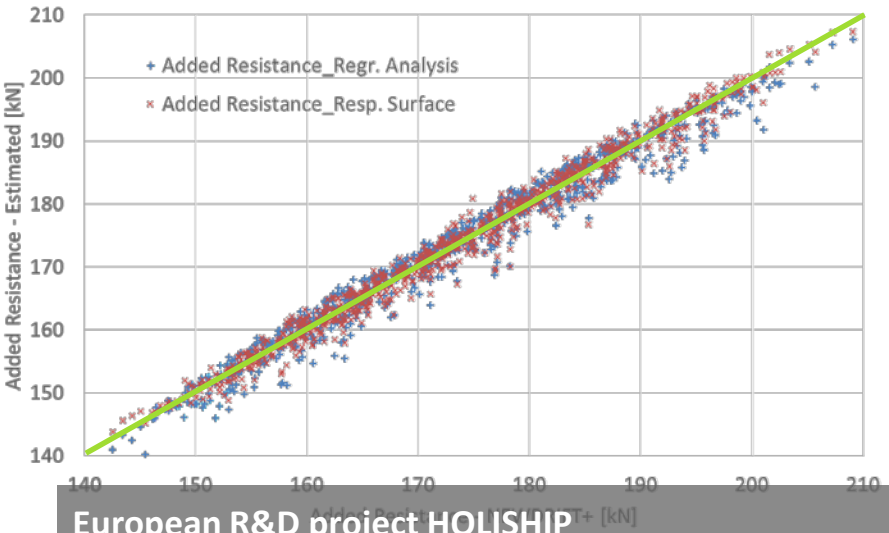
Example surrogate model for added resistance in waves for a RoPAX ferry by Fincantieri

Thesis proposition

- Idea (cont.)
  - Important questions to ask are
    - What potentials and limits do they bring about for which type of design task, e.g. hydrodynamics, structural analysis?
    - How does the effort scale with the number of free variables (dimensionality of the design space)?
    - Which approaches should be taken to estimate the required (training) sets and to quantify the approximations achieved?
  - The student will work on a RoPAX design



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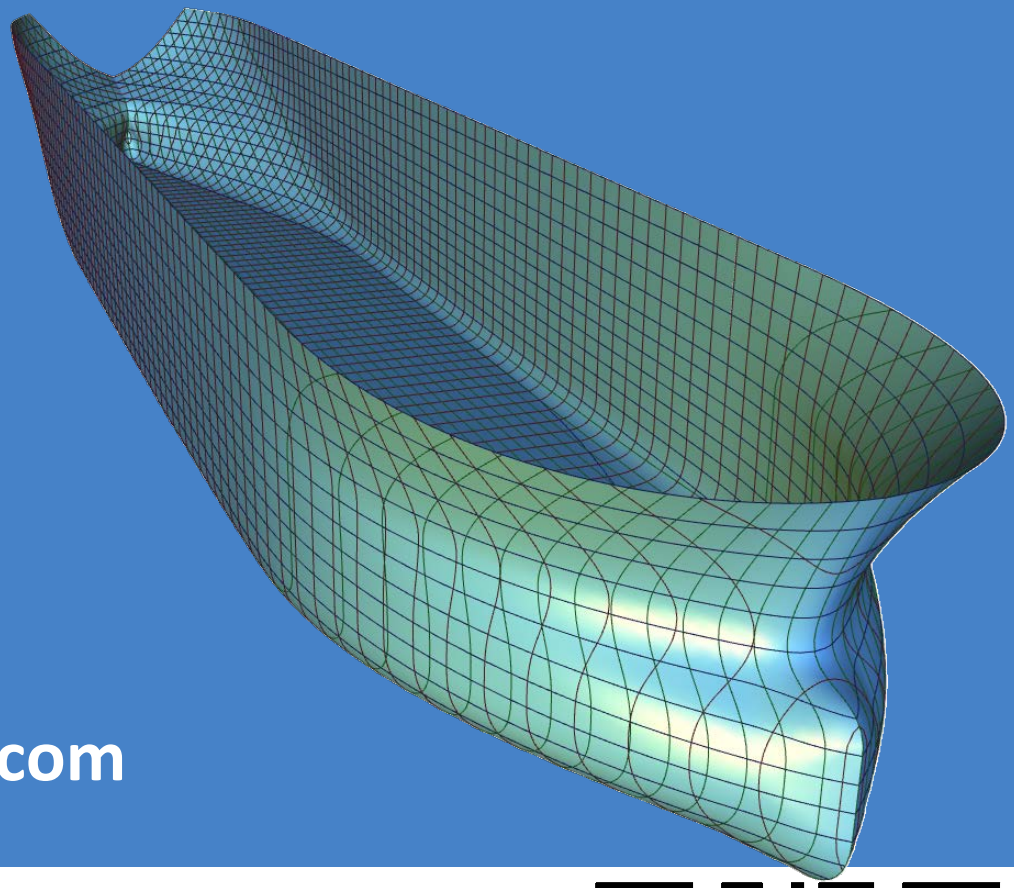
Example surrogate model for added resistance in waves for RoPAX ferry

Why FRIENDSHIP SYSTEMS

- Berlin / Potsdam is a cool place
- FRIENDSHIP SYSTEMS has a young team (at heart)
- CAESES® is fun to work with in a project
- Quite a few of our students have done well
  - National and international awards for their master's theses ☺
  - But that is not a self-fulfilling prophecy
- Prerequisites are
  - Strong knowledge of CAx
  - High command of English as a foreign language
  - Good skills of self-organization



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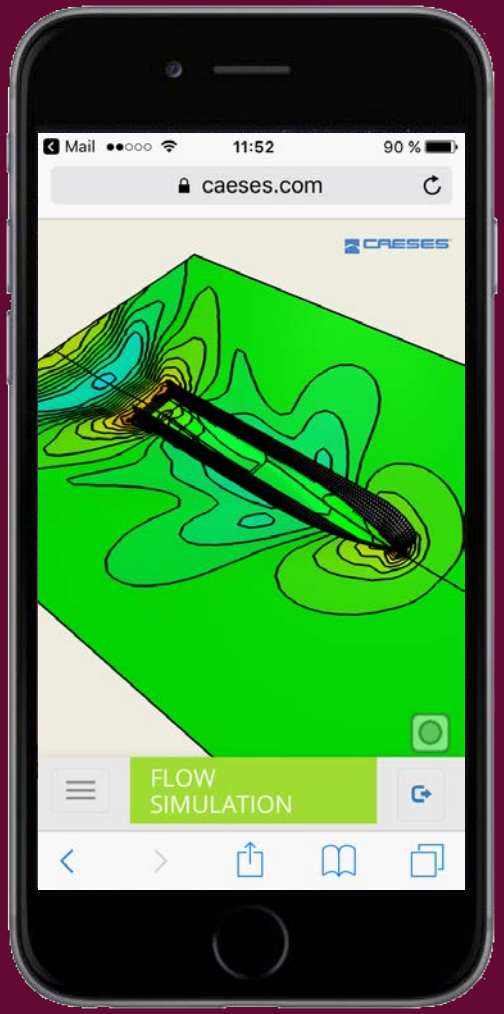
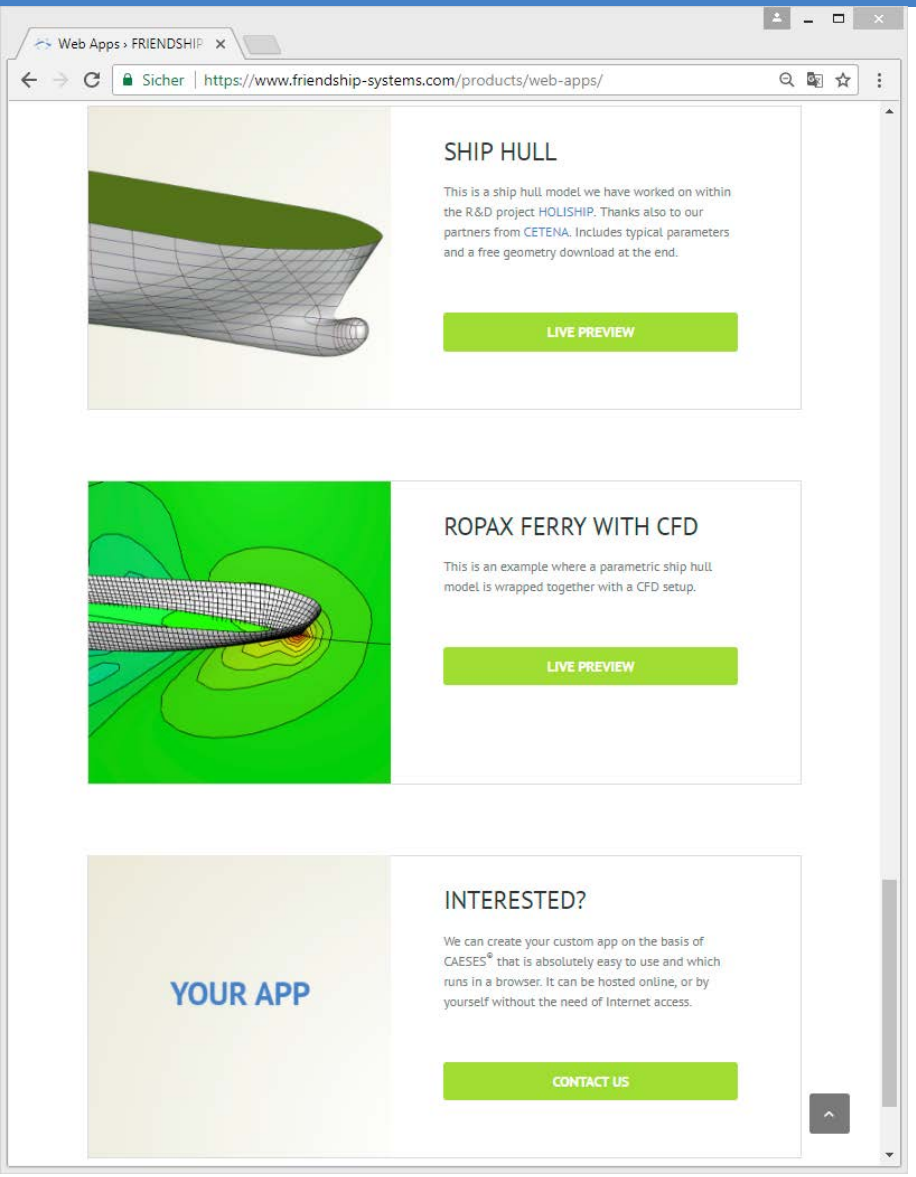
Appification and WebAPPs



Appification



Website

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