Looking back and looking forward: Simulation-Driven Design and Data-Driven Engineering

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FRIENDSHIP SYSTEMS AG

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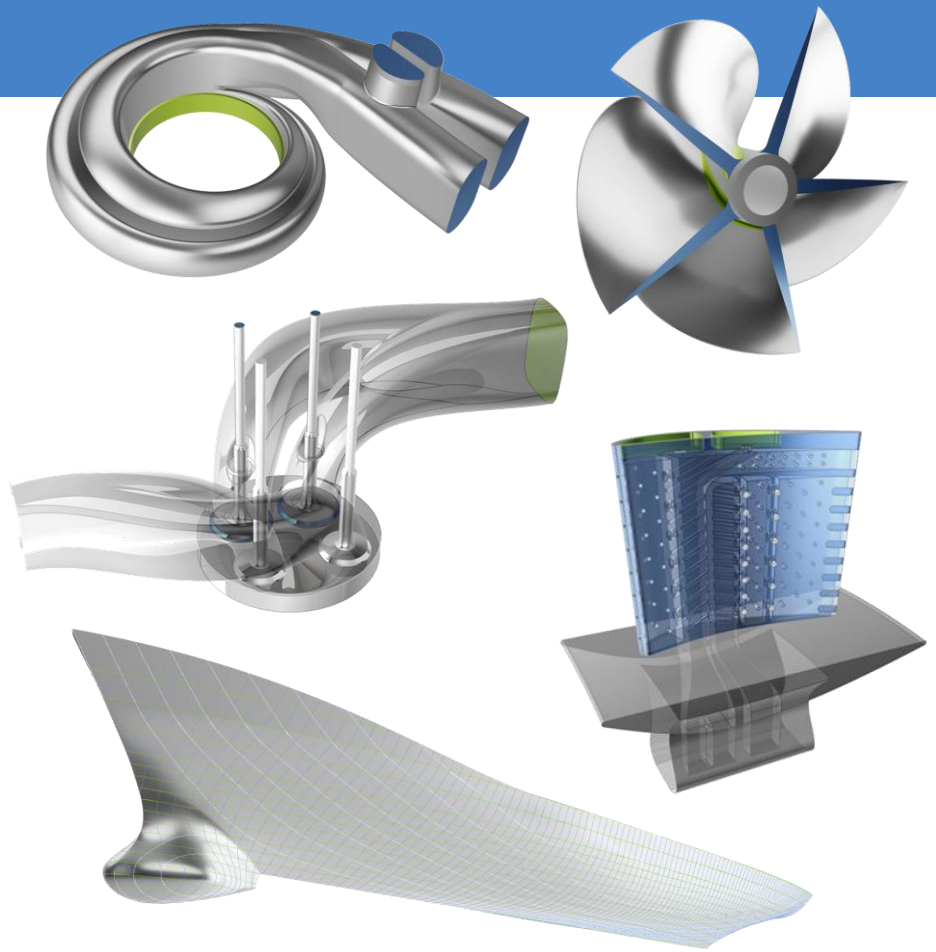
FRIENDSHIP SYSTEMS

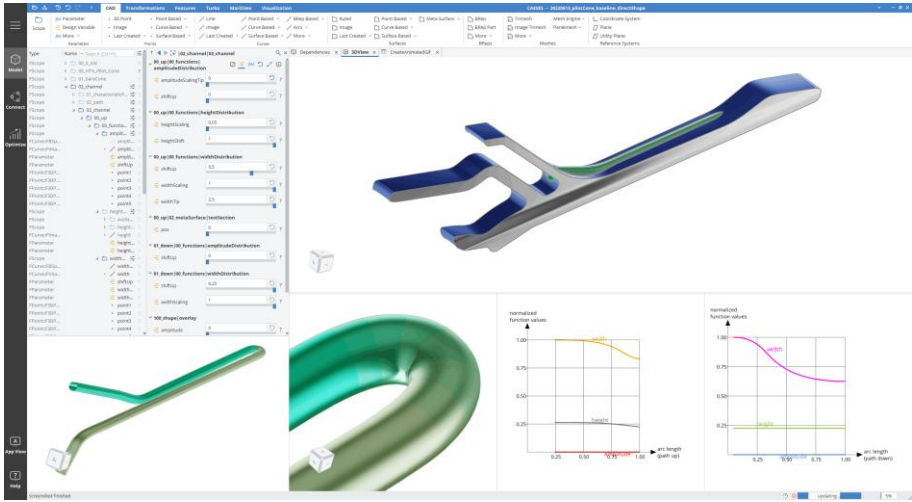
Overview

- Looking back
  - Simulation-driven design over 25 years
  - Dedicated functionality
    - Design velocities and parametric-adjoint simulation
    - Principal Component Analysis (PCA)
  - Synthesis and surrogates
  - Comprehensive toolbox
  - Dedicated workflows
- Looking forward
  - New R&D projects
    - DesignAssist
    - FIT-HORIZONS
  - CAESES Insight for data-driven engineering



Simulation-Driven Design (SDD)

- 2002: “Never heard of it!”
- 2007: “It worked for a double-ended ferry.
  But does it really work for a container carrier, too?”
- 2012: “We can do this by hand.
  And simulations are not reliable enough anyway.”
- 2017: “Well, we would like to try it, too.”
- 2022: “All of our designs undergo SDD.”



J.C.R. Licklider, 1965

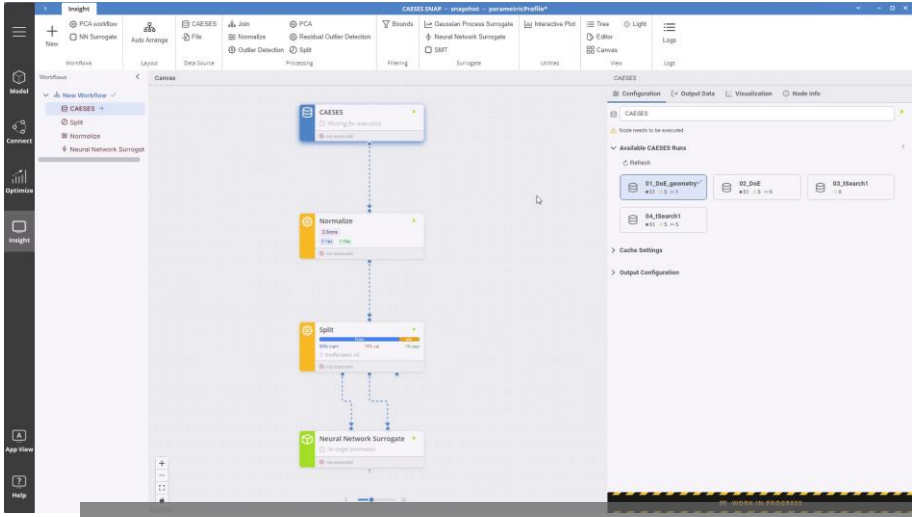
“People overestimate what can be done in one year, and underestimate what can be done in ten.”

American psychologist and computer scientist

A slide from 2022

Data-Driven Engineering (DDE)

- 1992: “A neural network?
  What is the professor talking about?”
- 2003: “ANNs correlate input data and output data?
  Really?”
- 2016: “What are surrogates?”
- 2024: “Where do we get the data from?”
- 2026: “We need AI to stay competitive!”



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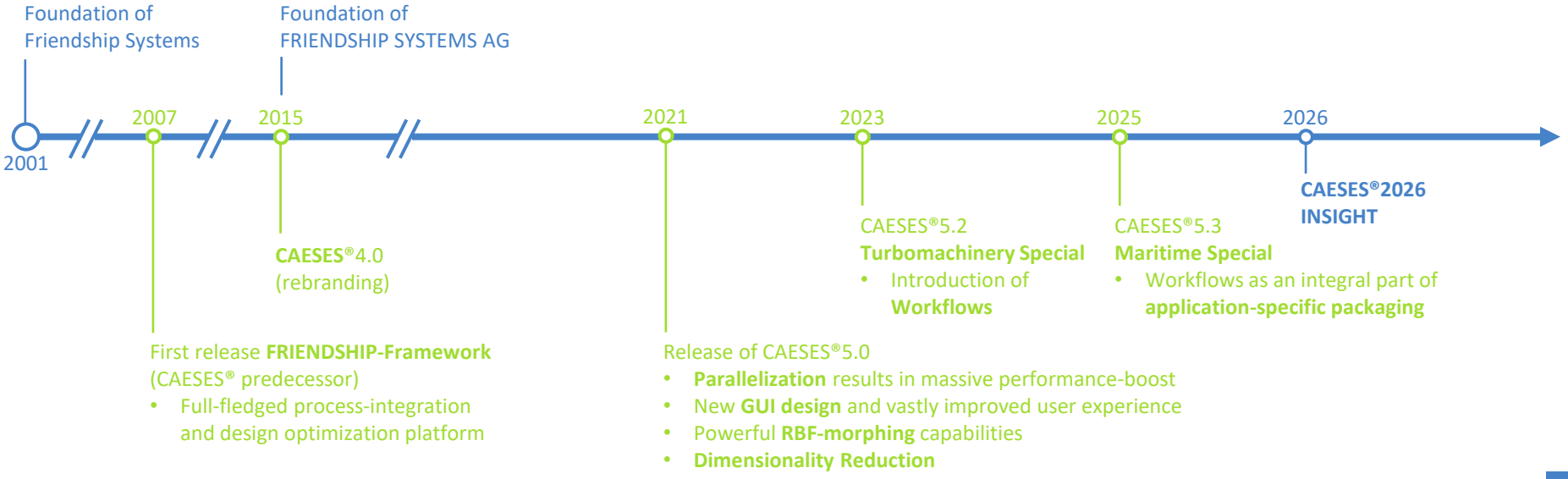
History and major technology and product upgrades

Simulation-Driven Design
- **Robust variable geometry:** Fully- and partially-parametric models
- **Integration:** Flexible coupling to external simulation codes
- **DoE and optimization:** Data generation and data management

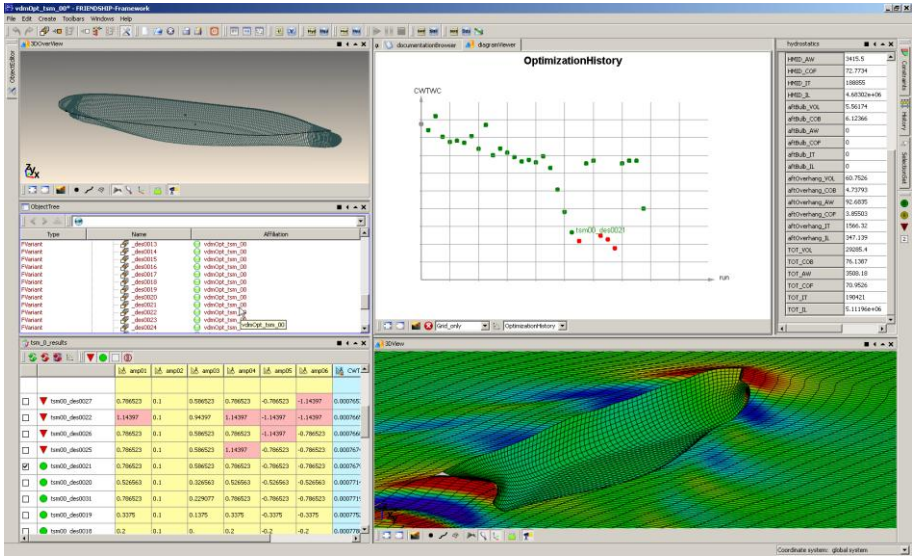
Data-Driven Engineering
- **Verticals:** Workflows, application-specific functionality, web apps
- **Usability:** UI-UX improvements, morphing, operations
- **Machine Learning and AI:** INSIGHT



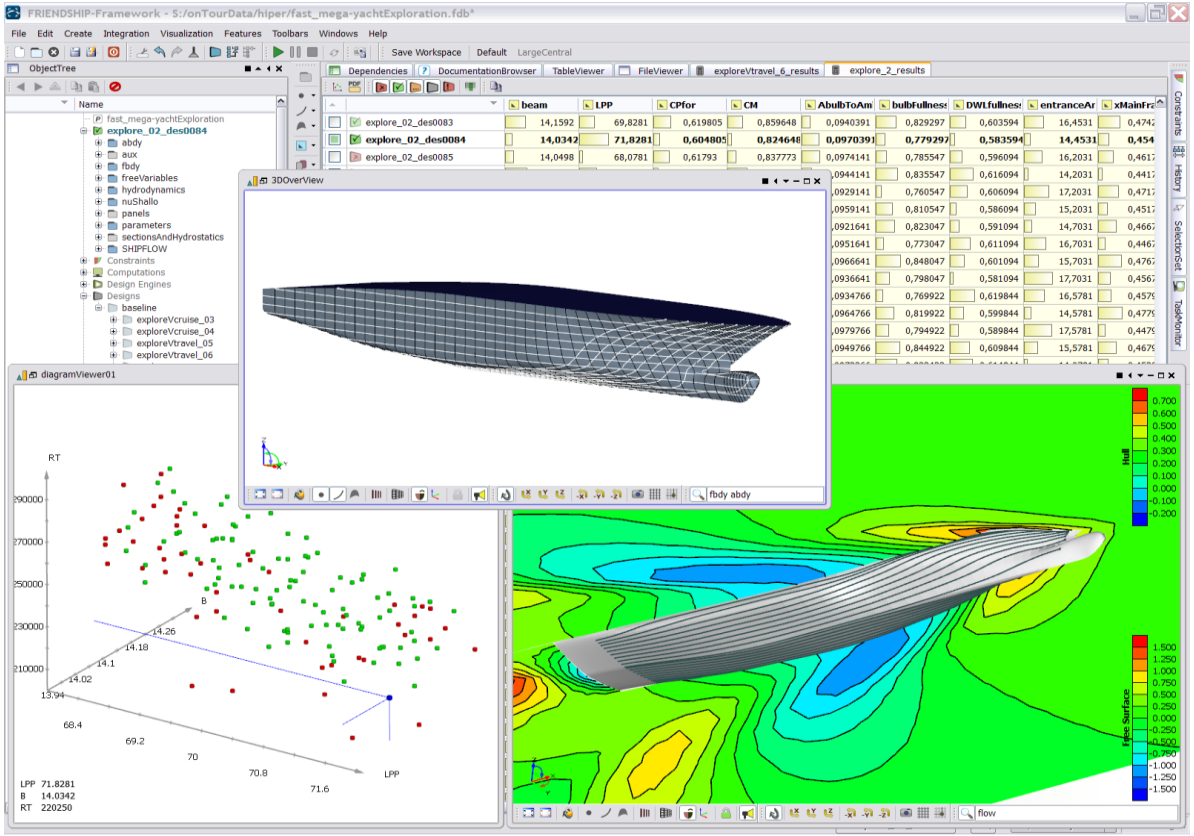
Looking back

Young and innocent in 2001

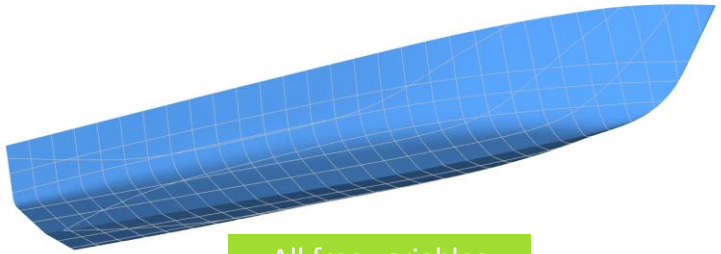
FRIENDSHIP-Framework replaces FRIENDSHIP-Modeler in 2007



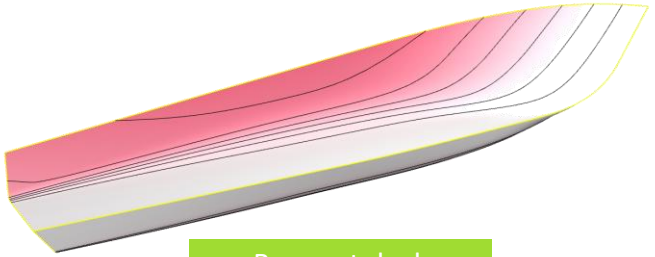
GUI in 2010 with first numerical hull series



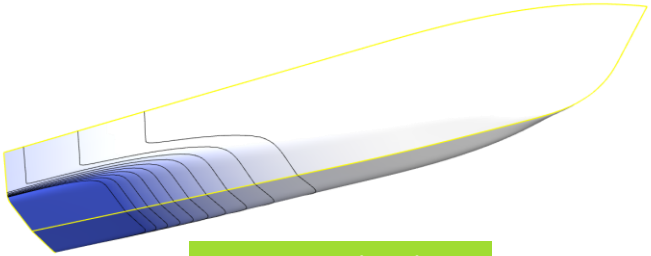
Design velocities for parametric-adjoint simulation



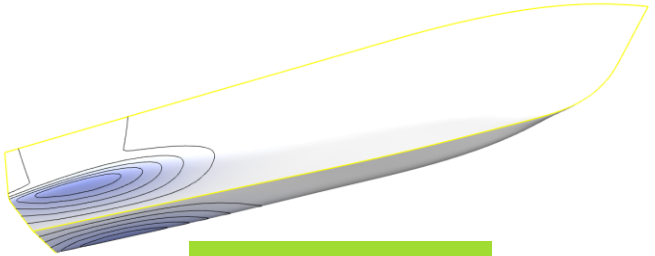
All free variables



Beam at deck

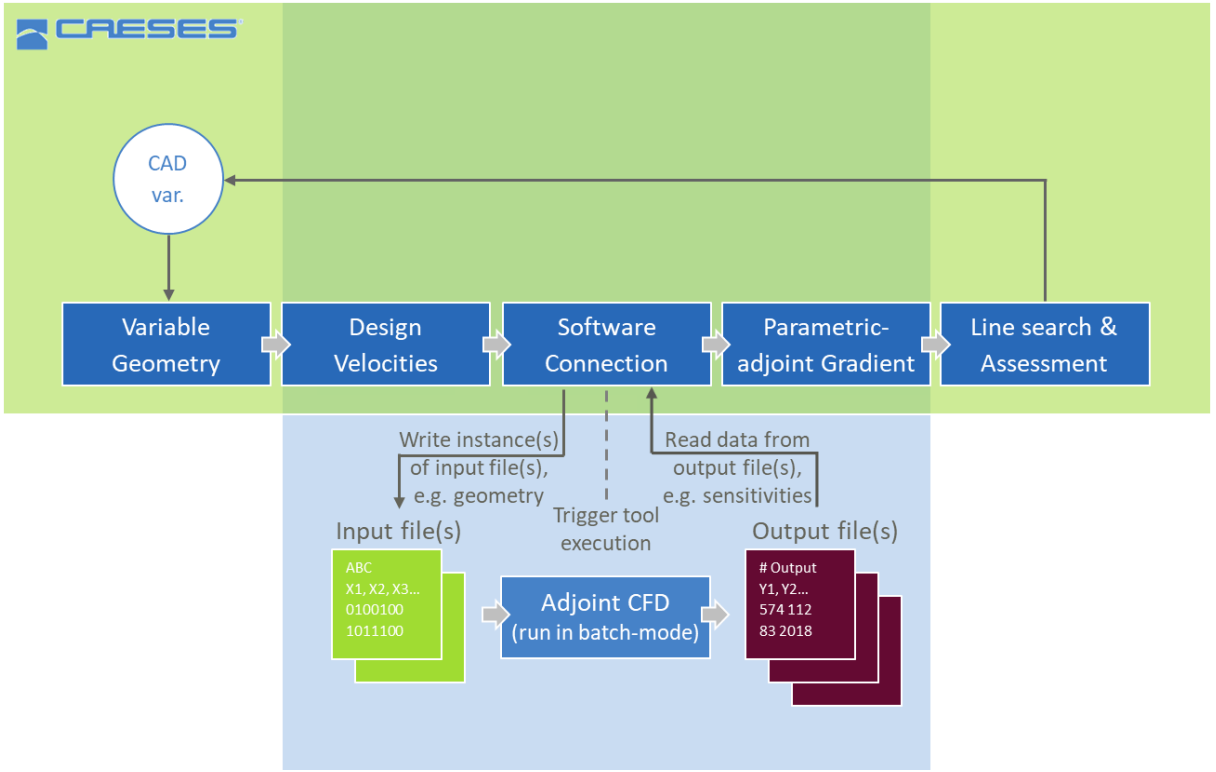


Transom height

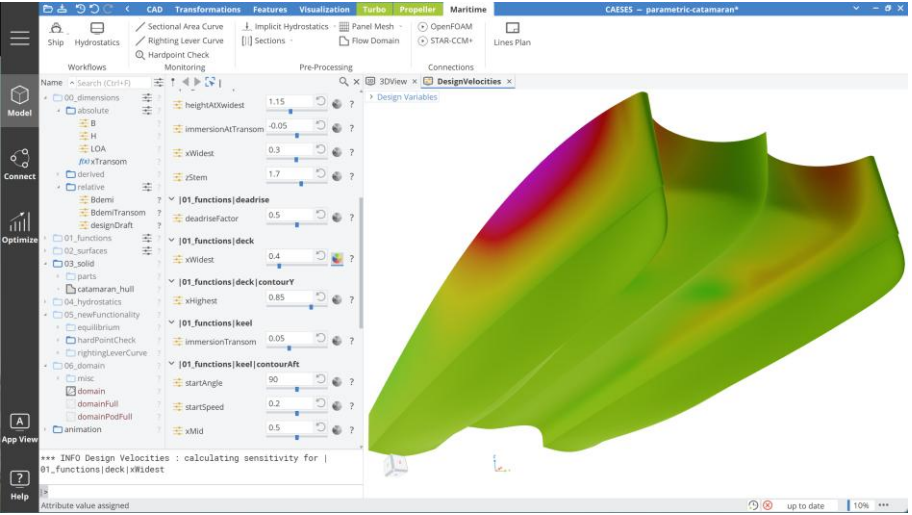


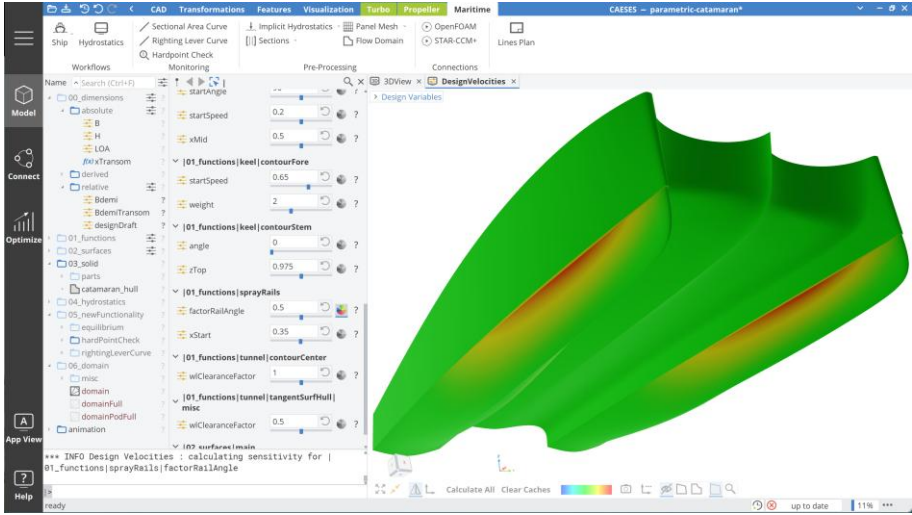
Transom twist

Introduction of parametric-adjoint simulation

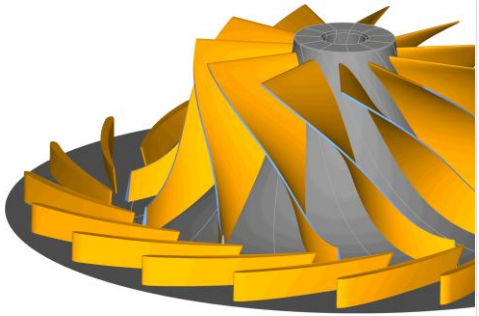


Design velocities for investigating parametric models





PCA for dimensionality reduction

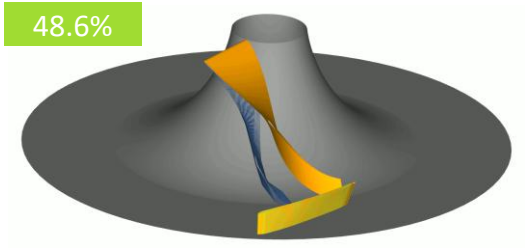


Design Variables

	Design Variable	Lower	Value	Upper
1	ANGLE_HUB	-10	0	10
2	ANGLE_SHROUD	-10	0	10
3	MID_SHIFT_DELTA	-2	0	2
4	MID_SHIFT_POS	0.3	0.5	0.8
5	BETA_HUB_LE	40	45	50
6	BETA_HUB_TE	45	50	55
7	BETA_SHROUD_LE	25	30	35
8	BETA_SHROUD_TE	40	41.7	50
9	BETA_TanFactor_HUB_LE	0.4	0.5	0.6
10	BETA_TanFactor_HUB_TE	0.4	0.5	0.6
11	BETA_Tan_HUB_LE	-45	-45	-35
12	BETA_Tan_HUB_TE	-65	-60	-55
13	BETA_TAN_SHROUD_LE	-15	-10	-5
14	BETA_TAN_SHROUD_TE	-40	-35	-30
15	THETA_DELTA_SHROUD_LE	-10	-2	0
16	THETA_DELTA_SHROUD_TE	-10	0	10
17	Diff_BETA_HUB_LE	17	19	25
18	Diff_BETA_HUB_TE	28	37	44
19	Diff_BETA_SHROUD_LE_Delta	-4.5	-2	3.5
20	Diff_BETA_SHROUD_TE_Delta	-5	-1	8
21	Diff_BETA_Tan_HUB_LE	-30	-20	-10
22	Diff_BETA_Tan_HUB_TE	-7.5	0	10
23	Diff_BETA_Tan_SHROUD_LE	-30	-20	-10
24	Diff_BETA_Tan_SHROUD_TE	-10	10	20
25	Diff_THETA_DELTA_SHROUD_LE	-15	-3	8.5
26	Diff_THETA_DELTA_SHROUD_TE	-5	0	5

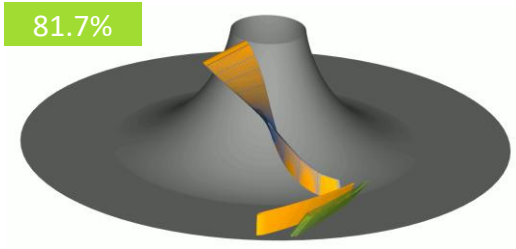
KLE mode 1 – main blade

48.6%



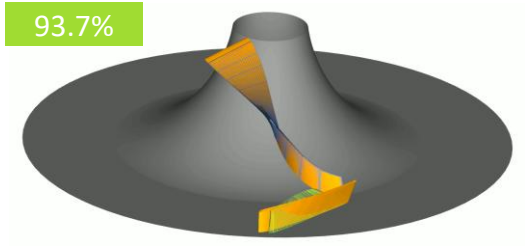
KLE mode 2 – diffuser

81.7%



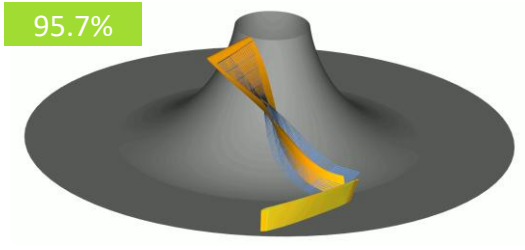
KLE mode 3 – diffuser

93.7%



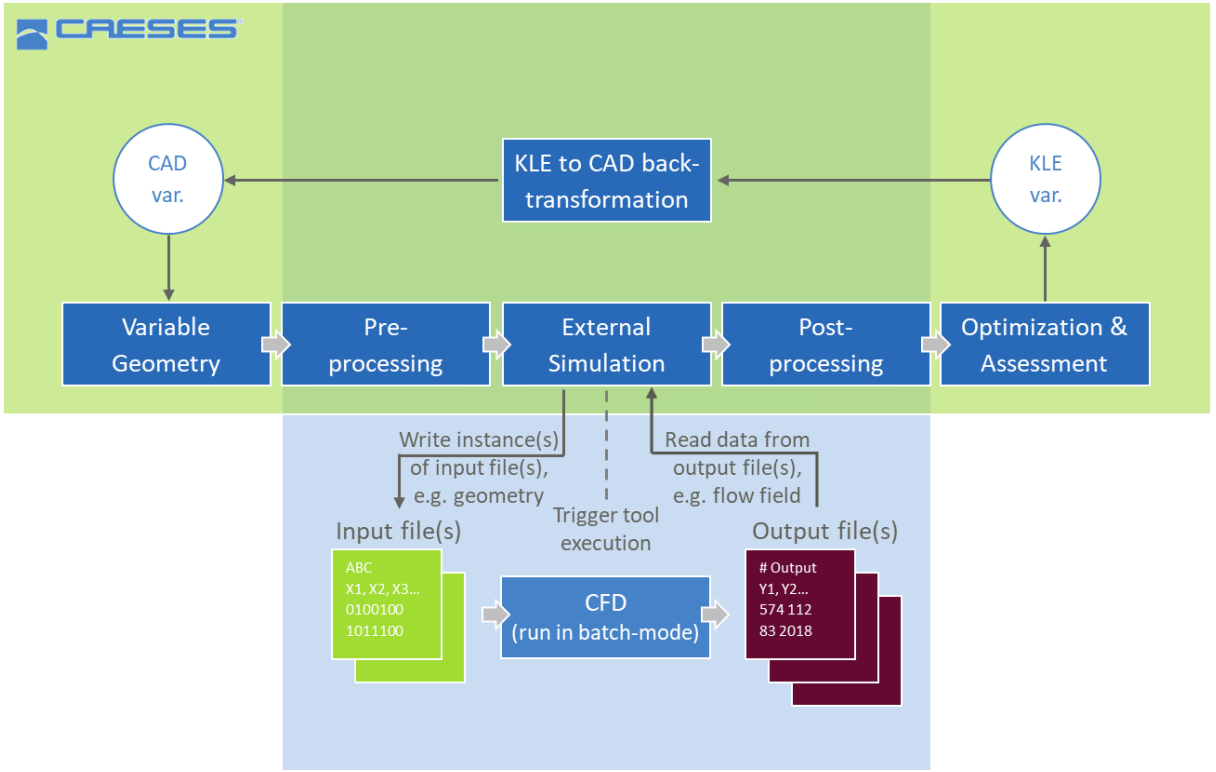
KLE mode 4 – main blade

95.7%

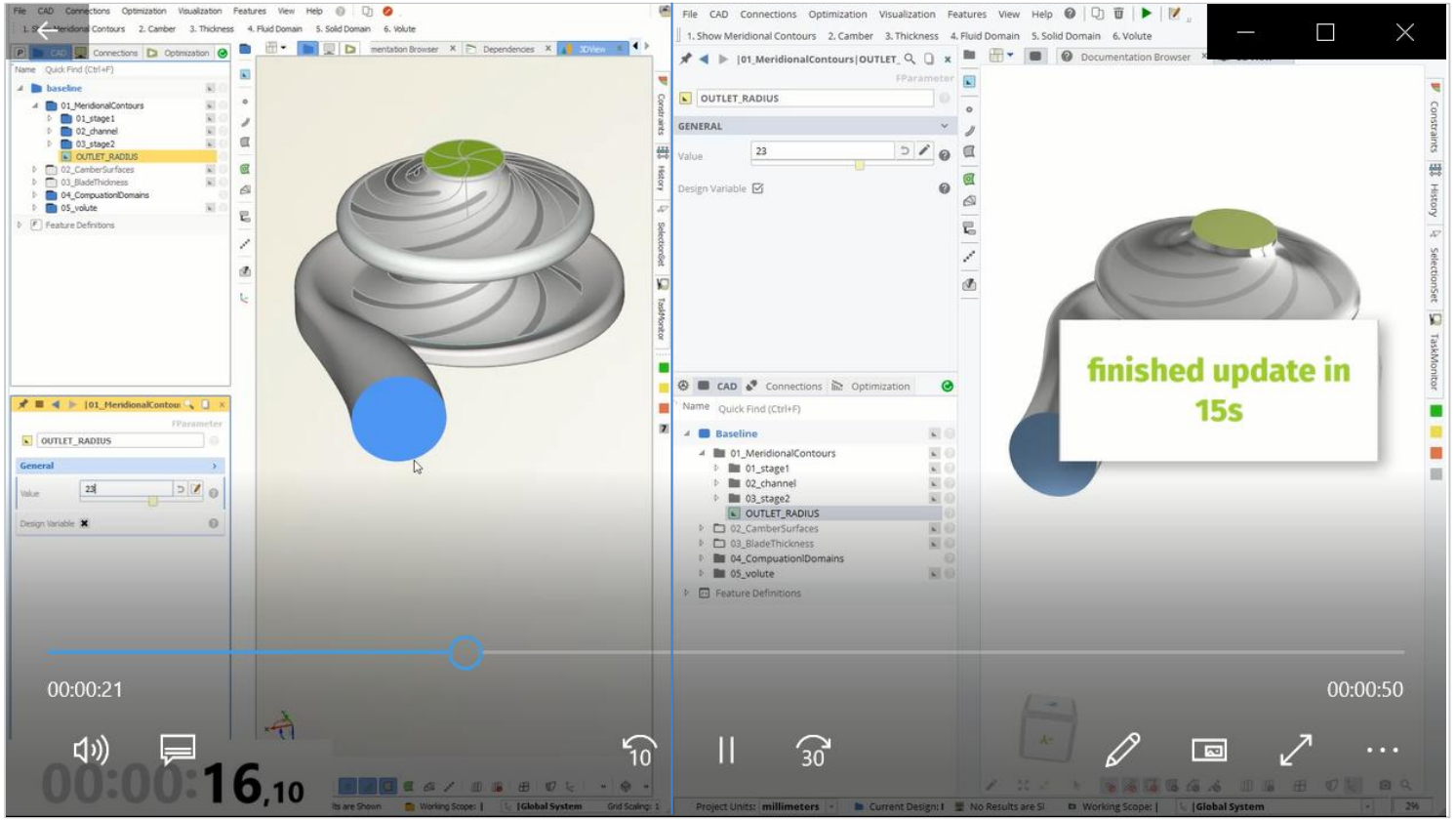


A slide from 2019

Introduction of PCA



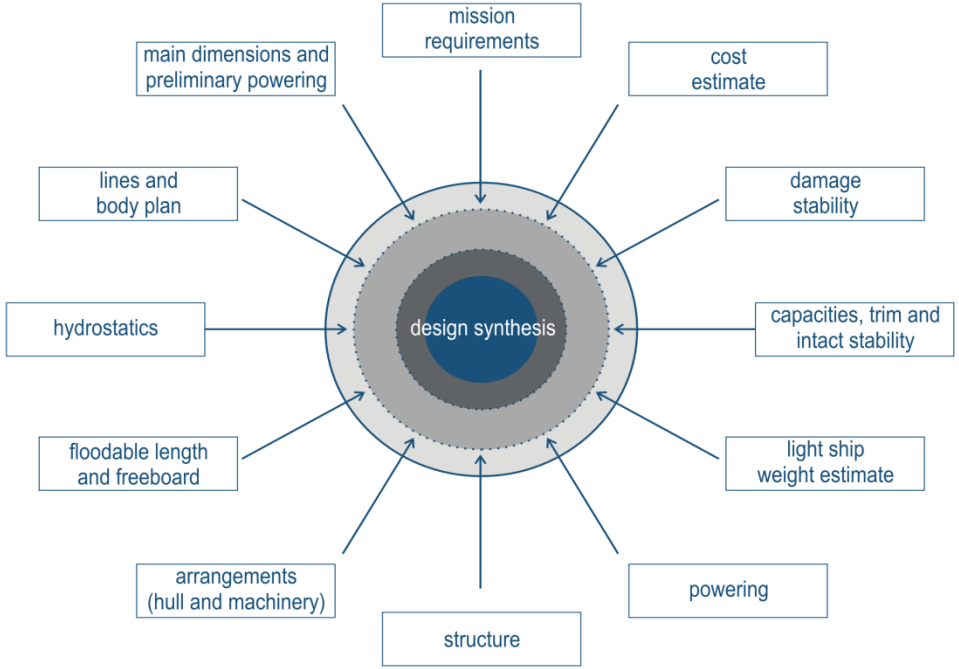
Sequential vs. parallel processing



Video from 2019

Design synthesis in combination with surrogates

Design phases – classic view of design spiral vs. holistic view



Synthesis model: OSV

Intact stability

Input:
Hull geometry
CoG
Basic hydrostatics
Crane info
Lifting weight

Output:
IMO469
Max heel and trim
Go/No-go

NAPA

Hull design

Input:
Base hull and transformations

Output: KONGSBERG
Hull design
Basic hydrostatics

CAESES feature

Motions

SINTEF

Input:
Hull geometry
Basic hydrostatics
Crane motion limits
Sea spectrum

Output:
RAOs
Limiting Hs, Tp
Operability

SHIPX - VERES

Weight estimations

Input:
Dimensions
Coefficients

Output:
Steel weight
Lightship weight
Operation. VcG/GM_0

CAESES feature

Station keeping

SINTEF

Input:
RAOs
Thruster config. fixed
Thruster location
Windage area
Waterplane shape
Wind and current

Output:
Max. thrust

SHIPX-SK

Fuel consumption

DNV·GL

Input:
Power
Thruster sizes

Output:
Fuel consumption

COSSMOS

Propulsion dim.

Input:
Thrusters database
DP thrust
Sailing thrust

Output: KONGSBERG
Propulsors
Power fore
Power aft

CAESES feature

Resistance

Input:
Hull geometry
Speed

Output:
Resistance
Sailing thrust /power

SHIPFLOW

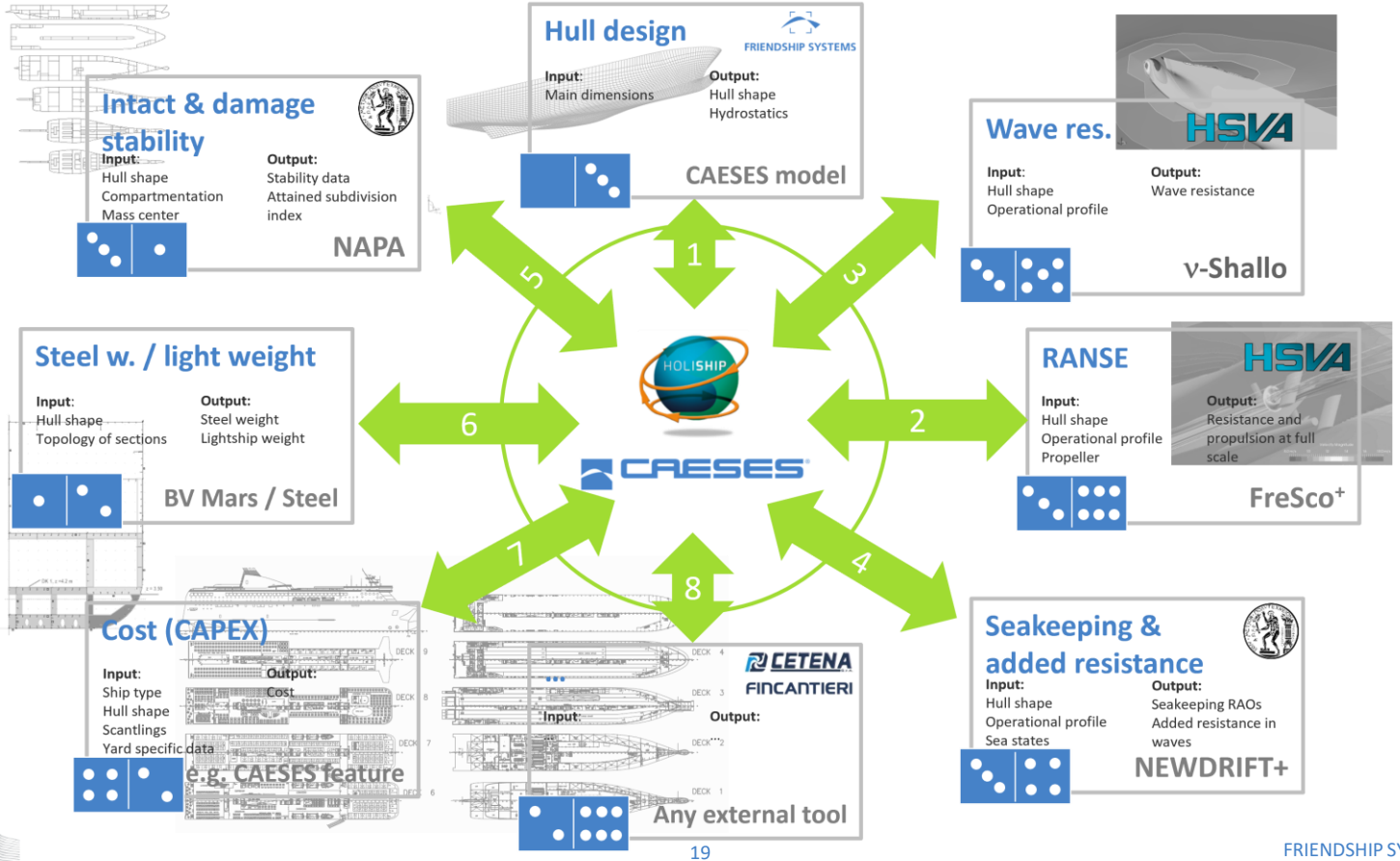
HOLISHIP

CAESES

1 2 3 4 5 6 7 8

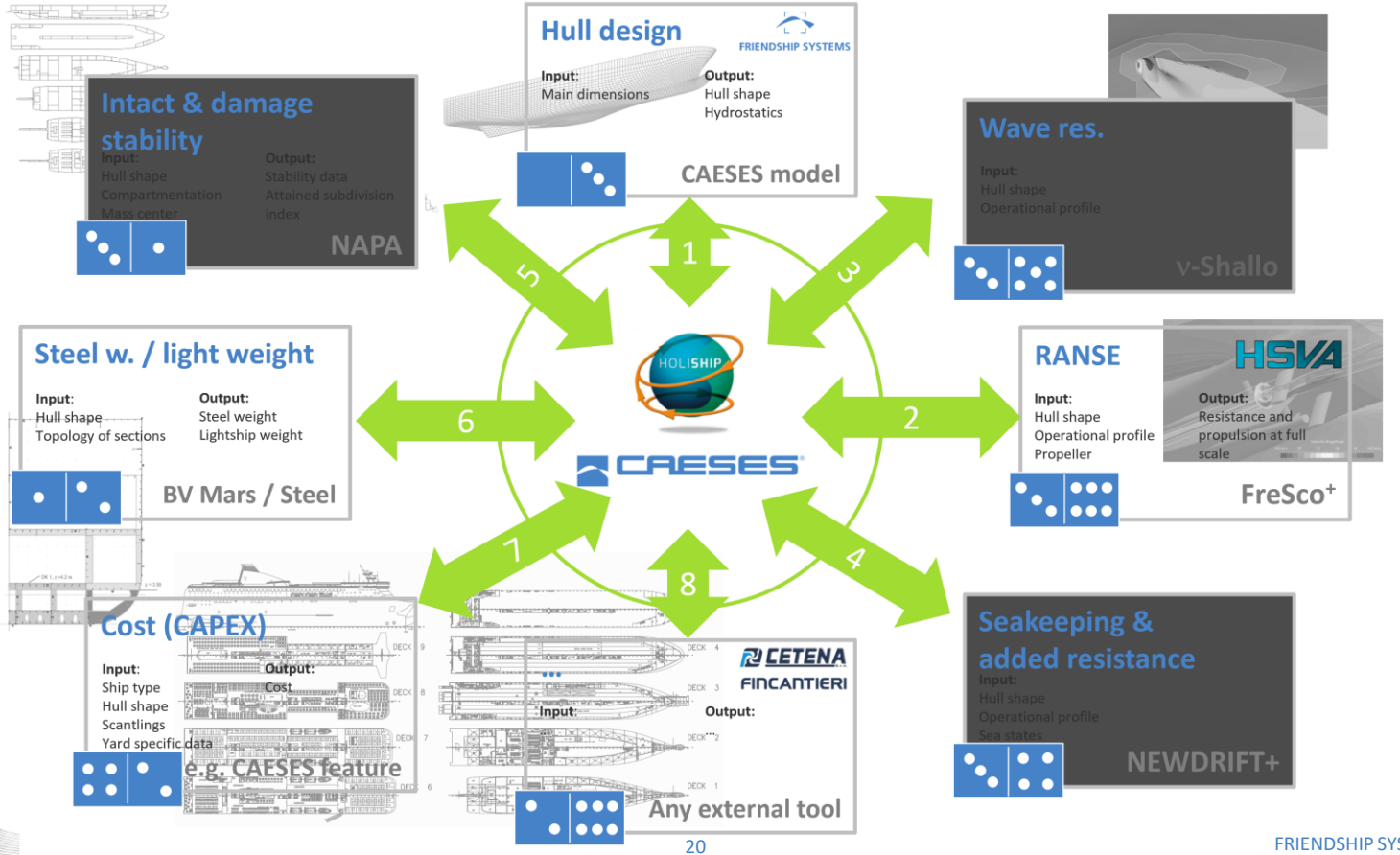
Funded by the European Union

Synthesis model: RoPax ferry



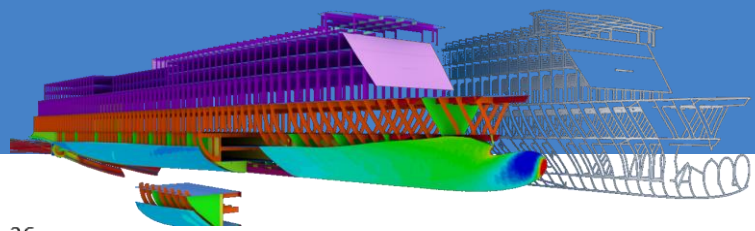
Funded by the European Union

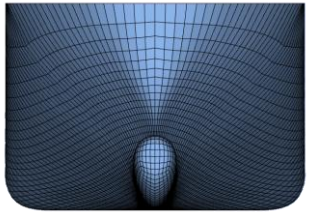
Synthesis model: RoPax ferry

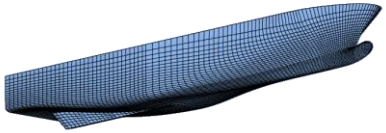


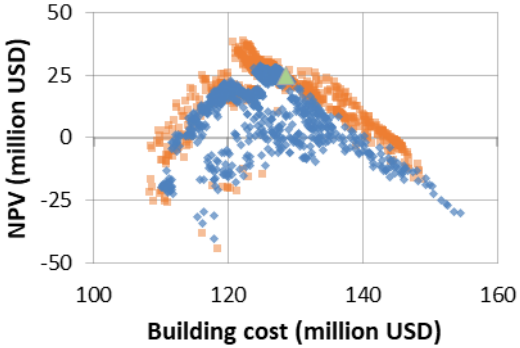
Funded by the European Union

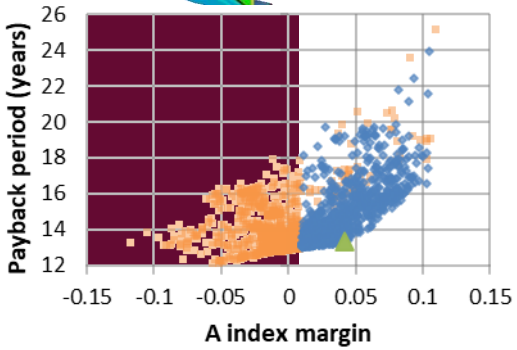
Selected results for RoPax ferry

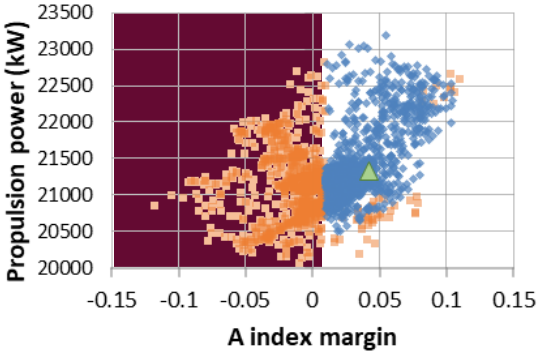


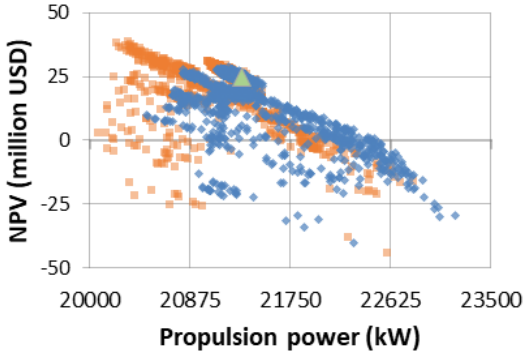








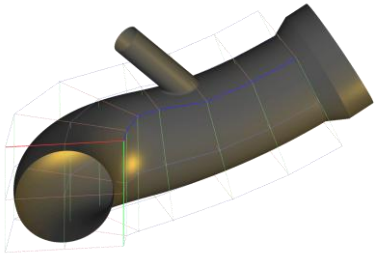


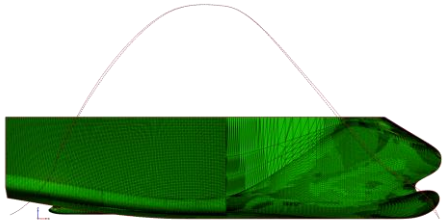


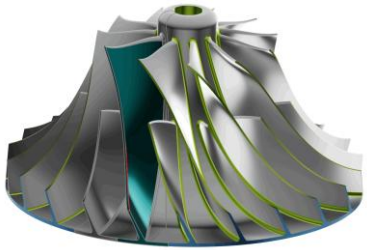
Funded by the European Union

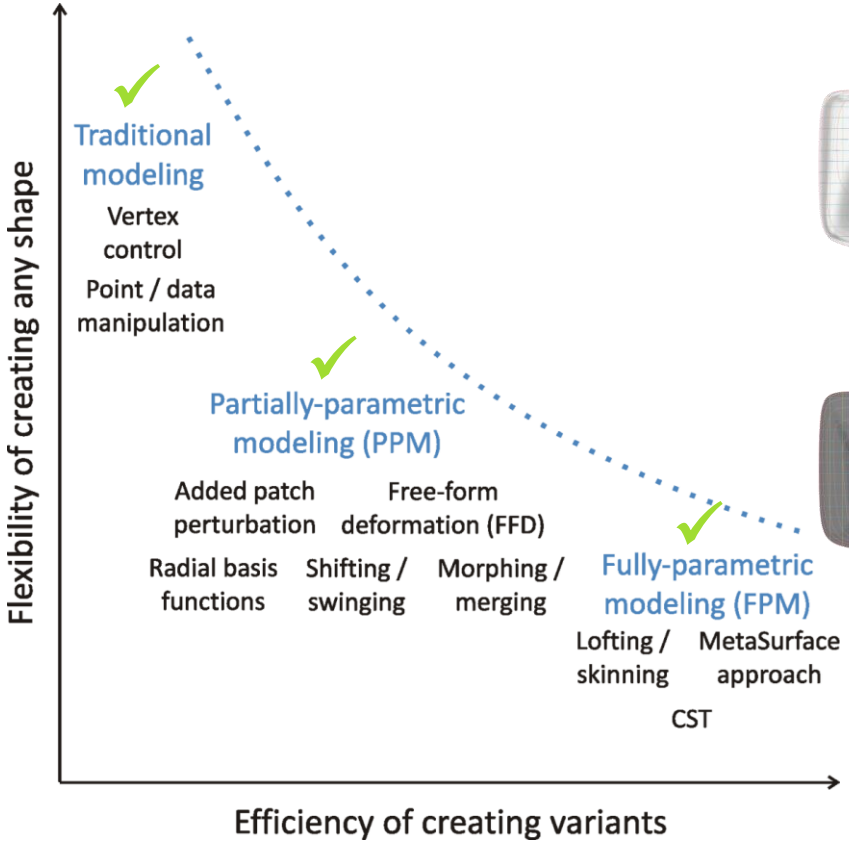
Comprehensive toolbox for parametric modeling

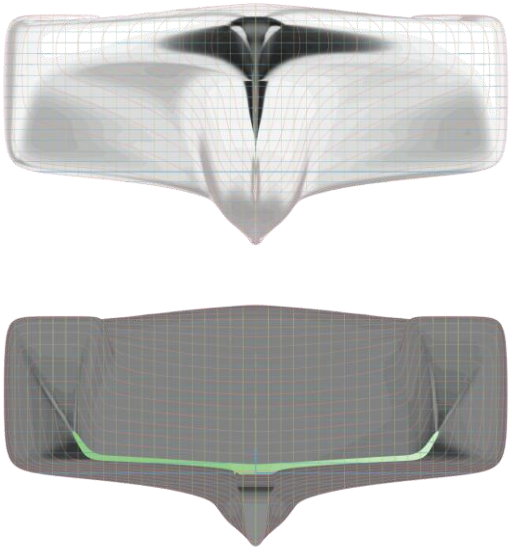
Comprehensive toolbox for parametric modeling



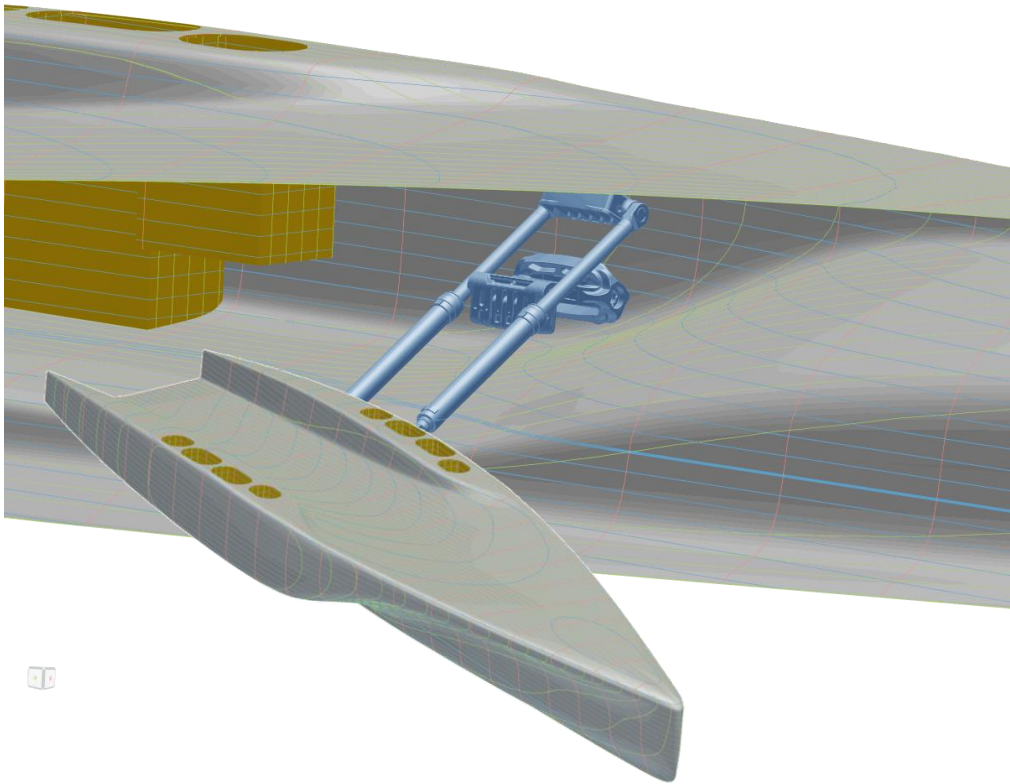




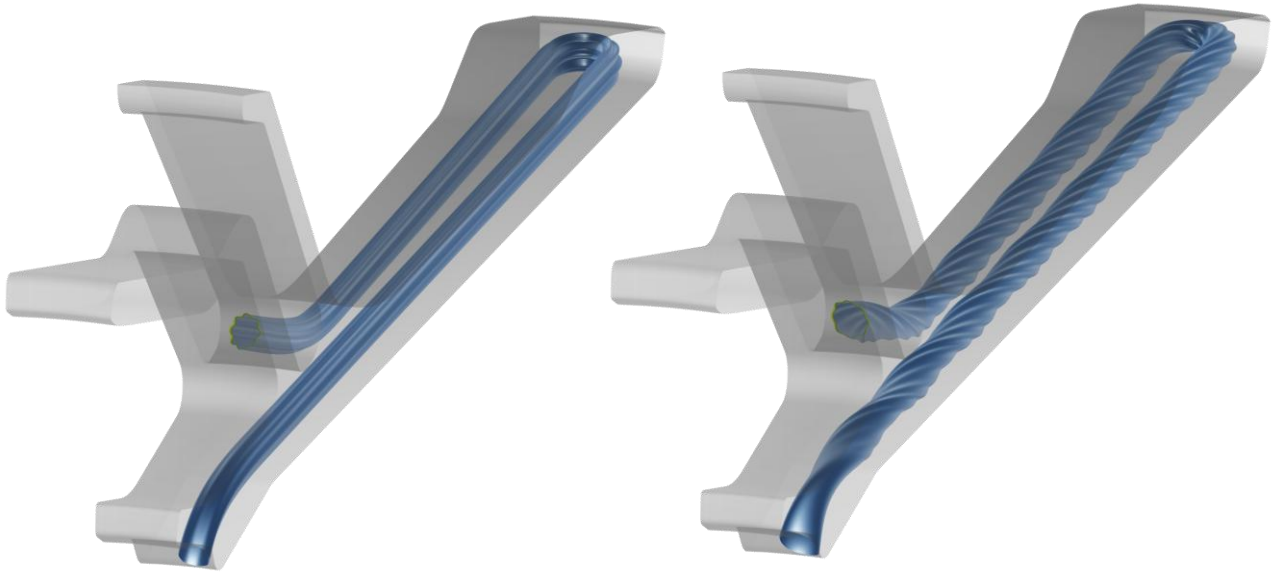




Parametric model with more than 100 built-in constraints

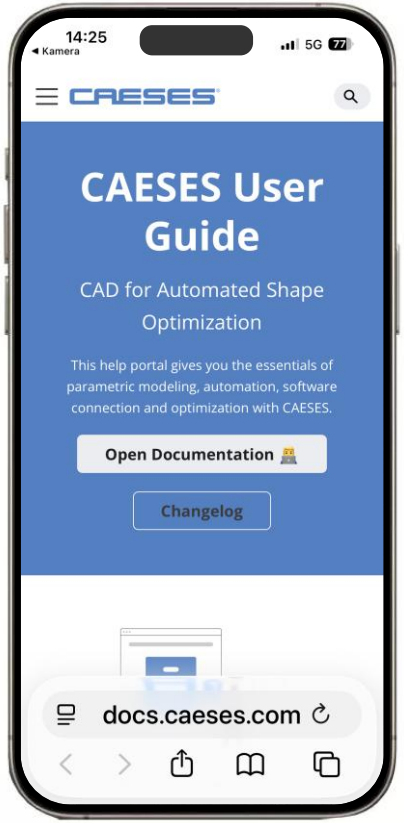


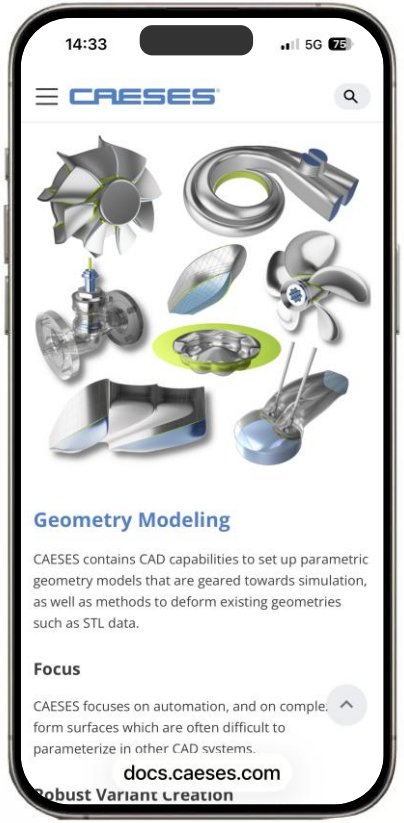
Parametric modeling for additive manufacturing in 2022



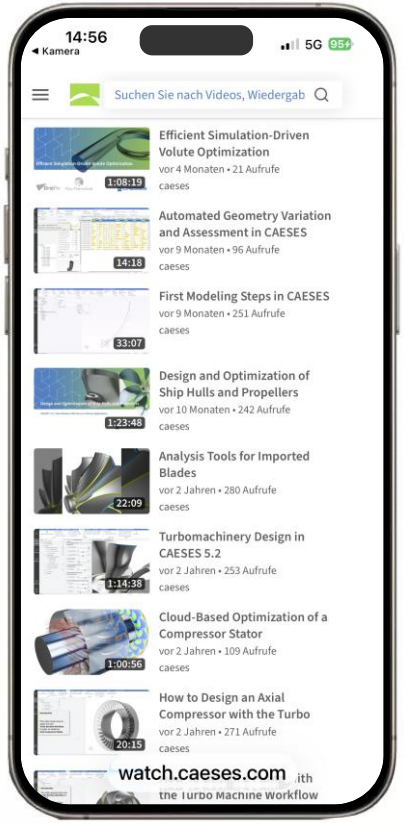
Documentation and videos

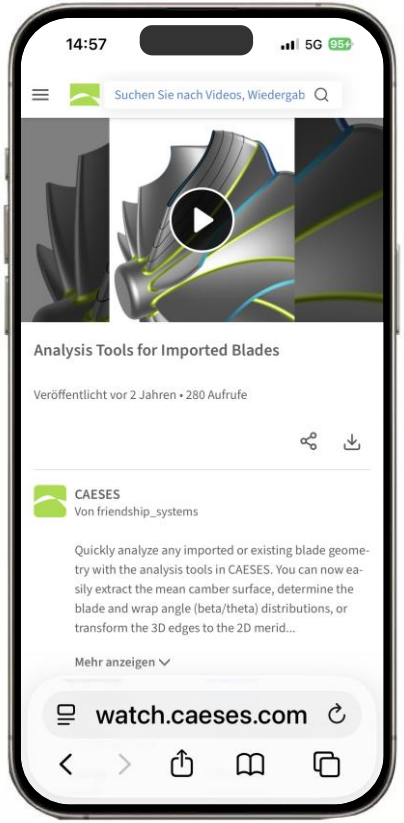
Comprehensive online documentation





Video channel



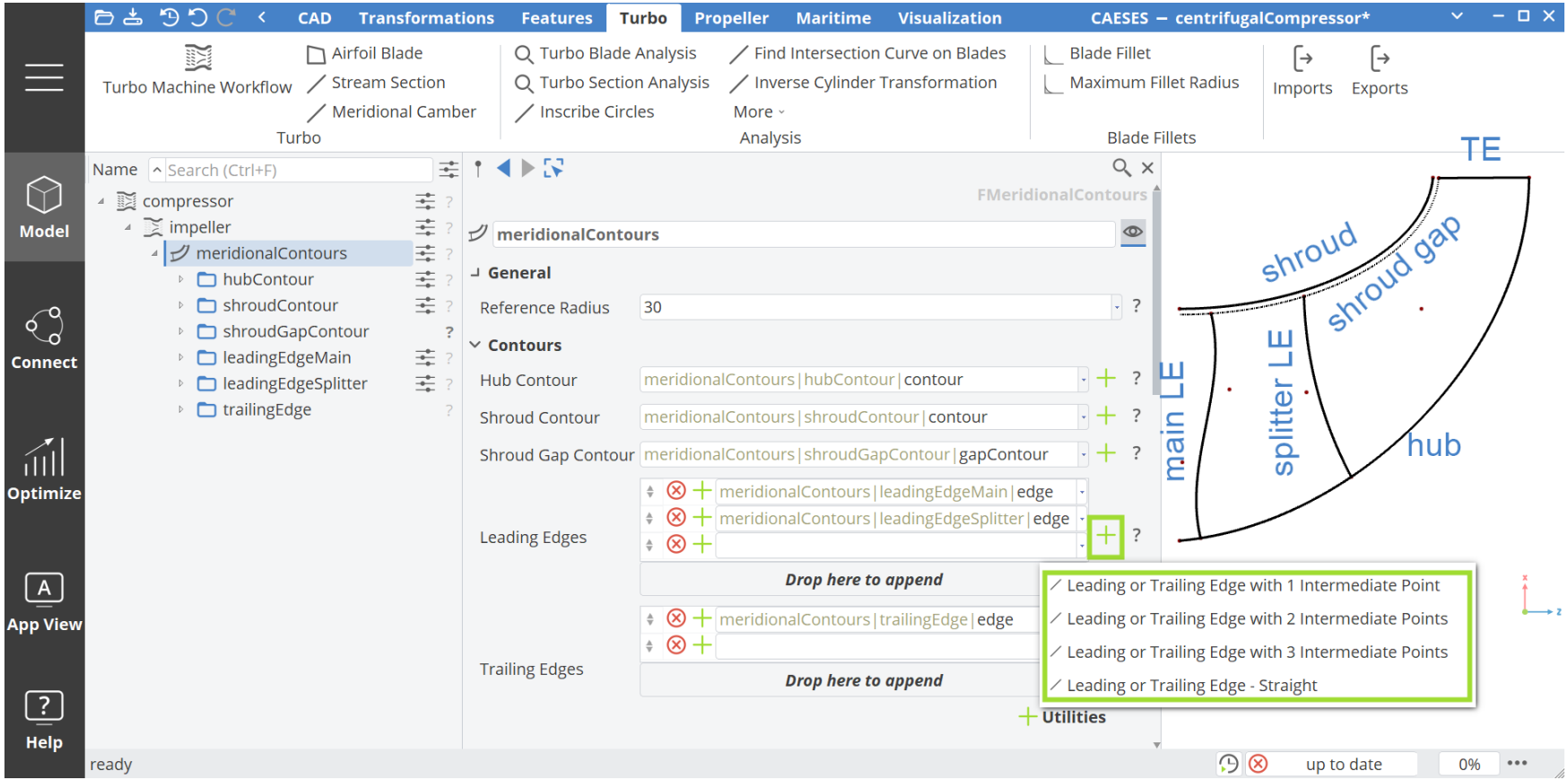


Dedicated workflows and appification

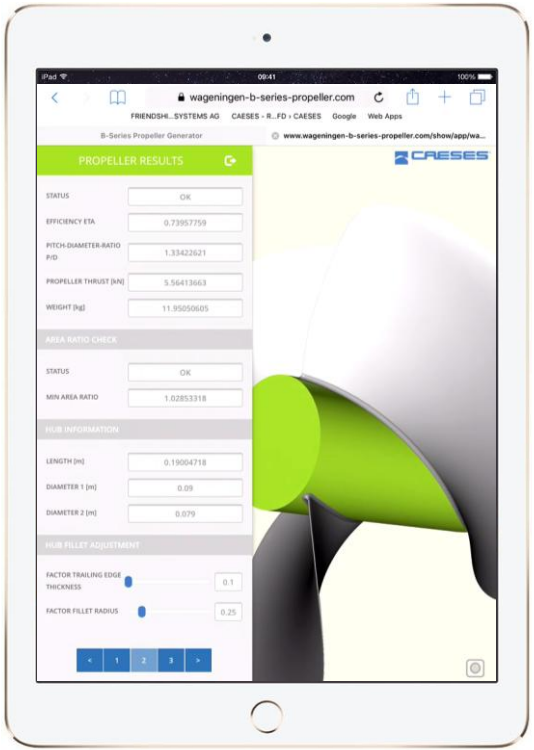
Dedicated workflows

- Motivation
  - Step-by-step process for the geometrical modeling of functional surfaces
  - Support designers in selecting and using context specific features (verticals)
  - Keep the project structure clean and organized
  - Speed up the modeling process
- Workflows
  - Turbomachinery
  - Propeller
  - Ship modeling

Dedicated workflows



Web applications based on CAESES



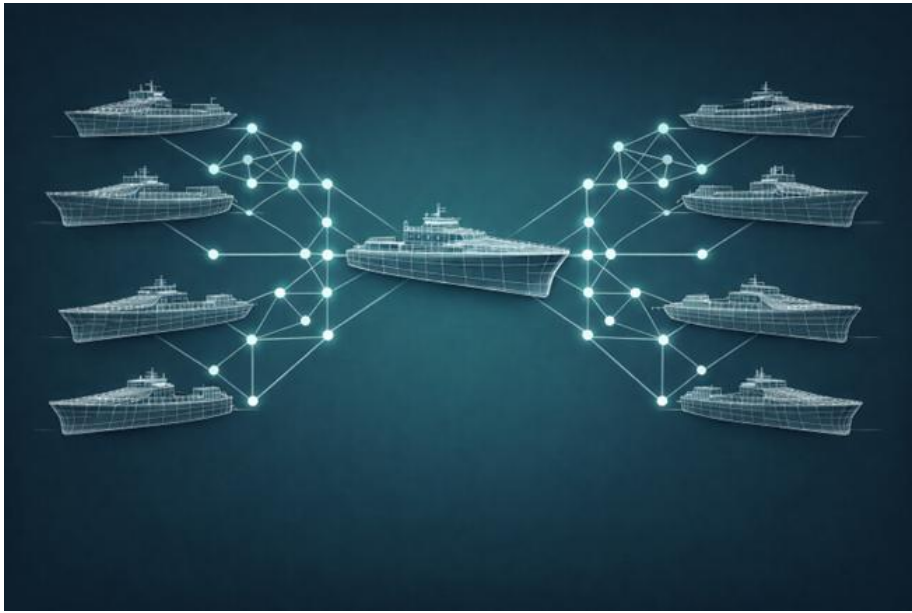
Looking forward

R&D and investments

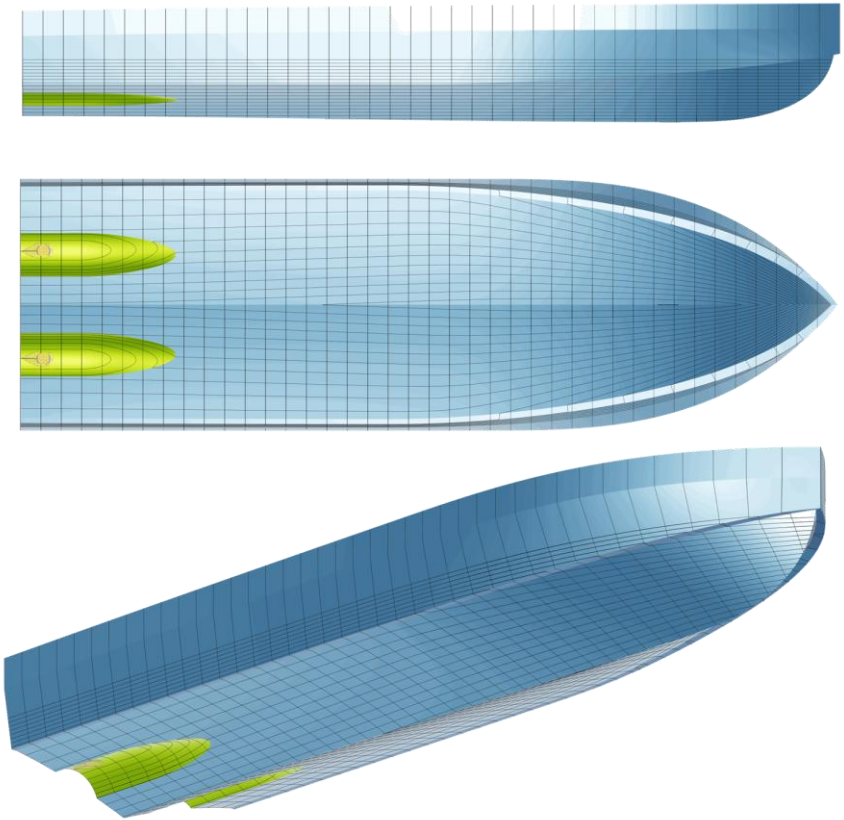
- Ongoing
  - RETROFIT55
    (EU project within Horizon Europe)
  - VIT-VI
    (German project within ProFIT)
  - DesignAssist
    (German project financed by BMWE)
- Upcoming
  - FIT-HORIZONS
    (EU project within Horizon Europe)

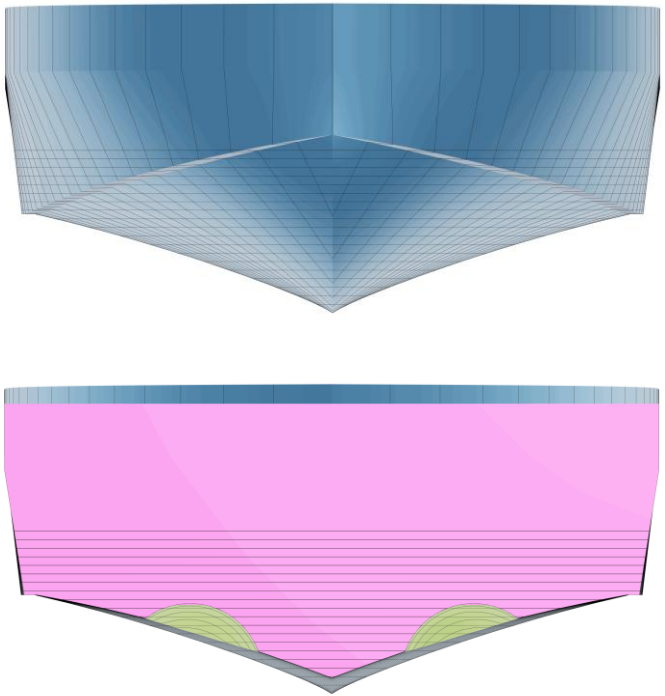
DesignAssist

- AI-Supported Systems for the Design of New Ships and Retrofits
  - Strategic extension: AI-supported design evaluation within CAESES
  - New capabilities: Weight estimation, stability assessment, automated layouts – all parametric and variant-based
  - Practical relevance: RoPax and electric ferries as demonstrators with direct link to the energy transition

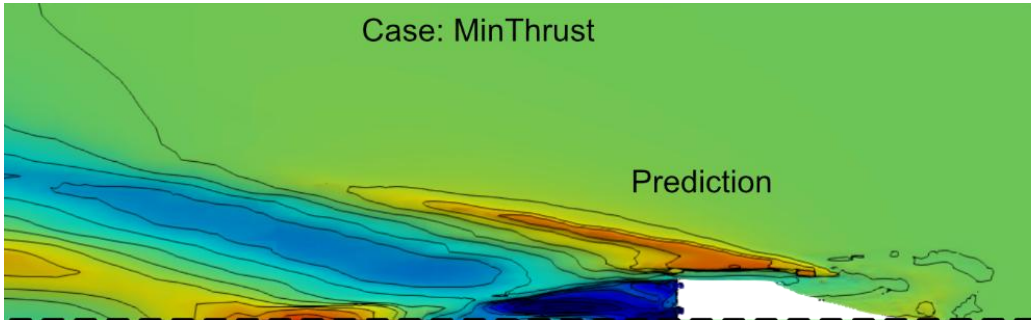


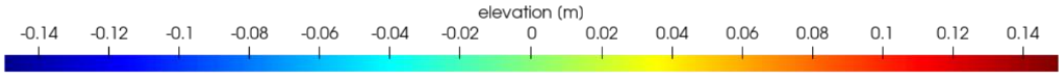
Variation of the bare hull with tunnel kept constant





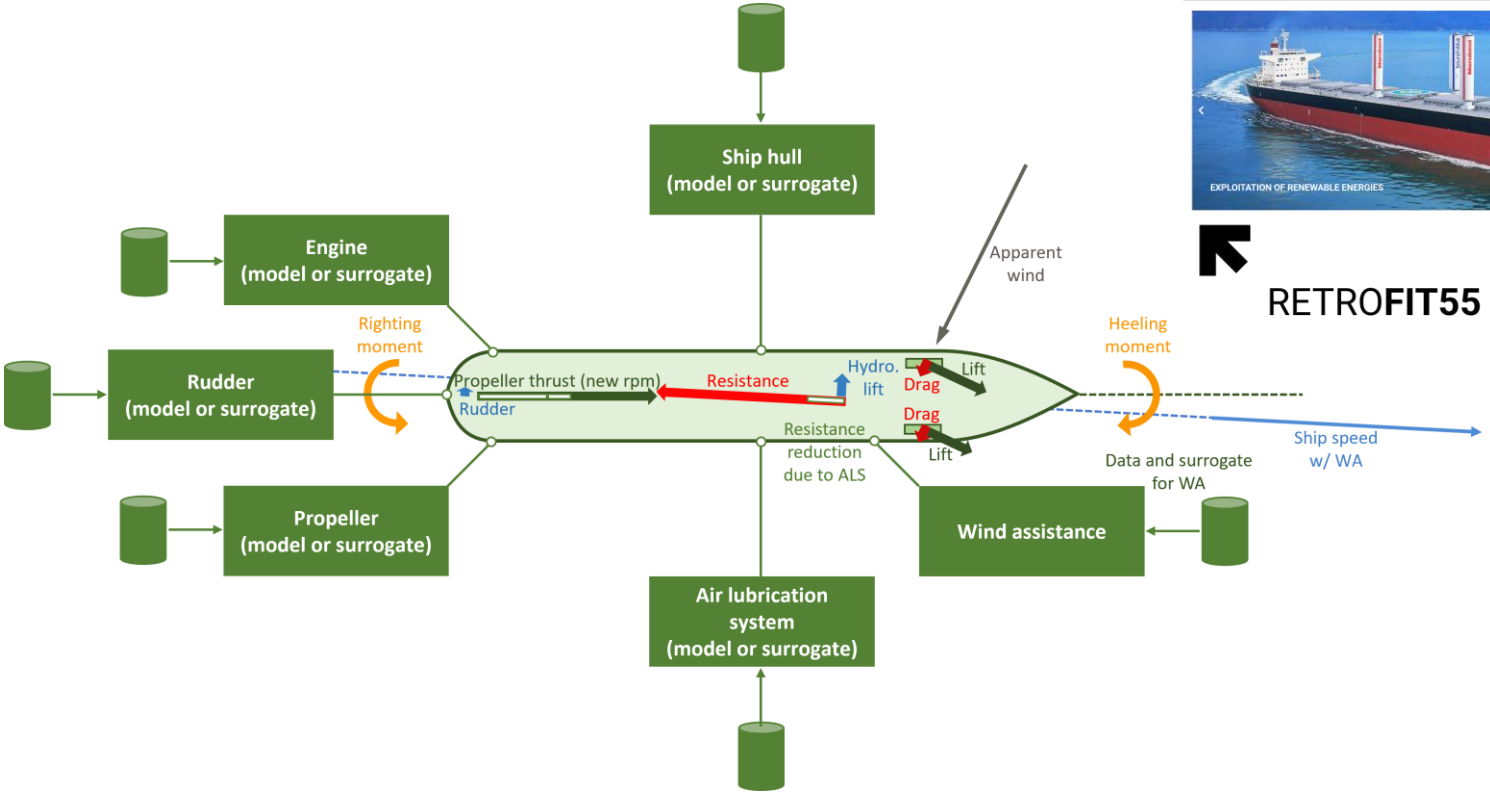
ML results vs. CFD – Wave field for design with min. thrust





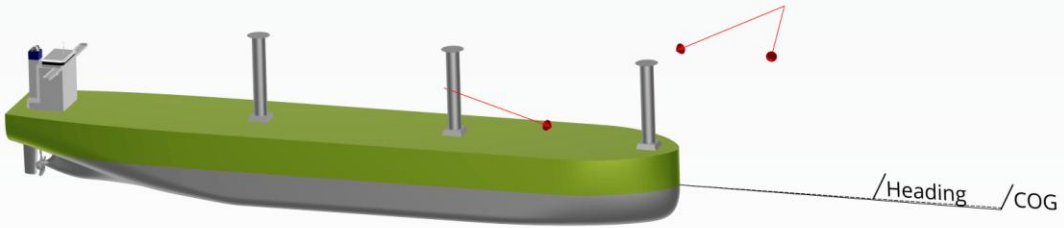
RETROFIT55 and FIT-HORIZONS

RETROFIT55

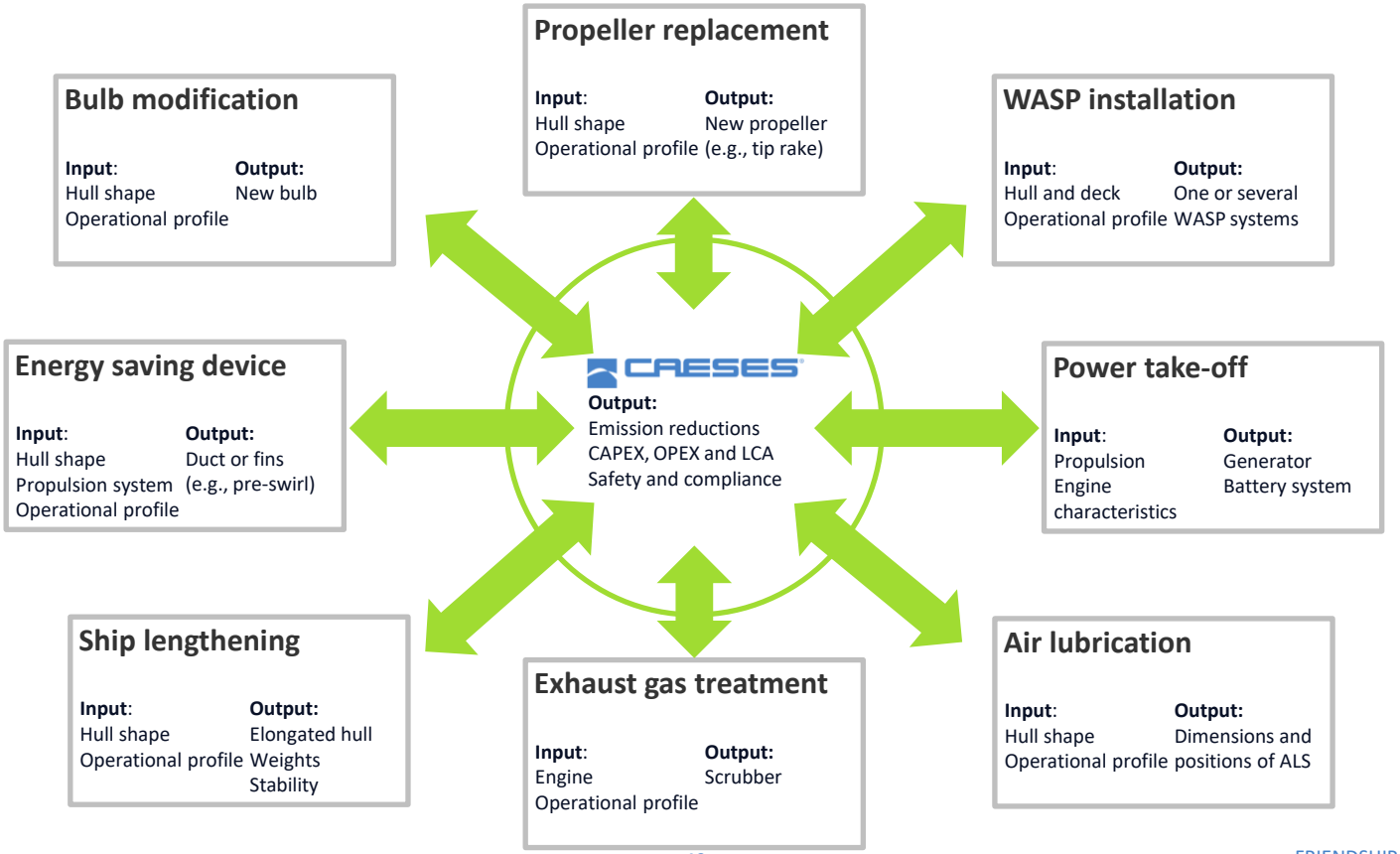


RETROFIT55 and FIT-HORIZONS

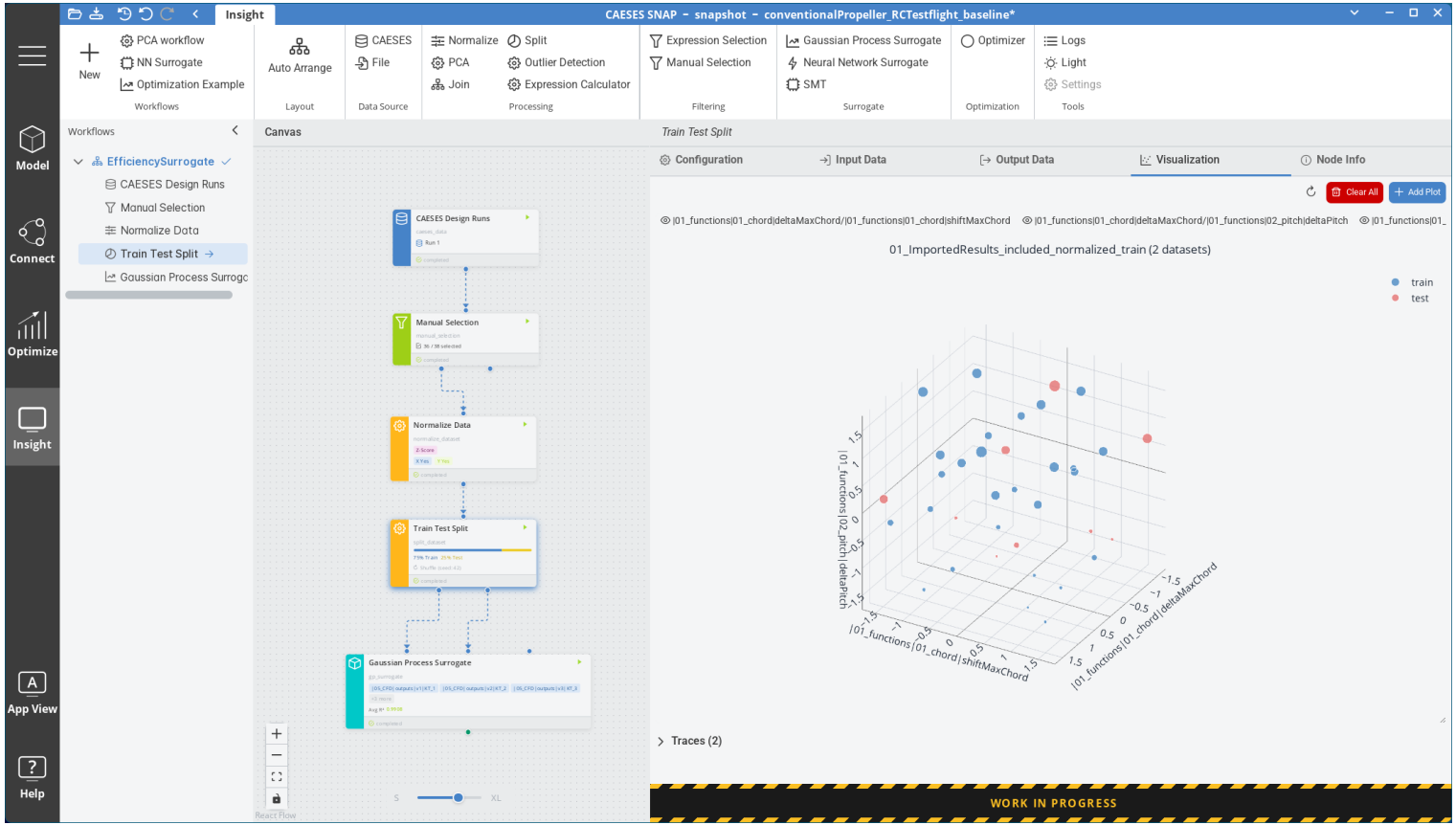
RETROFIT55



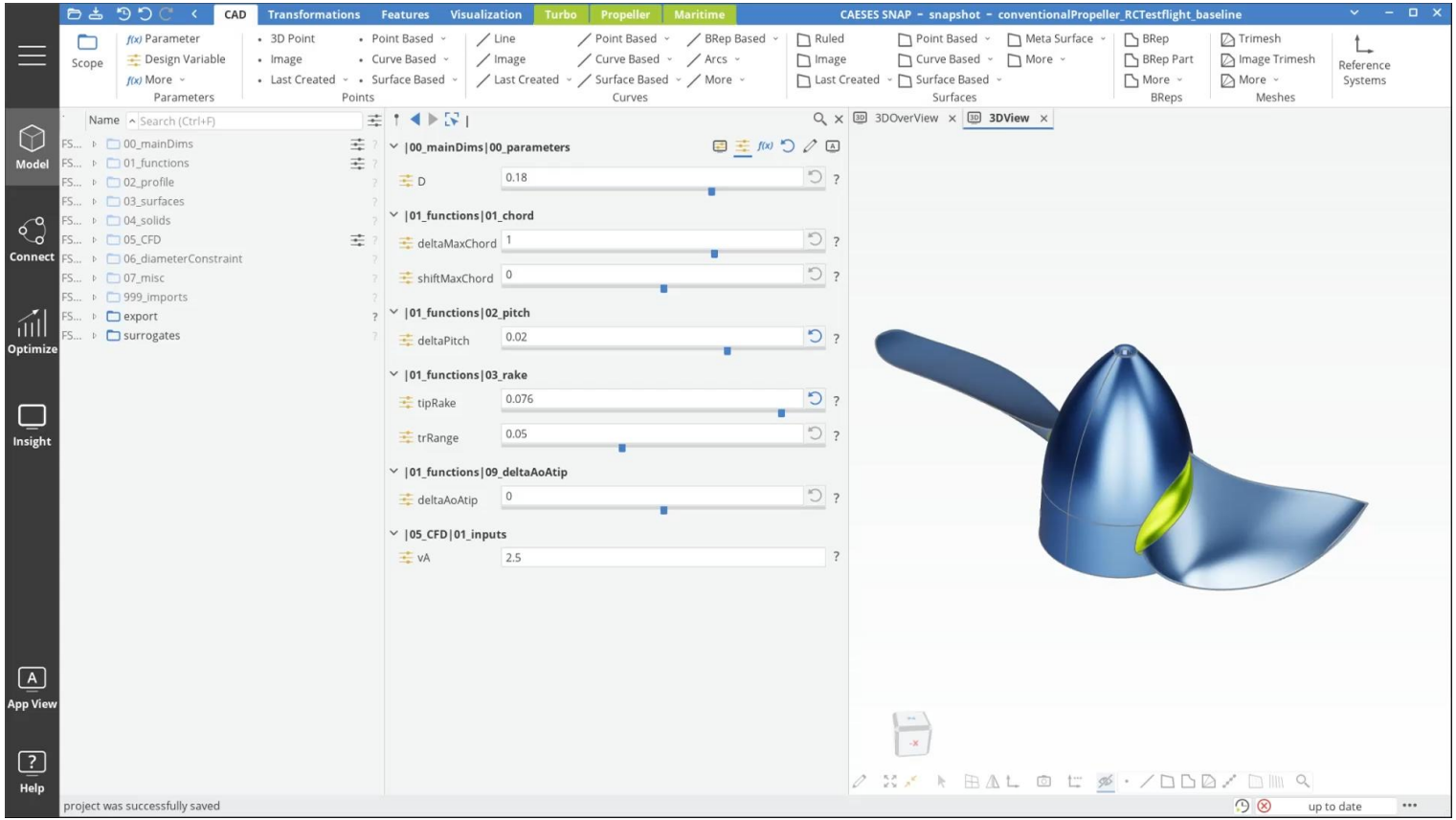
FIT-HORIZONS – Many combinations to improve ships in service



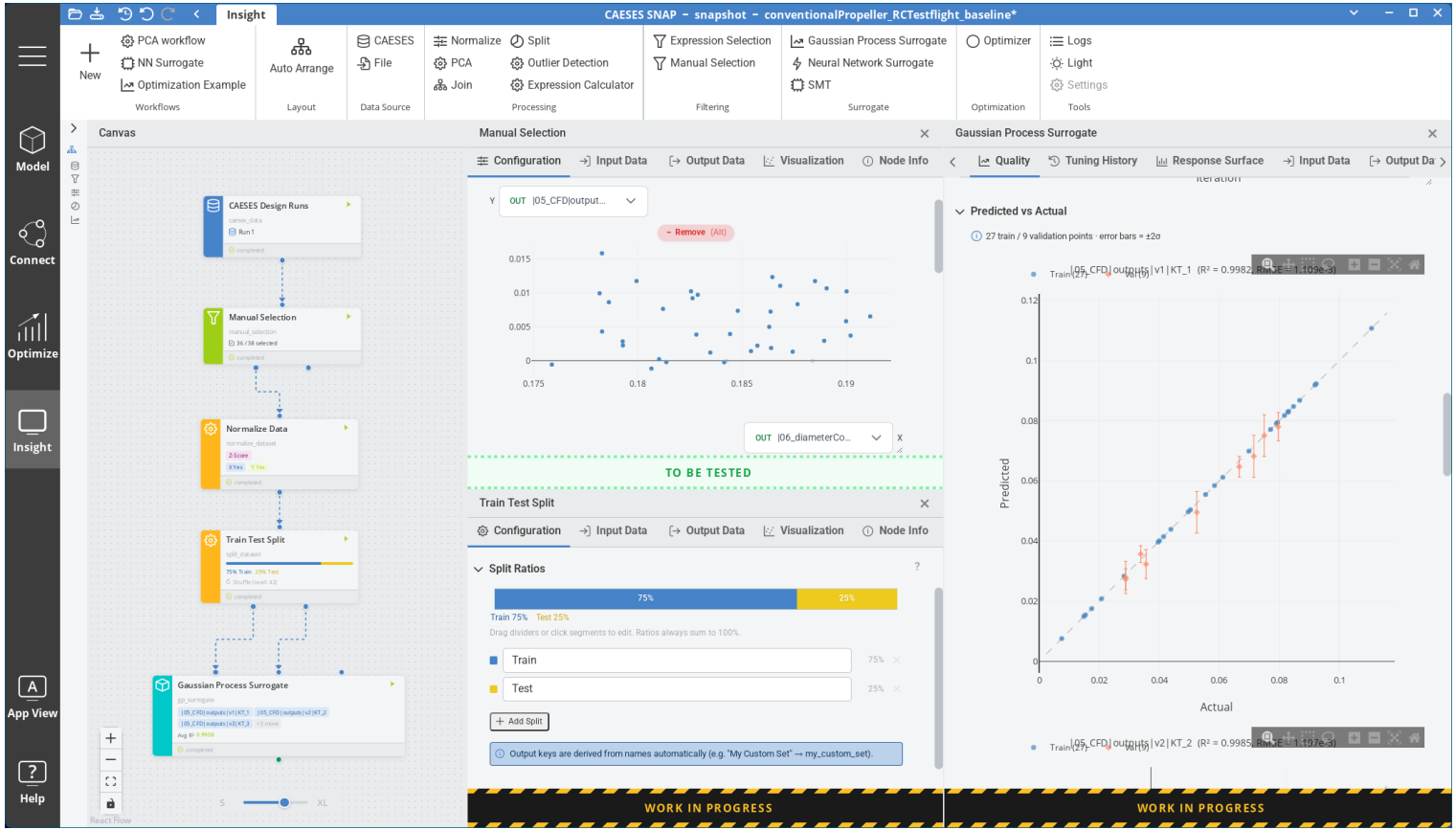
CAESES Insight (current developments)



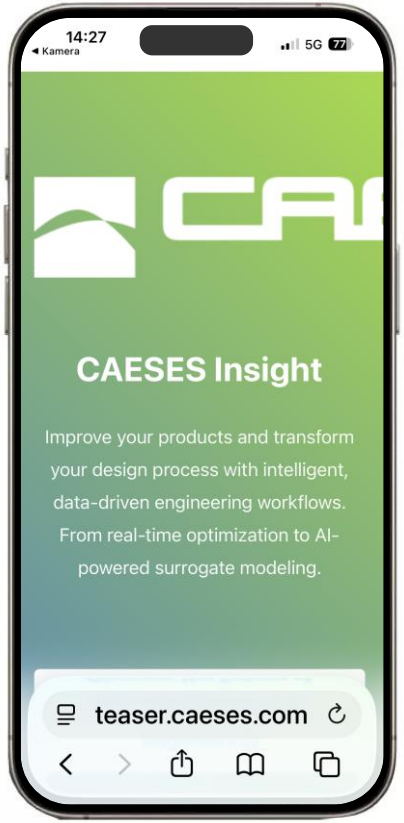
CAESES Insight (current developments)



CAESES Insight (current developments)



CAESES Insight (current developments)



Looking back and looking forward

FRIENDSHIP SYSTEMS

- Head office located in Potsdam, Germany
- Subsidiary in NYC, NY / Cambridge, MA
- Partner for simulation-driven design with 25 years of experience in parametric modeling, optimization and machine learning
- Agile team of 25+ people (primarily engineers, computer scientists and software developers)

2021 Climate Neutral Company with First Climate

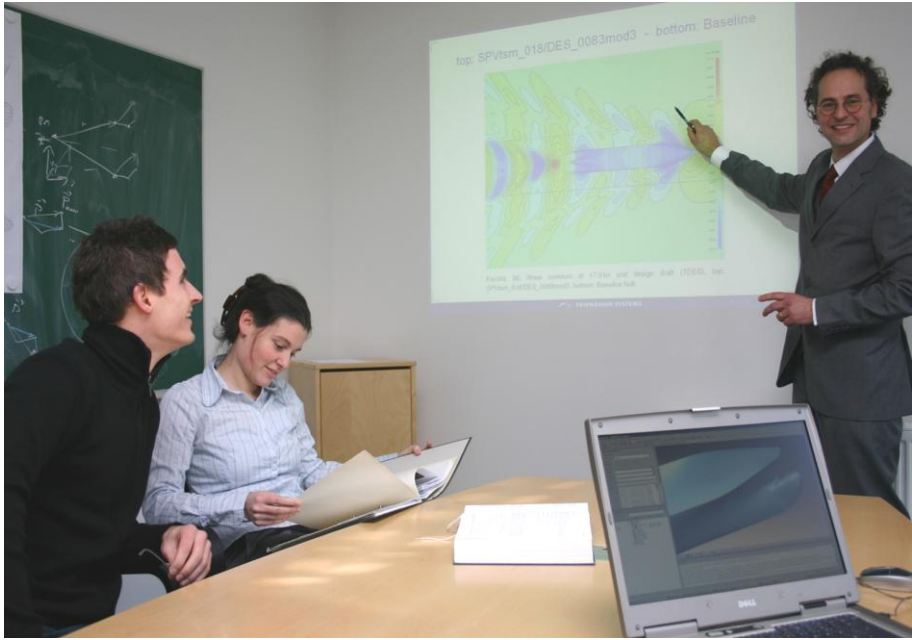
Clear focus and dedication

Simulation-Driven Design (SDD) and Data-Driven Engineering (DDE)

Customers (selection)

Thank you very much for celebrating 25 years with us

The years go by – but it is very worthwhile and still a lot of fun



Claus and Stefan in 2007

www.friendship-systems.com

Dr. Stefan Harries ***MSE***

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