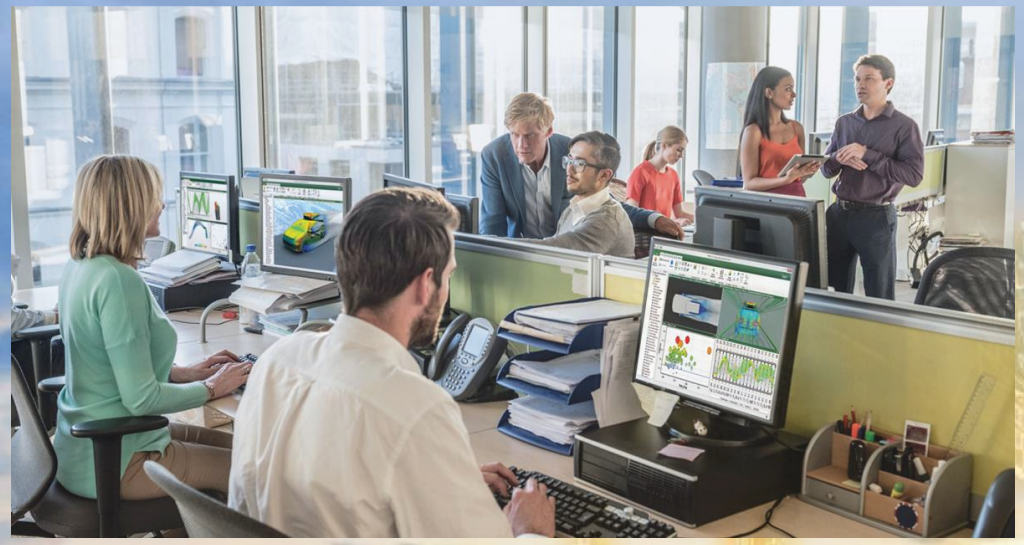

Discover Better Designs, *Faster!*

Driving Product Innovation Through Design Exploration

Realize Innovation.

Marine Ship Design

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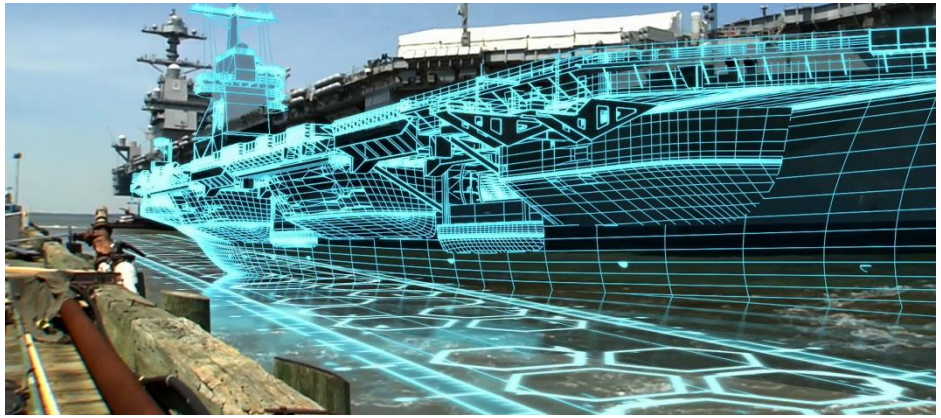

Modern ship design is a complex, and time consuming process. During tender phase, time is limited, and proposing a hull design that minimizes CAPEX during build, whilst meeting OPEX demands of the customer as well as certification requirements, remains a challenging task.

Securing margin early in the design phase is paramount to a Shipbuilder staying well afloat leading the field, and dominating the market.

This presentation highlights how modern **Process Automation**, **Simulation**, and **Design Space Exploration** using **HEEDS MDO**, deployed together with **Simcenter NX** and **STAR-CCM+** can power engineers to **discover better designs, *faster***!

Case Study: Simulation Driven Ship Design

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A Typical Offshore Supply Vessel (OSV) will be used as an example case, with a design speed of 13 knots.

Objectives:

- Minimize Steel Weight (CAPEX)
- Minimize Vessel Resistance (OPEX)

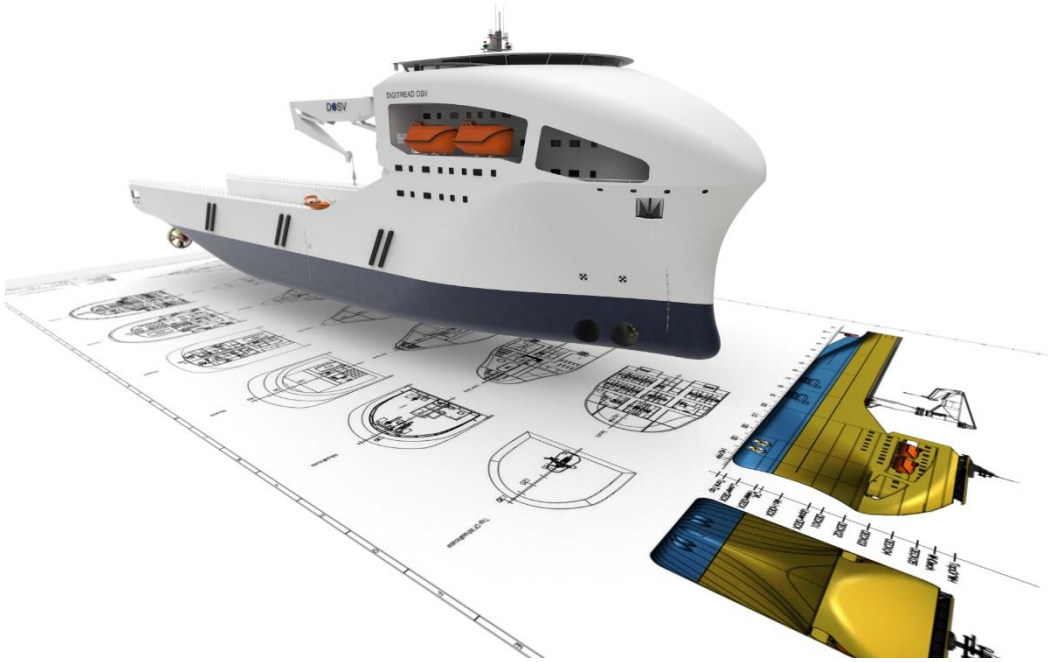
Constraints:

- -3 ≤ Pitch ≤ 3 (degrees)
- Metacentric Height (GM) **≥** 0.1m
- Main deck space area ≥ 800m2
- Freeboard ≥ 0.25m

Stability Period

$$T = \frac{2\pi k}{\sqrt{gGM}}$$

Offshore Supply Vessel D-OSV



D-OSV courtesy of Digitread AS

Case Study: Simulation Driven Ship Design

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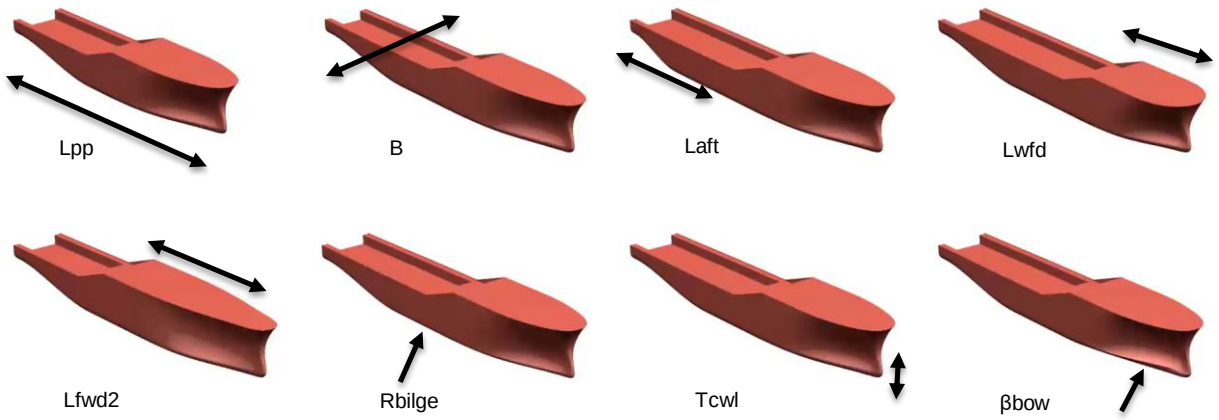
Design Variables:

- Eight independent variables are used to modify the baseline design vessel's hull shape.
- For each design, these variables are used to update the NX CAD model used directly within STAR-CCM+ for the Resistance and Hydrostatics calculations.



Parameter			Range		
			Min	Baseline	Max
length	Lpp	[m]	105	115	130
beam	B	[m]	20	25	30
bilge radius	Rbilge	[m]	2	2.8	3.6
bow shape	Tcwl	[m]	6	7	8
bow tightness	βbow	[deg]	40	65	75
run entry fwd	Lfwd	[m]	45	57	80
run entry shoulder	Lfwd2	[m]	5	30	50
run entry aft	Laft	[m]	20	40	65

Case Study: Simulation Driven Ship Design

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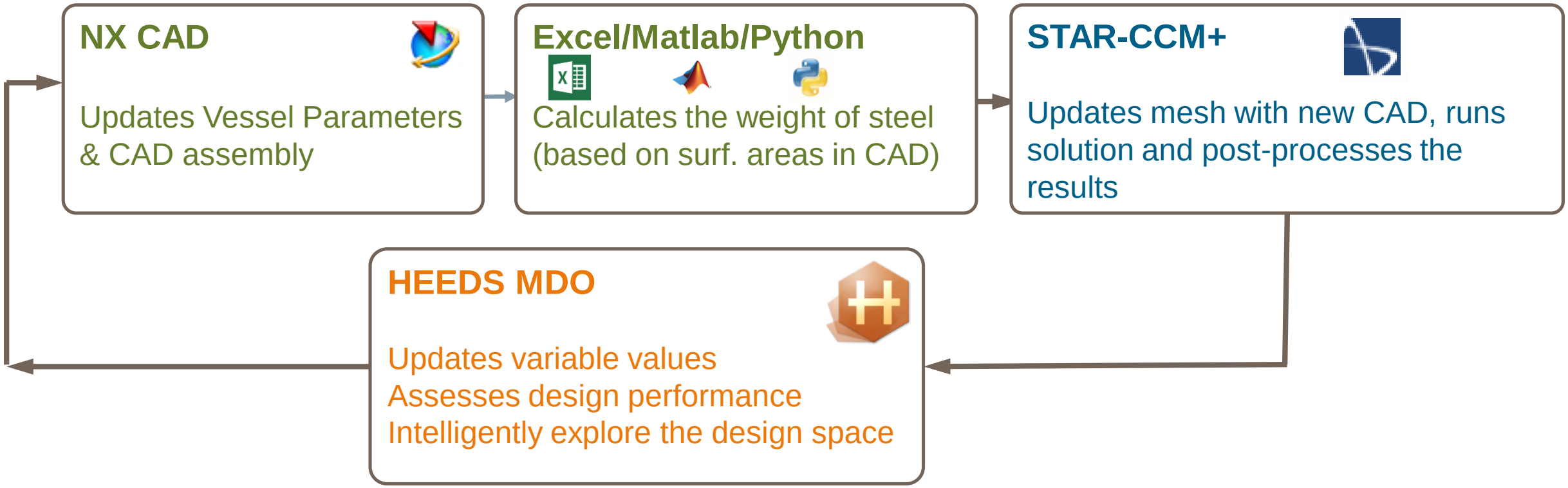
Process Automation:



Process Automation
NX CAD Portal

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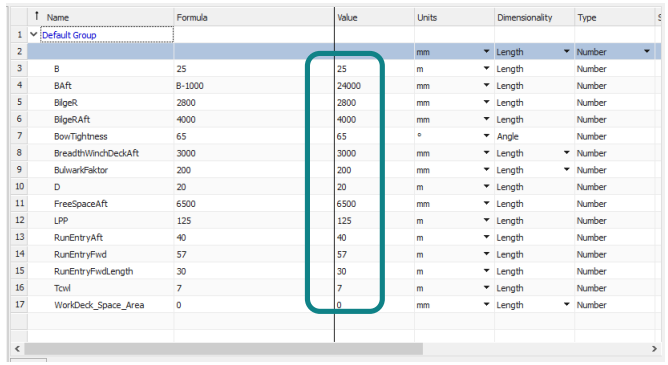
A parametric CAD model is built using NX CAD
HEEDS drives the parametric CAD model via the Expressions Table using its direct interface (portal) to NX

NX CAD

HEEDS

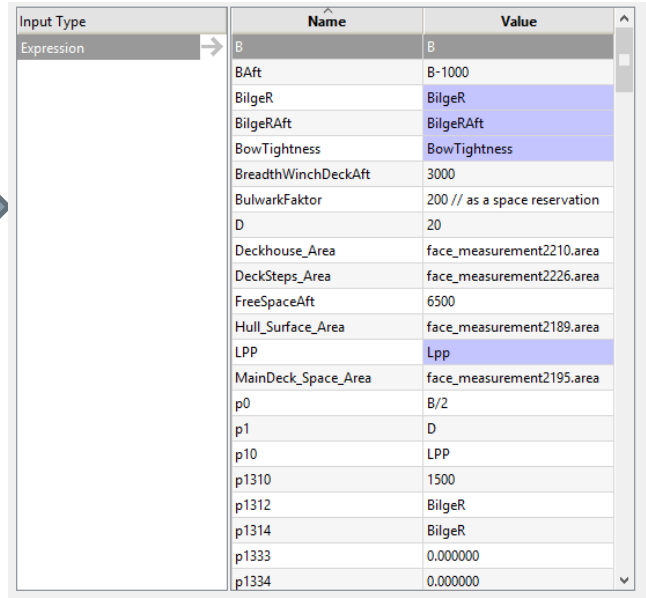
Tag

NX CAD



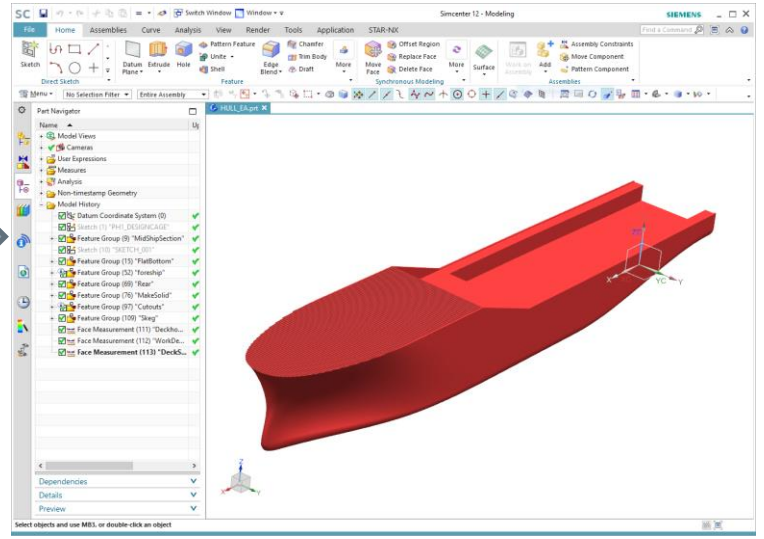
	Name	Formula	Value	Units	Dimensionality	Type
1	Default Group					
2				mm	Length	Number
3	B	25	25	m	Length	Number
4	BAft	B-1000	24000	mm	Length	Number
5	BilgeR	2800	2800	mm	Length	Number
6	BilgeRAft	4000	4000	mm	Length	Number
7	BowTightness	65	65	°	Angle	Number
8	BreadthWinchDeckAft	3000	3000	mm	Length	Number
9	BulwarkFaktor	200	200	mm	Length	Number
10	D	20	20	m	Length	Number
11	FreeSpaceAft	6500	6500	mm	Length	Number
12	LPP	125	125	m	Length	Number
13	RunEntryAft	40	40	m	Length	Number
14	RunEntryFwd	57	57	m	Length	Number
15	RunEntryFwdLength	30	30	m	Length	Number
16	Tcwl	7	7	m	Length	Number
17	WorkDeck_Space_Area	0	0	mm	Length	Number

Parametric CAD Expressions



Input Type	Name	Value
Expression	B	B
	BAft	B-1000
	BilgeR	BilgeR
	BilgeRAft	BilgeRAft
	BowTightness	BowTightness
	BreadthWinchDeckAft	3000
	BulwarkFaktor	200 // as a space reservation
	D	20
	Deckhouse_Area	face_measurement2210.area
	DeckSteps_Area	face_measurement2226.area
	FreeSpaceAft	6500
	Hull_Surface_Area	face_measurement2189.area
	LPP	Lpp
	MainDeck_Space_Area	face_measurement2195.area
	p0	B/2
	p1	D
	p10	LPP
	p1310	1500
	p1312	BilgeR
	p1314	BilgeR
	p1333	0.000000
	p1334	0.000000

HEEDS NX CAD Tagging



Updated Assembly

Process Automation
Simcenter STAR-CCM+ Portal

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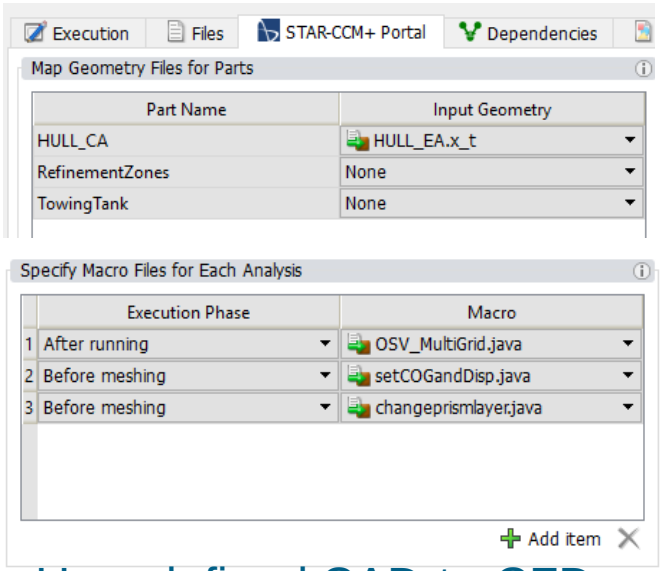
HEEDS‘ STAR-CCM+ Portal works directly with .sim files, performs any user-defined procedures (execution of Java macros, exporting of reports, plots, scenes, etc.)

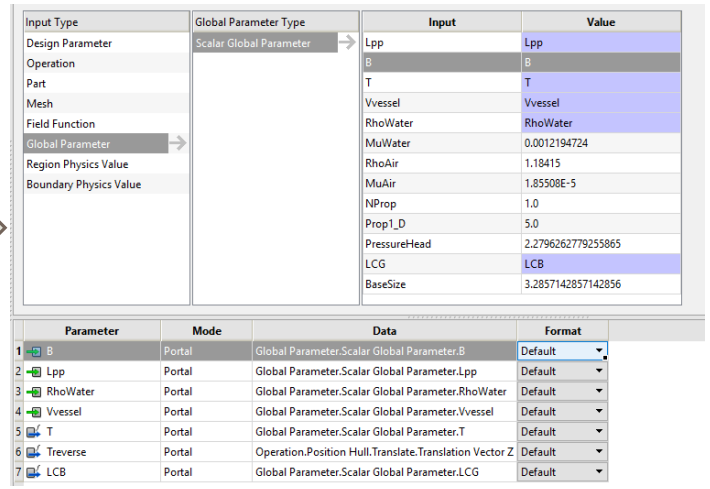
HEEDS



User defined CAD-to-CFD preparation

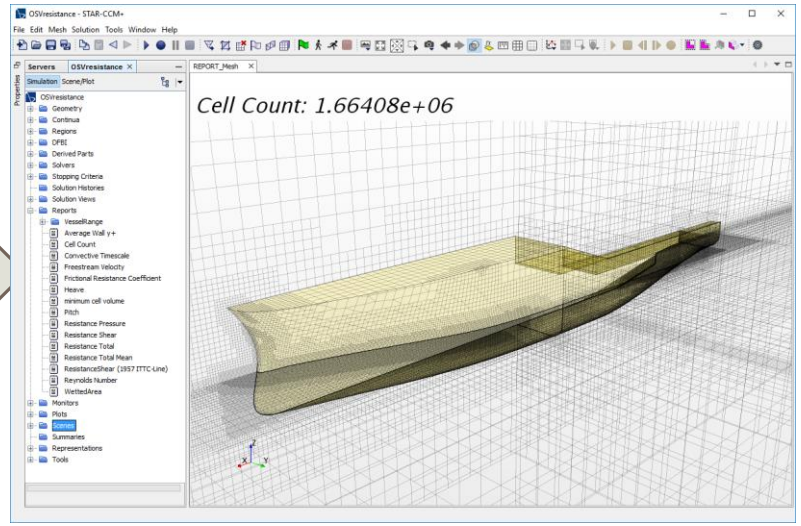
HEEDS

Tag



HEEDS Tagging

STAR-CCM+



Updated mesh ready for simulation

Efficient Design Exploration

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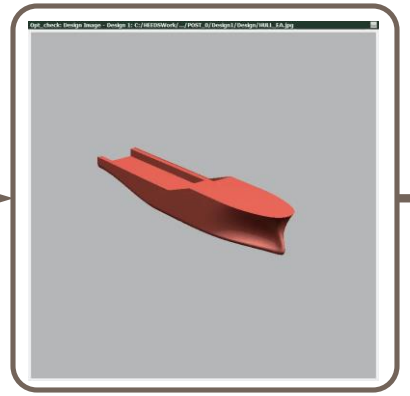
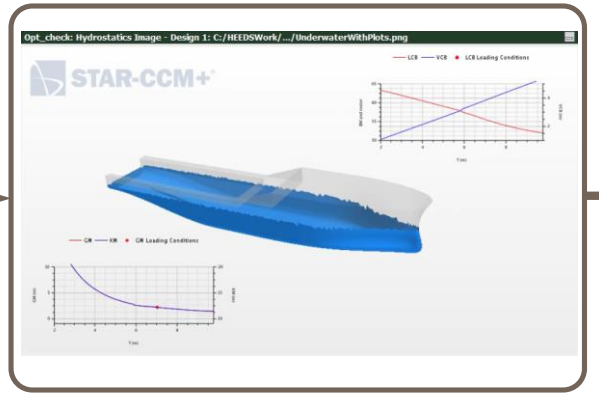
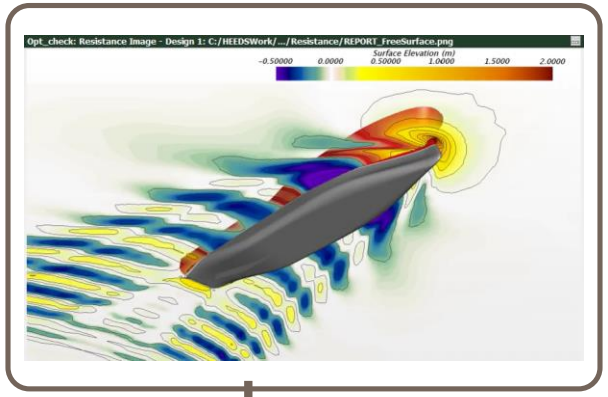
Update Ship Geometry

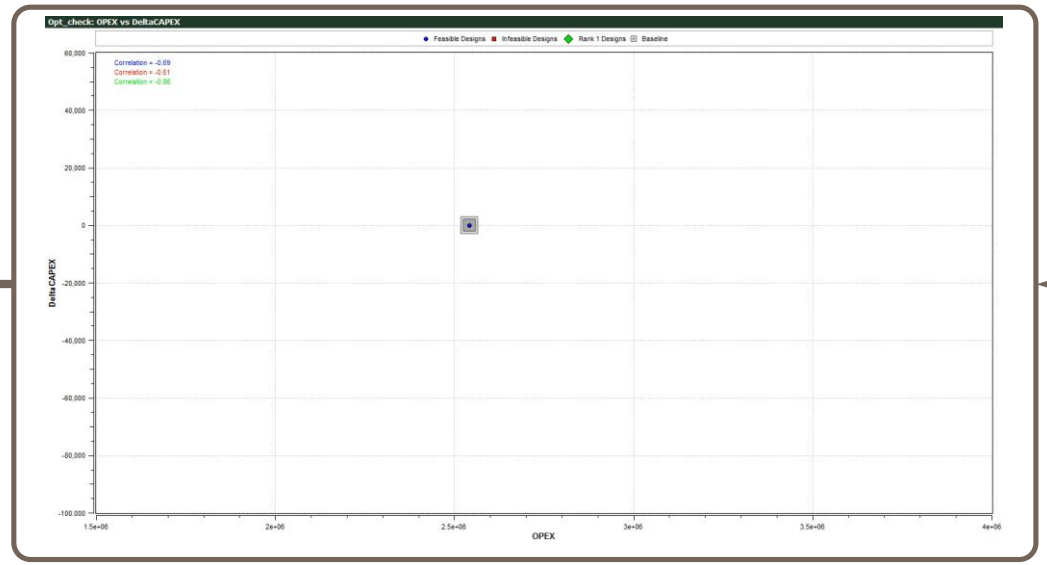


Calculate Steel Weight

Calculate Hydrostatics & Resistance







Directed Modification

HEEDS' intelligent search method

- **Hybrid & Adaptive**
- **No tuning parameters or expertise required**
- **No model fitting or surrogates**

Scalable Computation

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Ingenuity for life

NX CAD
- Windows Laptop
- 1 core / job
- 4 concurrent jobs

Hydrostatics
- Linux Workstation
- 1 core / job
- 8 concurrent jobs

Resistance
- Linux Cluster
- 24 core / job
- 8 concurrent jobs

HEEDS MDO
- Windows Laptop
- 1 core

Design Exploration

500 Designs Evaluated
- < 4 days of wall time
- **~2 hours** per design

Design Trade-Off

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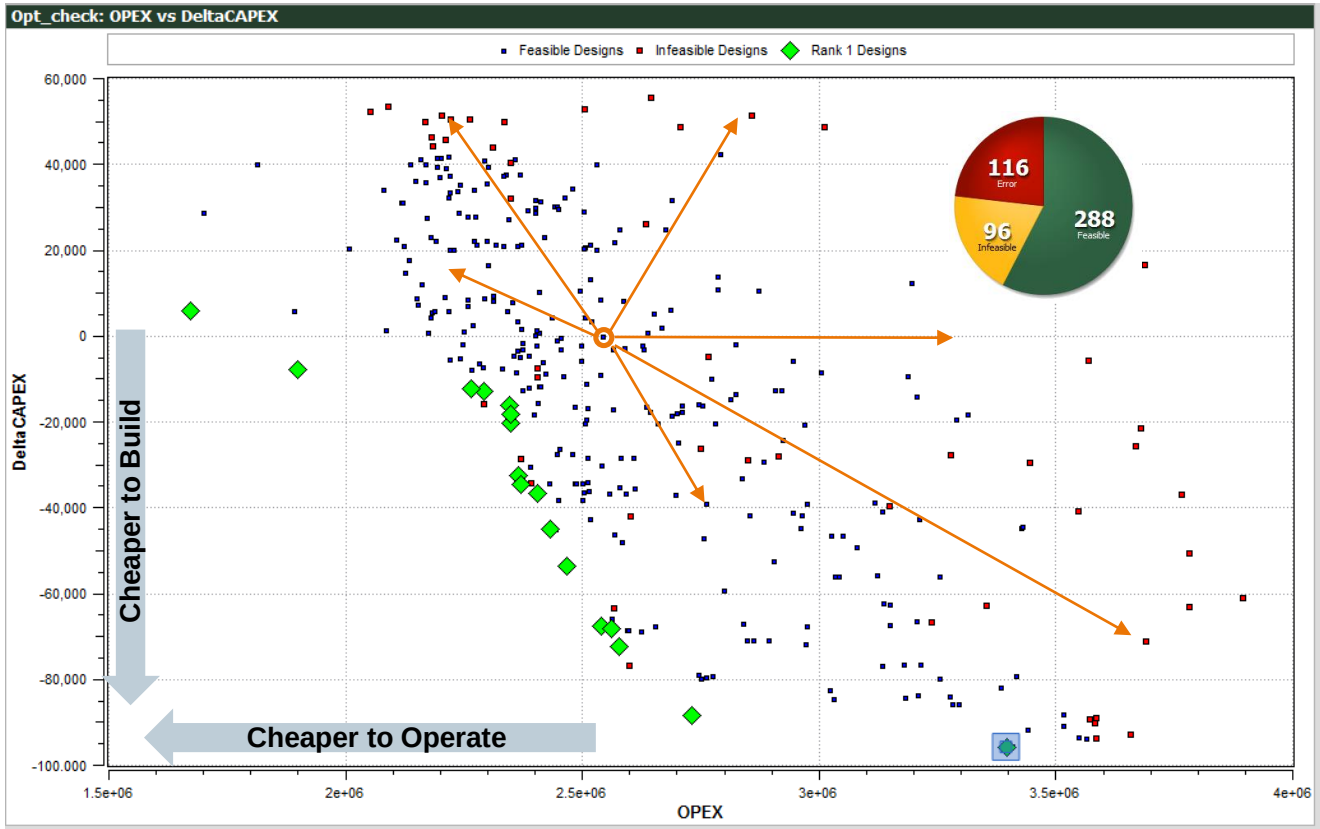

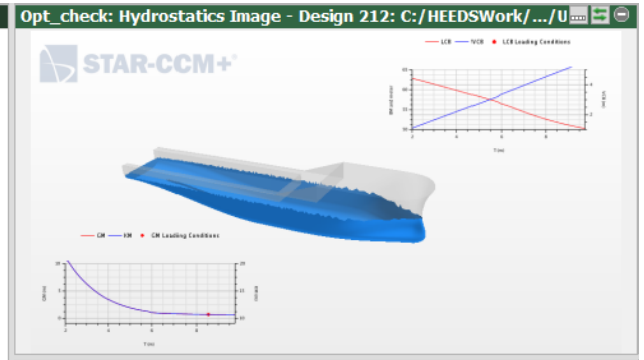

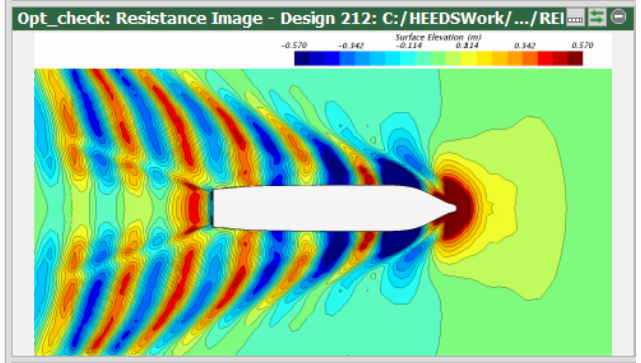

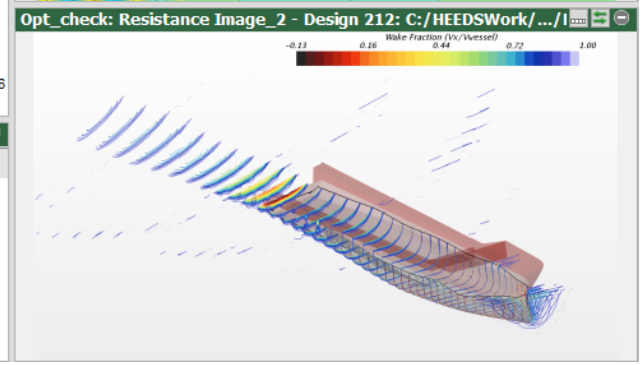

Opt_check: DesignTable_13

Design ID	DeltaCAPEX	OPEX	GM	LCB	B	Lpp	BilgeR	BowTightnes	RunEntryAft	RunEntryFwd	RunEntryFwdLengt	Tcwl
217	-53579.4	2.46726e+06	0.163022	55.1557	22	114	3600	41.1667	30.5	45	36	6.7
190	-67629.2	2.53975e+06	0.633322	51.6571	22.75	107.5	3600	56.3333	30.5	45	36.5	6.1
229	-68182.6	2.56228e+06	0.347796	50.2444	22.5	107.5	3200	58.6667	24.5	46	36	6.5
203	-72287.1	2.57834e+06	0.433653	49.0076	22.75	105.5	3600	56.3333	22	45	35	6.8
226	-88308.1	2.73108e+06	0.13836	49.6604	22	105	3600	56.3333	28.5	45	36	6.8
212	-95852	3.39548e+06	0.632084	51.8542	22	105	3600	62.1667	48	46.5	36	6.7

Design Trends – Parallel Coordinates & Multi-View

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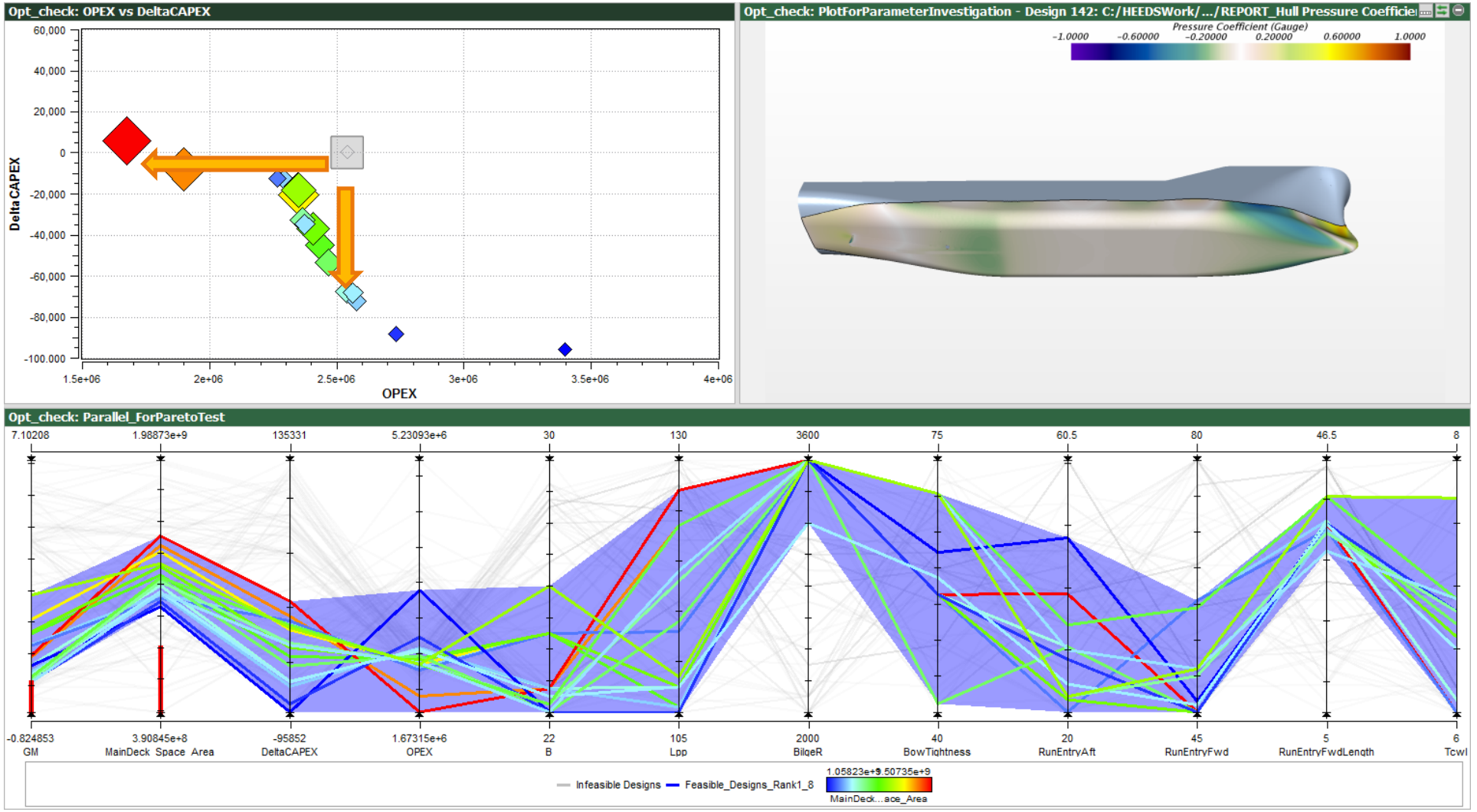

Design Trends – Correlation Matrix

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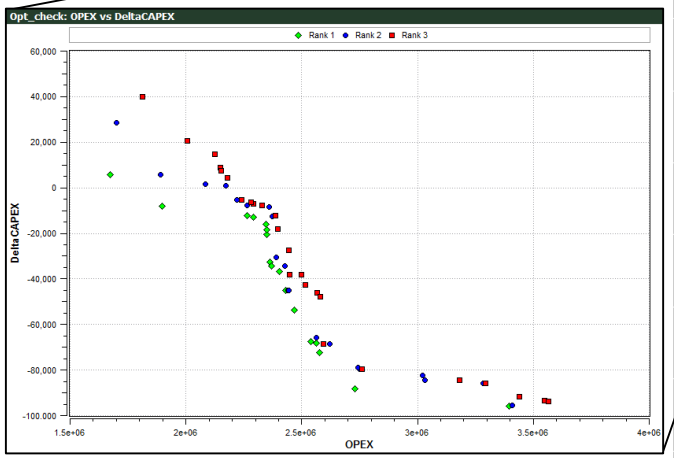

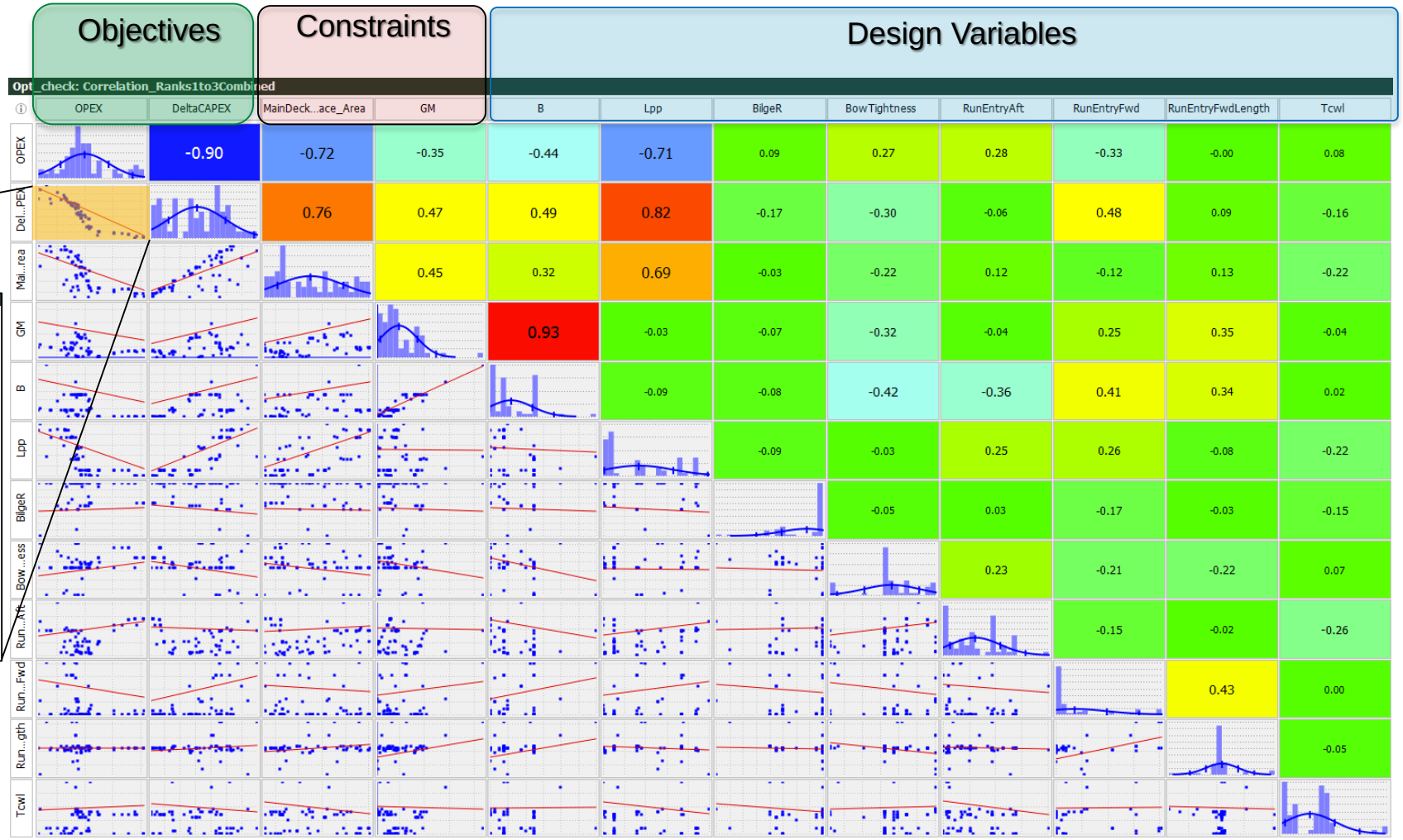

Design Trends – Parallel Coordinates Plot

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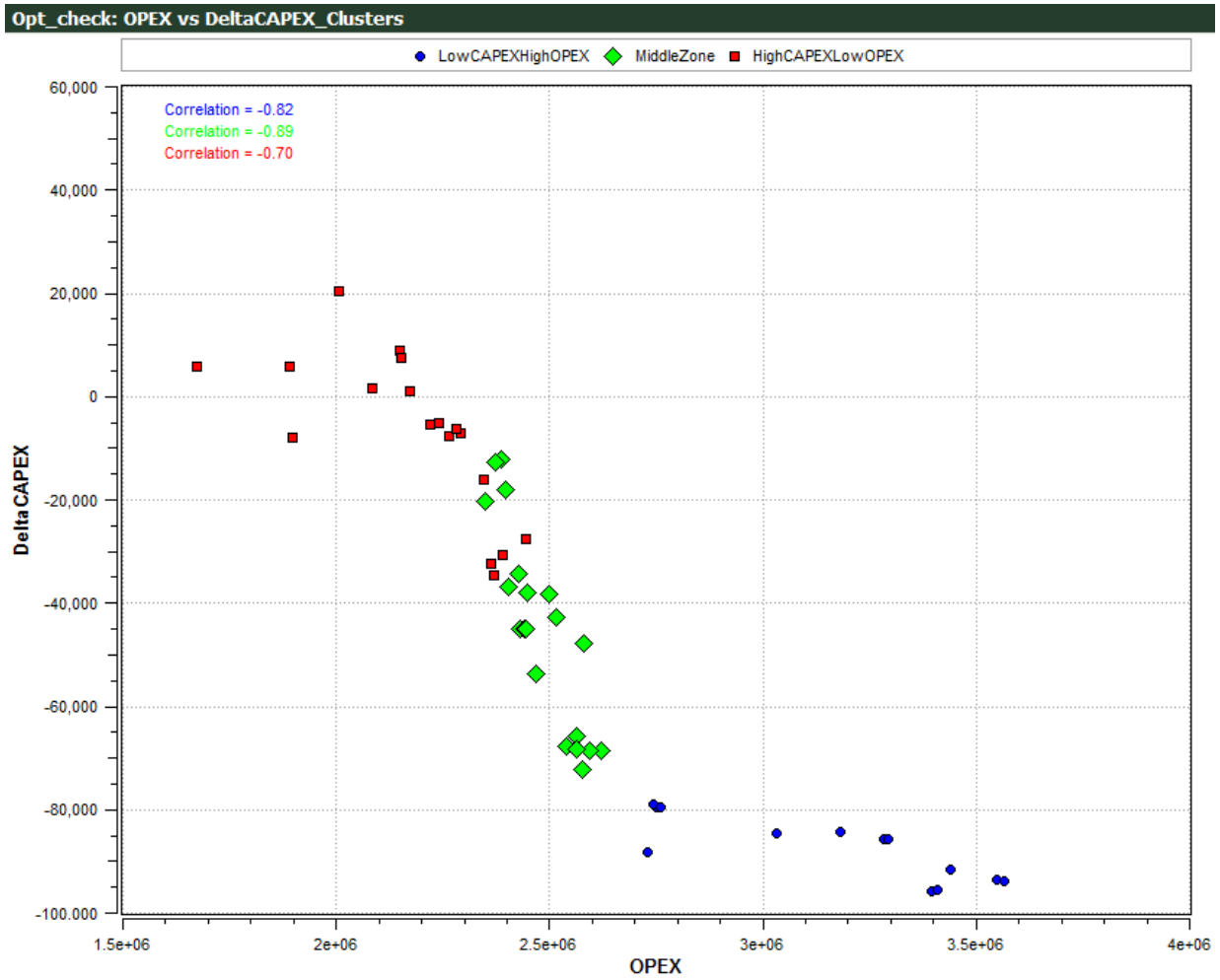

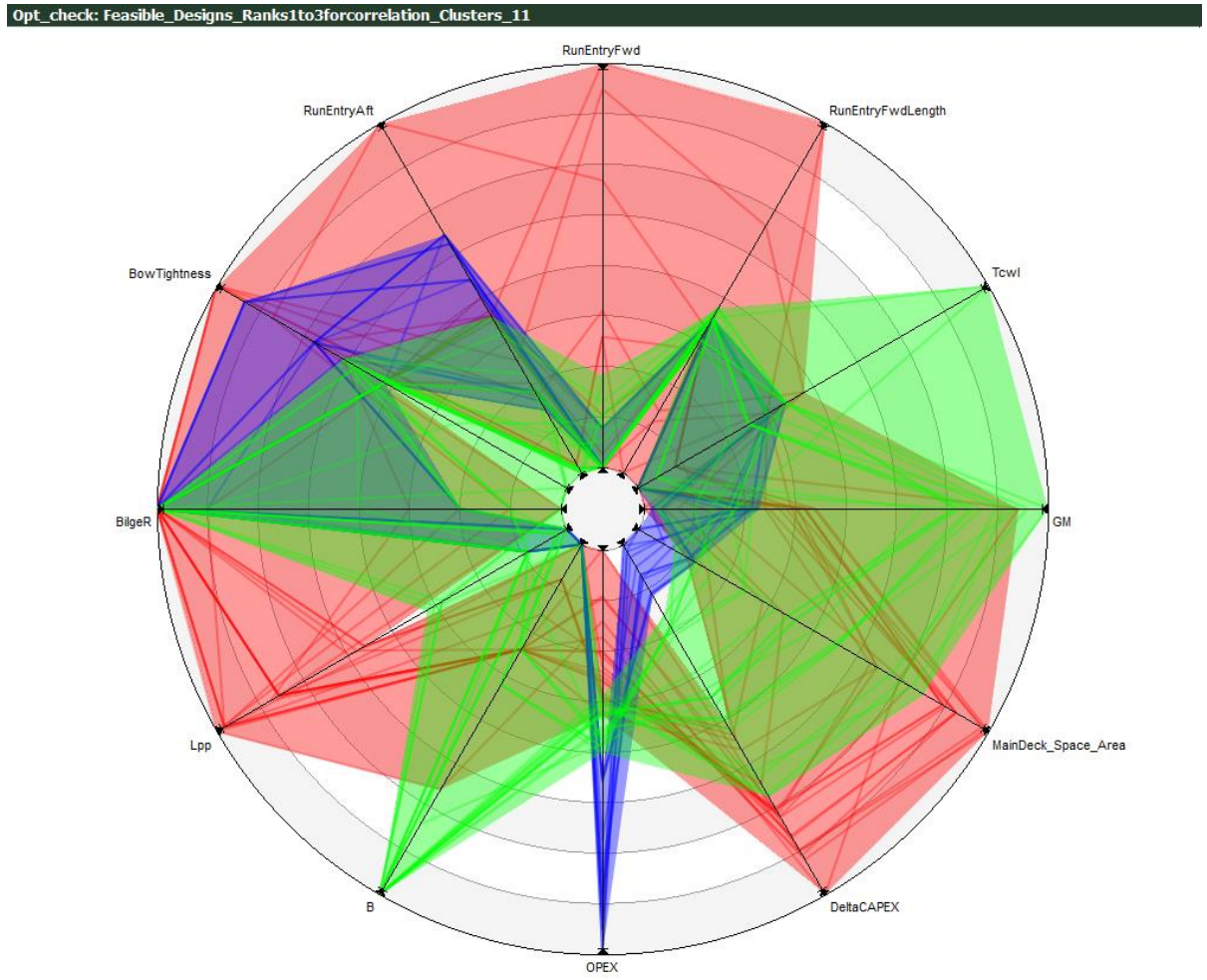

Constrained Design Space

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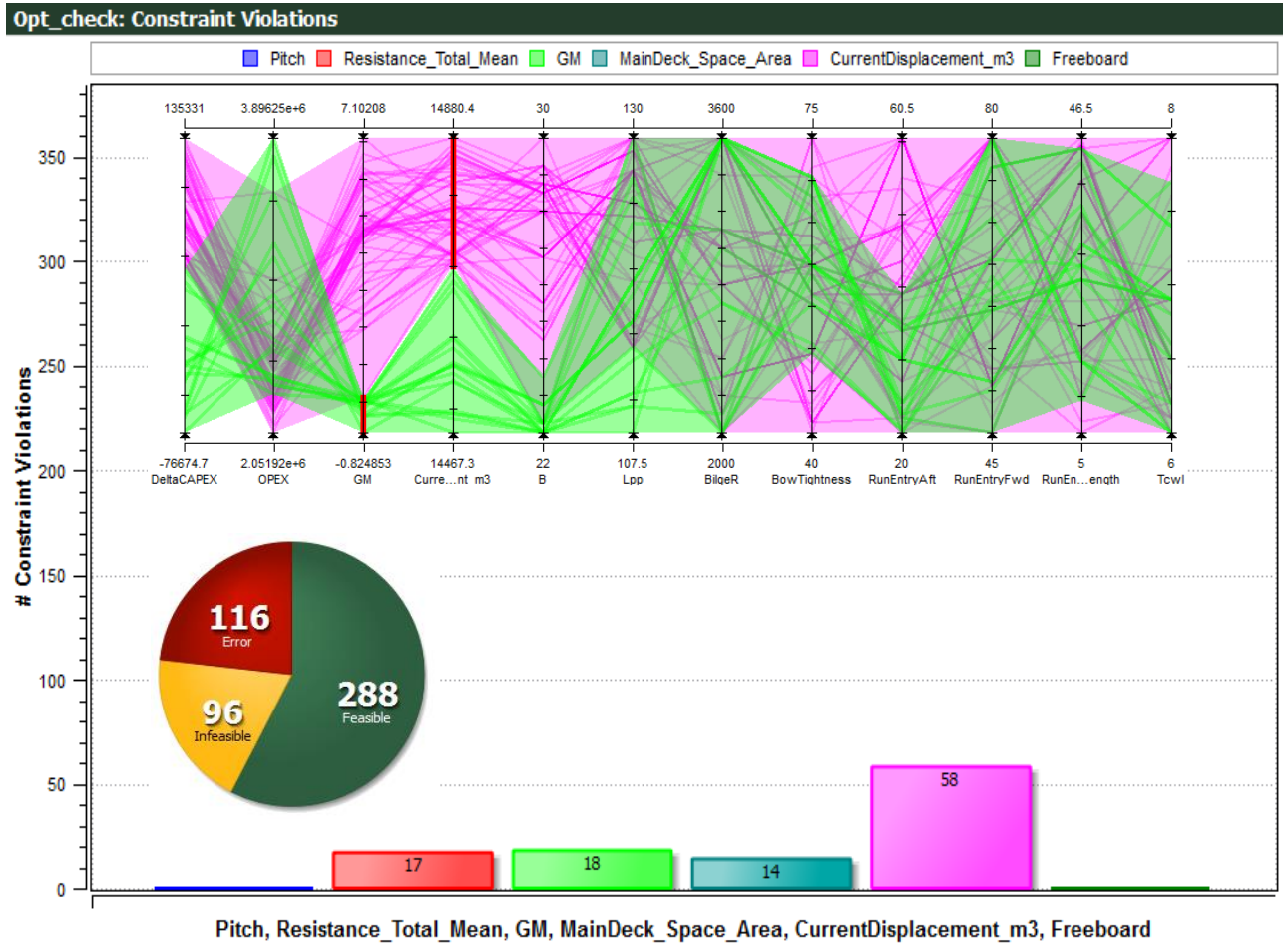

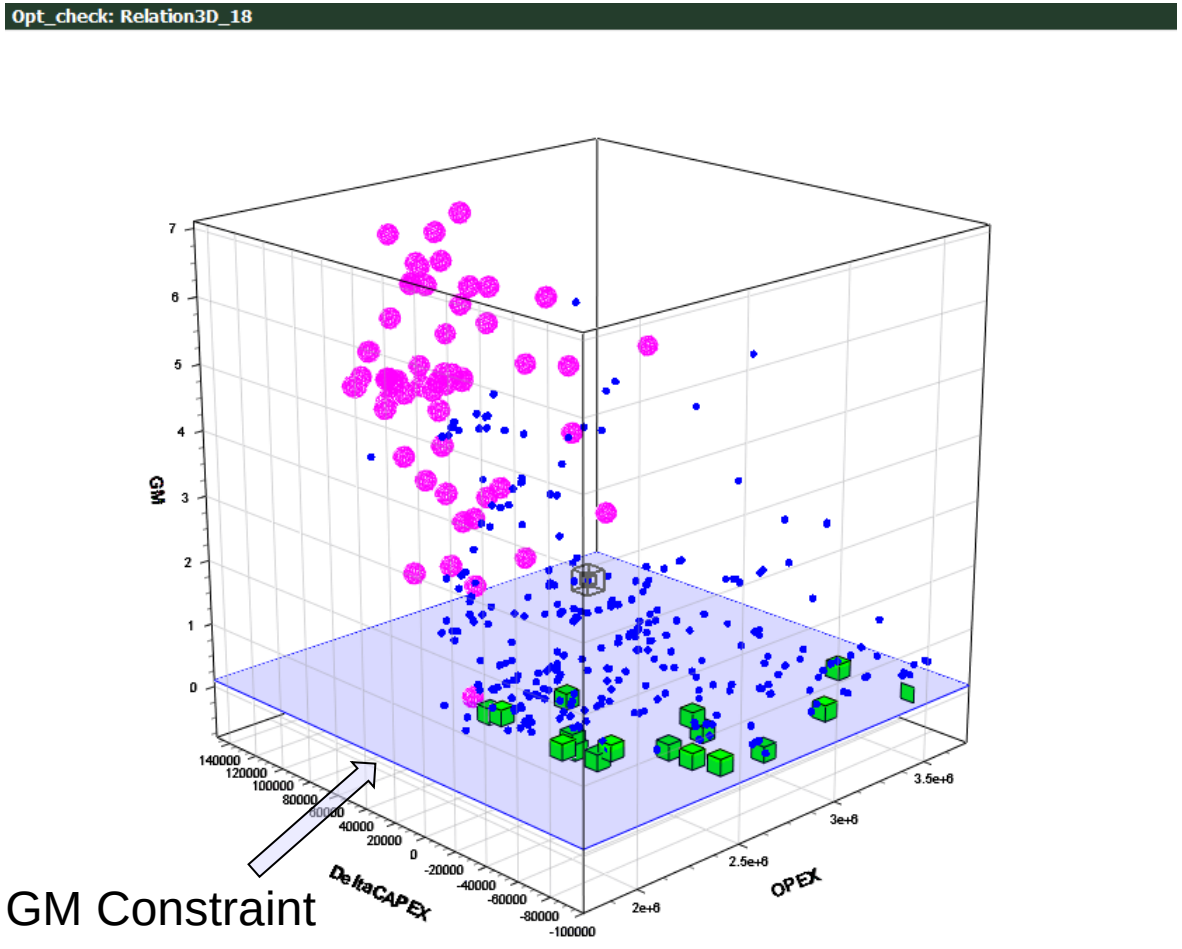

GM Constraint Boundary

Summary

SIEMENS
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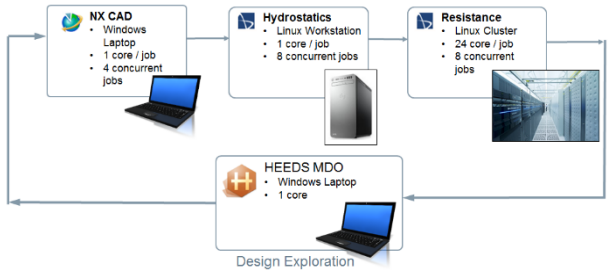
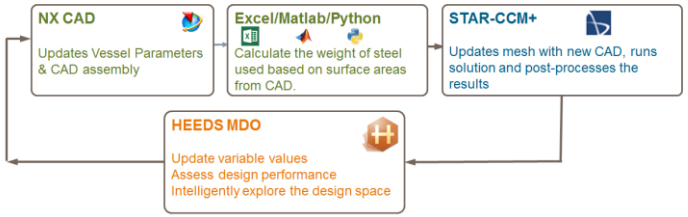
- Demonstrated process automation to simplify virtual prototype construction
  - ✓ CAD: Simcenter NX (automatic change and update of Hull)
  - ✓ STAR-CCM+: Hydrostatics & Resistance Calculation

Process Automation



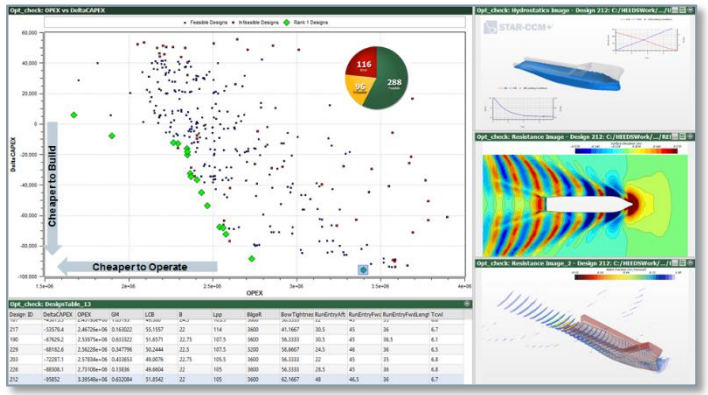
- Demonstrated that scalable computation hardware and software can be effectively used to accelerate virtual prototype testing
  - ✓ 384 designs successfully evaluated in <4 days

Scalable Computation



- Proved that intelligent search can help engineers to discover better designs, *faster*
  - ✓ Discovered family of designs that demonstrate Multi-Objective trade-off between CAPEX and OPEX
  - ✓ Identified critical design variables and design trends

Efficient Exploration



Summary

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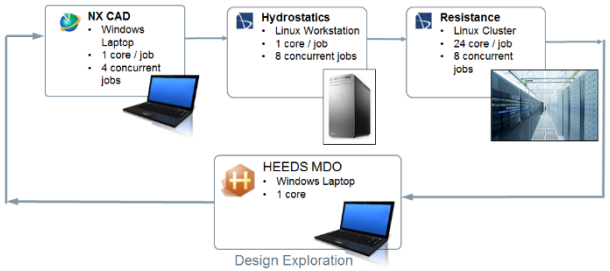
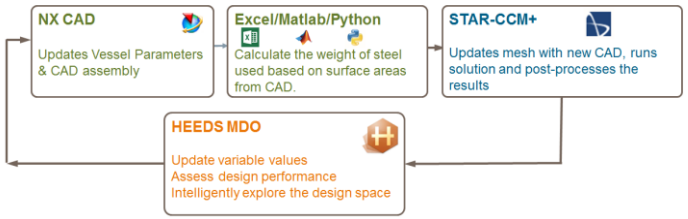
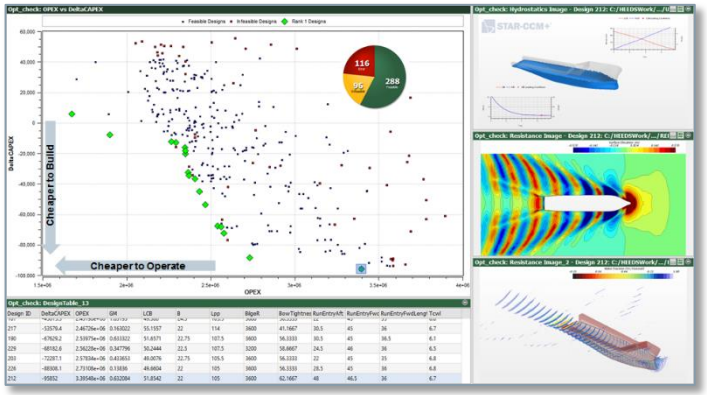
Process Automation



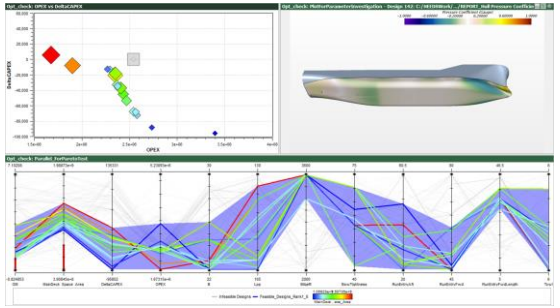
Scalable Computation

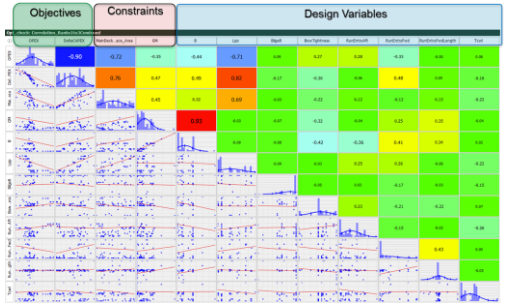


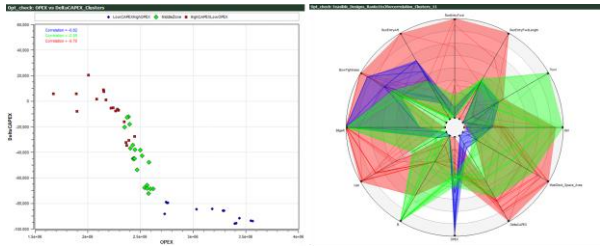
Efficient Exploration

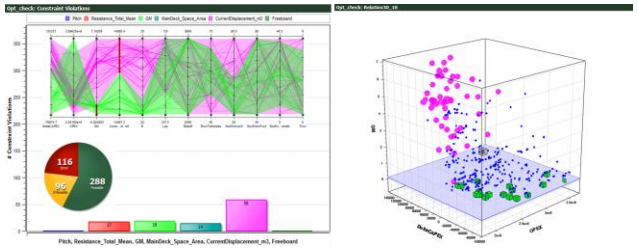


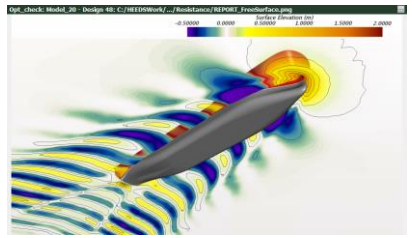
Insight & Discovery

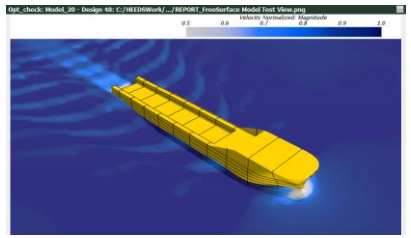












Discover Better Designs, *Faster!*
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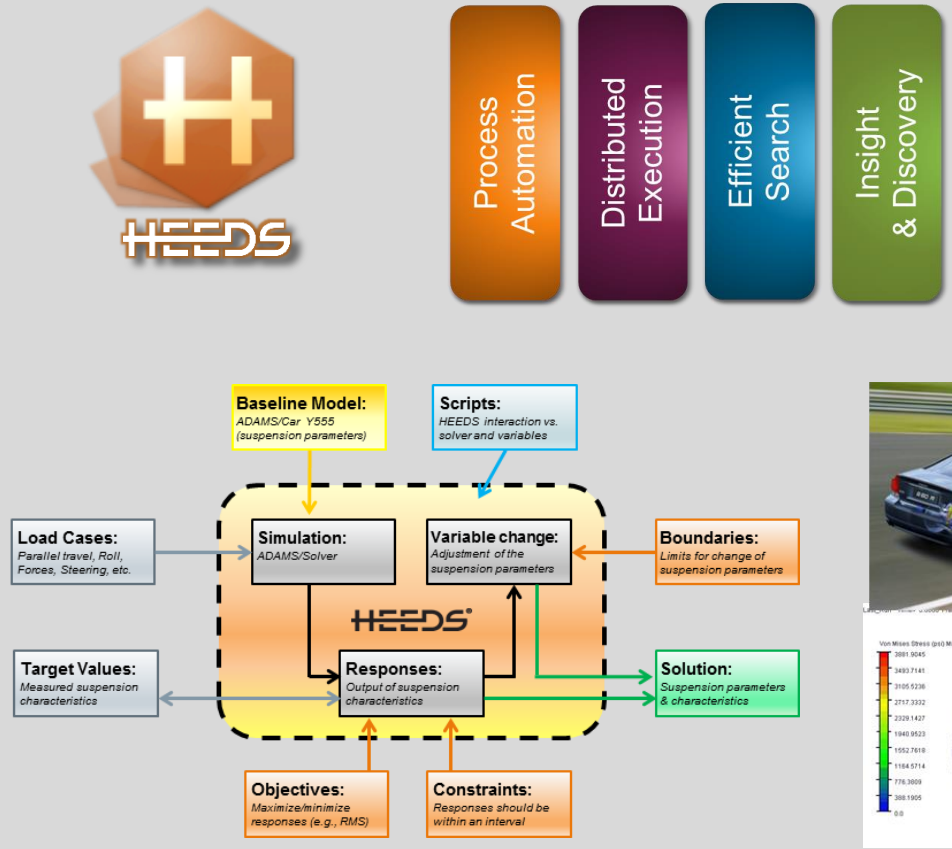
Multidisciplinary Design Exploration Platform

- Accelerate design process with automated workflow
- Explore early & often with a streamlined process
- Increase product knowledge with multi-variant analysis
- Discover better designs faster with automated intelligent search
- Assess design robustness
- In PLM context, configurations are stored, managed and can be reused
- **Easy to use – no need to be an optimization specialist**
- **Easy to deploy across organizations**



Suspension Auto-Correlation reduced time from months to under 1 week
"HEEDS drastically reduces correlation time." — Erik Wendeberg, Chalmers