



KONGSBERG

CAESES USERS MEETING 2019

Multi-phase design and optimization of an OSV

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20/09/2019

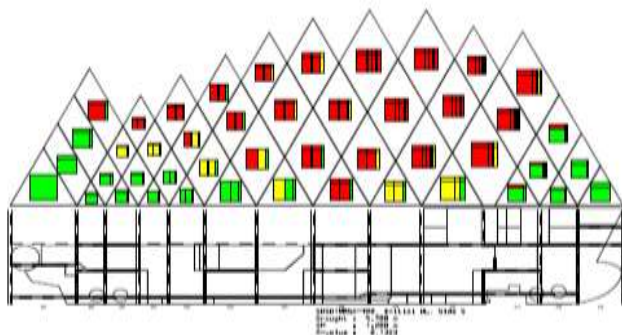


Presentation Structure

- HOLISHIP Background
- WP9 background – The OSV
- Recent developments
- CASE 1 – On theory
- CASE 1 – On practice
- CASE 1 – Results
 - RSM DoE
 - Optimization routine
- Arrangement Generation
 - NAPA damage stability

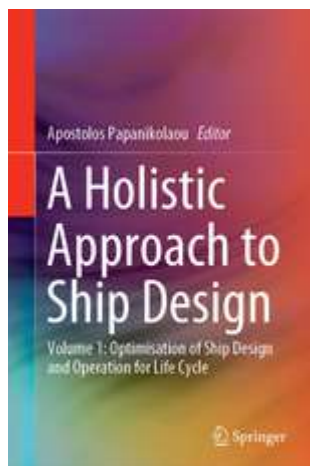
Recent Developments

- Refinement of the CAESES project
- Improved User Interface
- SHIPFLOW resistance estimation via Response Surface Model (RSM)
- NAPA Arrangement generation for damage stability (On-going)



HOLISHIP Background

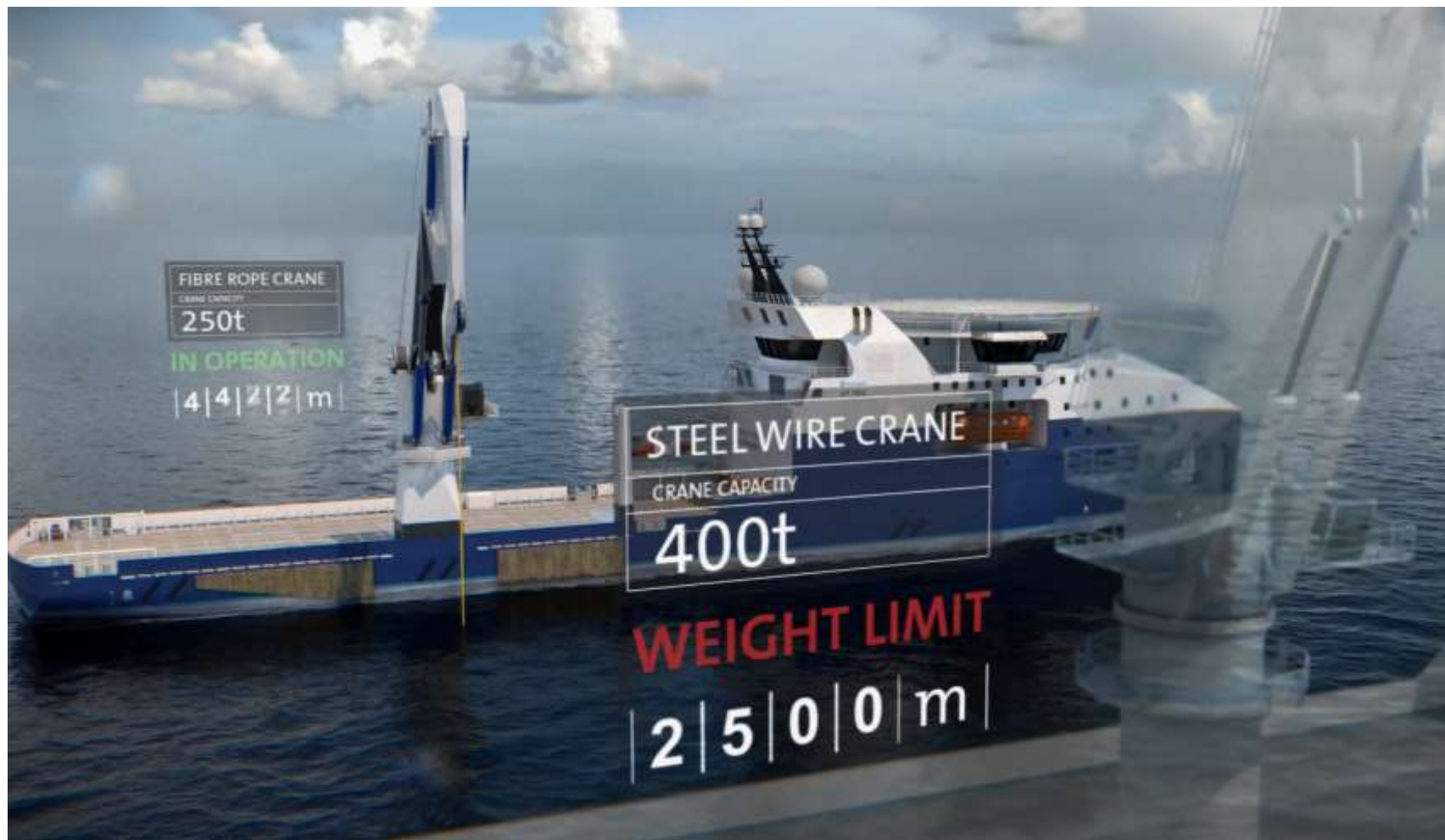
- 9 vessels/structures being holistically designed and optimized
- 35+ partners
- Check out the book:
 - “A Holistic Approach to Ship Design”



we are creating the ship of tomorrow



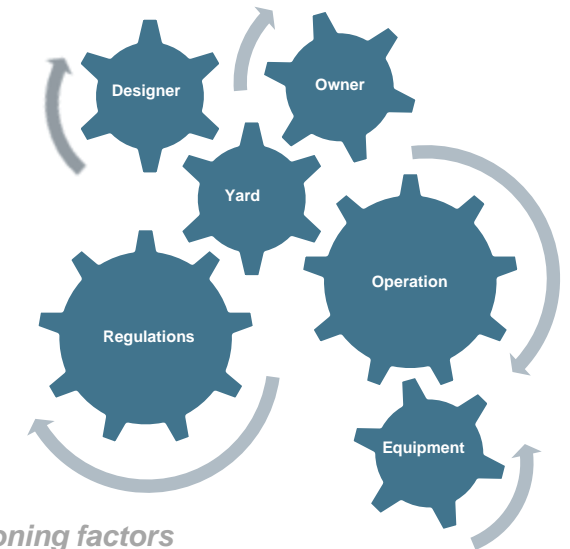
WP9 Background – The OSV



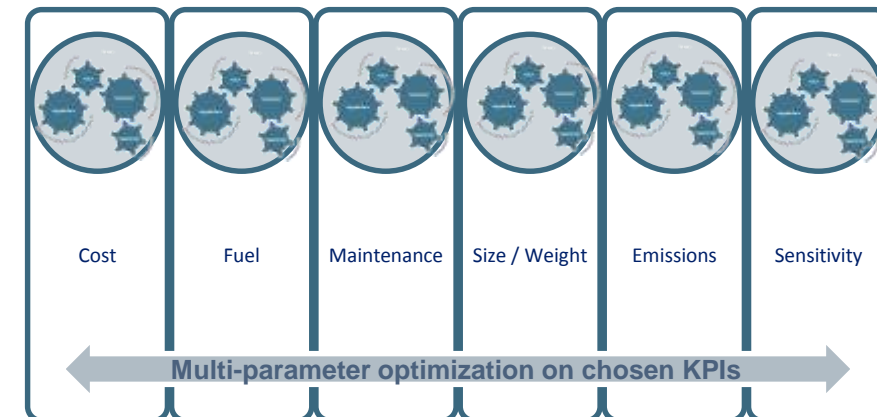
WP9 Background – The OSV

- Demo Case 1: Hull and propulsor dimensioning tool
 - CAESES
- Demo Case 2: Power system optimization tool
 - MPSET
- Demo Case 3: Power system verification tool
 - Simulator at NMK Ålesund

“Stakeholders” in a power system optimization



Power system dimensioning factors

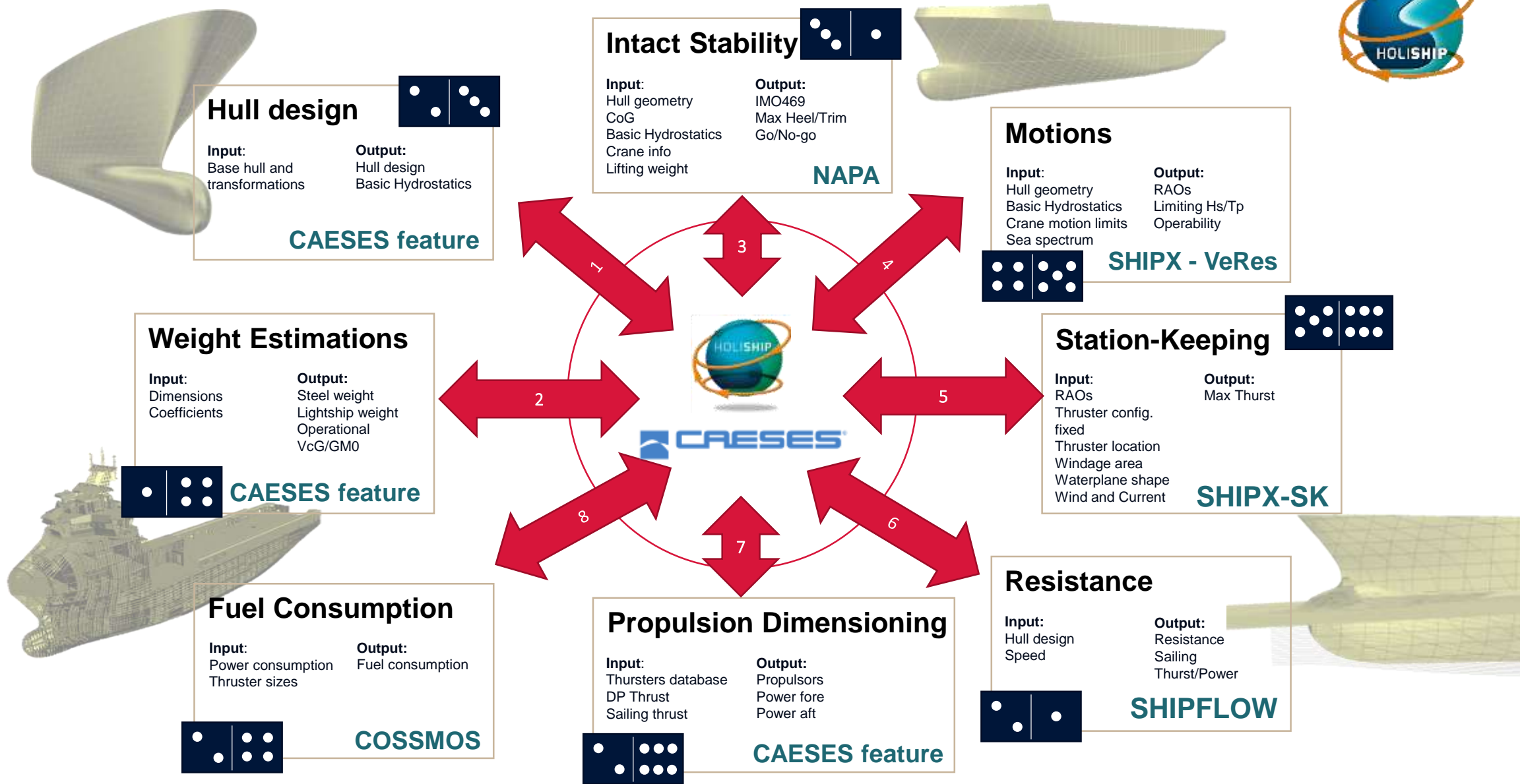




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On Theory





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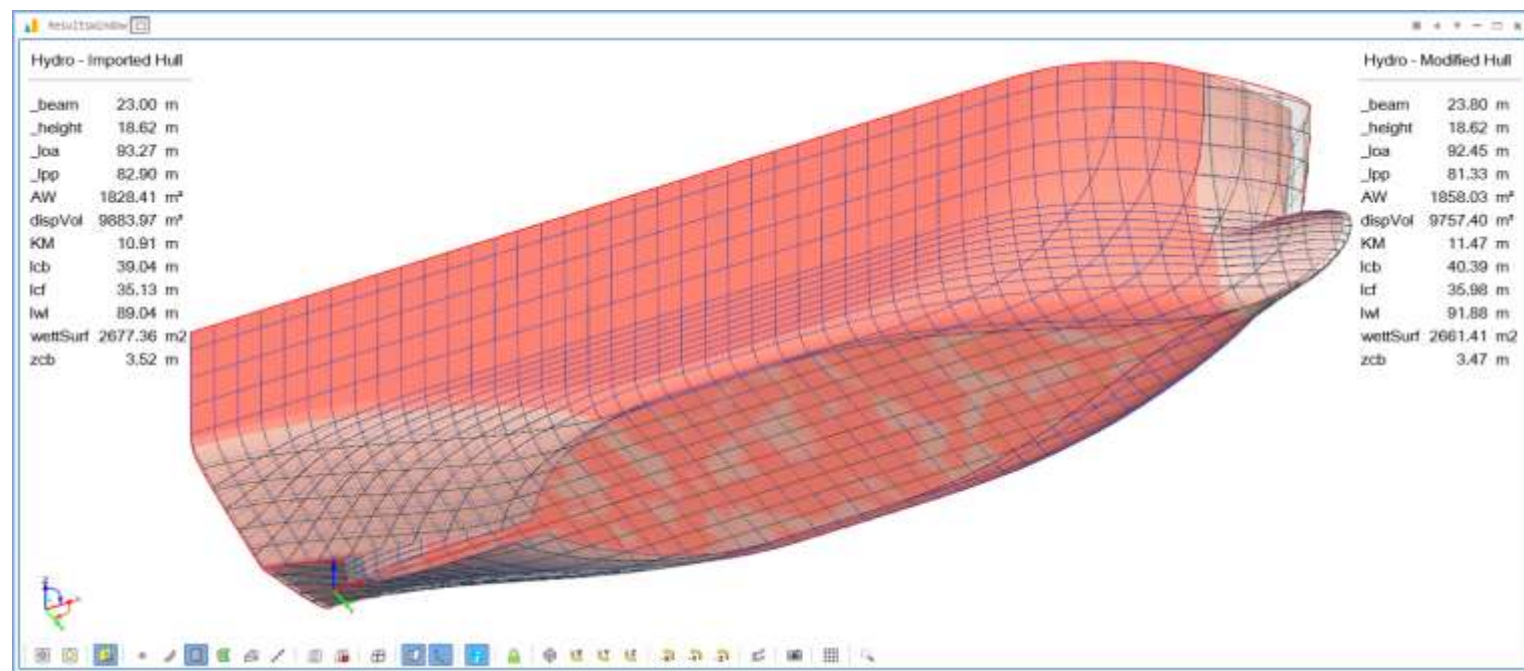
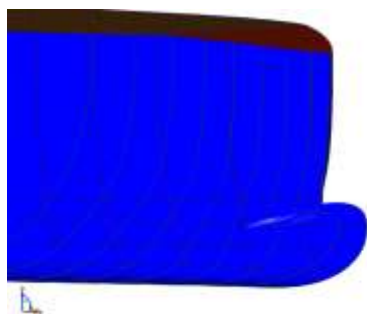
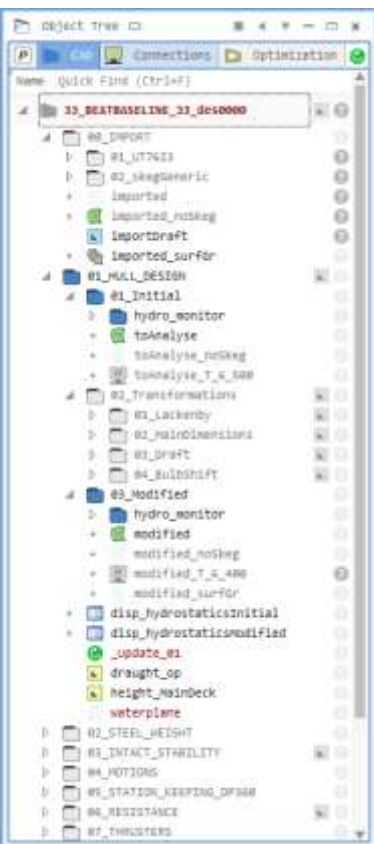


01 – Hull Design

On practice

Import → Monitor → Transform → Monitor → Advance

- Lackenby
- Main Dimensions
- Design Draught
- Bulb





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02 – Weight Estimations

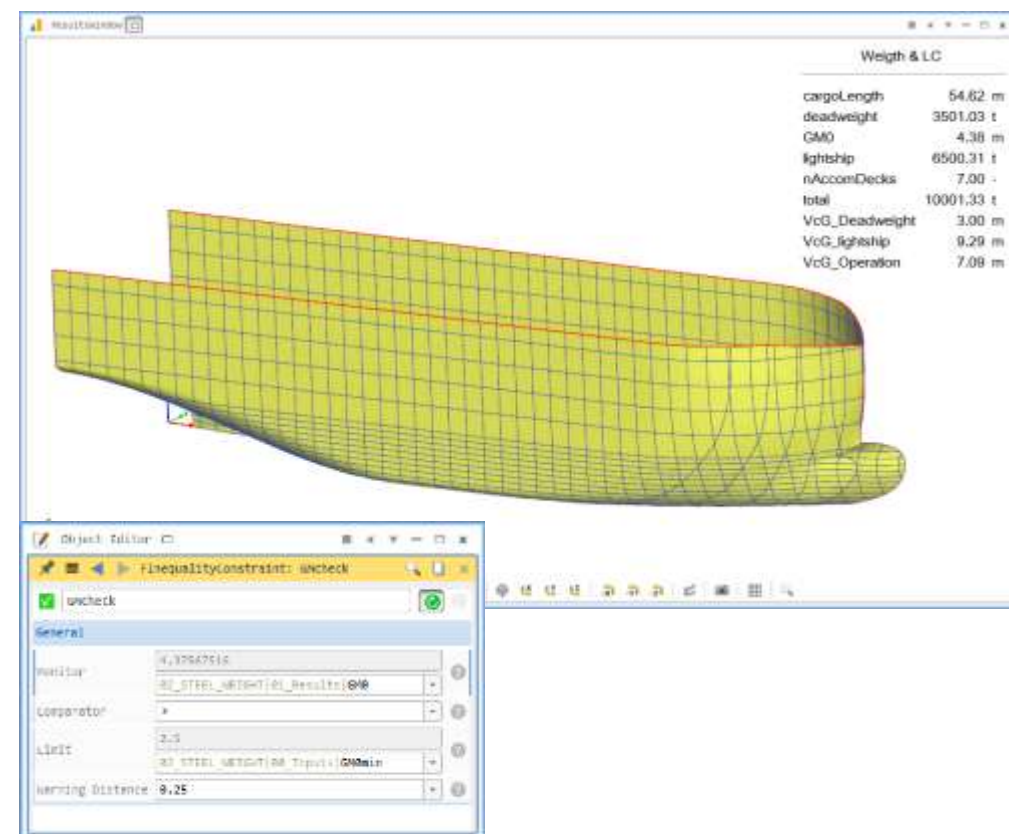
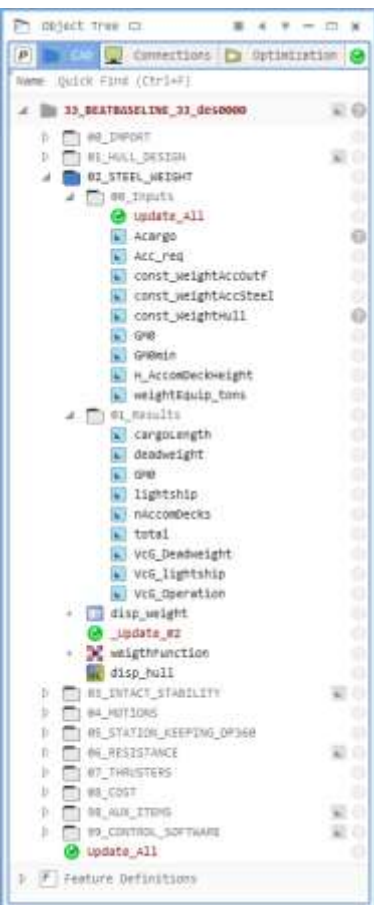
On practice

Inputs → Empirical Function → Monitor → Advance

- Area required for cargo
- Area required for accommodation
- Accommodation deck height
- Weight constants based on existing vessels

Outputs:

- VcGs – lightship, equipment and accommodation
- Loading condition
- Operation's centre of gravity and GMT0 → **First Constraint**





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03 – Intact Stability

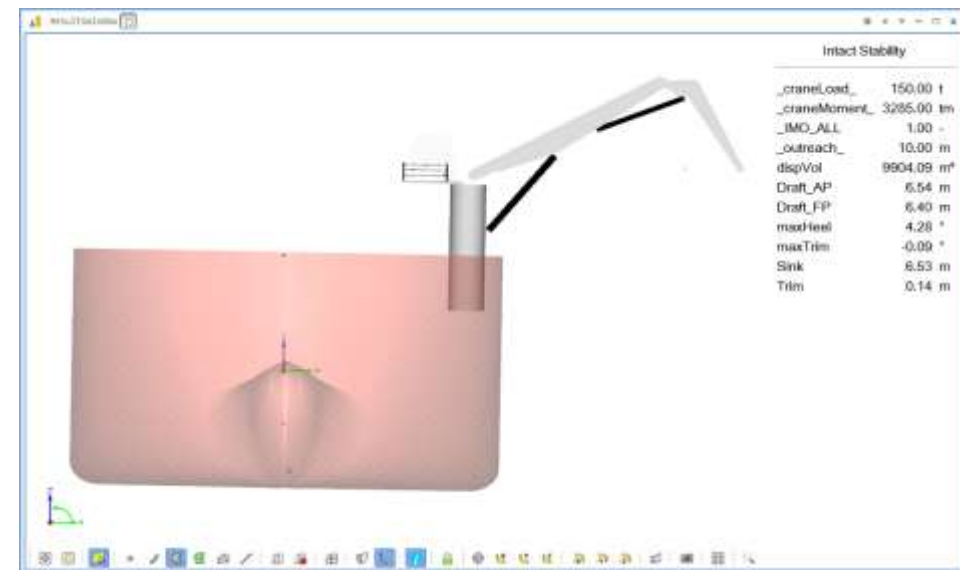
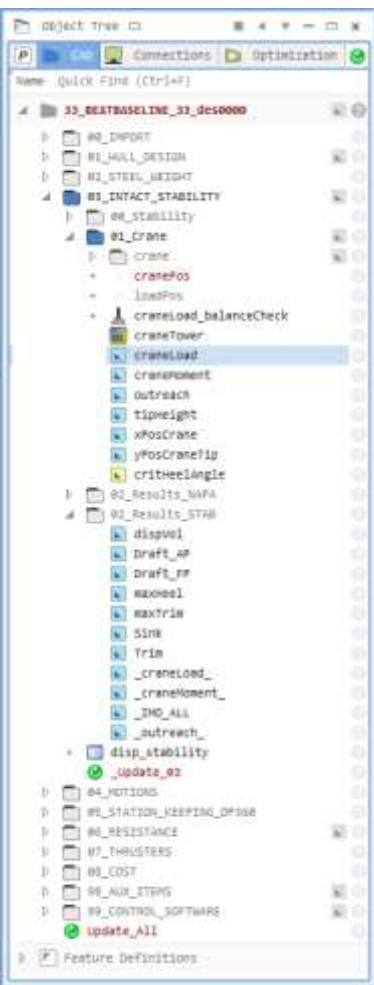
On practice

Inputs → NAPA HYD → Crane Balance Feature → Monitor → Advance

- Simplified Watertight+Buoyant hull (IGES)
- Crane load and position
- Criteria limits

Outputs:

- IMO 469 Pass/Fail → Second Constraint
- Maximum heel/trim



Loading condition: T=6.4 m; TR=0 m

BCR	TEXT	REQ	ATTN	UNIT	STAT	MIN/MAX
IMO469.1	Area depending on GZ-curve top	0.055	0.599	msad	OK	0.610
IMO469.2	Area between 30 deg and 40 deg	0.030	0.373	msad	OK	0.328
IMO469.3	Required maximum GZ-value	0.200	2.158	m	OK	0.599
IMO469.4	Position of maximum GZ-value	15.000	35.340	deg	OK	-0.224
IMO469.5	Required initial GM-value	0.150	4.376	m	OK	0.150
CAE.CONSTHEEL.1	Heel subject to oae.cranemom1	12.000	4.278	deg	OK	1.468



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04 – Motions

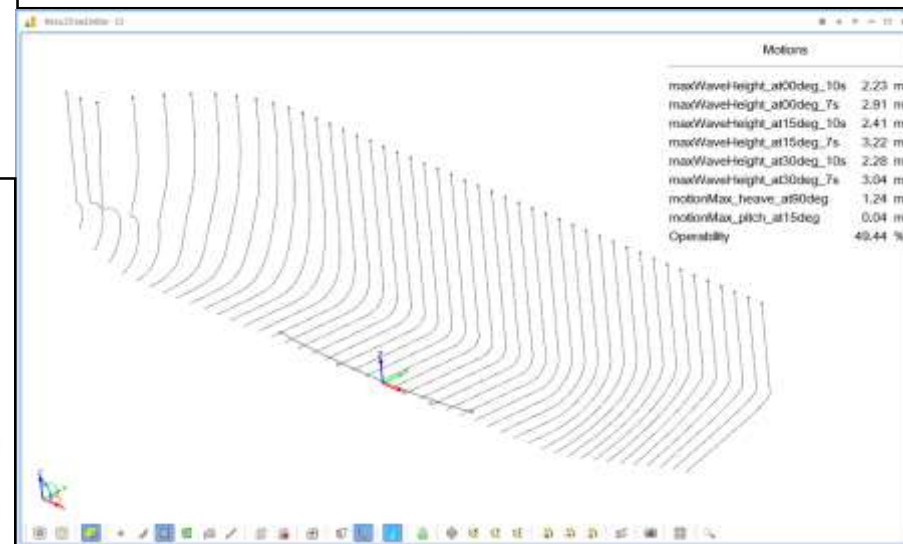
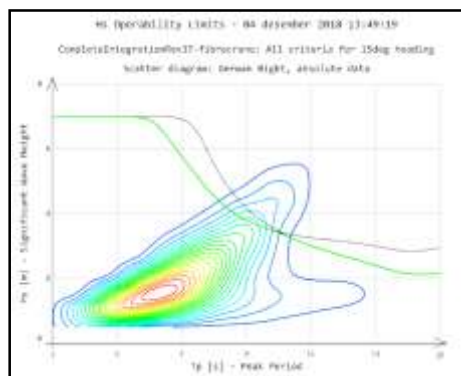
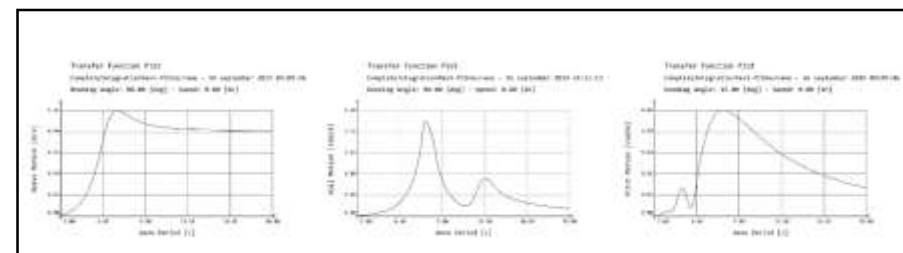
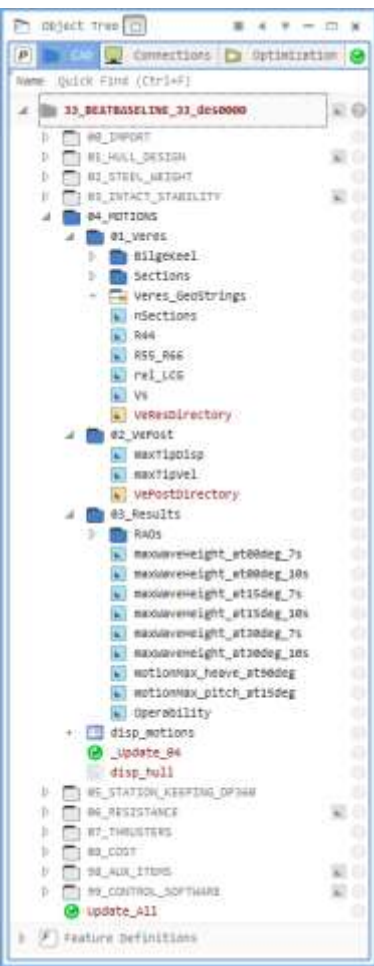
On practice

Inputs ➡ **SHIPX VeRes** ➡ **SHIPX VePost** ➡ **Monitor** ➡ **Advance**

- VeRes format sections
- Crane motions criteria
- Roll reduction tanks
- Bilge keels

Outputs:

- Limiting Hs/Tp
- RAOs





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05 – Station Keeping

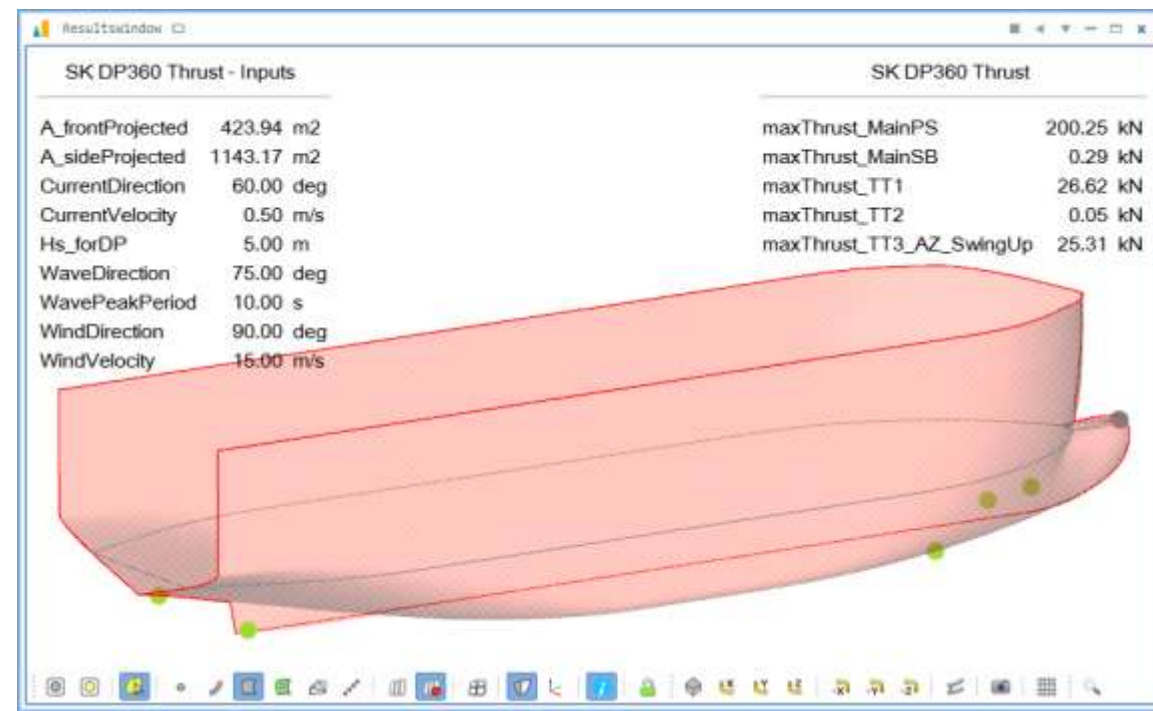
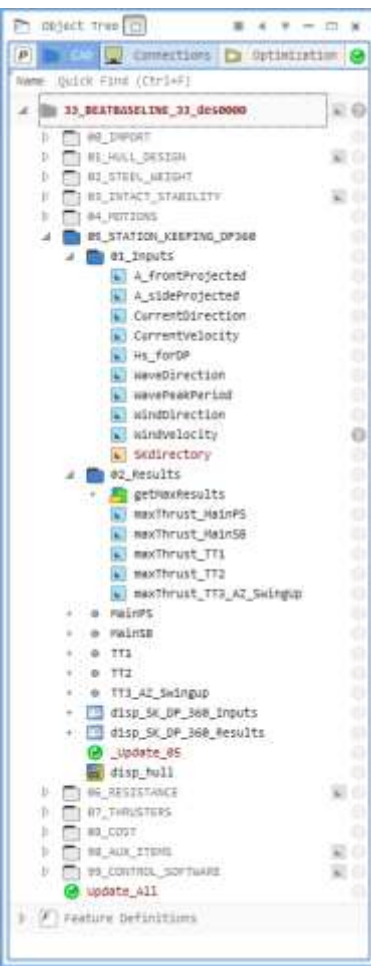
On practice

Inputs → SHIPX SK → Monitor → Advance

- VeRes output files
- Projected areas
- Environmental conditions
- Waterline shape
- Propulsion arrangement

Outputs:

- Thrust required for DP
 - Each propulsor
 - Each heading





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06 – Resistance

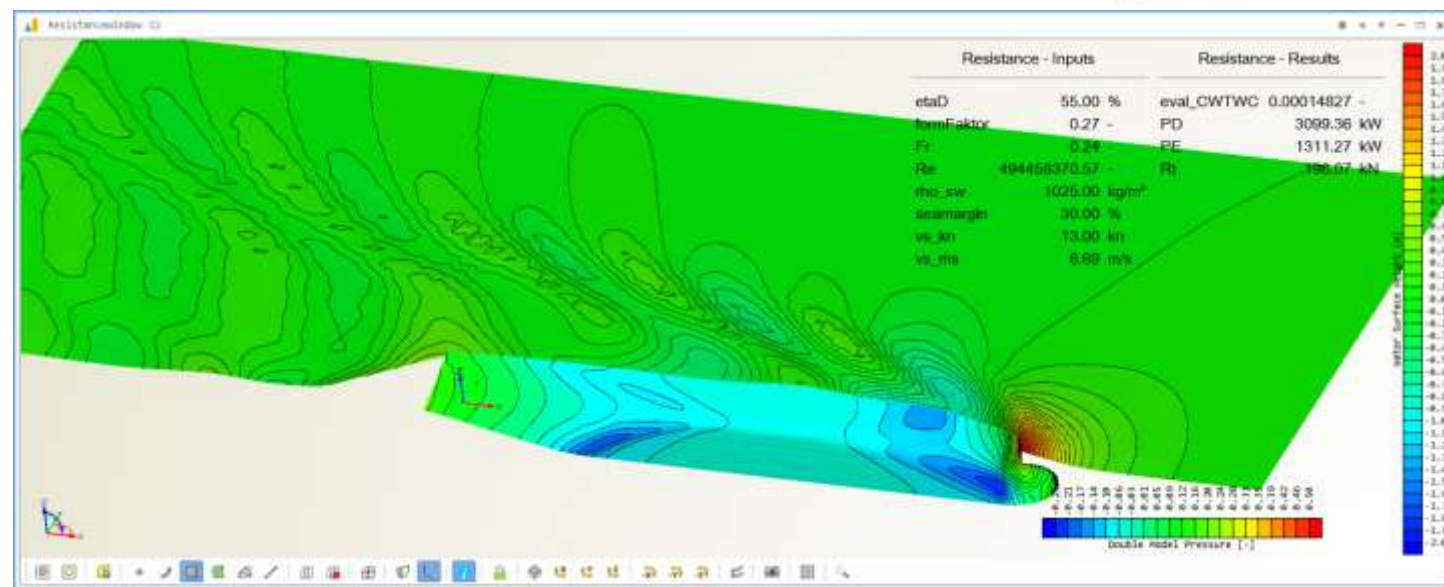
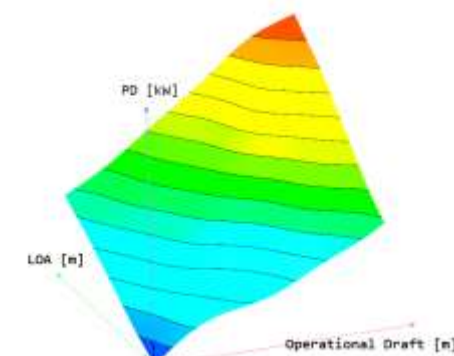
On practice

Inputs ➡ **Shipflow - XPAN** ➡ **RSM DoE** ➡ **Monitor** ➡ **Advance**

- Shipflow format sections
- Speed
- Empirical resistance formulation
- Form factor

Outputs:

- Thrust required sailing





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07 – Propulsion Dimensioning

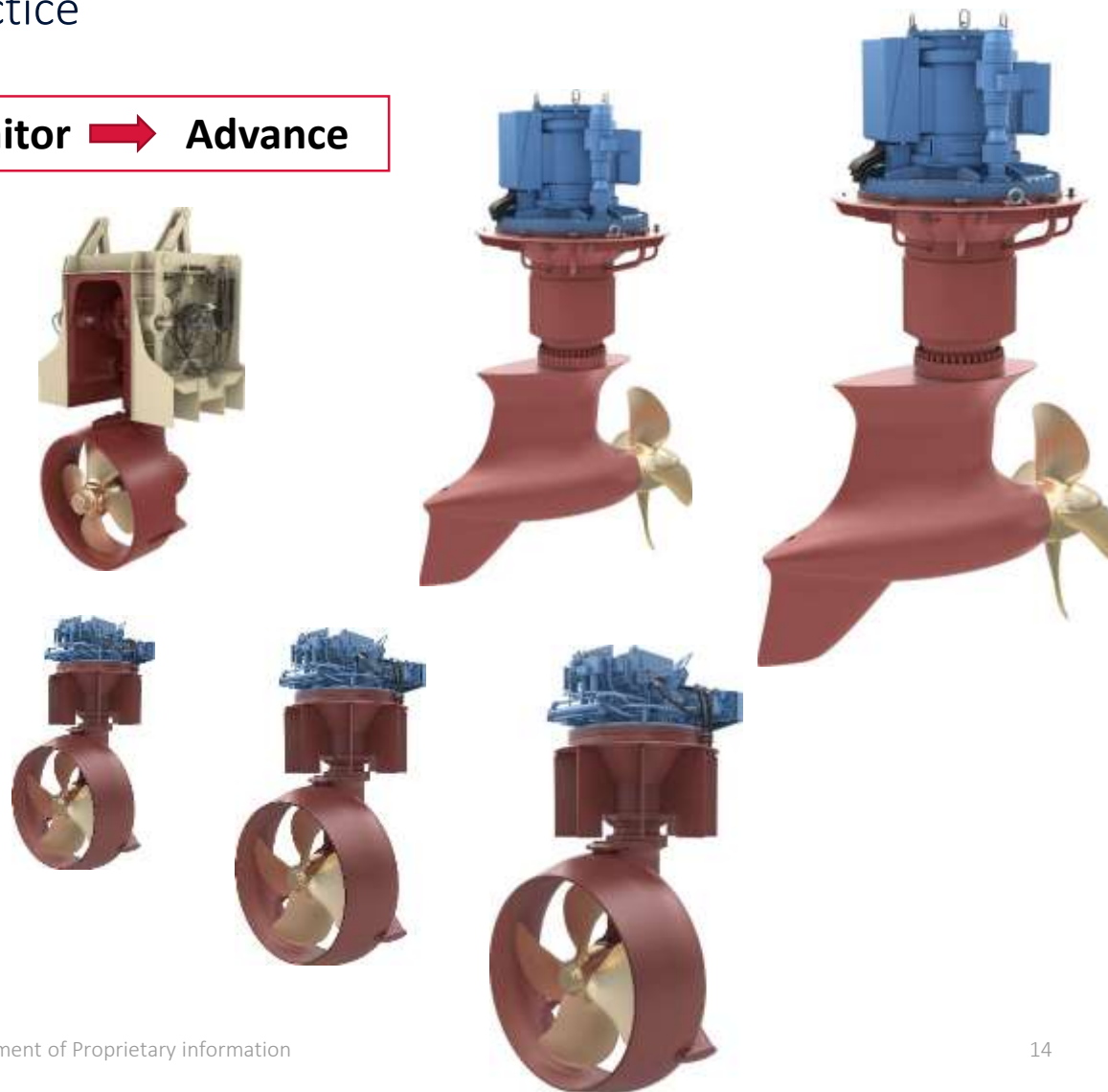
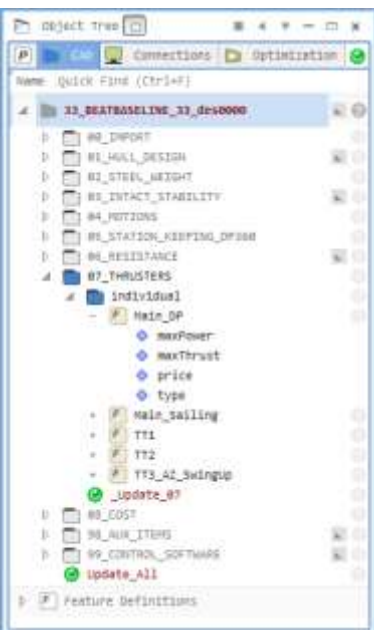
On practice

Inputs → CAESES Feature → Monitor → Advance

- Thrust required for DP
- Thrust required sailing
- Propulsors catalogue

Outputs:

- Each propulsor
 - Type
 - Power
 - Thrust
 - Price



On practice

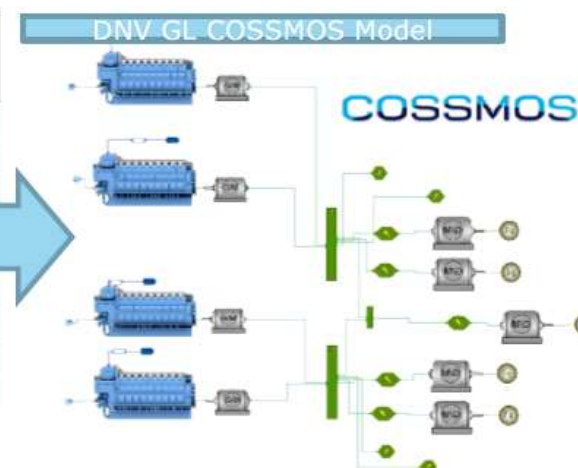


- Thrust delivered
- Power required

Outputs:

- Fuel Consumption
 - 4 different engine types

	Case Settings (<i>power for thruster dimensioning & demands from Station keeping & Resistance tools</i>)		
Operation mode	Sailing mode	DP mode	Harbour
Time spent [%]	40%	40%	20%
Aft thruster #1 [kW]	1511	1500	0
Aft thruster #2 [kW]	1511	1500	0
Fore Thruster #1 [kW]	0	950	0
Fore Thruster #2 [kW]	0	950	0
Azimuth Thruster	0	880	0
Hotel [kW]	400	400	400
Switchboard mode	closed	split	closed

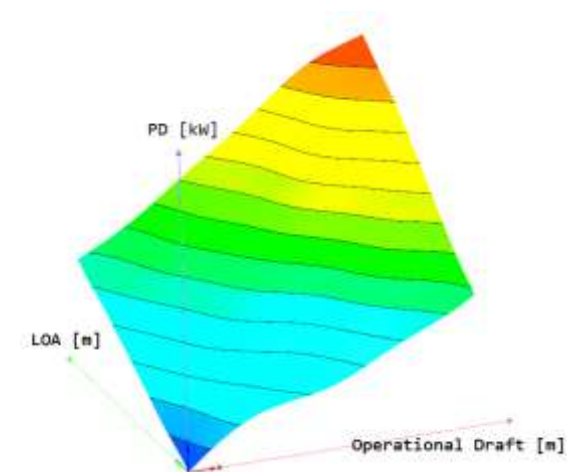


RSM DoE

Results

- Response surface model for Shipflow
 - Over 500 design variants
- Allows fast obtainment of PD for future design variants

	beam	loa	draftShift	draught	PDoptimised	PD_initial	KM	dispVol
DoE_wi...000	23	90	0	6.25	2525.88	2540.53	11.00523	9077.7805
DoE_wi...001	24.5	85	0.25	5.875	2465.47	2467.39	12.237259	8475.4325
DoE_wi...002	21.5	95	-0.25	6.625	2659.94	2667.87	9.9587299	9608.671
DoE_wi...003	22.25	87.5	0.125	5.6875	2277.16	2284.95	10.732538	7618.5922
DoE_wi...004	25.25	97.5	-0.375	6.4375	2952.9	2962.84	12.468365	11187.714
DoE_wi...005	23.75	82.5	-0.125	6.0625	2400.47	2419.07	11.598332	8282.6238
DoE_wi...006	20.75	92.5	0.375	6.8125	2535.48	2562.77	9.4935117	9338.0323
DoE_wi...007	21.125	86.25	-0.1875	6.53125	2414.54	2452.73	9.7555677	8425.885
DoE_wi...008	24.125	96.25	0.3125	5.78125	2553.61	2563.91	12.019692	9267.8224
DoE_wi...009	25.625	81.25	0.0625	6.90625	2734.91	2739.9	12.491939	10297.437
DoE_wi...010	22.625	91.25	-0.4375	6.15625	2525.22	2546.47	10.793672	8890.3171
DoE_wi...011	21.875	83.75	0.4375	6.34375	2327.33	2334.74	10.253761	8180.0396
DoE_wi...012	24.875	93.75	-0.0625	5.59375	2572.48	2578.62	12.713418	8943.9604
DoE_wi...013	23.375	88.75	-0.3125	6.71875	2687.88	2730.7	11.085868	9925.9444
DoE_wi...014	20.375	98.75	0.1875	5.96875	2352.88	2375.32	9.4218353	8345.8563
DoE_wi...015	20.5625	89.375	0.34375	6.109375	2265.16	2288.99	9.5058637	7841.0745



Optimization Routine

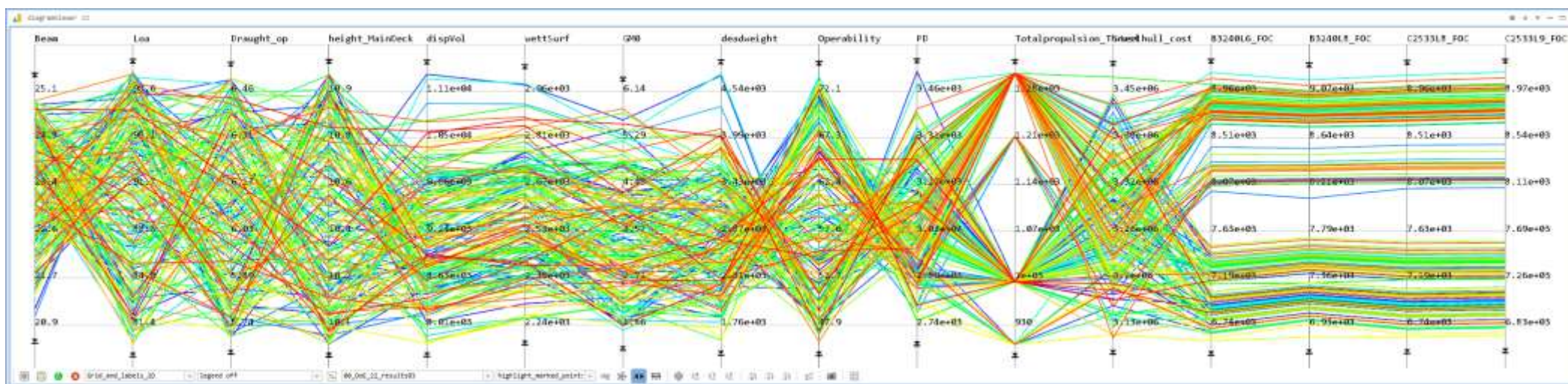
Results

- Requirements for new variants:
 - Achieve similar deadweight or higher compared to baseline design
 - Achieve GMT0 of 2.5m or higher
 - Dropload maximum heel of 12°
- Procedure:
 - *Sobol* start for robustness check
 - Large design space
 - *Ensemble Investigation* (permute variables)
 - Focused design space
 - Refine the region around the potential candidate
 - Final design refinement

Optimization Routine

Results

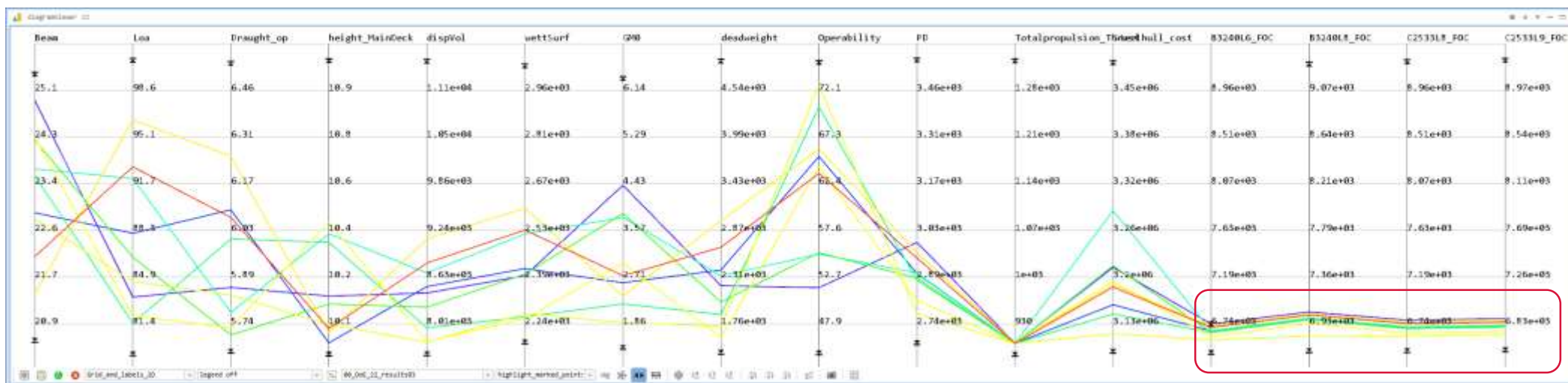
- *Sobol* start for robustness check (250 designs)
 - Difficult to identify trends



Optimization Routine

Results

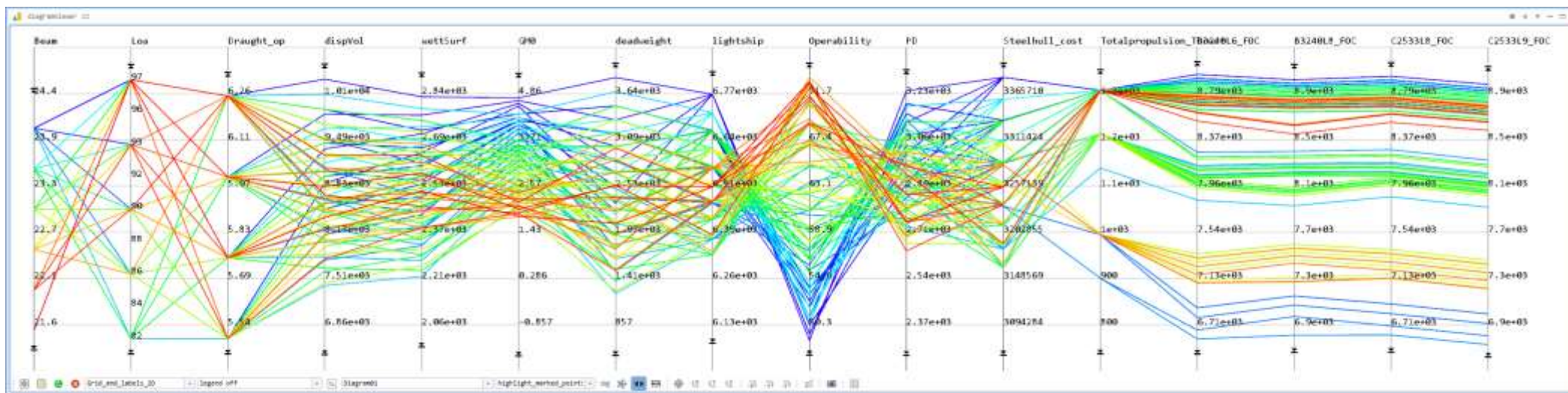
- *Sobol* start for robustness check (250 designs)
 - Difficult to identify trends
 - Clusters of propulsors size combination
 - Focusing on lowest fuel consumption



Optimization Routine

Results

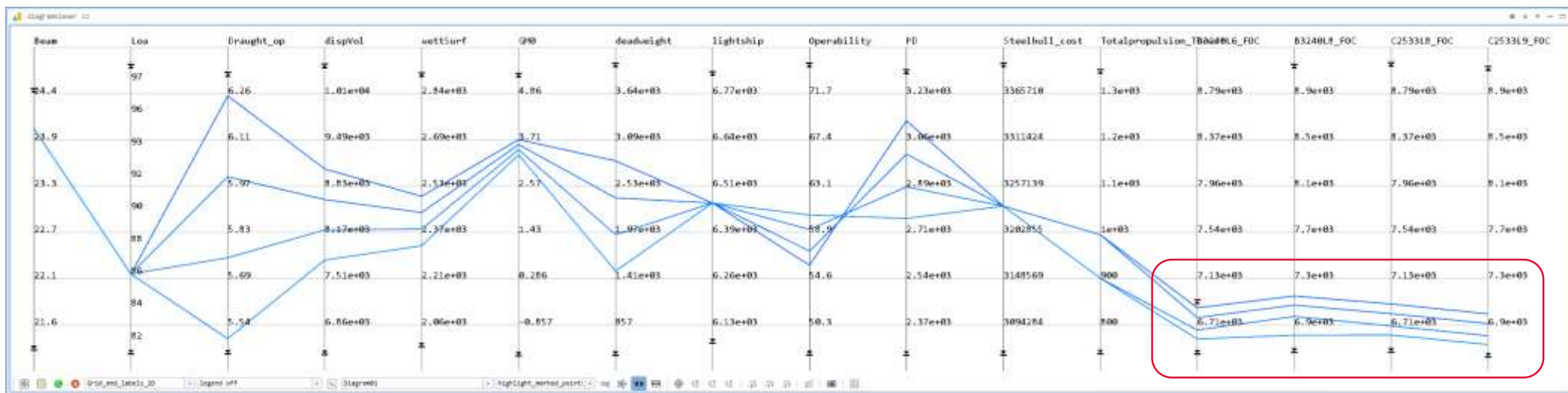
- Large design space
 - From 120 designs, 79 valid results
 - Clusters of propulsors size combination



Optimization Routine

Results

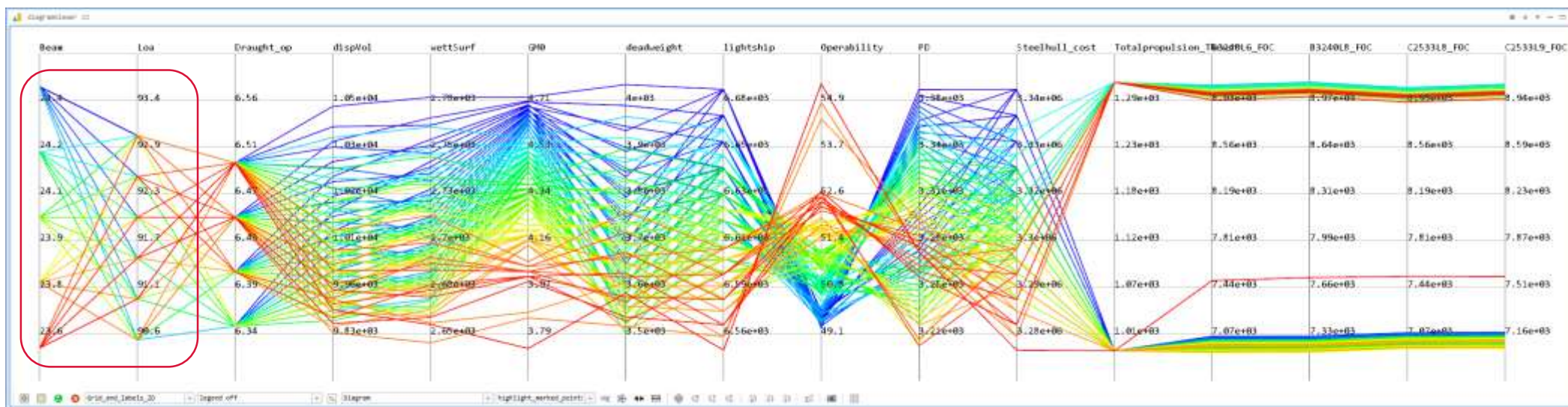
- Large design space
 - From 120 designs, 79 valid results
 - Clusters of propulsors size combination
 - Easier to identify the impact of design variables



Optimization Routine

Results

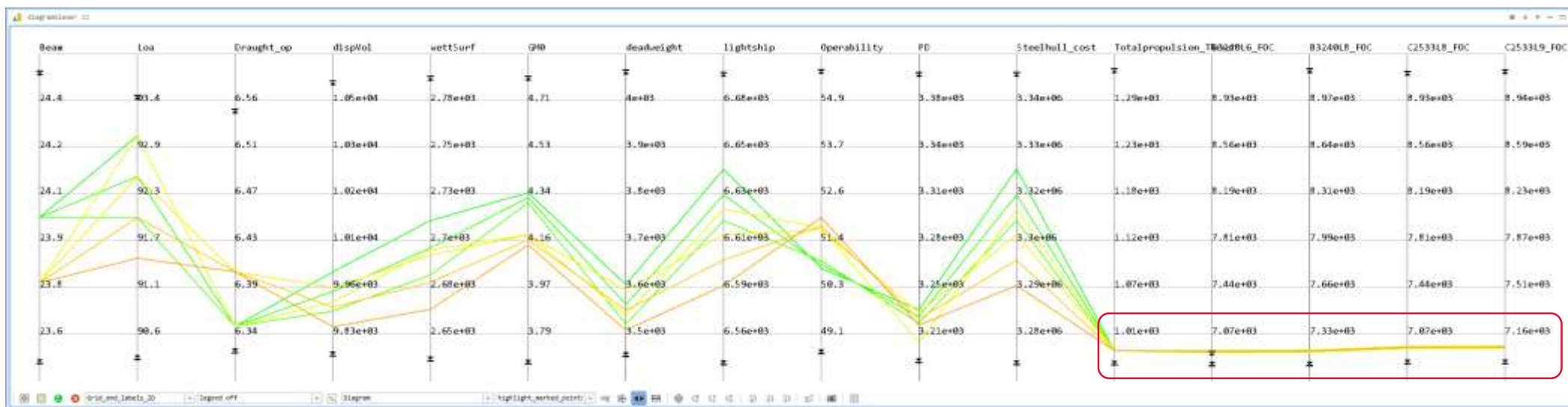
- Focused design space
 - Only 1m variation on Beam, 3m on LOA



Optimization Routine

Results

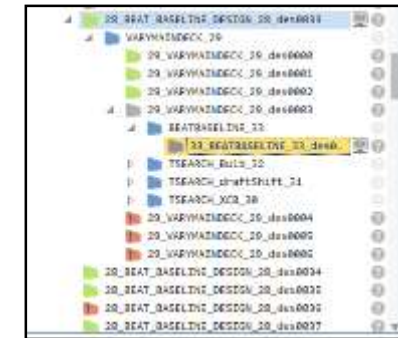
- Focused design space
 - Only 1m variation on Beam, 3m on LOA
 - Lower draught trend identified



Optimization Routine

Results

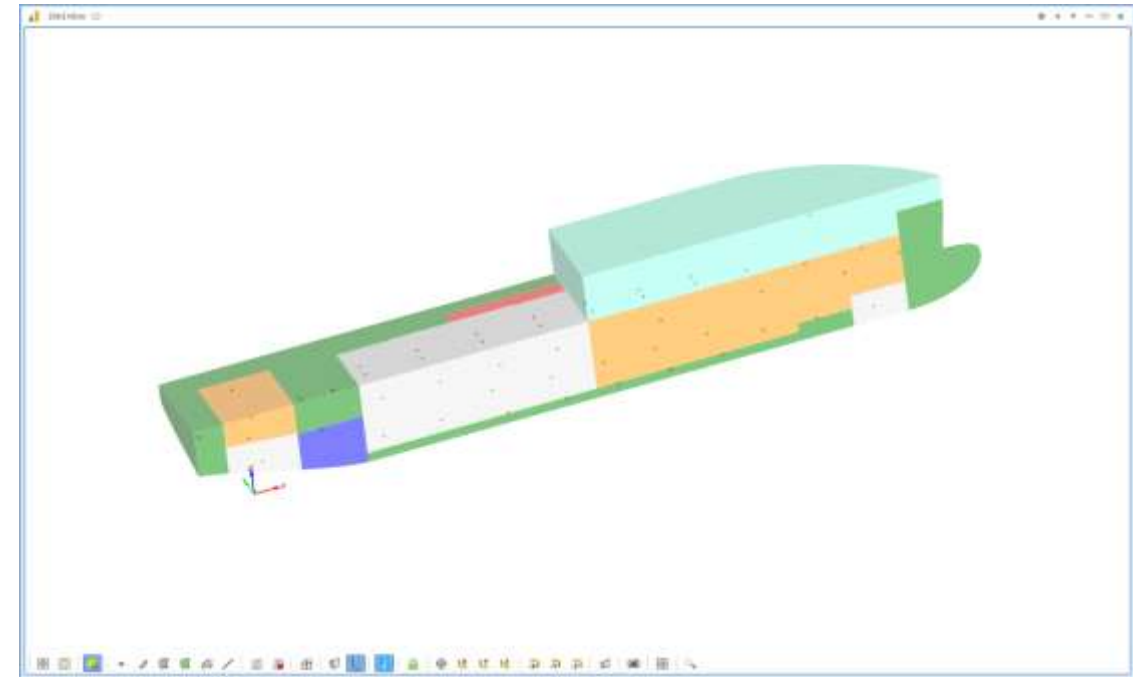
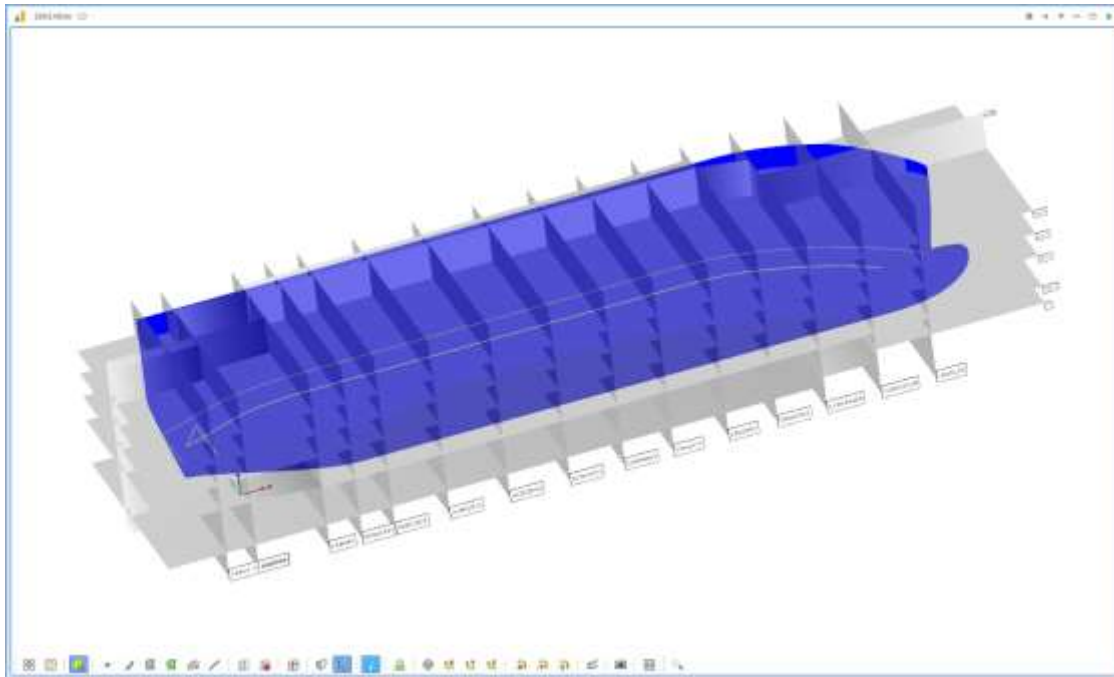
- Final design refinement
 - *TSearch* Design Engine for each hull deformation (SHIPFLOW)
- Healthy and thorough results review via staging the process
- Multiple designs are possible, depending on the final focus
- Fine tuning of coefficients might be necessary
- **Optimised design:**
 - FOC from 8962 to 6846 tonns/Year (-24.3%)
 - Station-keeping highly impact thruster sizes, costs and consumption
 - Slightly wider, shorter vessel
 - Reduced number of accommodation decks = reduced side windage area
 - Beats baseline design due to smaller thrusters possibility



Arrangement Generation

NAPA Damage Stability

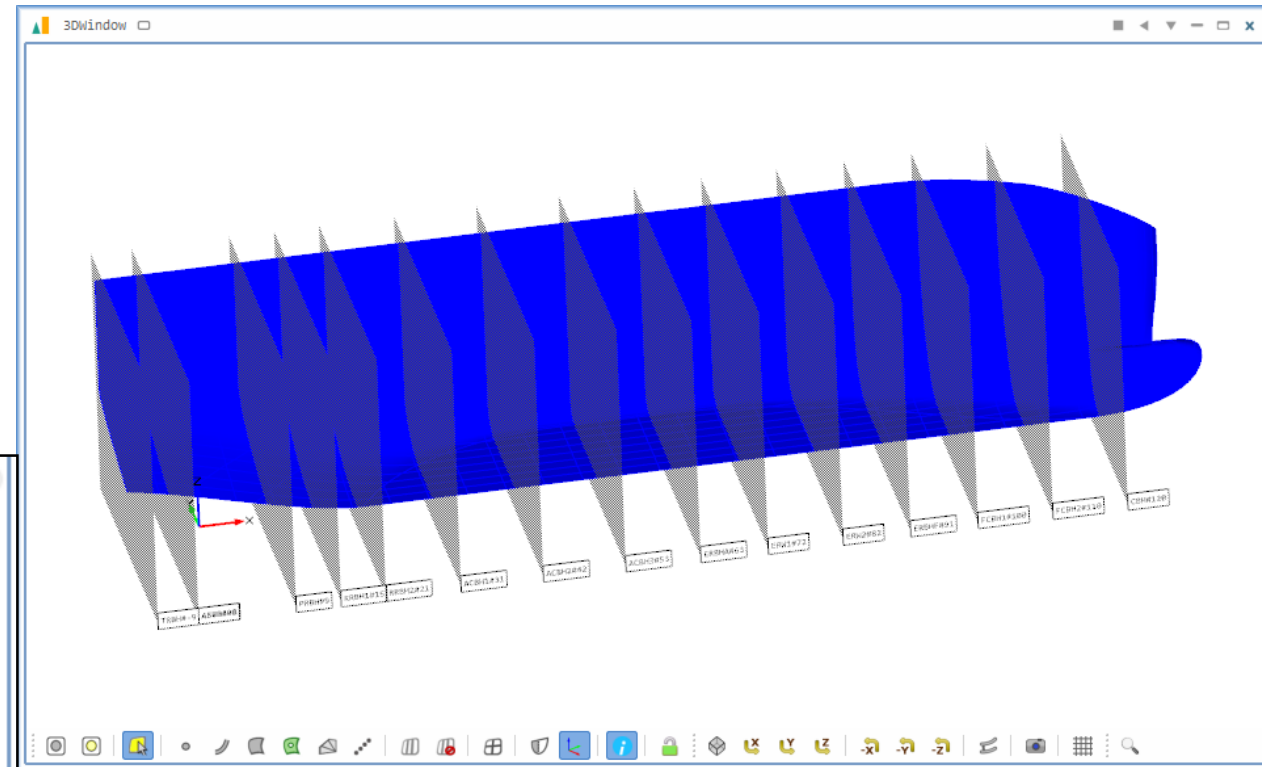
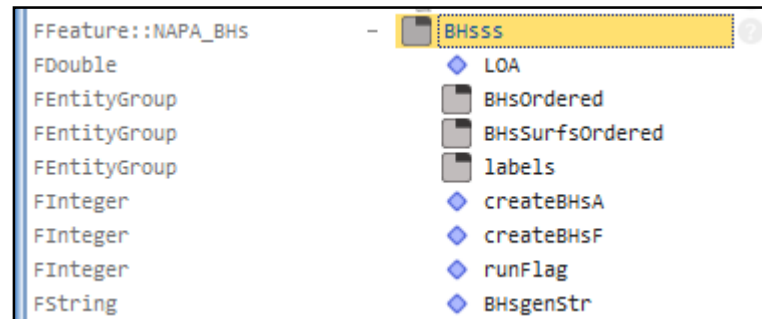
- Flexible arrangement creation
- NAPA equivalent (user friendliness)



Arrangement Generation

NAPA Damage Stability

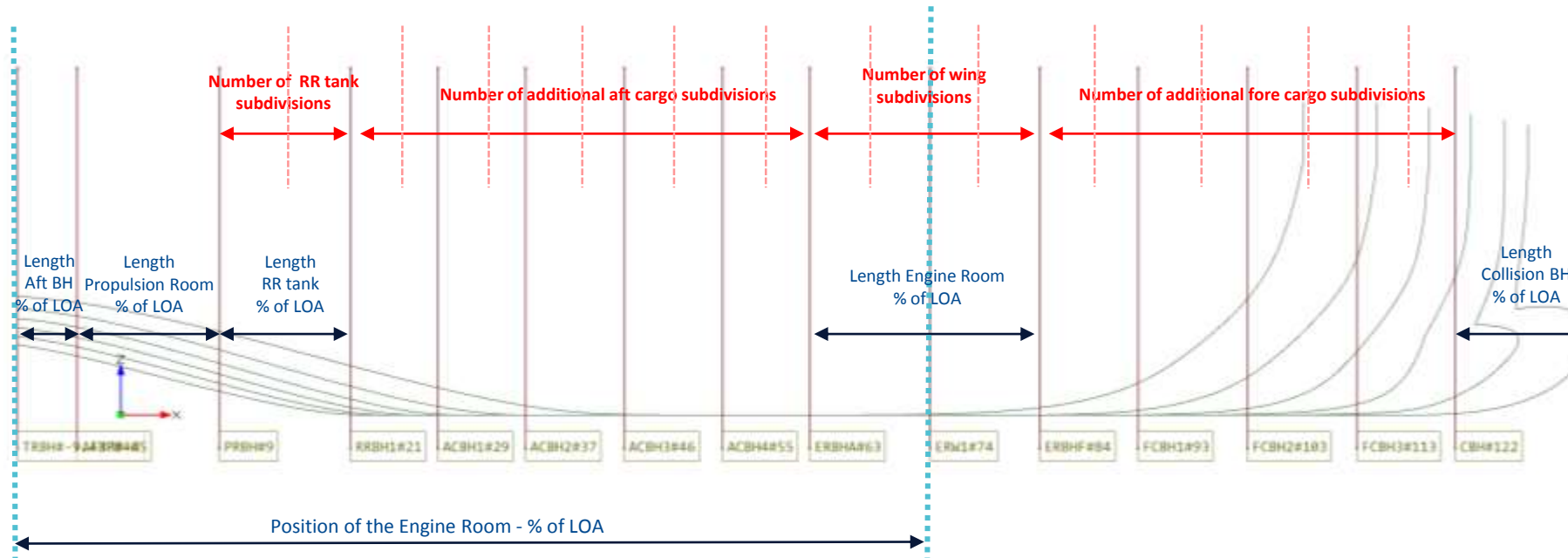
- Flexible arrangement creation
- NAPA equivalent (user friendliness)
- Transversal bulkheads
 - *FFeature:NAPA_BHs*



Arrangement Generation

NAPA Damage Stability

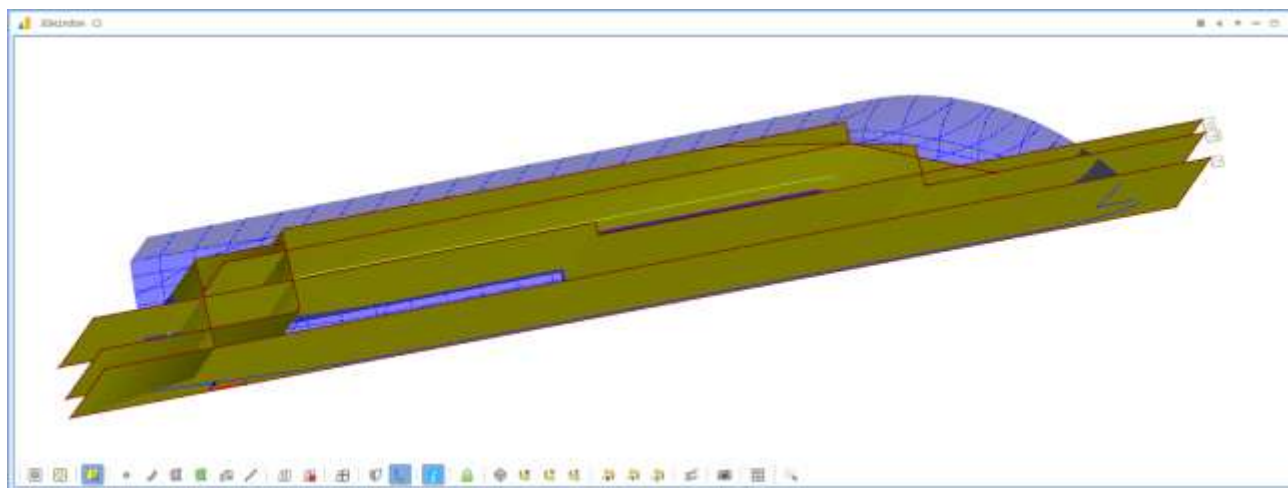
- Transversal bulkheads
 - *FFeature:NAPA_BHs*
- Auto ordering, naming and numbering
- #Frames positioning system
- Custom manual BHs
- Auto restriction of BH length and/or quantity



Arrangement Generation

NAPA Damage Stability

- Flexible arrangement creation
- NAPA equivalent (user friendliness)
- Longitudinal bulkheads
 - *FFeature:NAPA_LHs*



FFeature::NAPA_LHs: |02_RO

LBH

General

Source

BHs

Properties

LBH Name

Description

List

X Positions

+	-20
+	"ACBH" + 02_ROOMS BHsss:createBHSA.toString()
+	"ACBH" + 02_ROOMS BHsss:createBHSA.toString()
+	01_Hull_Design 03_NewVessel newHull_y.getMax():x * 1.05

Drop here to append

Y Positions

+	4.8
+	4.8
+	3.6
+	3.6

Drop here to append

Visualization

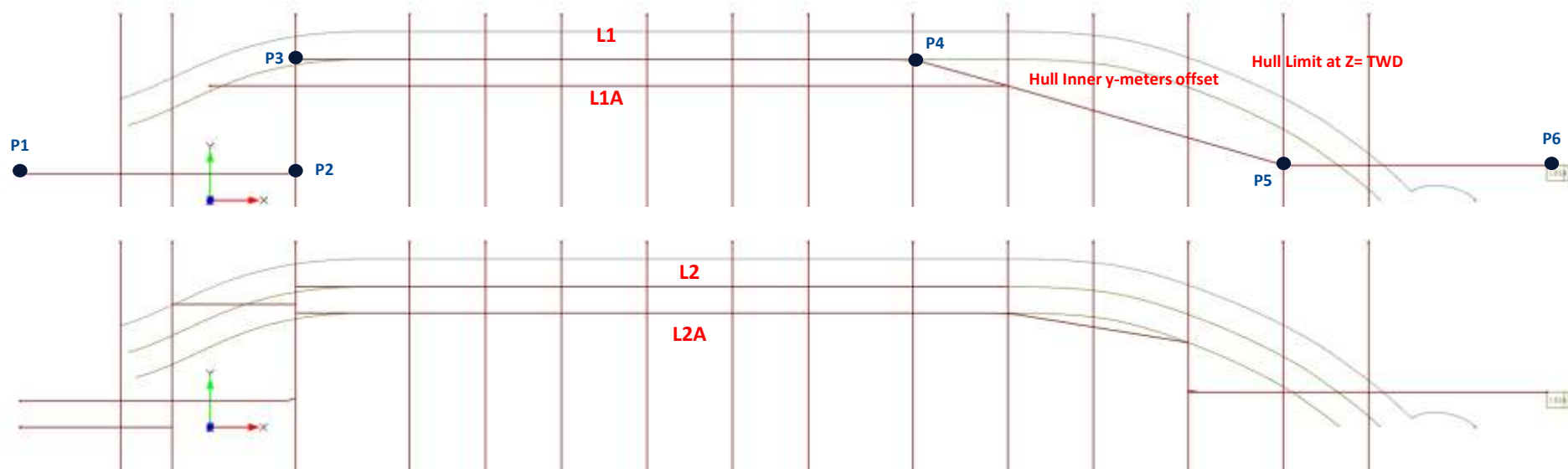
Display Options

color

Arrangement Generation

NAPA Damage Stability

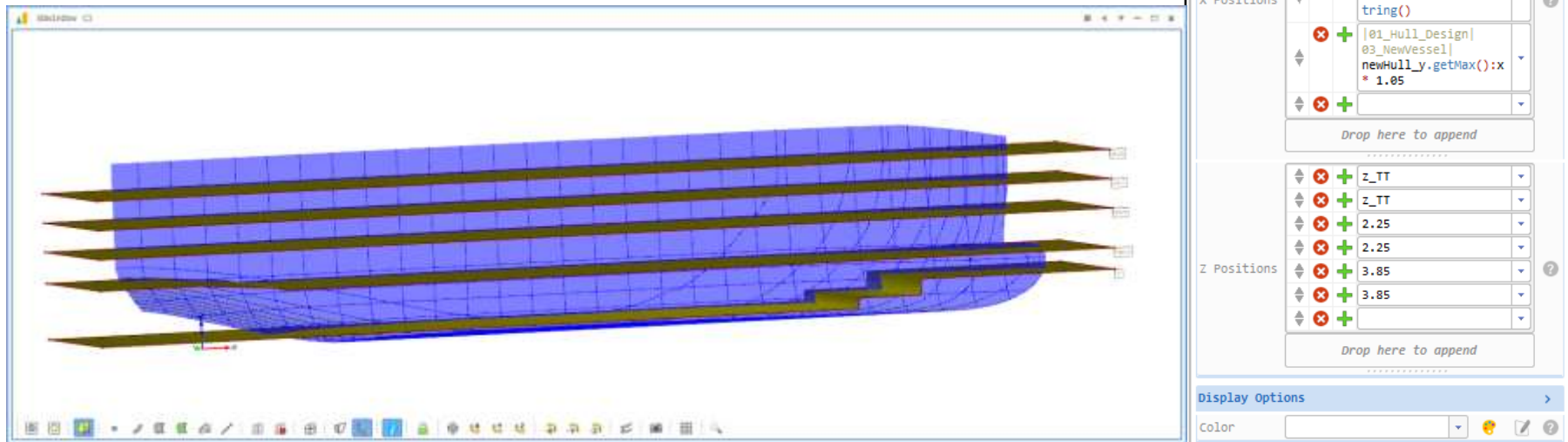
- Longitudinal bulkheads
 - *FFeature:NAPA_LHs*
- Point based
- As many as you need
- BHs snapping
- Hull clearance/offset snapping



Arrangement Generation

NAPA Damage Stability

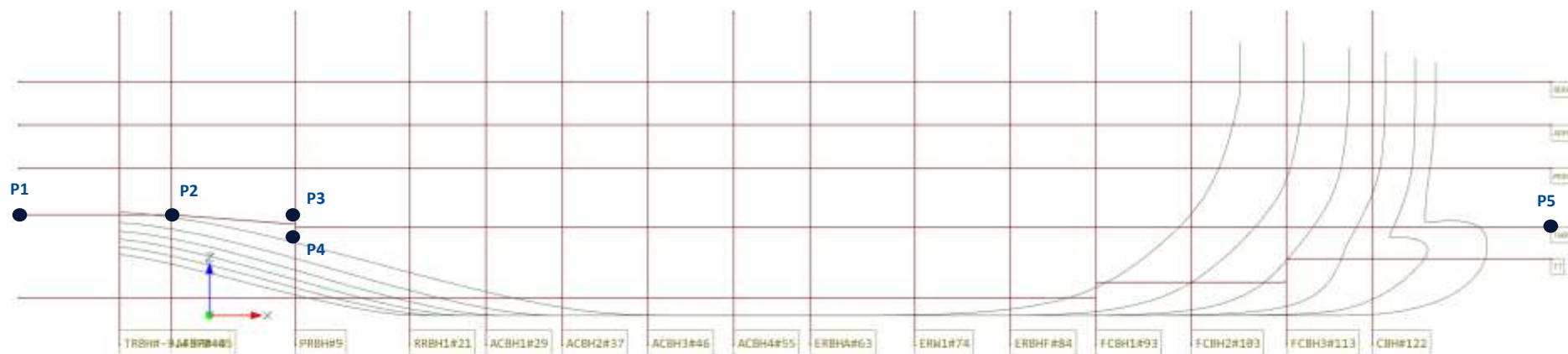
- Flexible arrangement creation
- NAPA equivalent (user friendliness)
- Deck level bulkheads
 - *FFeature:NAPA_THs*



Arrangement Generation

NAPA Damage Stability

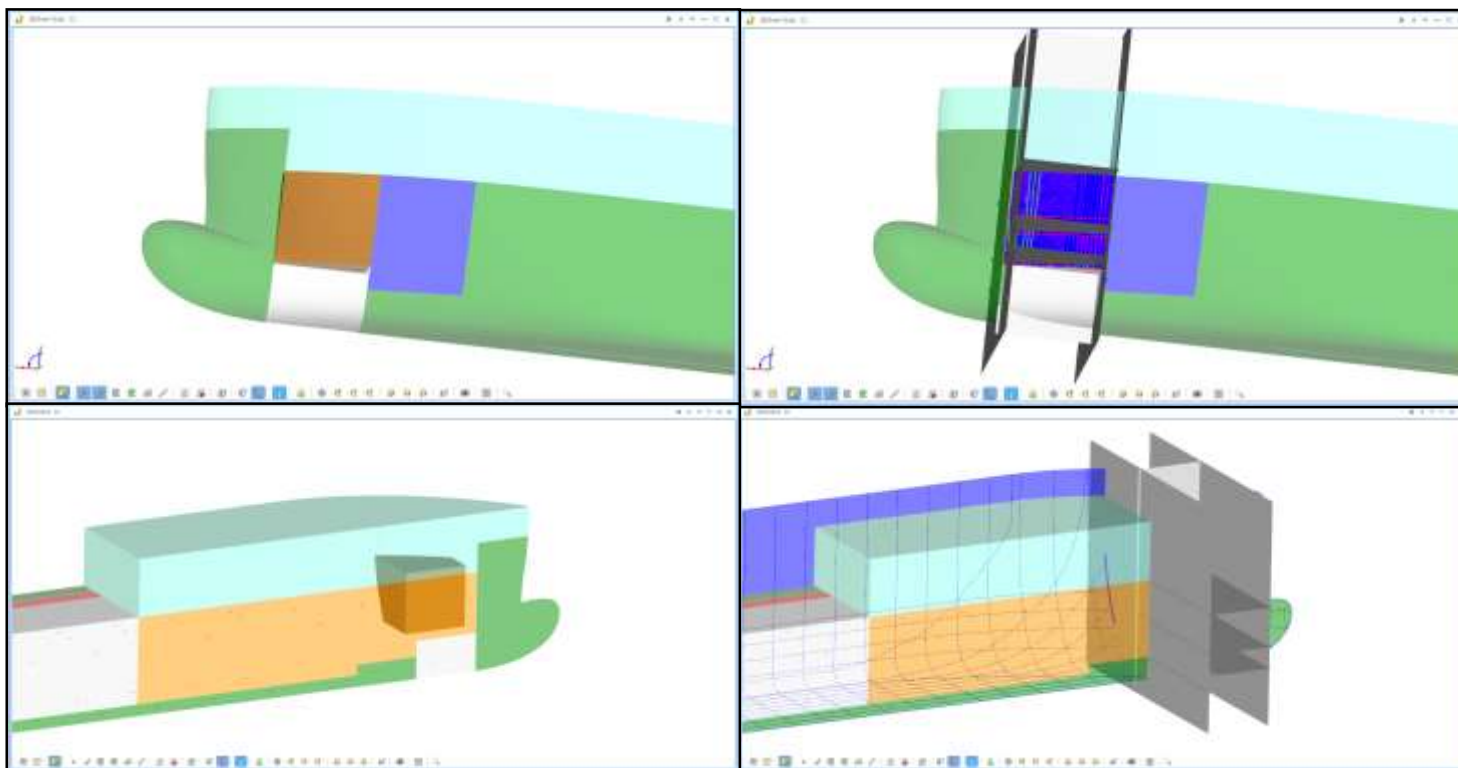
- Deck level bulkheads
 - *FFeature:NAPA_THs*
- Point based
- As many as you need
- BHs snapping



Arrangement Generation

NAPA Damage Stability

- The arrangement
 - Tank intersections
 - Tank merging



Arrangement Generation

NAPA Damage Stability

- Resulting geometry: CAESES -> NAPA (via Software connection)

```

1  ## Note 1: 3-4 non-essential or blank lines in beginning - required for napa
2  ## Note 2: double# is interpreted as a comment line in napa
3  ## Note 3: commands in this script are restricted to "command window" in napa
4
5  #projname='KONGSBERG CAESES DMO' <entry> projname</entry>
6  #descr='CAESES DMO STABILITY DEMO FOR HOLISHIP'
7  ## array maindim containing reference dimensions (Lpp,B,T,frdnet)
8  @maindim=arr(2)
9  @maindim(1)=<entry>length</entry>
10 @maindim(2)=<entry>beam</entry>
11 @maindim(3)=<entry>draught</entry>
12 @maindim(4)=0.65
13 #run.deleteproject(projname)
14 #run.newproject(projname,descr,'','','',maindim)
15
16
17
18 ref
19 coord RIGHTHANDED
20 end
21
22 def
23 from iges <entry>Exports(hull.iges</entry> HULL out-y !
24 ok
25 ROOM DAMHULL
26 LIM = - 0 hull - MDECK
27 ADD ERBHA - 0 hull MDECK BDECK
28 SYM
29
30
31 <entry>genHsPlanes</entry>
32 <entry>genTHs</entry>
33 <entry>genLHs</entry>
34 ok
35 <entry>SICH_T</entry>
36 ok
37 end
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