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CAESES USERS MEETING 2019

Multi-phase design and optimization of an OSV

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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

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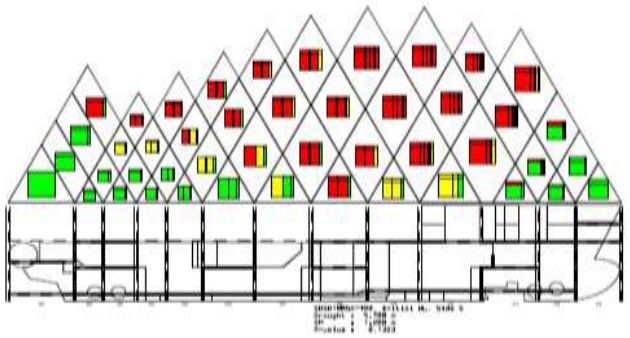
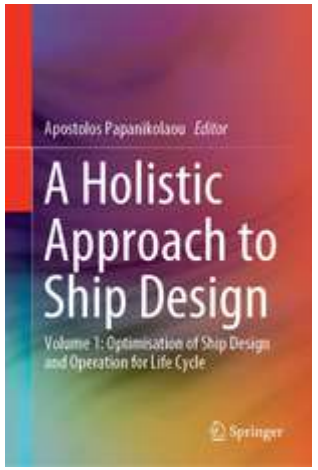
Recent Developments

- 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"



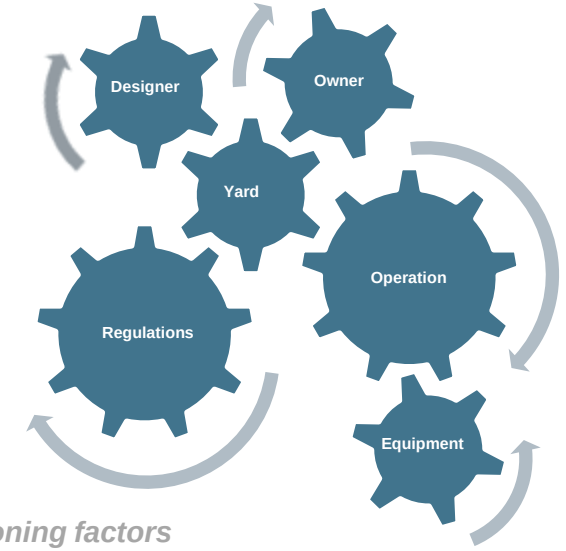
HOLISHIP we are creating the ship of tomorrow

WP9 Background – The OSV

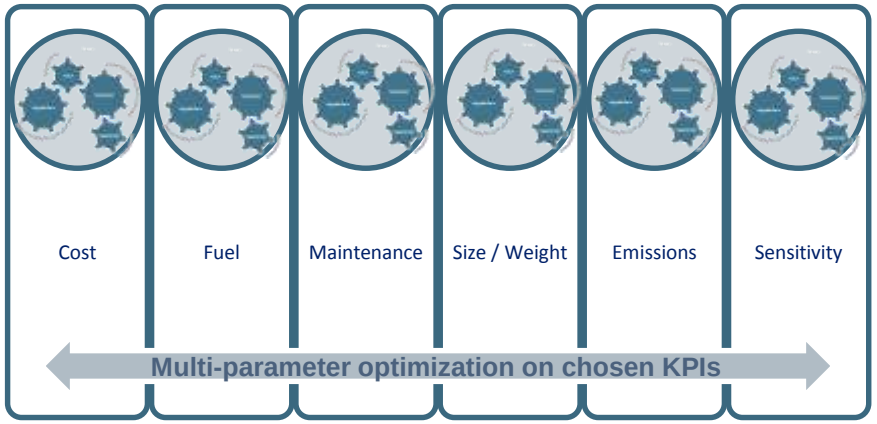
WP9 Background – The OSV

- 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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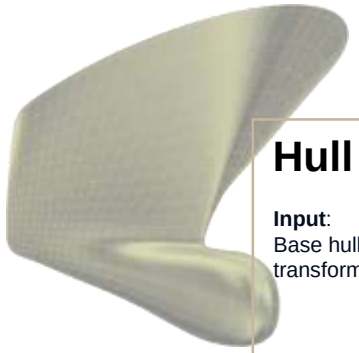
On Theory



Hull design

Input:
Base hull and transformations

Output:
Hull design
Basic Hydrostatics

CAESES feature

Intact Stability

Input:
Hull geometry
CoG
Basic Hydrostatics
Crane info
Lifting weight

Output:
IMO469
Max Heel/Trim
Go/No-go

NAPA

Motions

Input:
Hull geometry
Basic Hydrostatics
Crane motion limits
Sea spectrum

Output:
RAOs
Limiting Hs/Tp
Operability

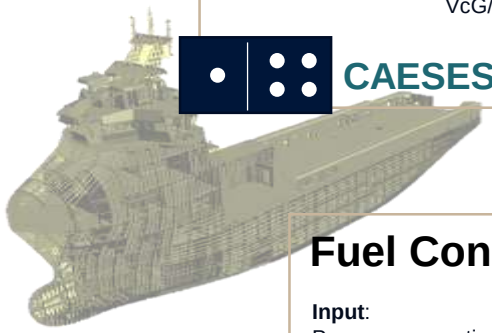
SHIPX - VeRes

Weight Estimations

Input:
Dimensions
Coefficients

Output:
Steel weight
Lightship weight
Operational
VcG/GM0

CAESES feature



Station-Keeping

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

Output:
Max Thurst

SHIPX-SK

Fuel Consumption

Input:
Power consumption
Thruster sizes

Output:
Fuel consumption

COSSMOS

Propulsion Dimensioning

Input:
Thursters database
DP Thrust
Sailing thrust

Output:
Propulsors
Power fore
Power aft

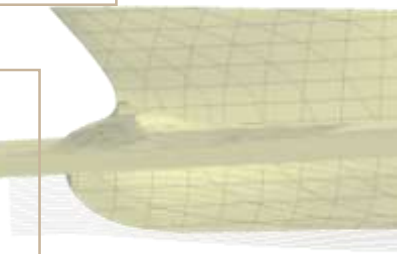
CAESES feature

Resistance

Input:
Hull design
Speed

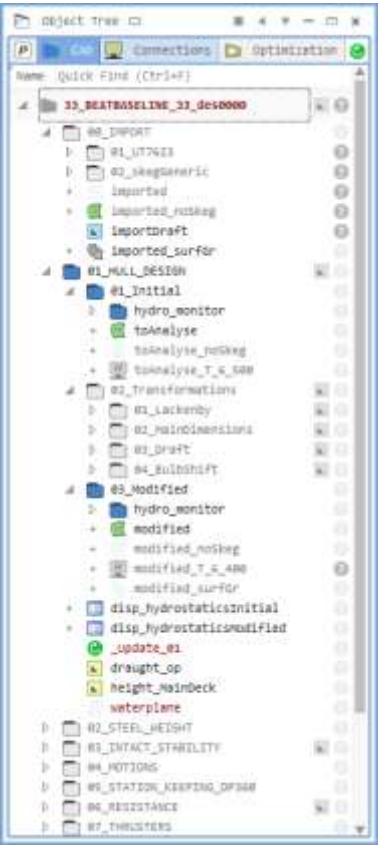
Output:
Resistance
Sailing
Thurst/Power

SHIPFLOW



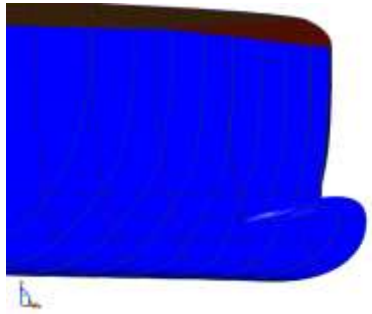
01 – Hull Design

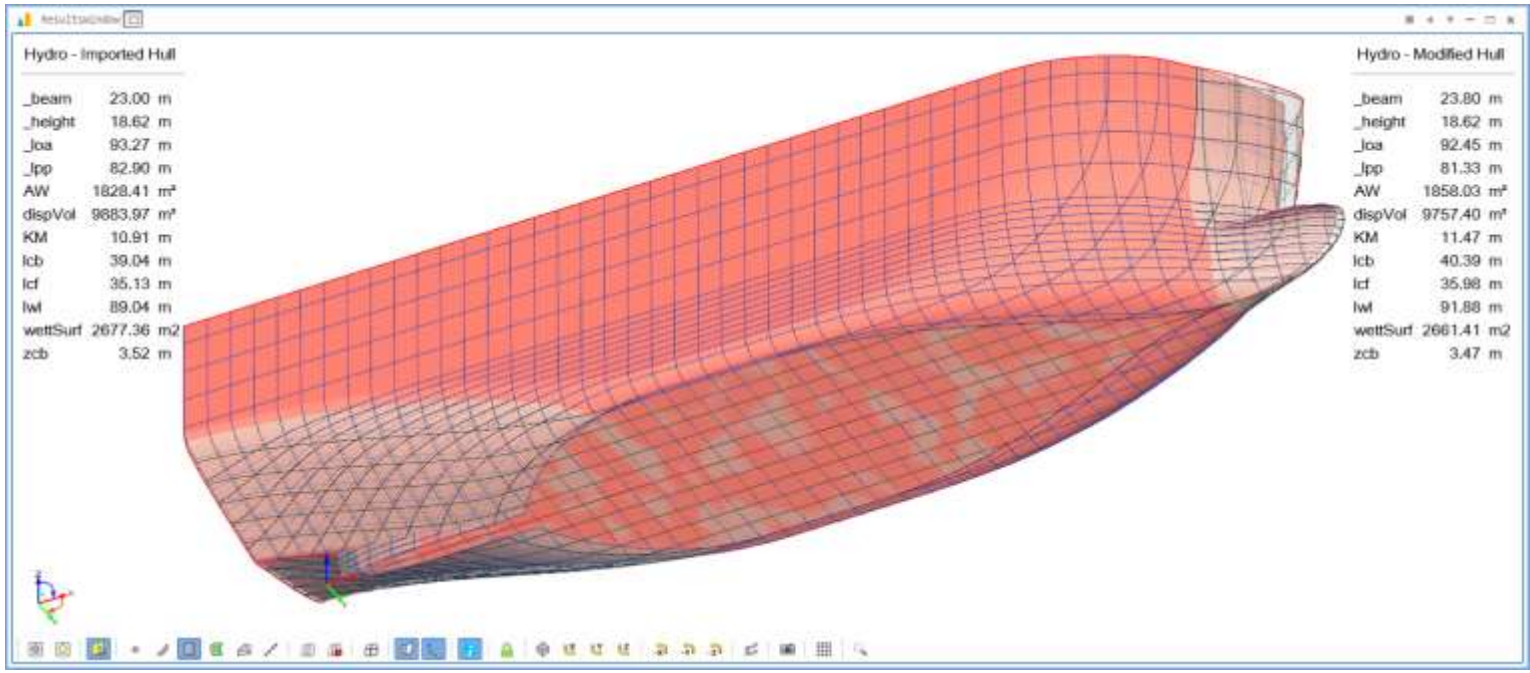
On practice



Import ➡ **Monitor** ➡ **Transform** ➡ **Monitor** ➡ **Advance**

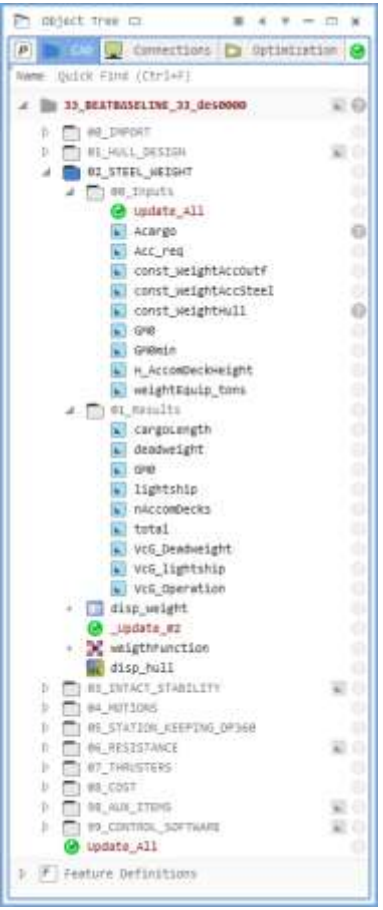
- Lackenby
- Main Dimensions
- Design Draught
- Bulb





02 – Weight Estimations

On practice

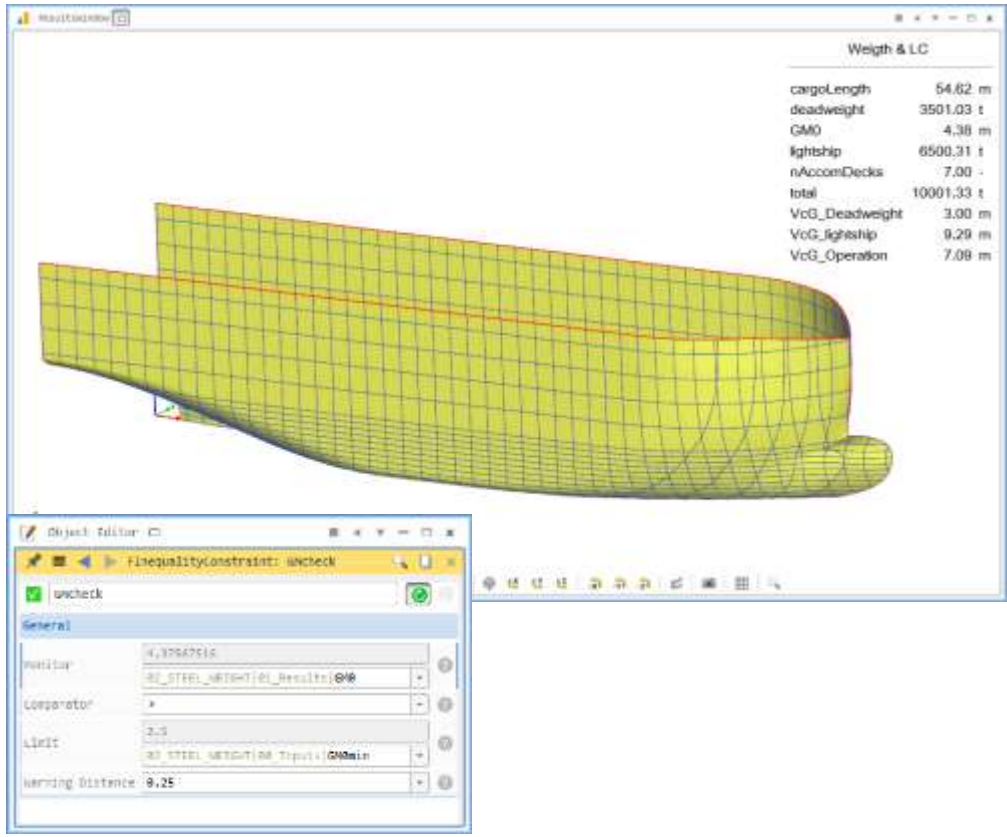


Inputs ➡ **Empirical Function** ➡ **Monitor** ➡ **Advance**

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

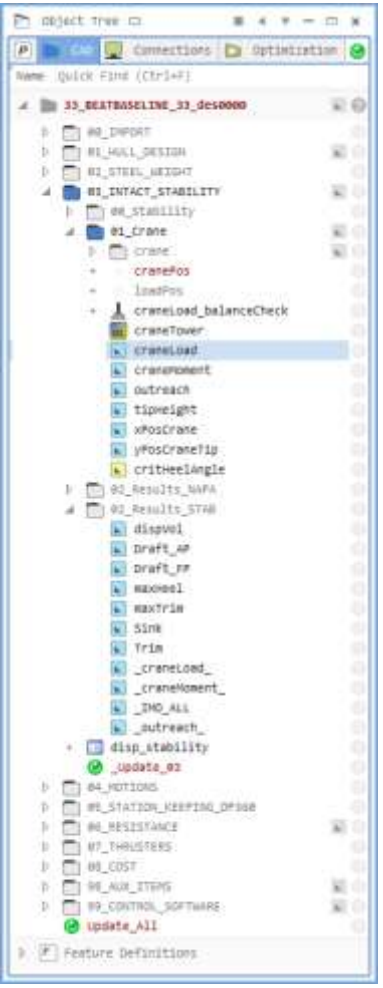
Outputs:

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



03 – Intact Stability

On practice

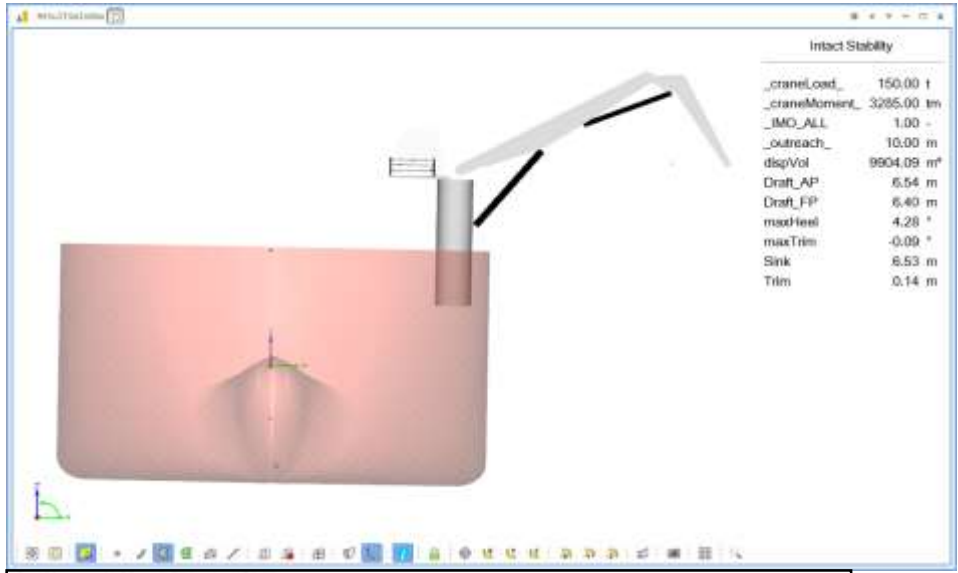


Inputs → **NAPA HYD** → **Crane Balance Feature** → **Monitor** → **Advance**

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

Outputs:

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

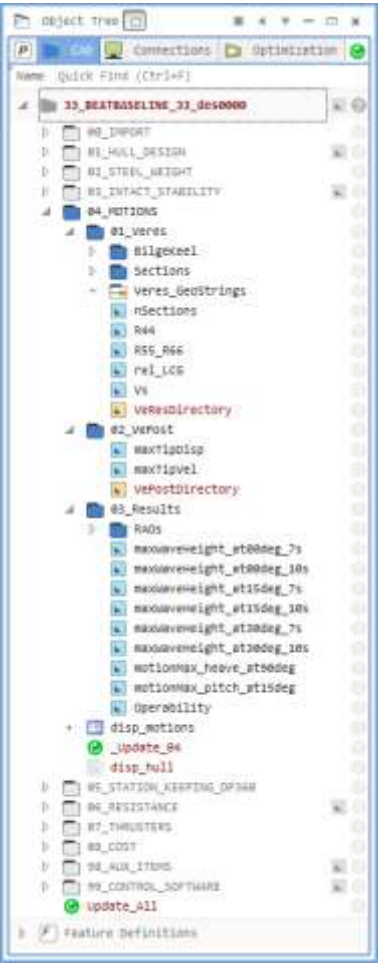


Loading condition: T=6.4 m; TR=0 m

RCR	TEXT	REQ	ATTV	UNIT	STAT	MINGM
IMO469.1	Area depending on GZ-curve top	0.055	0.599	mrad	OK	0.610
IMO469.2	Area between 30 deg and 40 deg	0.030	0.373	mrad	OK	0.928
IMO469.3	Required maximum GZ-value	0.200	2.156	m	OK	0.599
IMO469.4	Position of maximum GZ-value	15.000	35.840	deg	OK	-0.224
IMO469.5	Required initial GM-value	0.150	4.376	m	OK	0.150
CAE.CONSTHEEL.1	Heel subject to cae.craneMoml	12.000	4.278	deg	OK	1.468

04 – Motions

On practice

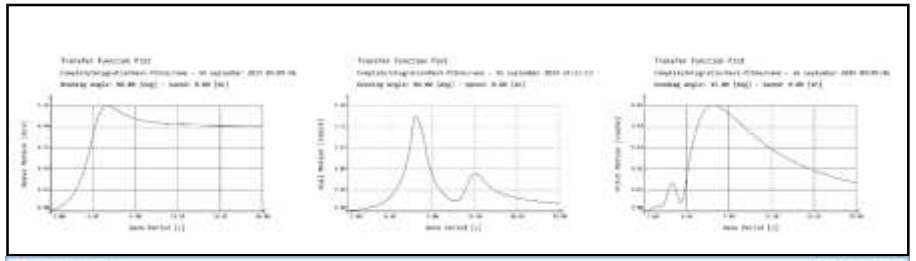


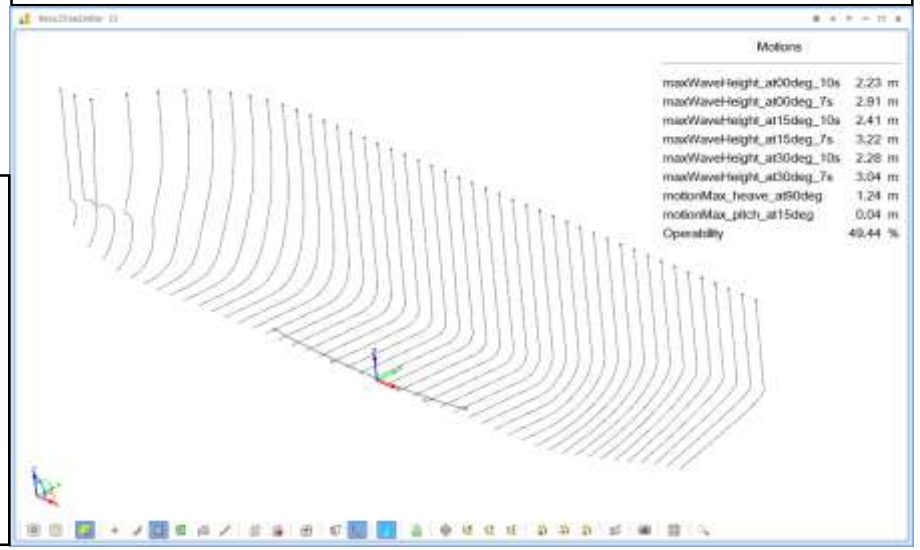
Inputs → **SHIPX VeRes** → **SHIPX VePost** → **Monitor** → **Advance**

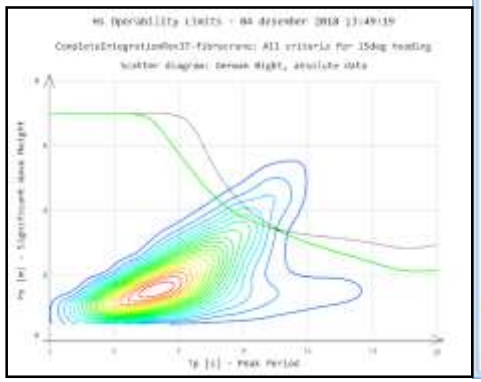
- VeRes format sections
- Crane motions criteria
- Roll reduction tanks
- Bilge keels

Outputs:

- Limiting Hs/Tp
- RAOs

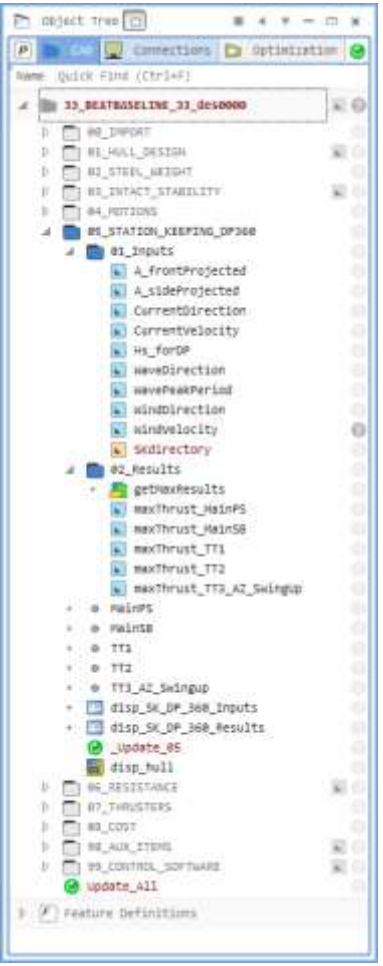






05 – Station Keeping

On practice

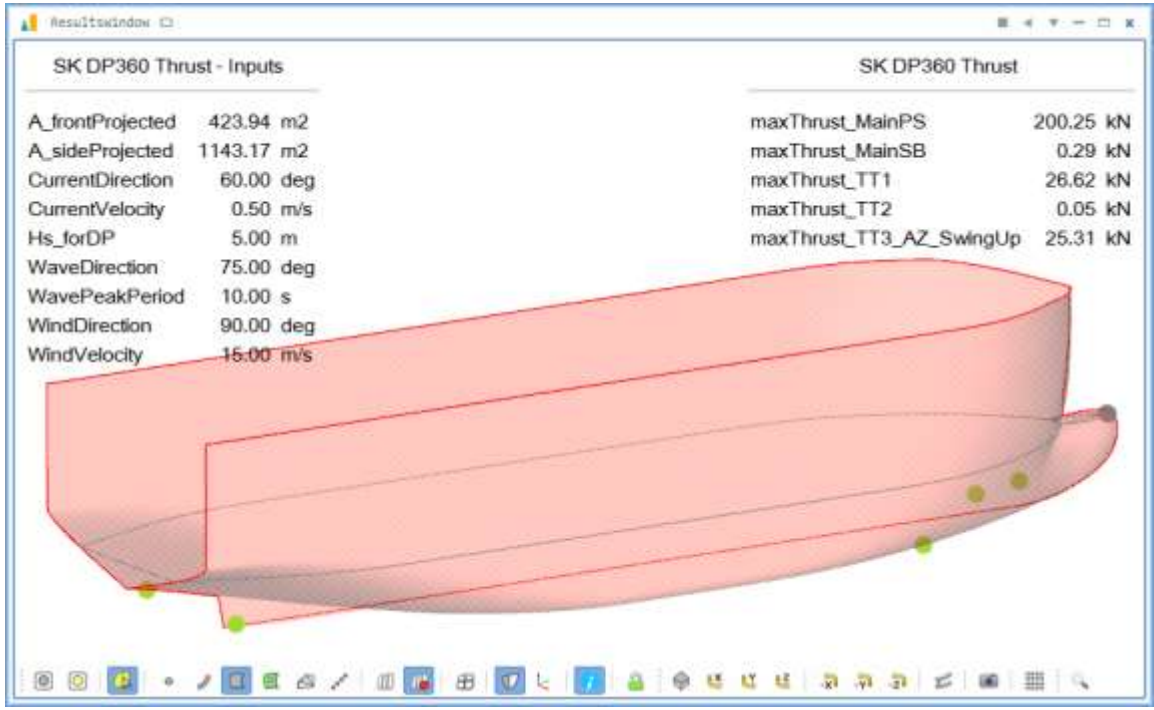


Inputs → **SHIPX SK** → **Monitor** → **Advance**

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

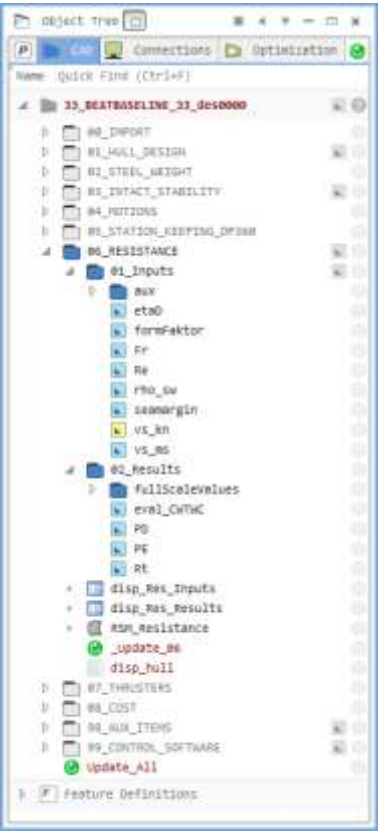
Outputs:

- Thrust required for DP
  - Each propulsor
  - Each heading



06 – Resistance

On practice

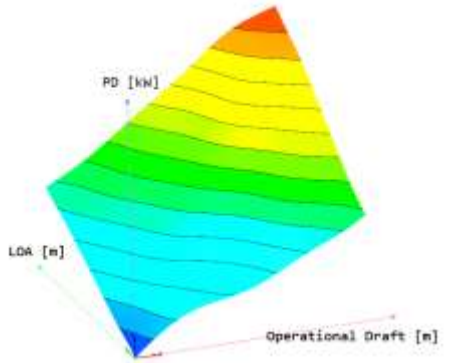


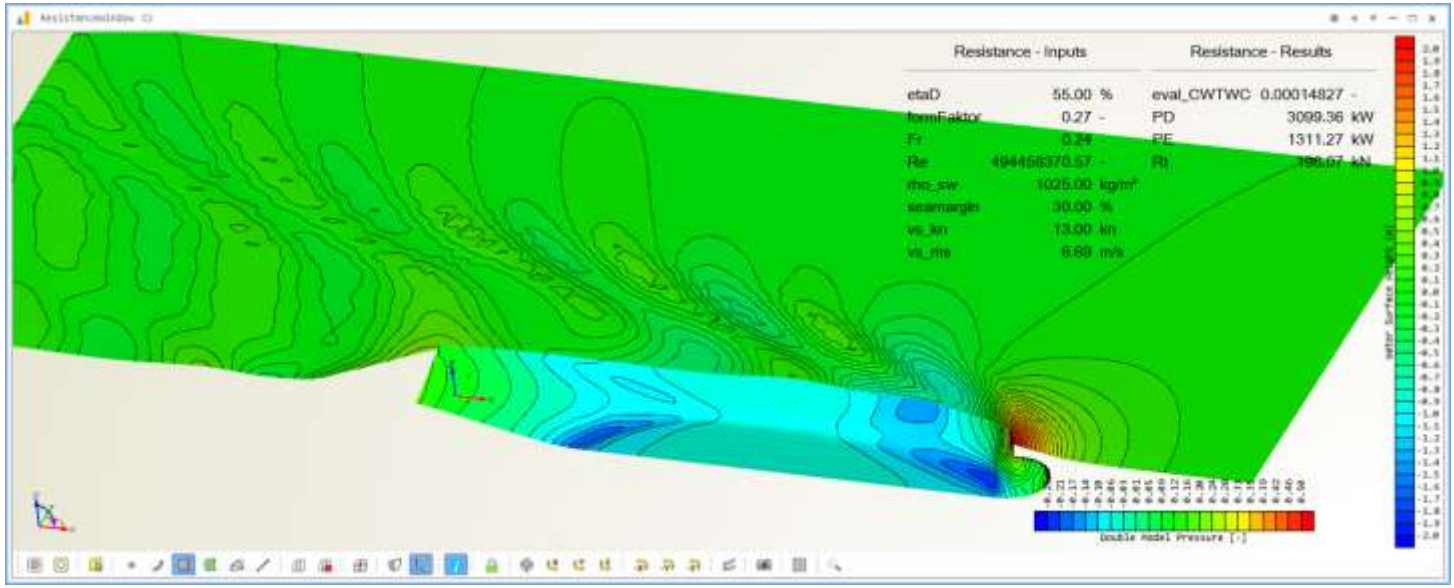
Inputs → **Shipflow - XPAN** → **RSM DoE** → **Monitor** → **Advance**

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

Outputs:

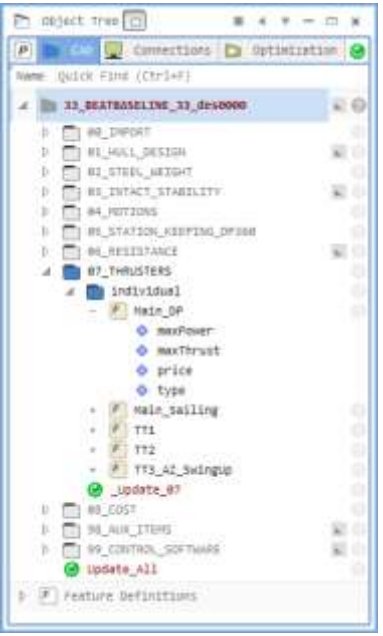
- Thrust required sailing





07 – Propulsion Dimensioning

On practice

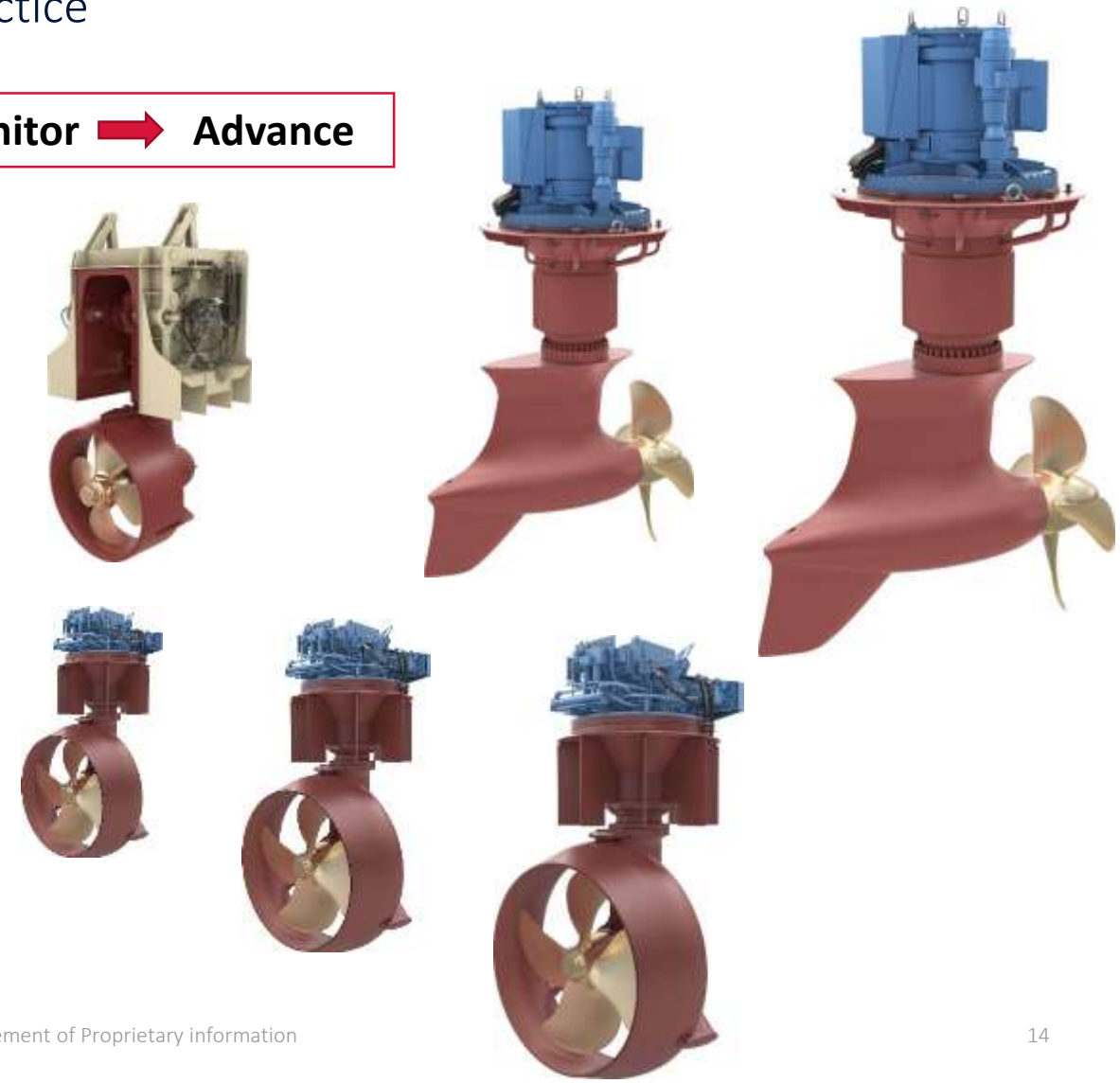


Inputs ➡ **CAESES Feature** ➡ **Monitor** ➡ **Advance**

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

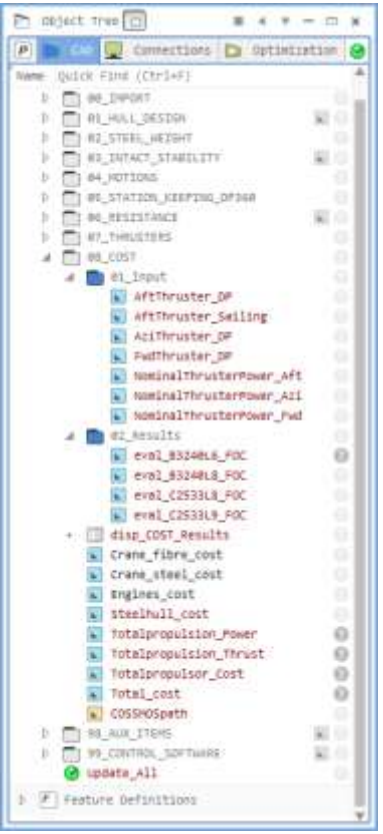
Outputs:

- Each propulsor
  - Type
  - Power
  - Thrust
  - Price



08 – Fuel Consumption

On practice



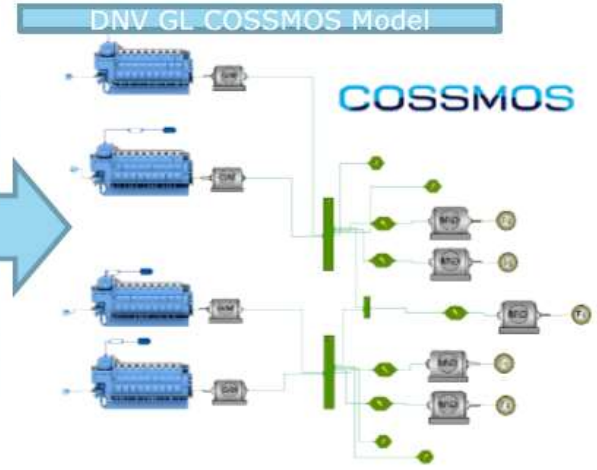
Inputs → **COSSMOS** → **Monitor**

- Thrust delivered
- Power required

Outputs:

- Fuel Consumption
  - 4 different engine types

	Case Settings (*power for thruster dimensioning & demands from Station keeping & Resistance tools*)		
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

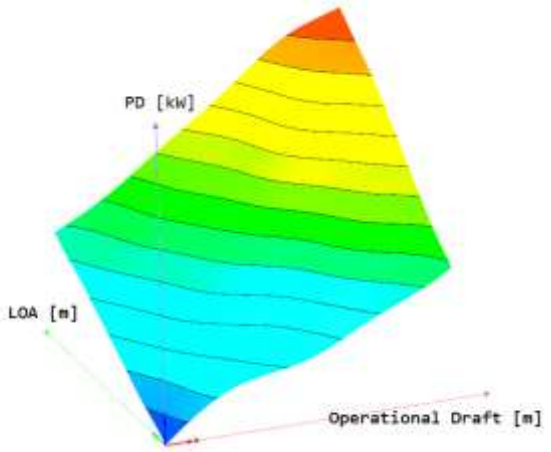


RSM DoE

Results

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

	beam	loa	draftShift	draught	PDoptmised	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

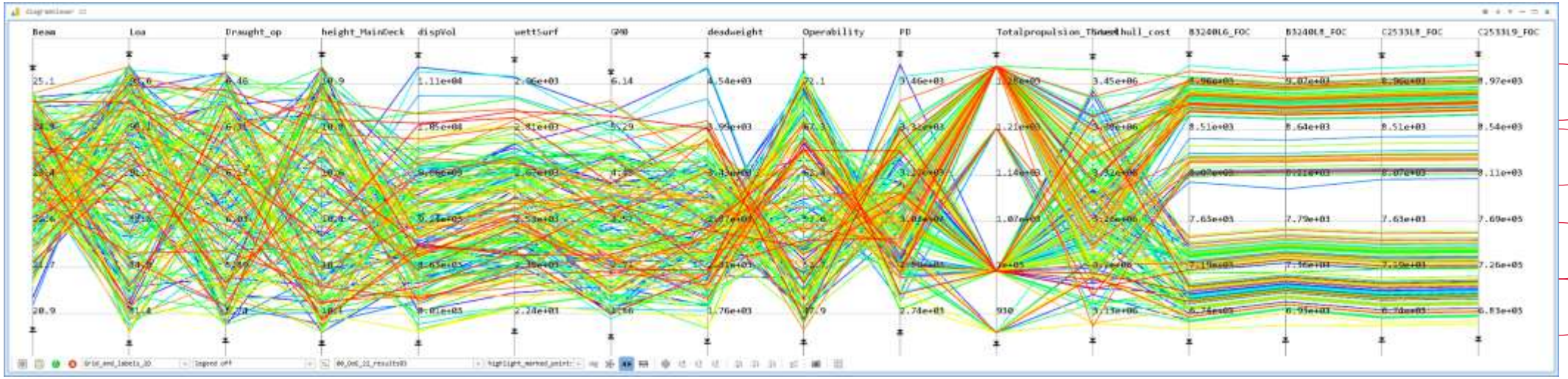
Results

- 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^{o}
- 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

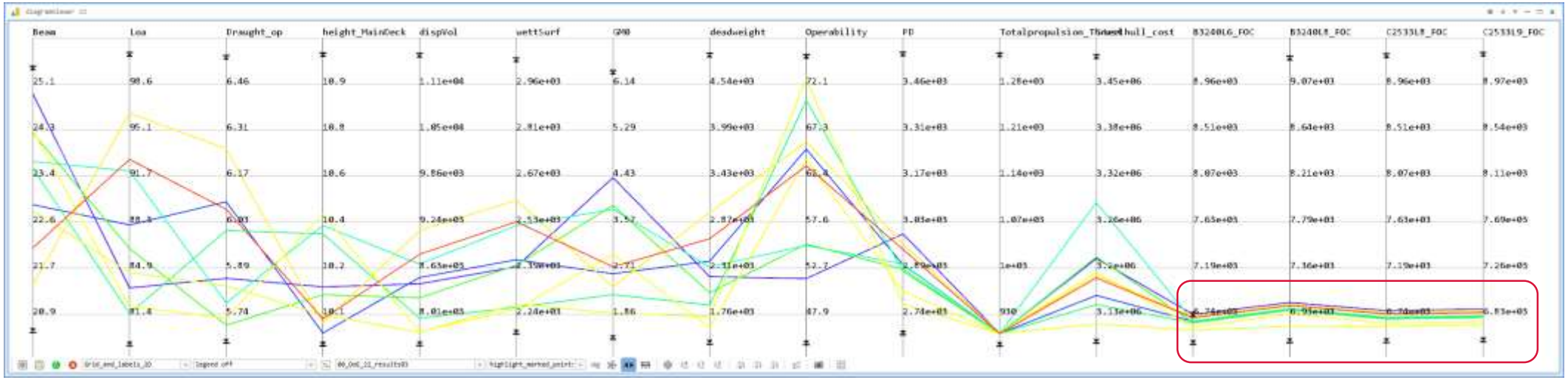
- *Sobol* start for robustness check (250 designs)
  - Difficult to identify trends



Optimization Routine

Results

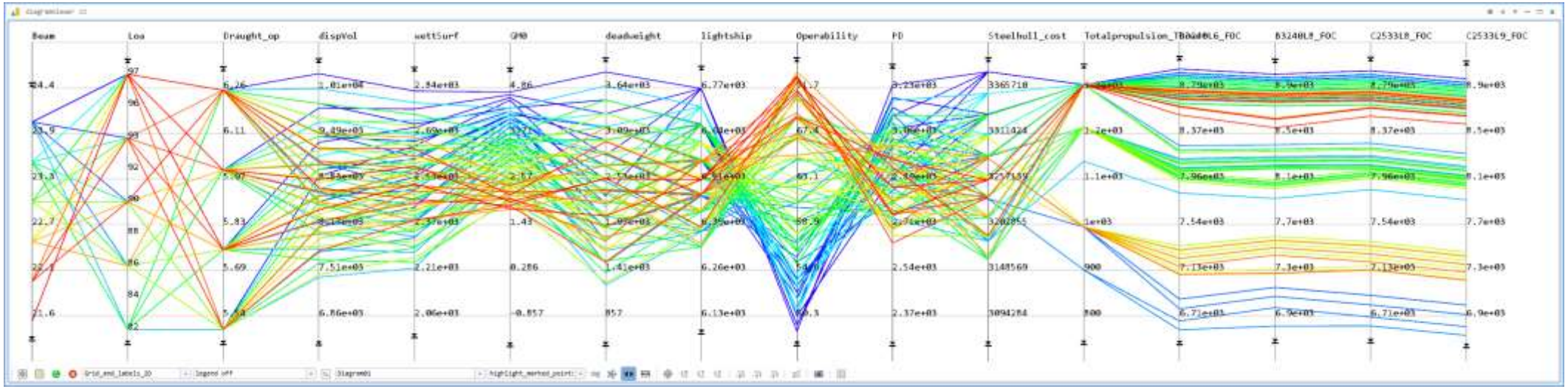
- *Sobol* start for robustness check (250 designs)
  - Difficult to identify trends
  - Clusters of propulsors size combination
  - Focusing on lowest fuel consumption



Optimization Routine

Results

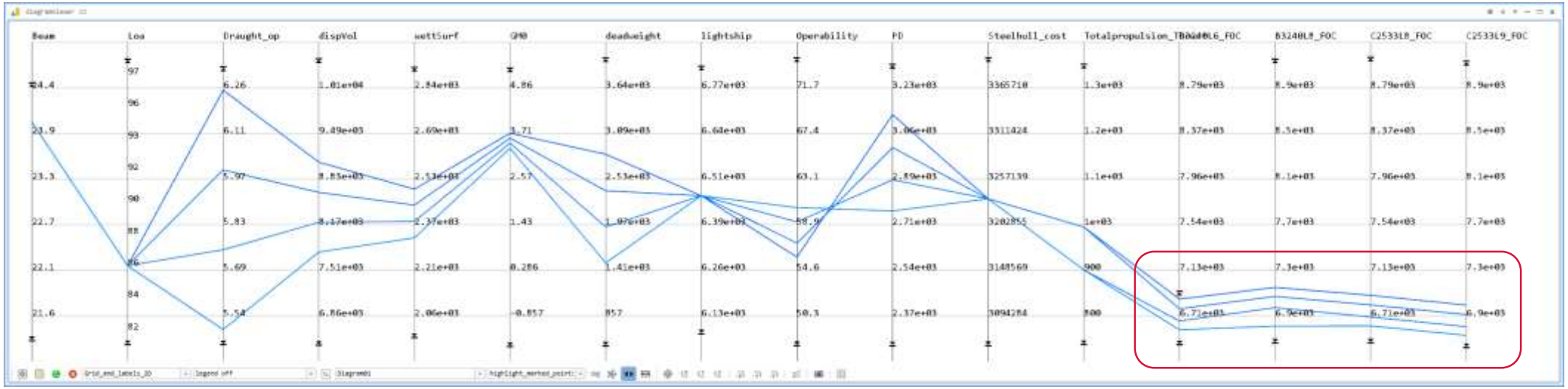
- Large design space
  - From 120 designs, 79 valid results
  - Clusters of propulsors size combination



Optimization Routine

Results

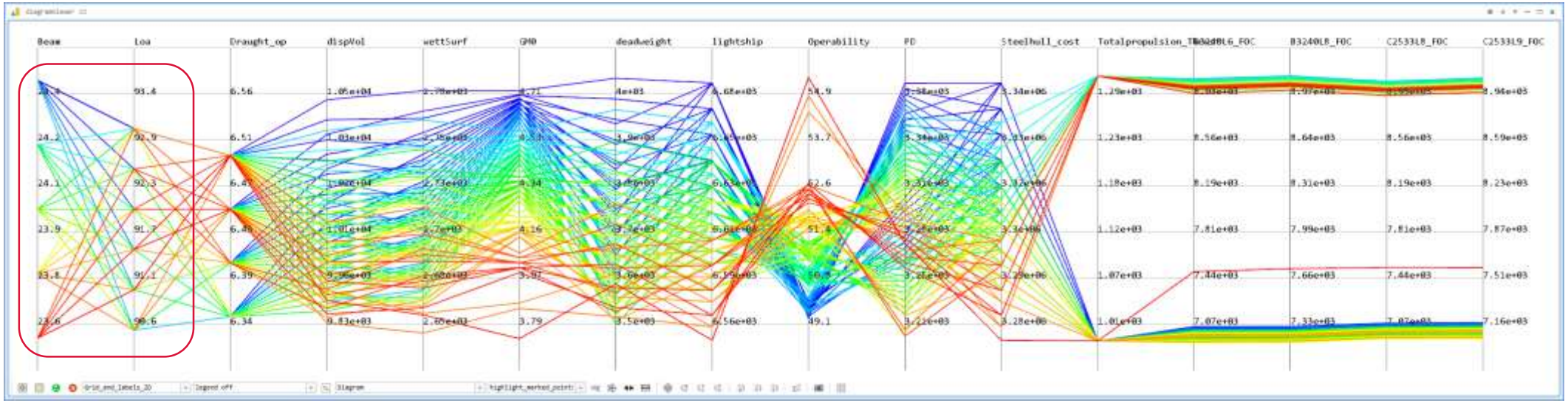
- Large design space
  - From 120 designs, 79 valid results
  - Clusters of propulsors size combination
  - Easier to identify the impact of design variables



Optimization Routine

Results

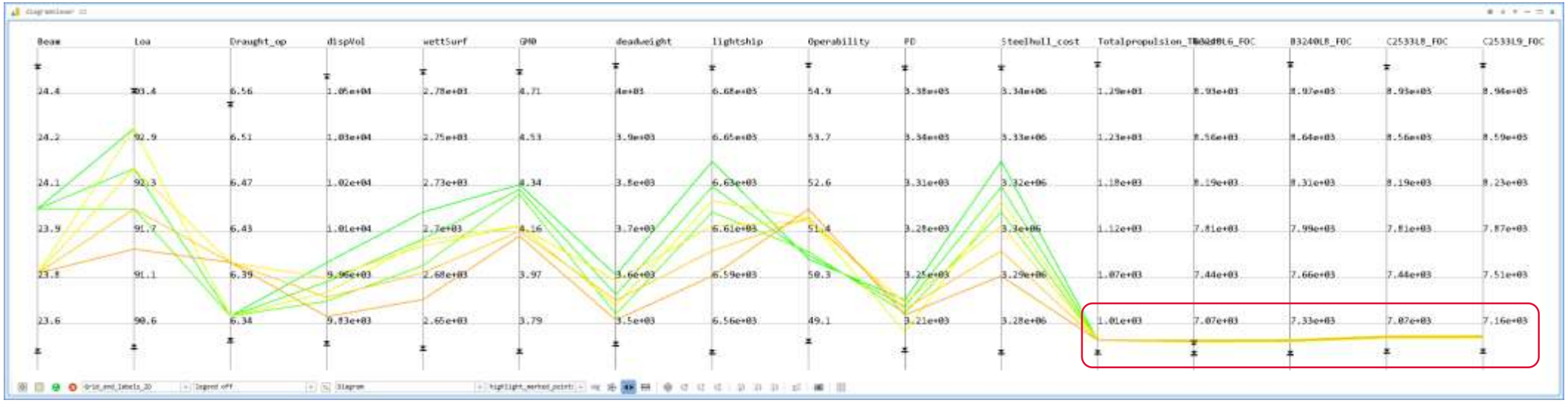
- Focused design space
  - Only 1m variation on Beam, 3m on LOA



Optimization Routine

Results

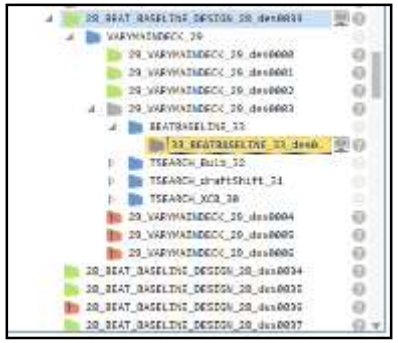
- Focused design space
  - Only 1m variation on Beam, 3m on LOA
  - Lower draught trend identified



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

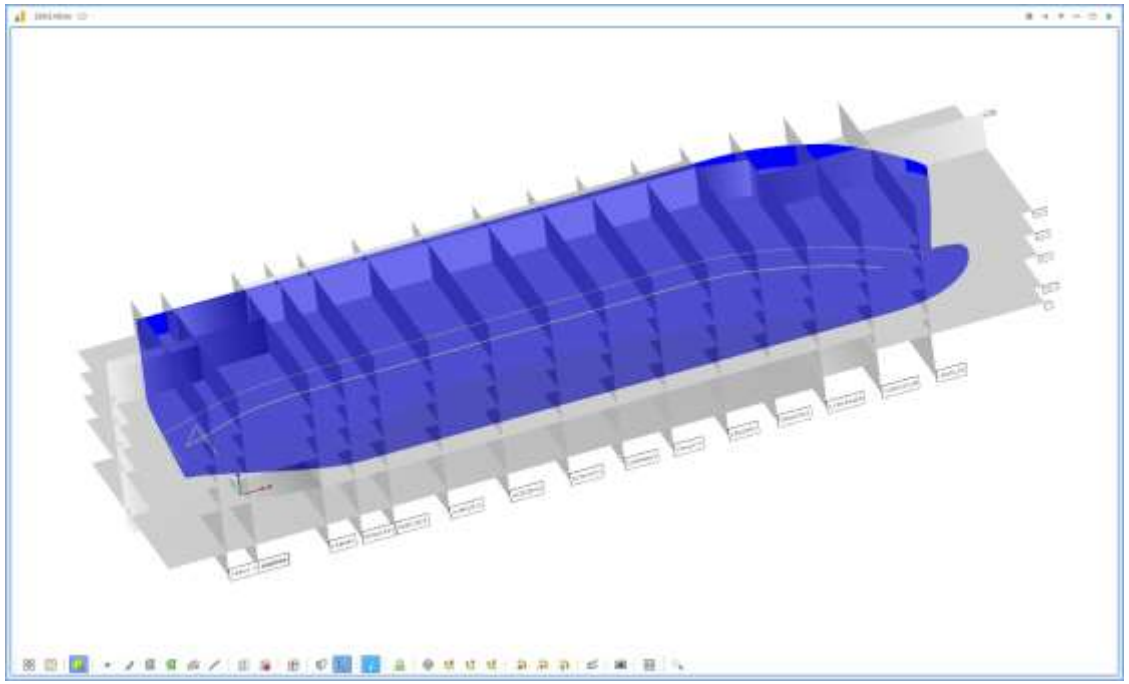


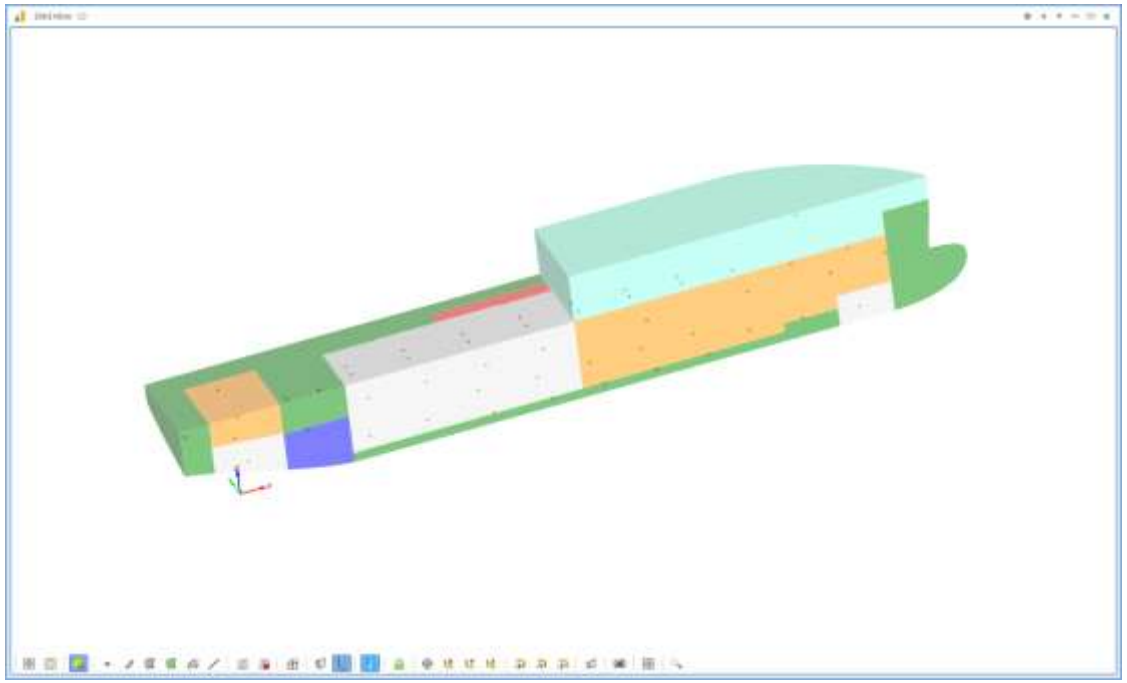
- **Optimised design:**
  - FOC from 8962 to 6846 tonns/Year (-24.3%)
  - Station-keeping highly impact thruster sizes, costs and consumption
  - Slightly wider, shorter vessel
    - Reduced number of accommodation decks = reduced side windage area
    - Beats baseline design due to smaller thrusters possibility

Arrangement Generation

NAPA Damage Stability

- Flexible arrangement creation
- NAPA equivalent (user friendliness)

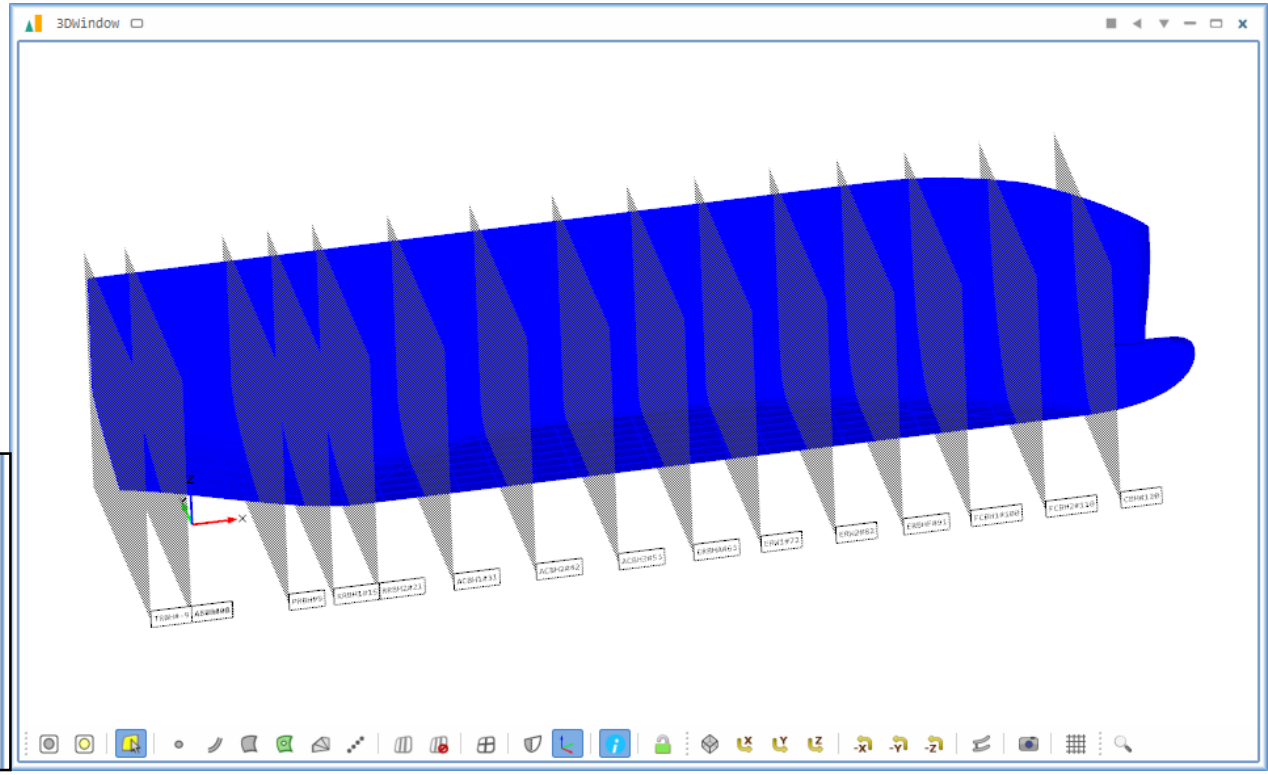




Arrangement Generation

NAPA Damage Stability

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



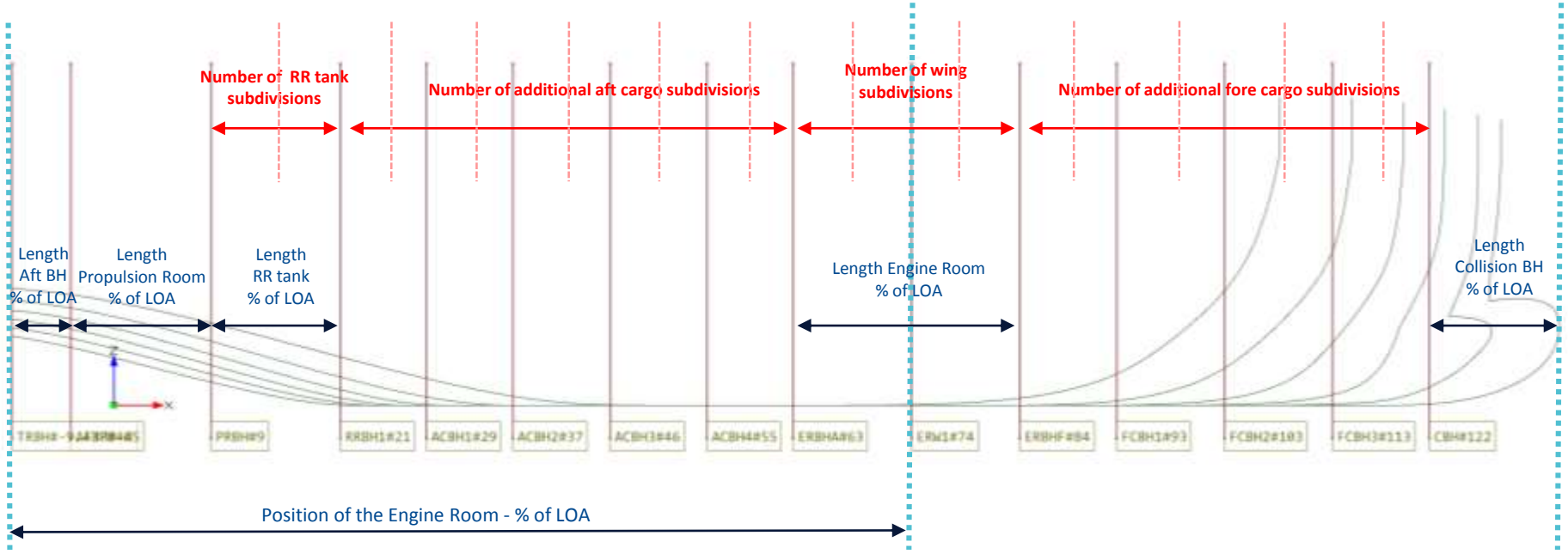
FFeature::NAPA_BHs	–	BHsss
FDouble		LOA
FEntityGroup		BHsOrdered
FEntityGroup		BHsSurfsOrdered
FEntityGroup		labels
FInteger		createBHsA
FInteger		createBHsF
FInteger		runFlag
FString		BHsgenStr

Arrangement Generation

NAPA Damage Stability

- Transversal bulkheads
  - *FFeature:NAPA_BHs*

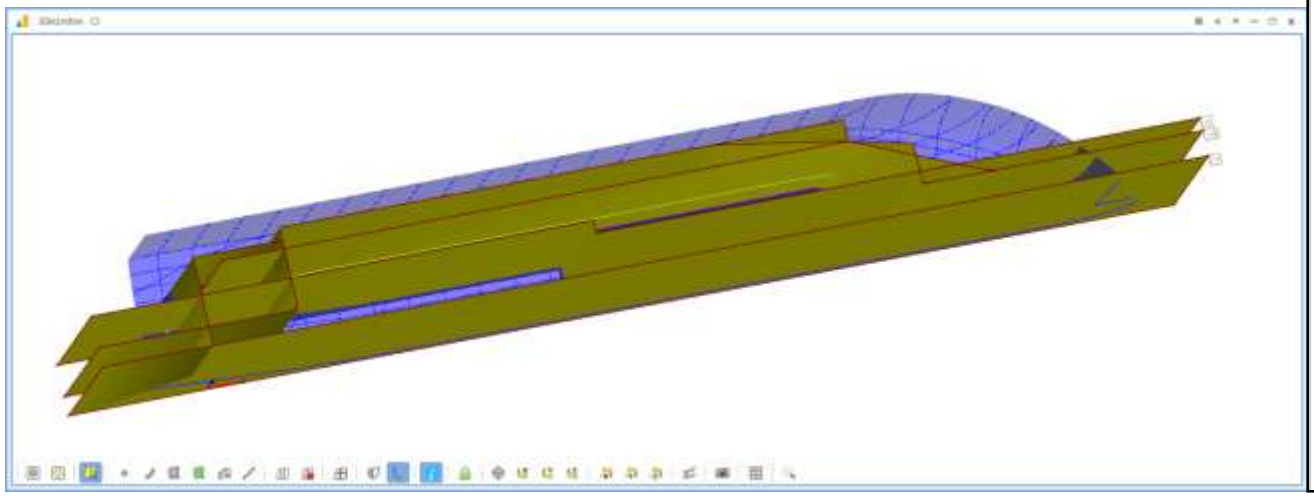
- Auto ordering, naming and numbering
- #Frames positioning system
- Custom manual BHs
- Auto restriction of BH length and/or quantity

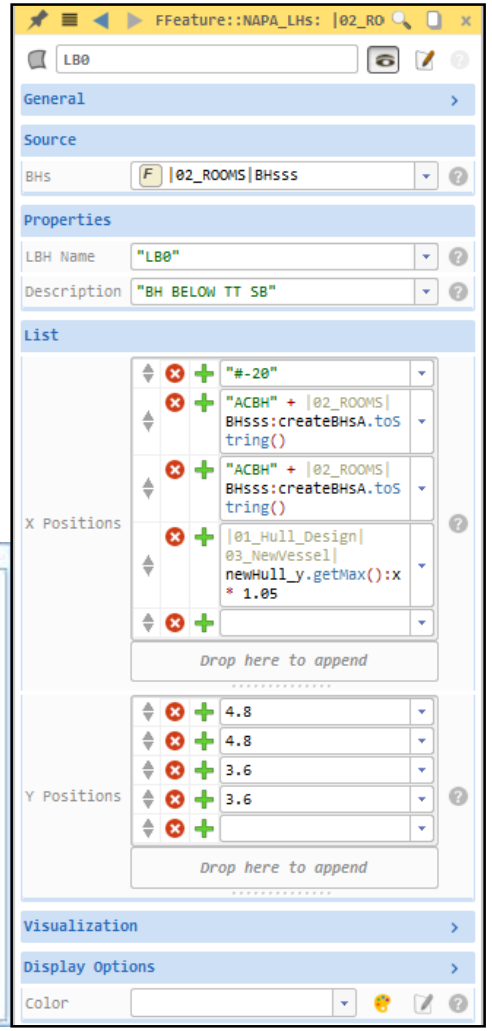


Arrangement Generation

NAPA Damage Stability

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



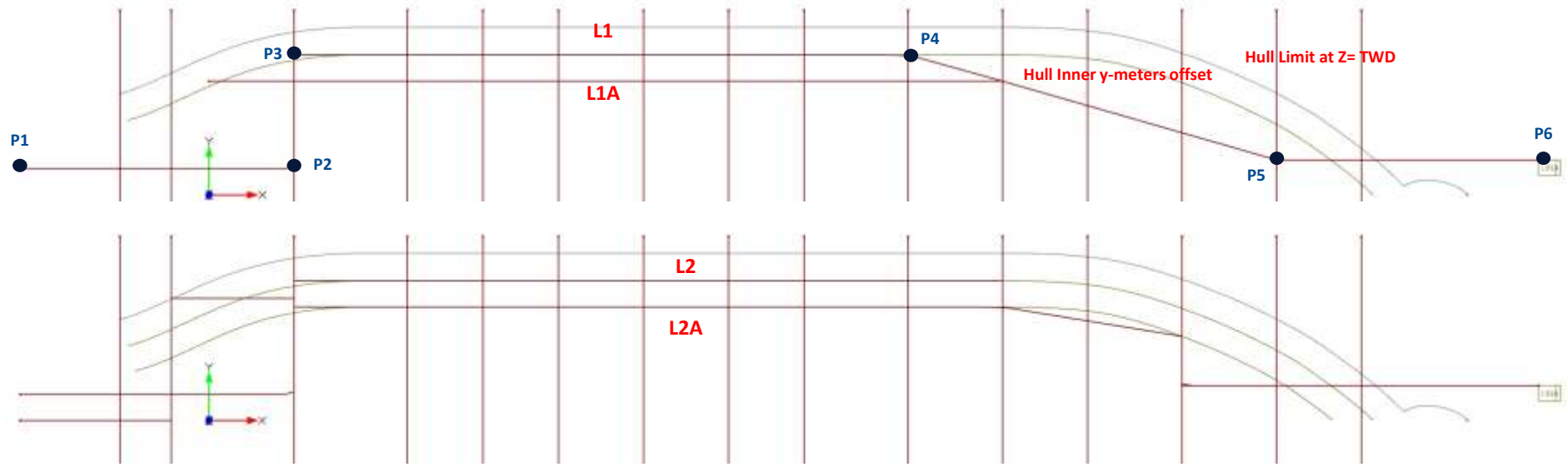


Arrangement Generation

NAPA Damage Stability

- Longitudinal bulkheads
  - *FFeature:NAPA_LHs*

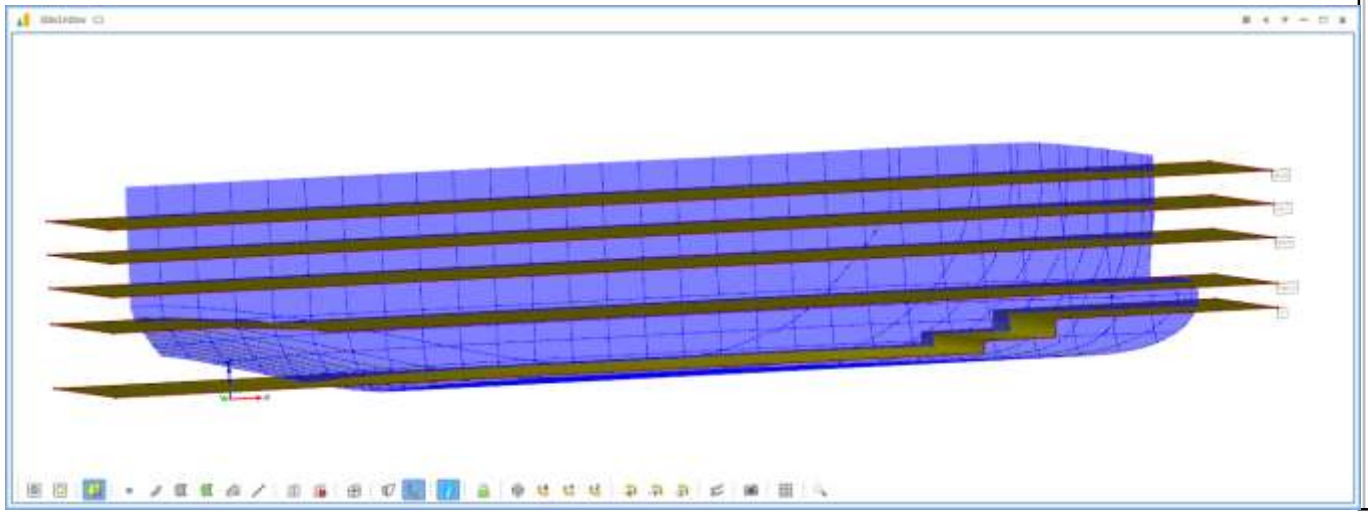
- Point based
- As many as you need
- BHs snapping
- Hull clearance/offset snapping

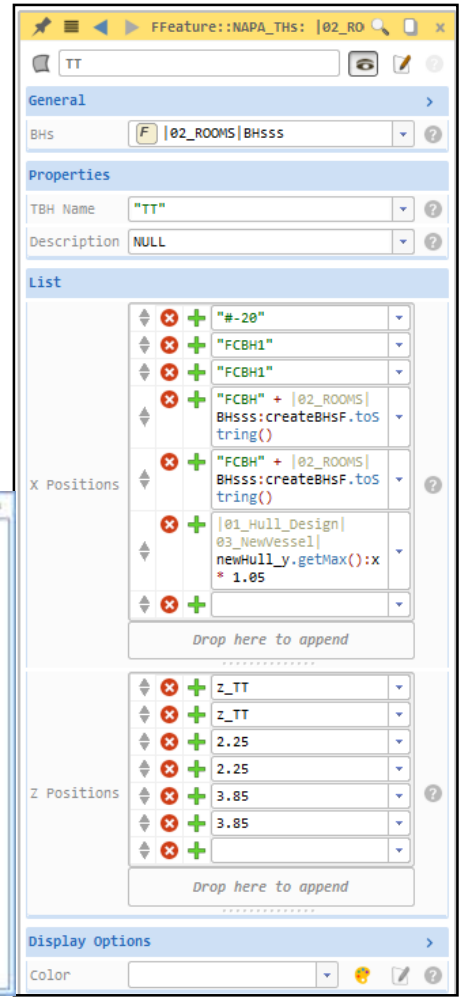


Arrangement Generation

NAPA Damage Stability

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



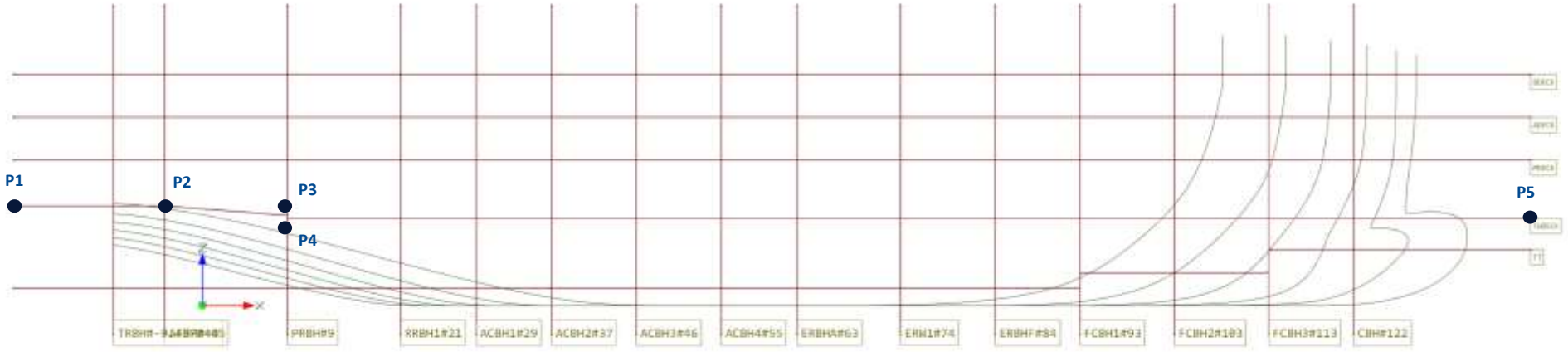


Arrangement Generation

NAPA Damage Stability

- Deck level bulkheads
  - *FFeature:NAPA_THs*

- Point based
- As many as you need
- BHs snapping

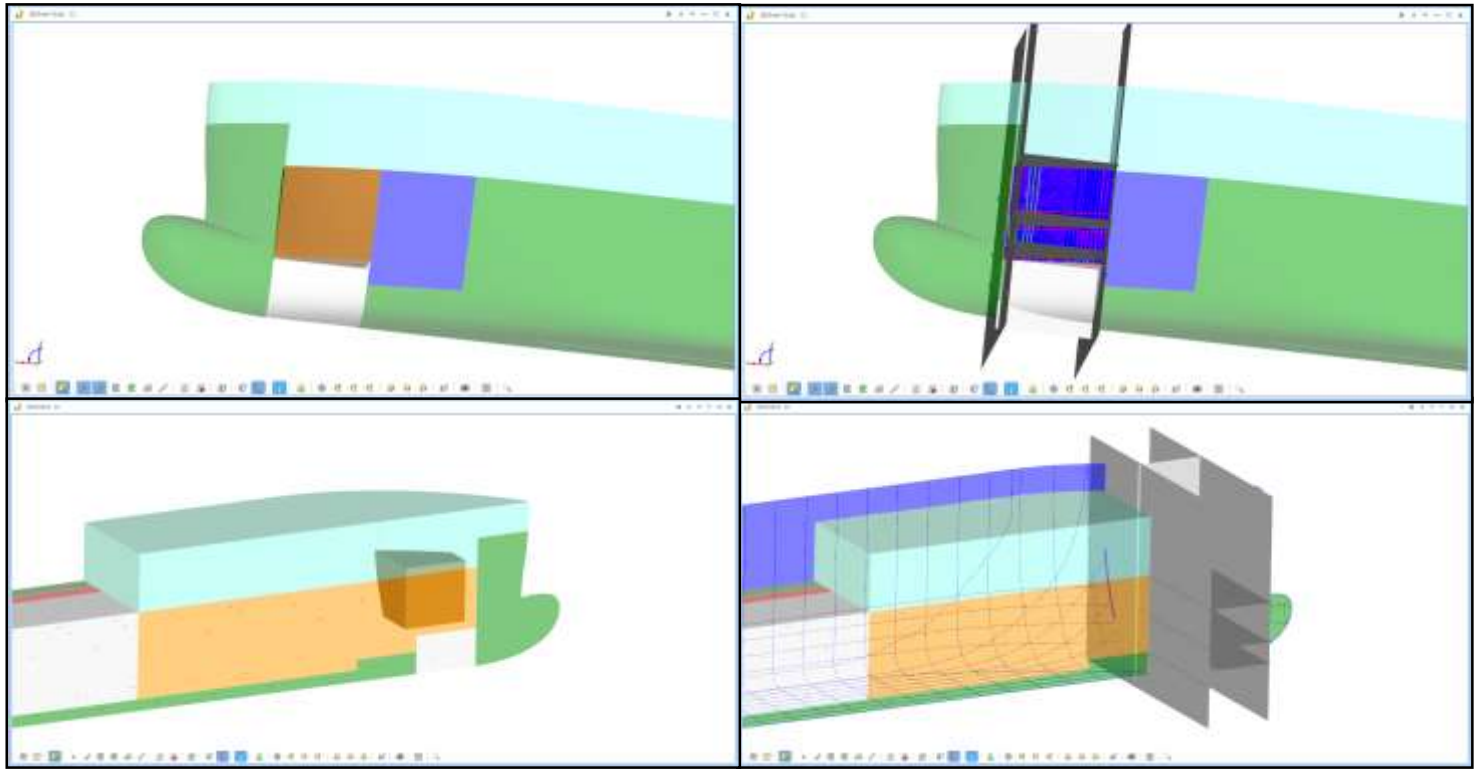


Arrangement Generation

NAPA Damage Stability

- The arrangement

- Tank intersections
- Tank merging

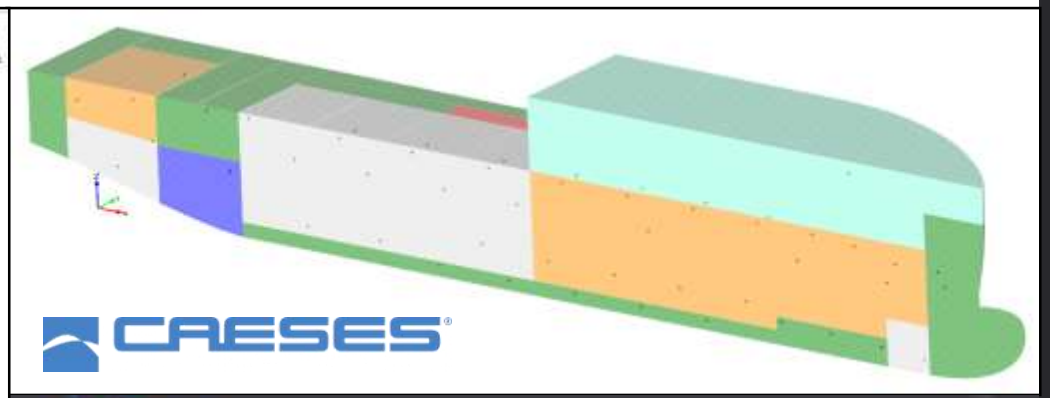


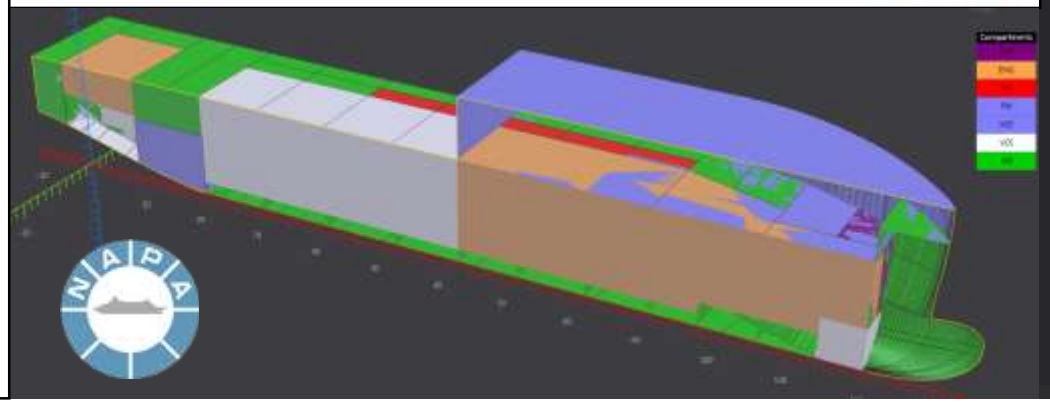
Arrangement Generation

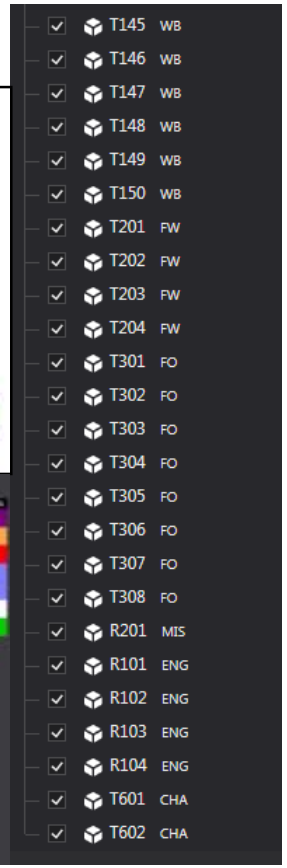
NAPA Damage Stability

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

```
## Note 1: 3-4 non-essential or blank lines in beginning - required for napa
## Note 2: double# is interpreted as a comment line in napa
## Note 3: commands in this script are restricted to "command window" in napa

@projnam='HLSHP_CAESES_DMG_<entry>projnam</entry>'
@descr='CAESES DMG STABILITY DEMO FOR HOLISHIP'
## array maindim containing reference dimensions (Lpp,B,T,frdist)
@maindim=arr(2)
@maindim(1)=<entry>length</entry>
@maindim(2)=<entry>beam</entry>
@maindim(3)=<entry>draught</entry>
@maindim(4)=0.65
@n=mn.deleteproject(projnam)
@n=mn.newproject(projnam,descr,'','','',maindim)

ref
coord RIGHTHANDED
end

def
from iges <entry>Exports\hull.igs</entry> HULL out-y !
ok
ROOM DAMHULL
LIM - - 0 hull - HDECK
ADD ERBEA - 0 hull HDECK BDECK
SYM
ok
<entry>genXMaPlanes</entry>
<entry>genTHRs</entry>
<entry>genLRRs</entry>
ok
<entry>RXRM_T</entry>
ok
!end

SM
NEW A
SAVE
##!HULL TYPE=R
@#ADD LIST()
<entry>ADD_PUMP</entry>
REFL
REG A PERM
!end

DEF
GEN  PROFIL, ARR*A/Y=0.01 MERGE
!END
```







KONGSBERG

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