Holistic design and optimization of a RoPax ferry

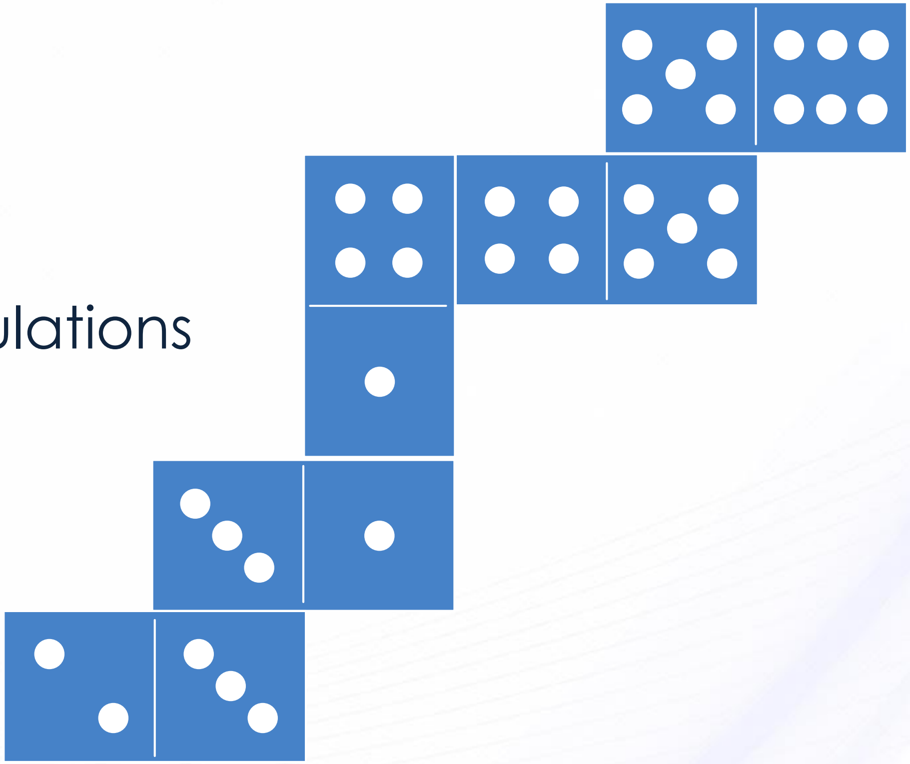
G. Zaraphonitis (NTUA), J. Marzi (HSVA),
A. Papanikolaou (HSVA& NTUA),S. Harries (FS),
A. Kraus (HSB)

CAESES User Meeting,
Berlin, September 19, 2019

Funded by the
European Union

Content

- EU-project HOLISHIP: Application case 8
  - The RoPax Ferry
- Integration approach
  - CAESES® platform
  - Coupling of tools
- Parametric models and simulations
  - Hull form
  - Internal Layout
  - Hydrodynamics
  - Stability
  - Surrogate models
- Design optimisation
- Conclusions / Next steps



Funded by the
European Union

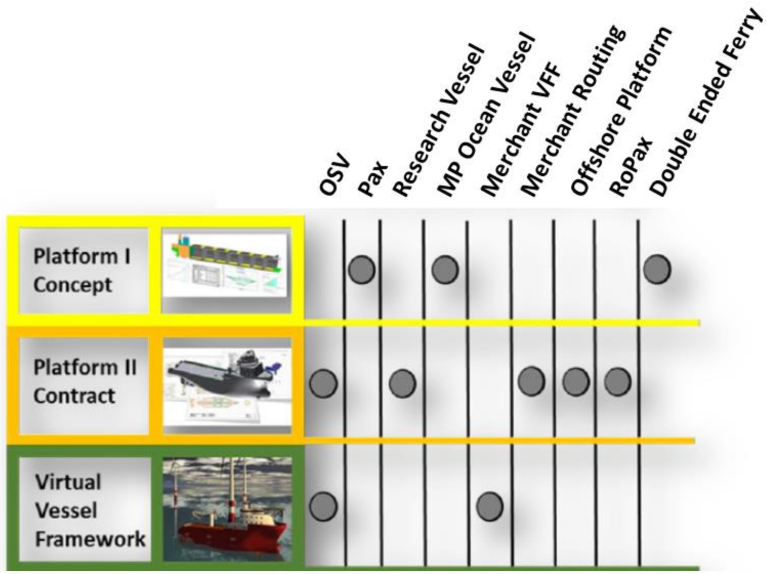
The HOLISHIP Application Cases

1. OSV

2. PAX

3. Research Vessel el

4. MP Ocean Vessel



The impact of the tools developed in HOLISHIP will be showcased using 9 different Demonstrators. All of these are characteristic for European Maritime Operations.

5./6. Merchant Vessel

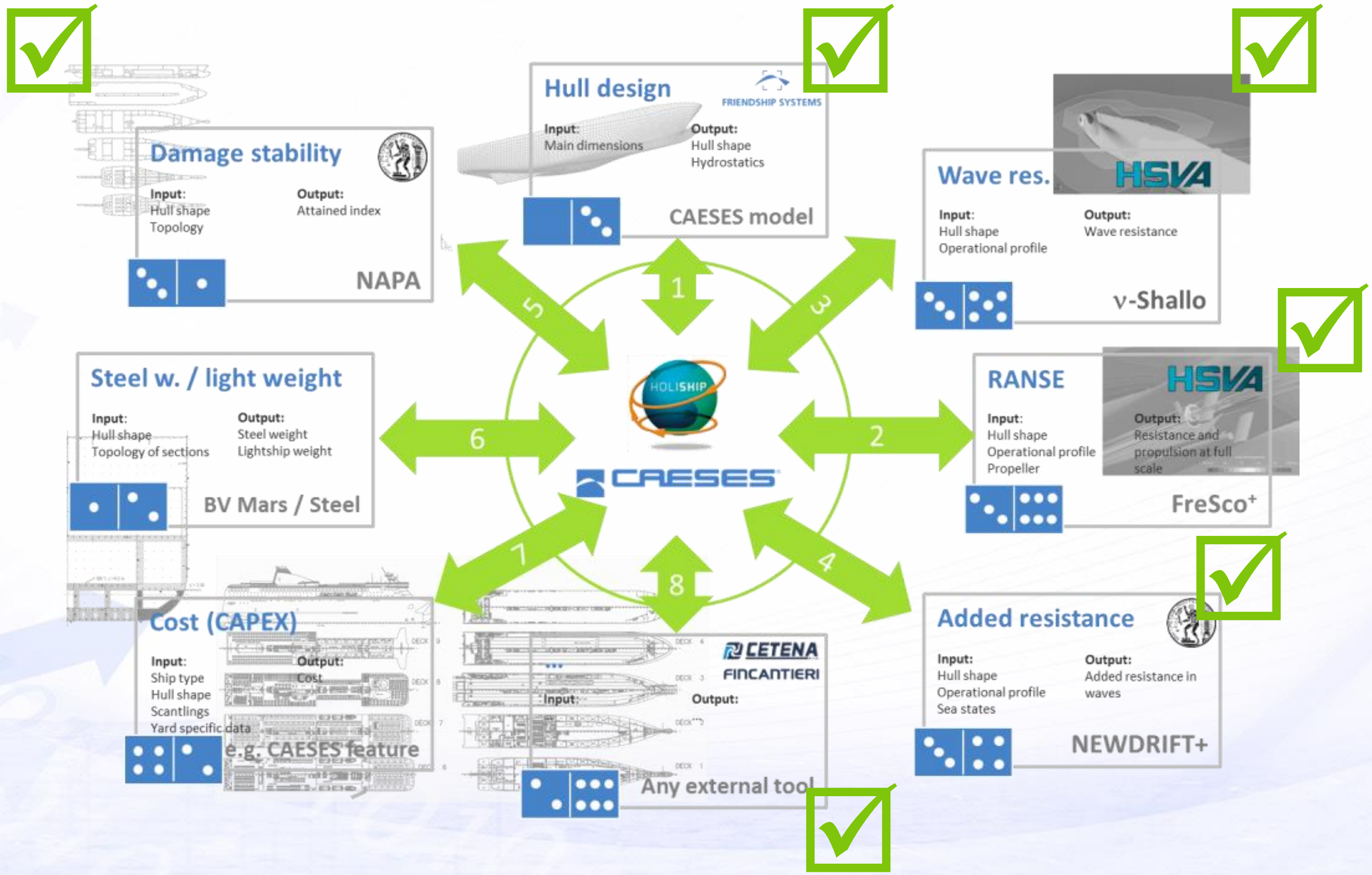
7. Offshore Structure

8. RoPAX

9. Double Ended Ferry

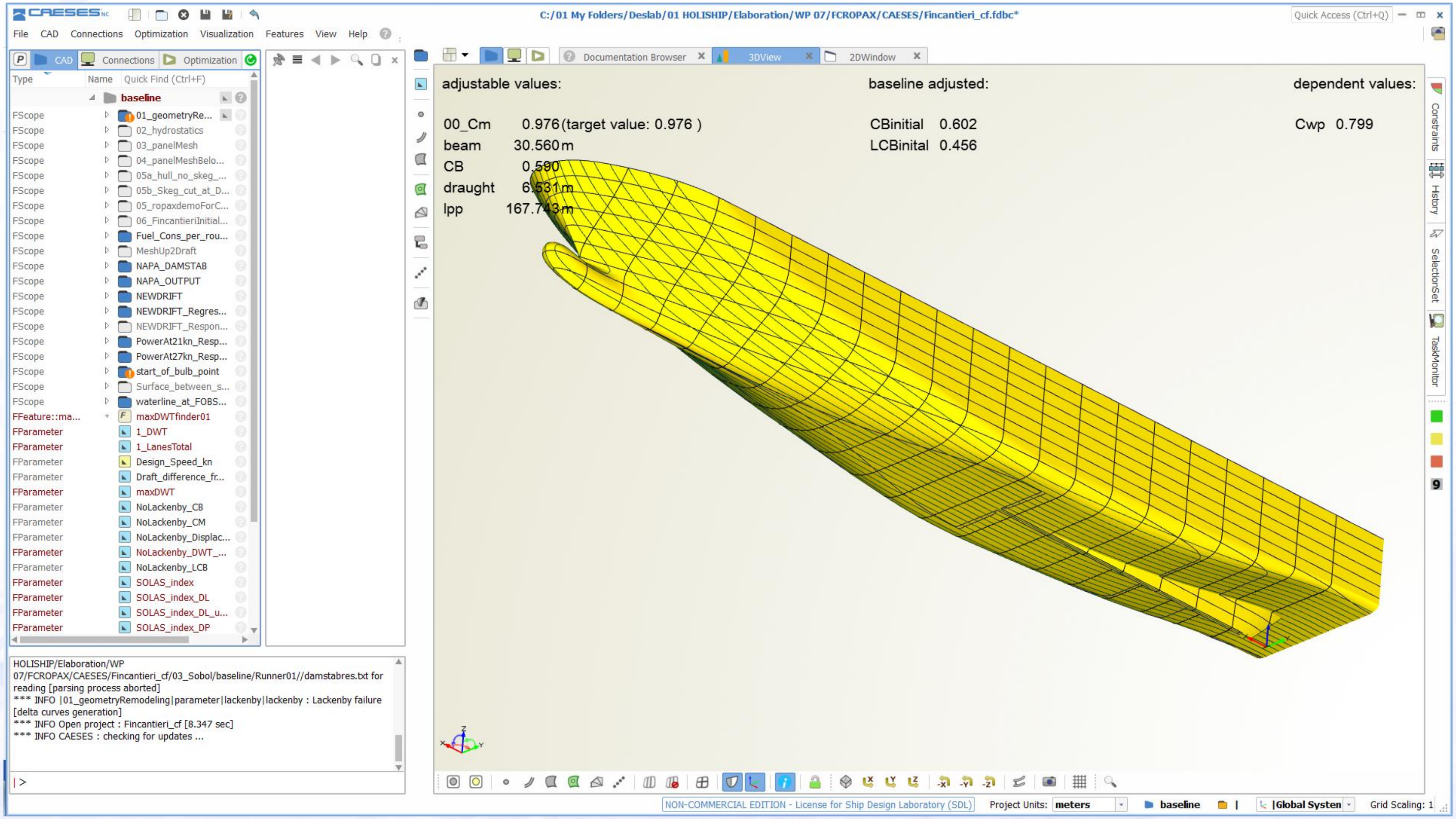
Funded by the
European Union

Coupling of tools for the design and optimization of a RoPax ferry



Funded by the European Union

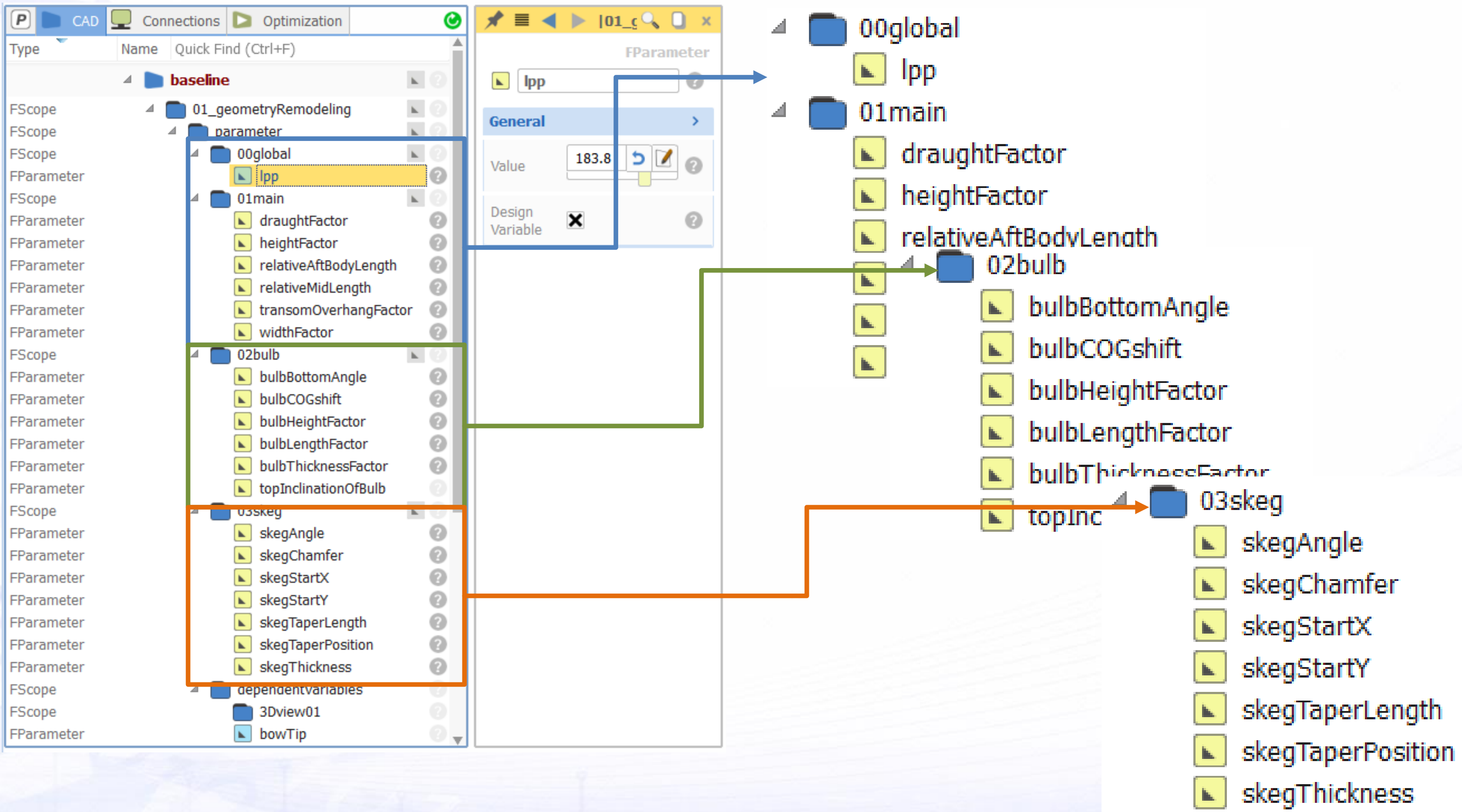
Parametric Hullform definition in CAESES® of Friendship Systems



Funded by the European Union

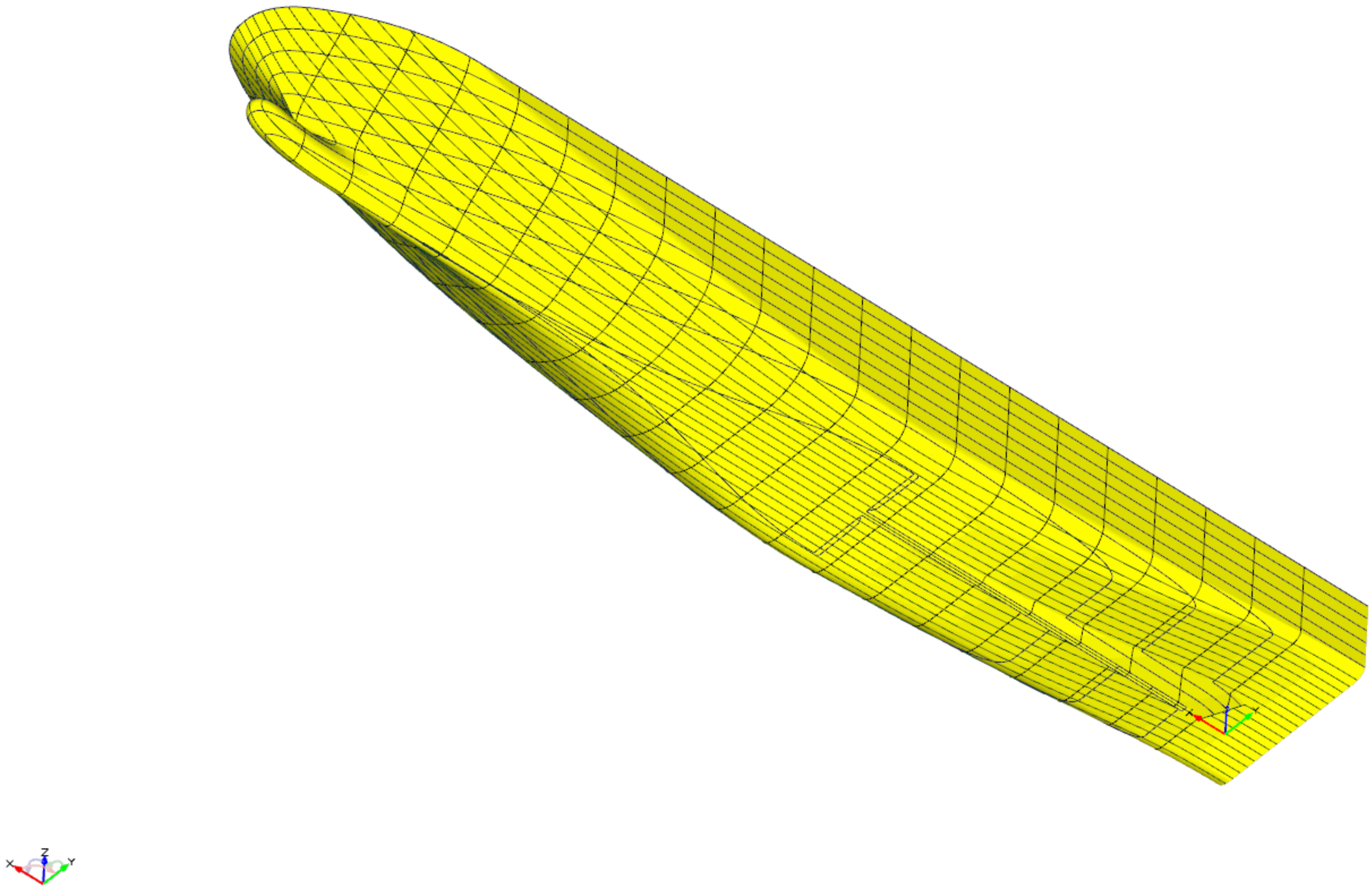
Parametric Hullform definition in CAESES® of Friendship Systems

HOLISHIP



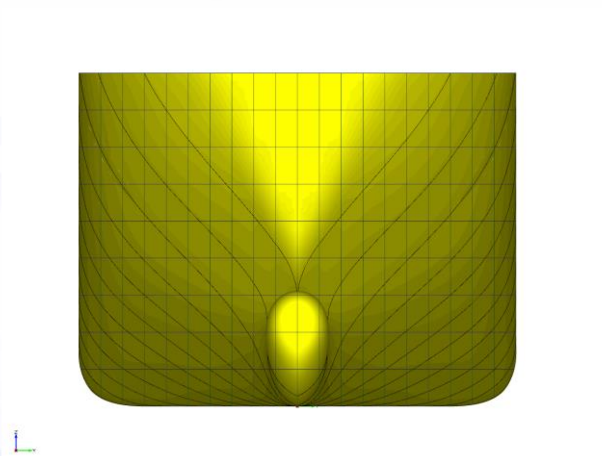
Funded by the European Union

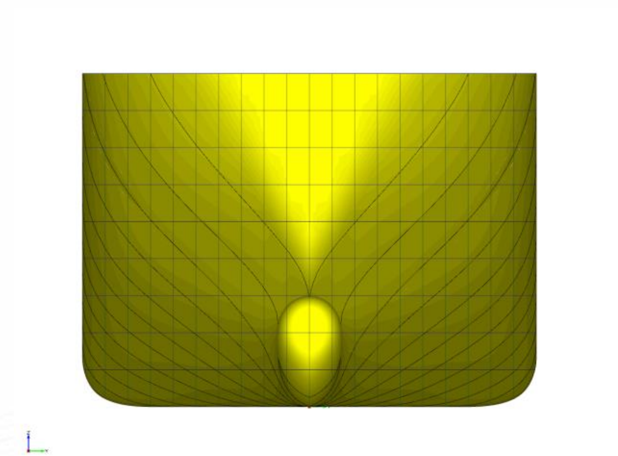
Parametric Hullform definition in CAESES® of Friendship Systems



Funded by the European Union

Parametric Hullform definition in CAESES® of Friendship Systems

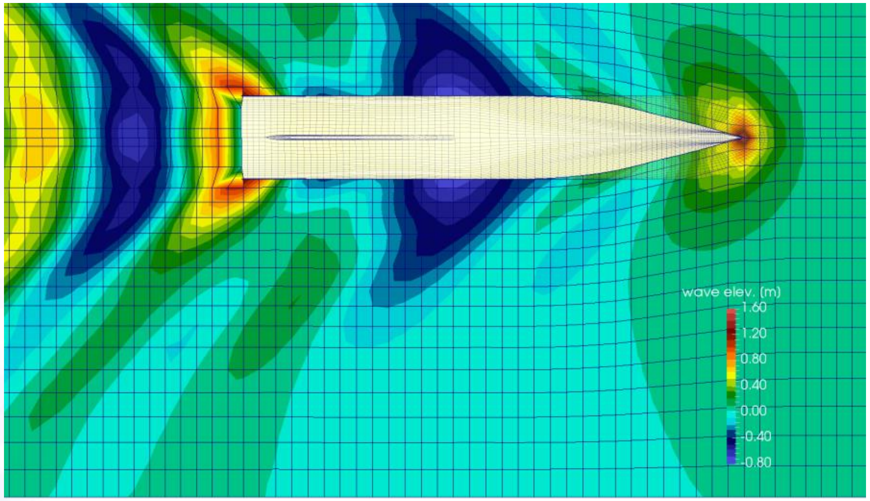




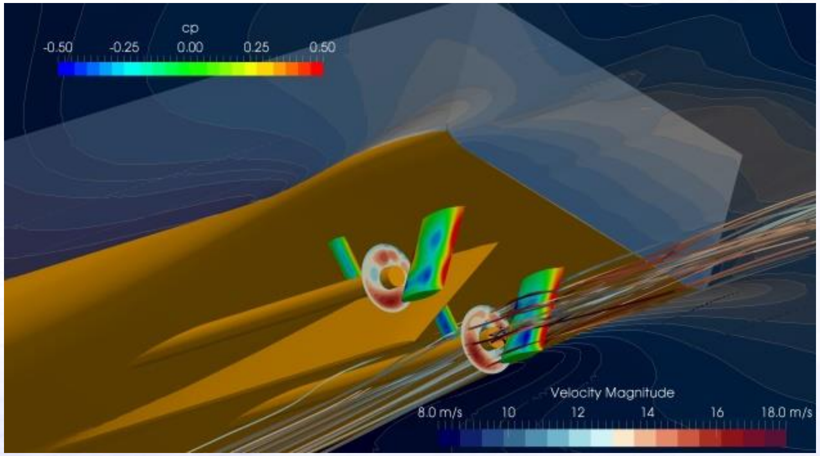
Funded by the
European Union

Calm water resistance prediction

Wave elevation calculated by Panel code ν-Shallo of HSVA

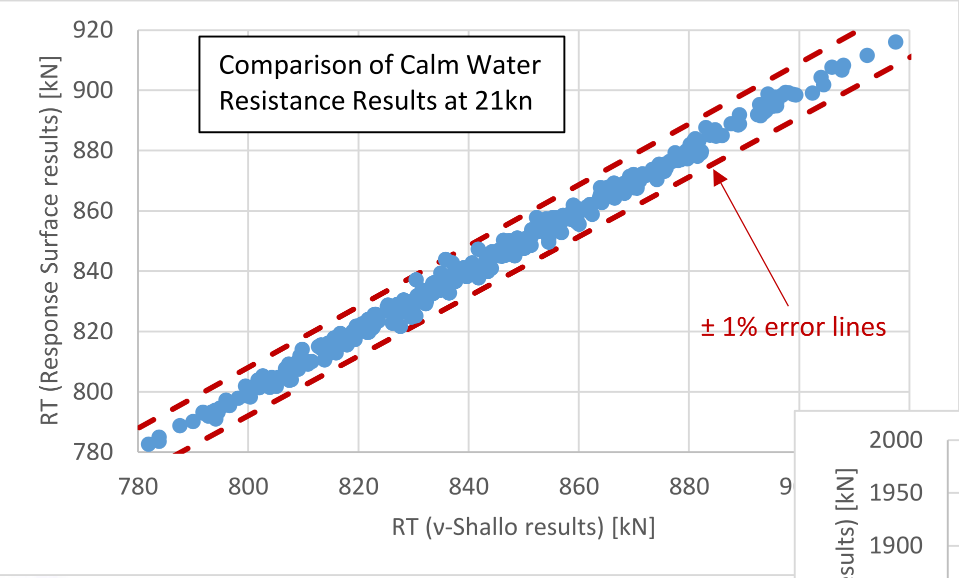


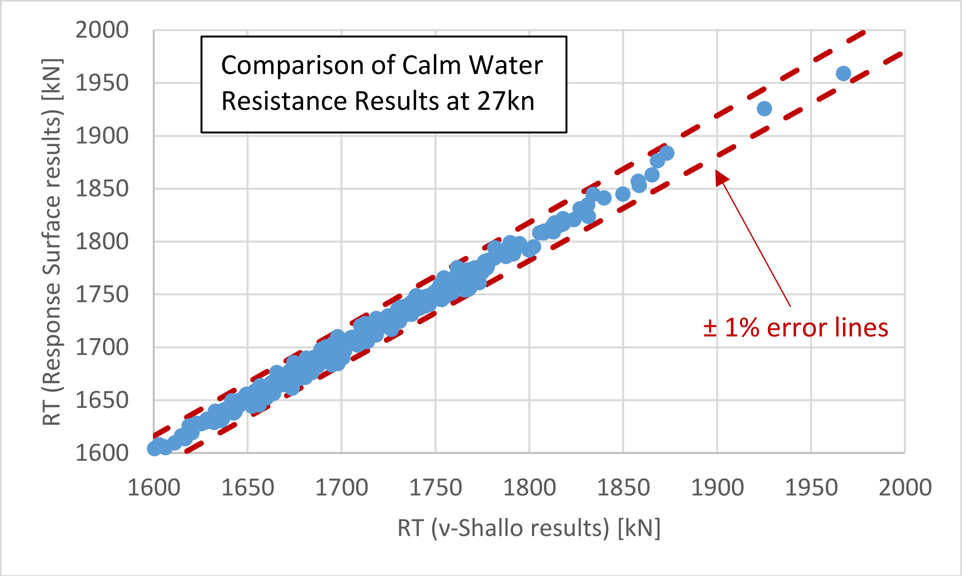
Viscous flow analysis of appended RoPAX ferry by means of HSVA's URANS FreSCo+



Funded by the European Union

Calm water resistance prediction/ response surfaces approach

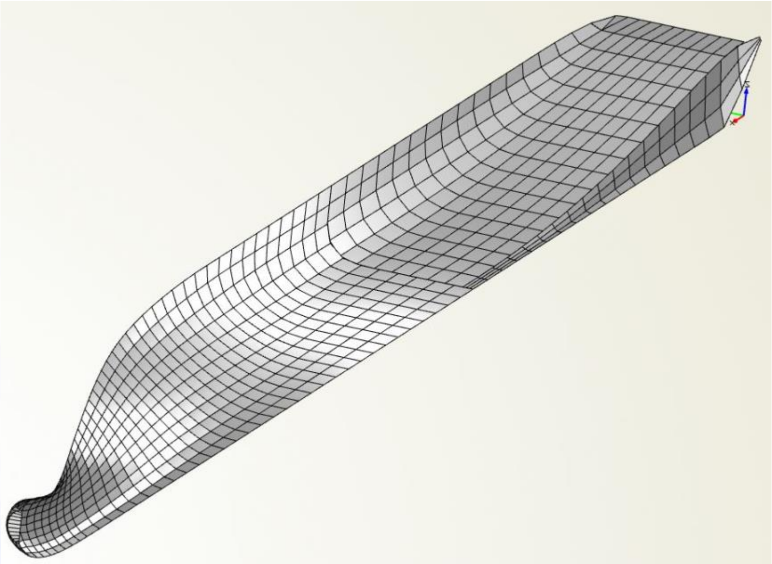


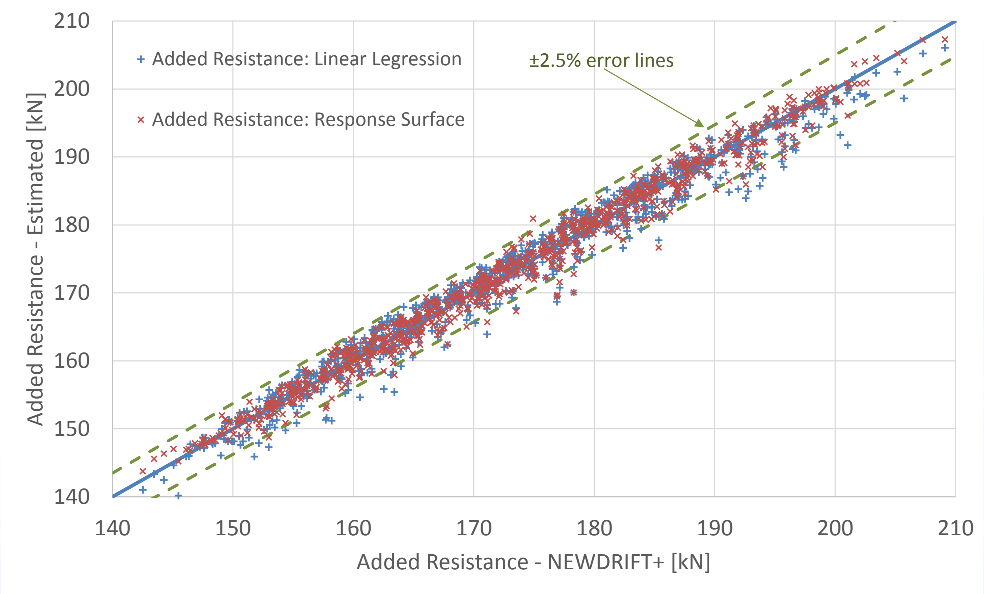


Funded by the European Union

Seakeeping and added resistance in waves

Seakeeping and added resistance in waves calculated by panel code NEWDRIFT+ (NTUA)





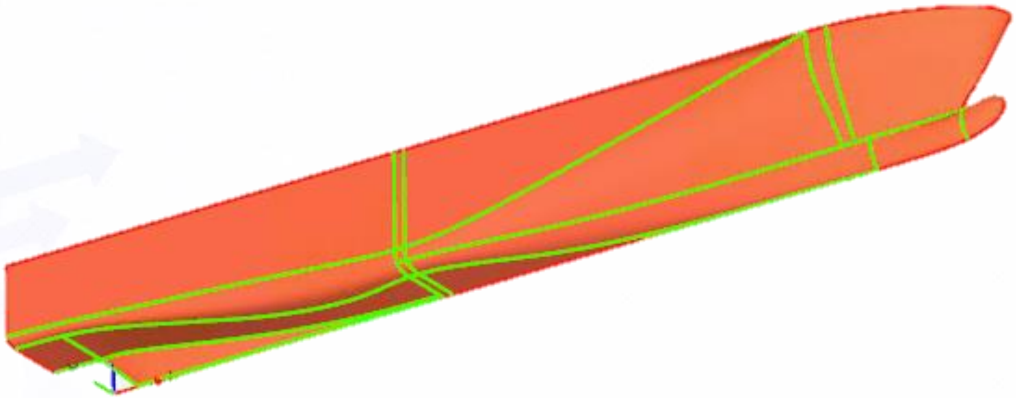
Funded by the European Union

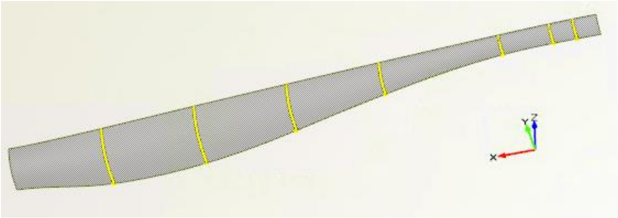
Transferring the hullform to NAPA®

The hullform may be directly transferred to NAPA in iges format

Alternatively, a feature was developed in CAESES, to enable the redefinition of the hullform in NAPA

- The original hullform in CAESES consists of a series of surfaces





- The rail curves of each surface are first identified and re-generated as image curves
- For each surface, a number of sections is generated and imported in the feature

Funded by the European Union

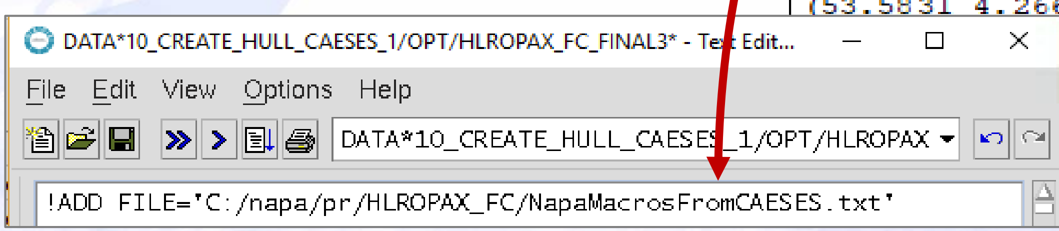
Transferring the hullform to NAPA®

- For each rail curve and section, a set of points is extracted. Their coordinates are exported in a text file
- The text file contains all the information <u>in NAPA format</u> for the definition of the curves
- The text file is essentially a NAPA macro, which will be executed directly in NAPA for the generation of the hull.

```
!end
gm
def
cur rail1_00; y 14.35
xz * (-11.6858 8.43557),
(-8.75149 8.38504),
(-5.81715 8.27765),
(0.553317 7.91672),
(16.3879 6.83045),
(28.7863 5.98276),
(41.1847 5.13328),
(53.5831 4.26627),
72696)
```

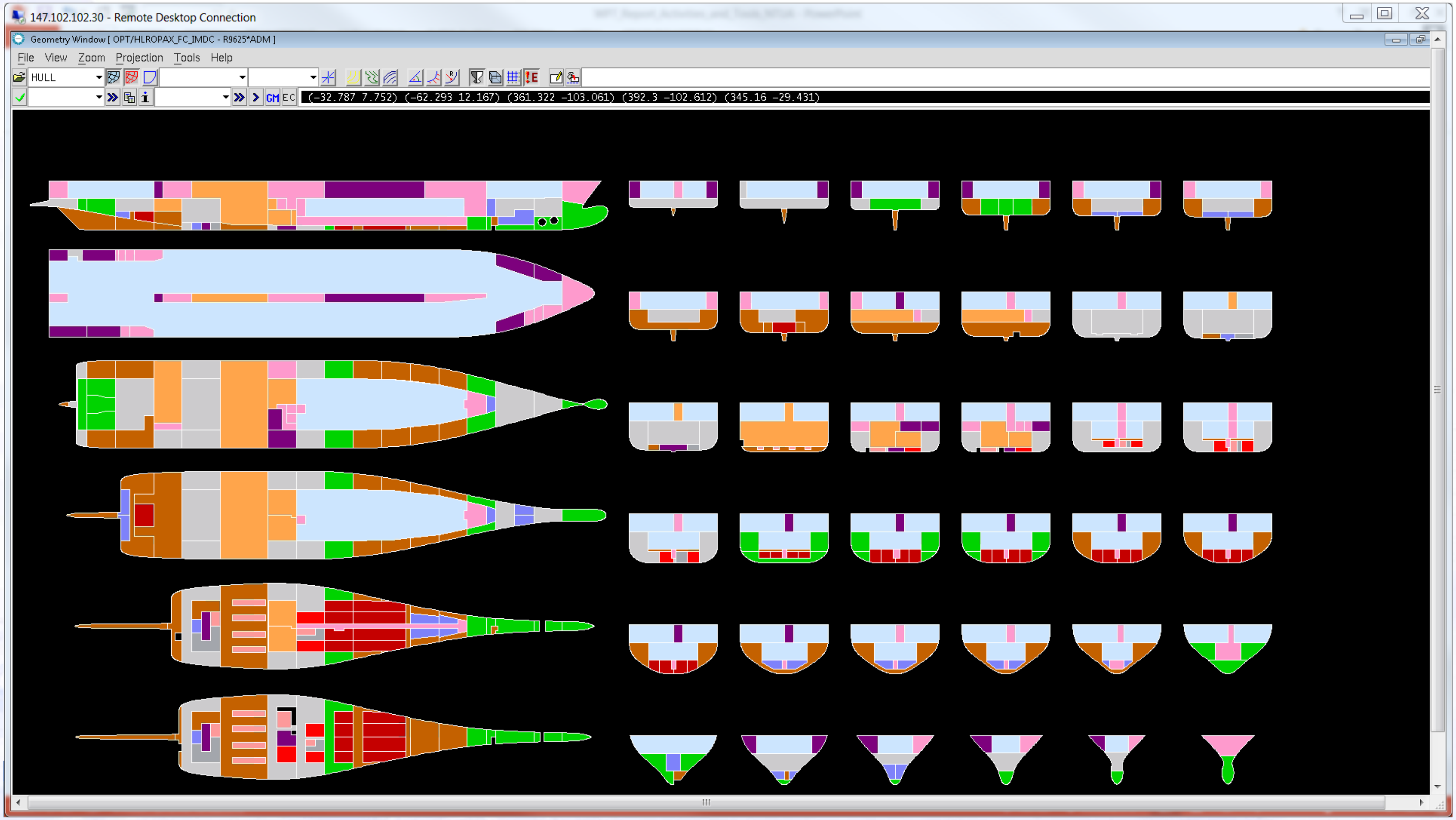
```
cur sections_00_1; X -8.75149
yz * rail3_00,
(12.4596 7.17793),
(13.0547 7.29147),
(13.6244 7.49689),
(14.1223 7.83737),
rail1_00
ok

cur sections_00_2; X -5.81715
yz * rail3_00,
(12.4572 7.12118),
(13.0554 7.20716),
(13.6302 7.39232),
(14.1283 7.72879),
rail1_00
ok
```



Funded by the European Union

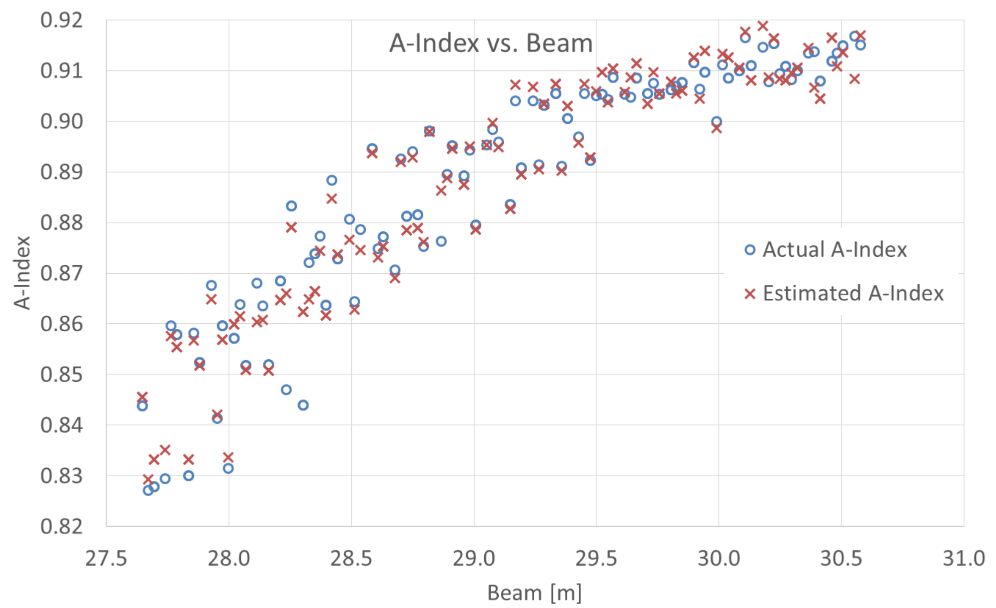
Development of internal layout in NAPA®



Funded by the European Union

Calculations in NAPA®

- ➢ Probabilistic Damage Stability
  - ✓ Direct calculation
  - ✓ Use of Surrogate model



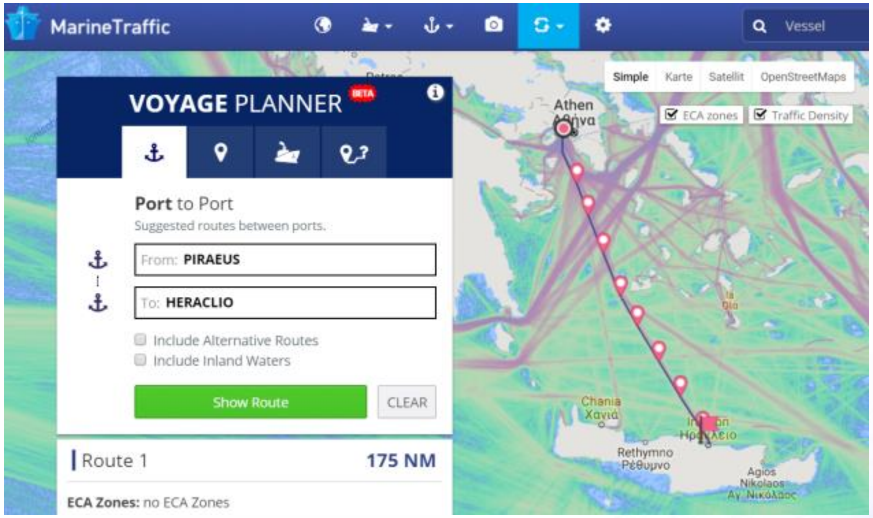
- ➢ Transport Capacity (Number of Passengers and Vehicles, Lanes Length)
- ➢ Light Weight and Weight Centre
- ➢ Definition of Loading Conditions
- ➢ Intact Stability
- ➢ Damaged Stability (minor damages)
- ➢ Stockholm Agreement
- ➢ Economic Assessment (NPV, RFR)

Funded by the European Union

Application case: Piraeus-Heraklion

European routes between150 and 230 nm

From	To	Distance in nm	Time at sea @ 21kn	Time at sea @ 27kn
KIEL	GOTHENBURG	230	11,0	8,5
NAPLES	OLBIA	222	10,6	8,2
GENOA	OLBIA	212	10,1	7,9
MARSEILLE	AJACCIO	189	9,0	7,0
GENOA	AJACCIO	185	8,8	6,9
IDEALIZED	ROUTE	175	8,3	6,5
PIREAS	HERACLIO	175	8,3	6,5
NAPLES	PALERMO	170	8,1	6,3
CIVITAVECCHIA	ARBATAX	160	7,6	5,9
TOULON	AJACCIO	153	7,3	5,7



Main owner's requirements

Number of passengers	≥ 2,080
Number of passenger cabins	≥ 300
Lane length	≥ 1,950 m
Payload	≥ 3,500 t
Number of crew	120

Funded by the European Union

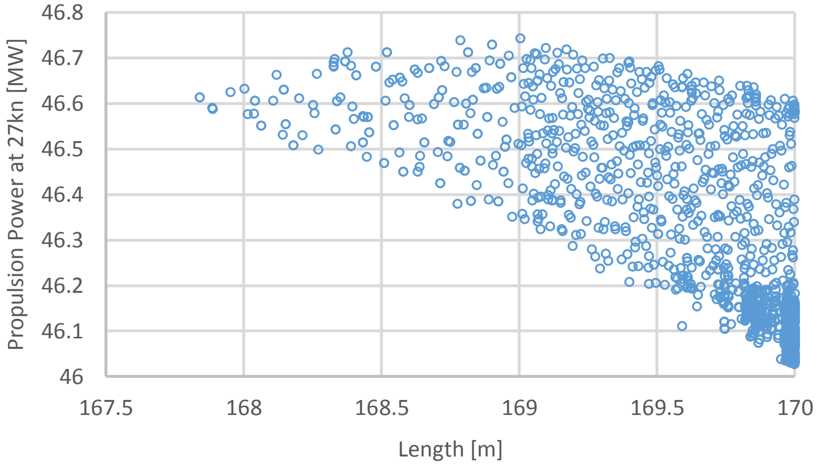
Application case

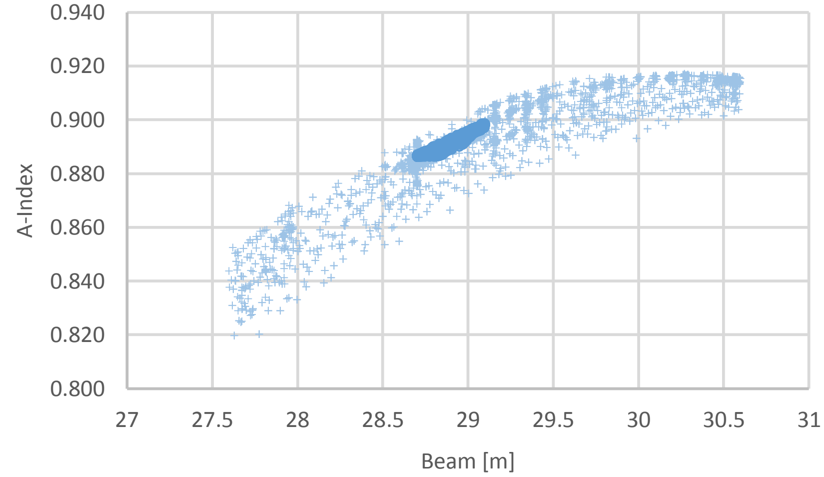
Free Variable	Lower bound	Baseline	Upper bound
Length L_{PP}	155.0 m	162.0 m	170.0 m
Beam	27.6 m	27.6 m	30.6 m
Des. draught	6.5 m	7.1 m	7.1 m

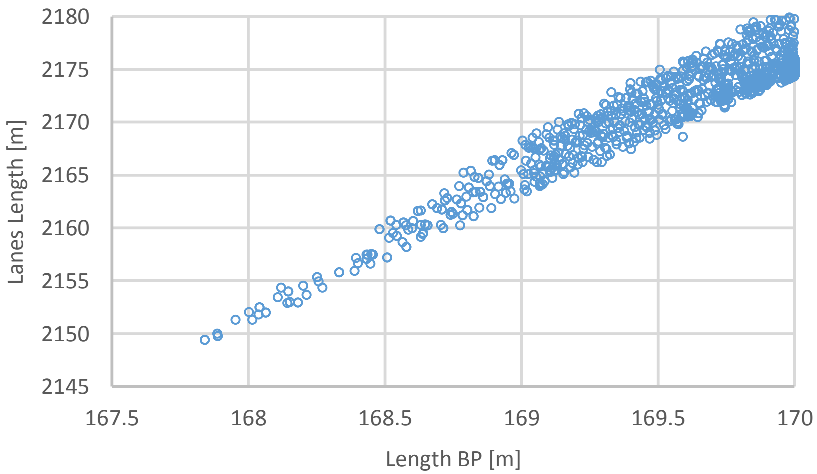
- A multi-disciplinary and multi-objective optimisation was carried out to:
  - ✓ Maximise Net Present Value (NPV)
  - ✓ Minimise fuel consumption per roundtrip
- The NSGA II genetic algorithm was used, resulting in:
  - ✓ 1130 feasible and
  - ✓ 799 infeasible designs

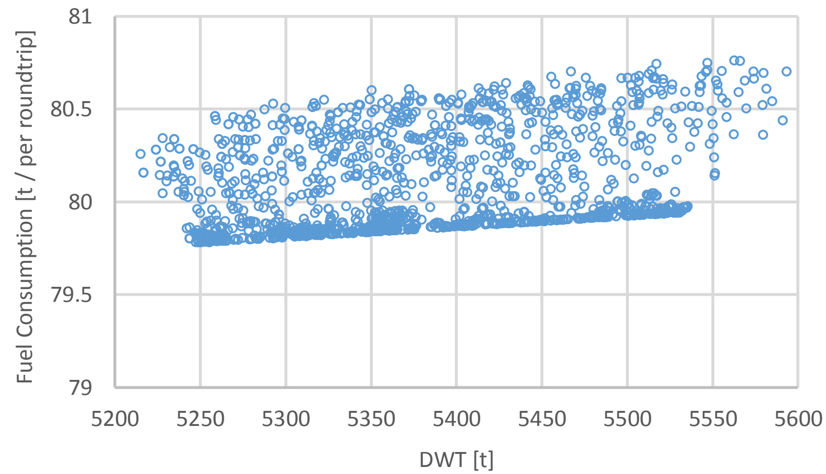
Funded by the European Union

Optimization results



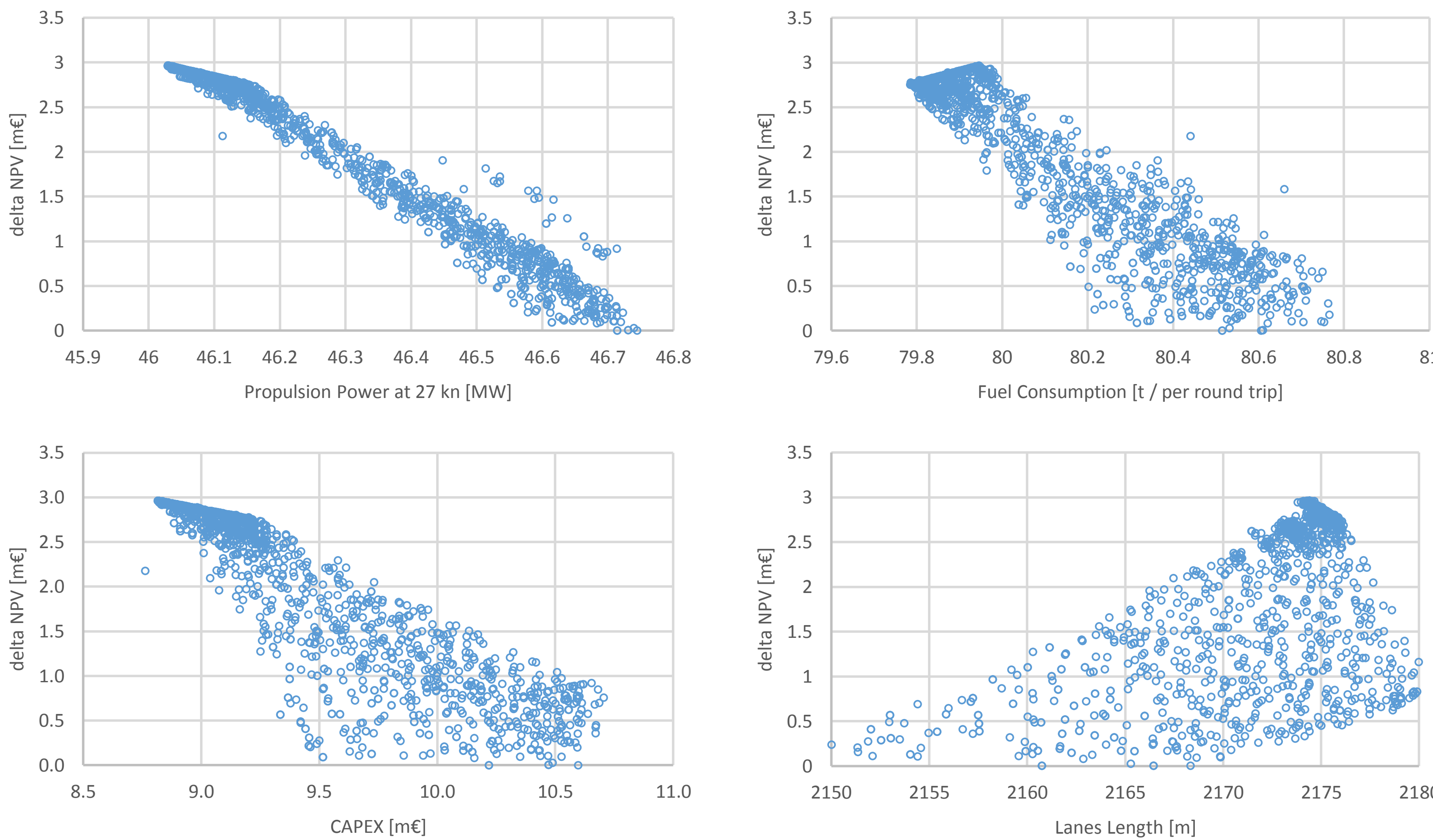






Funded by the European Union

Optimization results

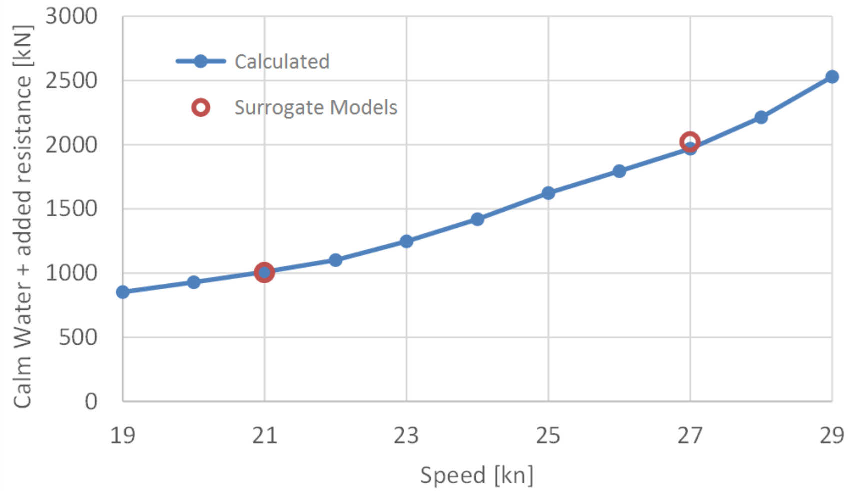


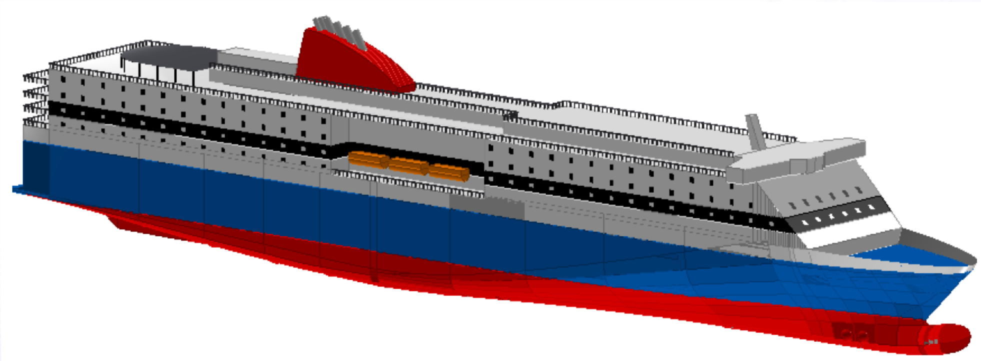
Funded by the European Union

Optimal design

Design 1324

L_{PP}	170.00 m
B	28.70 m
T	6.80 m
C_B	0.599
A-index	0.88650
R-index	0.86637
DWT (Design)	5530.4 t
Lanes Length	2174.40
Pass. Number	2202
Prop. Power @21kn	17775.5 kW
Prop. Power @27kn	46028.6 kW
Fuel cons/roundtrip	79.95 t
deltaCAPEX	8.81 m€
deltaNPV	2.964 m€



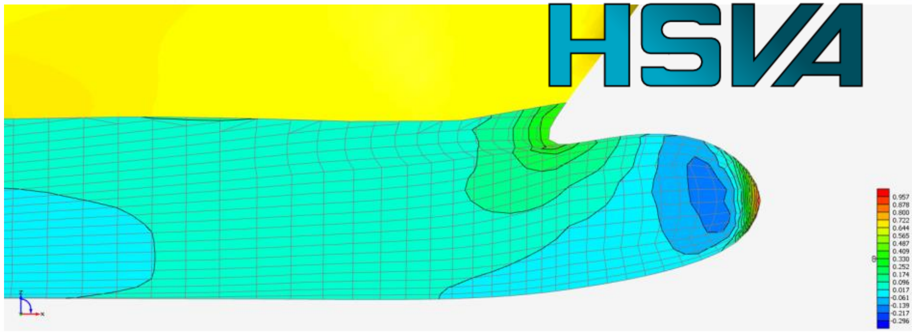


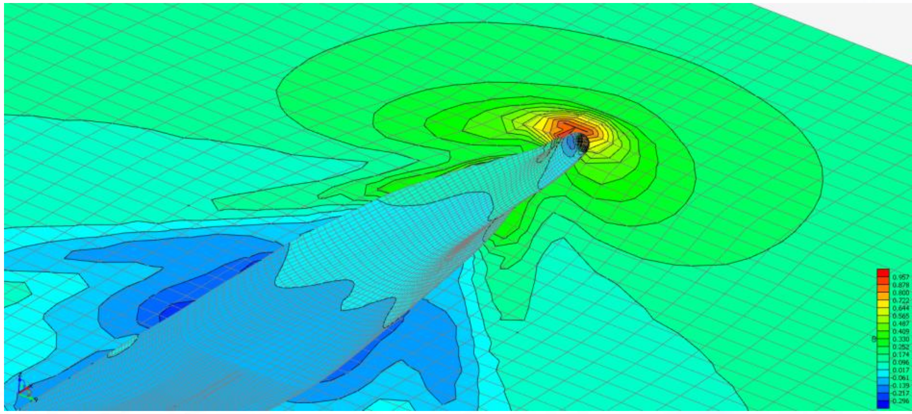
Funded by the European Union

Conclusions

- Different ways of using the HOLISHIP platform(s) are supported
  - Interactive
    - Local work flows
    - Dominos (e.g. WebApps)
  - Automated
    - DoE
    - Optimisation
  - Encapsulated
    - Surrogate models

- Integration of many tools enables both
  - Specific fine-tuning
    - Optimisation of subsystems
  - Holistic design
    - Comprehensive optimisation of the system





Funded by the European Union

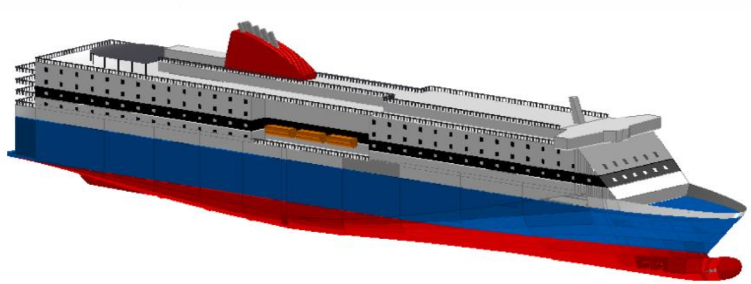
Next steps

To demonstrate the added value of the HOLISHIP design platform, it will be applied in the development of two ROPAX designs with the same specifications (route, passenger number, lane metres, speed, …)

- The first one will be based on technology and arrangements similar to contemporary ships operating in European waters
- The second will use state-of-the-art technology (power plant, propulsion, arrangement, …) to demonstrate the capacity of the platform to capture advanced requirements and to pave the way for the shipping industry to seek more fit-for-purpose solutions

Funded by the European Union

Thank you very much for your attention !



Funded by the
European Union