Holistic design and optimization of a RoPax ferry

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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
The impact of the tools developed in HOLISHIP will be showcased using 9 different Demonstrators. All of these are characteristic for European Maritime Operations.
Coupling of tools for the design and optimization of a RoPax ferry
Parametric Hullform definition in CAESES® of Friendship Systems
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Calm water resistance prediction

Wave elevation calculated by Panel code v-Shallo of HSVA

Viscous flow analysis of appended RoPAX ferry by means of HSVA's URANS FreSCo+
Calm water resistance prediction/response surfaces approach

Comparison of Calm Water Resistance Results at 21kn

± 1% error lines

Comparison of Calm Water Resistance Results at 27kn

± 1% error lines

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Seakeeping and added resistance in waves
calculated by panel code NEWDRIFT+ (NTUA)
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
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 in NAPA format 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.
Development of internal layout in NAPA®
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)
Application case: Piraeus-Heraklion

European routes between 150 and 230 nm

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Distance in nm</th>
<th>Time at sea @ 21kn</th>
<th>Time at sea @ 27kn</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIEL</td>
<td>GOTHENBURG</td>
<td>230</td>
<td>11,0</td>
<td>8,5</td>
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<tr>
<td>NAPLES</td>
<td>OLBIA</td>
<td>222</td>
<td>10,6</td>
<td>8,2</td>
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<td>GENOA</td>
<td>OLBIA</td>
<td>212</td>
<td>10,1</td>
<td>7,9</td>
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<td>MARSEILLE</td>
<td>AJACCIO</td>
<td>189</td>
<td>9,0</td>
<td>7,0</td>
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<td>185</td>
<td>8,8</td>
<td>6,9</td>
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<tr>
<td>IDEALIZED</td>
<td>ROUTE</td>
<td>175</td>
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<tr>
<td>CIVITAVECCHIA</td>
<td>ARBATA</td>
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<td>5,9</td>
</tr>
<tr>
<td>TOULON</td>
<td>AJACCIO</td>
<td>153</td>
<td>7,3</td>
<td>5,7</td>
</tr>
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</table>

Main owner's requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Requirement Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of passengers</td>
<td>≥ 2,080</td>
</tr>
<tr>
<td>Number of passenger cabins</td>
<td>≥ 300</td>
</tr>
<tr>
<td>Lane length</td>
<td>≥ 1,950 m</td>
</tr>
<tr>
<td>Payload</td>
<td>≥ 3,500 t</td>
</tr>
<tr>
<td>Number of crew</td>
<td>120</td>
</tr>
</tbody>
</table>

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Funded by the European Union
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
Optimization results

- Propulsion Power at 27kn [MW]
- A-Index
- Lanes Length [m]
- Fuel Consumption [t / per roundtrip]

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Optimization results

- Propulsion Power at 27 kn [MW]
- Fuel Consumption [t / per round trip]
- CAPEX [m€]
- Lanes Length [m]
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
- $\Delta$CAPEX: 8.81 m€
- $\Delta$NPV: 2.964 m€

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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
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
Thank you very much for your attention!