Comparison of Motion Sickness Incidence (MSI) of three Crew Transfer Vessels with different hull forms

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  - what is it?
  - How to estimate it?
• Methodology
• SWATH - experiments
• Monohull
• Catamaran
• General results & Conclusions
SEASICKNESS PHENOMENON

What?

• Motion sickness phenomena - discomfort associated to all mode of transports
• Results in breathing irregularities, warmth, disorientation and vomiting
• Mismatch theory

How?

• Motion Sickness Incidence (MSI)
• Algorithm to predict the incidence of motion sickness induced by exposure of vertical sinusoidal accelerations (McCaugley and al. 1976)

\[
MSI(\%) = 100 \times \Theta(z_a) \times \Theta(z'_t)
\]

Term depending on significant vertical acceleration and peak frequency response (ship response)  
Time dependent term

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MOTION SICKNESS – HOW?

RMS acceleration: highest one third vertical accelerations of the temporal statement.

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

METHODOLOGY

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms
Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

**Experimental**
- Duhnen - experiments
- Fast Fourier Transform of Time domain signal
- Significant wave height
- Significant vertical accelerations
- Peak frequency

**Numerical steps**
- Comparative models
  - JONSWAP spectrum
  - Inputs: speeds, heading angles, measurement positions...
  - 2D-strip theory
  - Significant vertical accelerations, peak response frequency

**Time of exposure**

MSI curves: percentage of sick people on board according to the time of exposure

---

**SWATH – DUHNEN**

<table>
<thead>
<tr>
<th>Speeds [knots]</th>
<th>Significant wave height [m]</th>
<th>Heading angles [°]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2</td>
<td>All (*)</td>
</tr>
<tr>
<td>8</td>
<td>2.4</td>
<td>180°</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>All (*)</td>
</tr>
<tr>
<td>12</td>
<td>1.5</td>
<td>180°</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>180°</td>
</tr>
</tbody>
</table>

* Following seas, Beam seas, Quartering stern and bow seas, Head seas

Accelerometers position on the main deck of the Duhnen.
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**METHODOLOGY**

**Experimental** & **Numerical steps**

- Duhnen - experiments
- Significant wave height
- Significant vertical accelerations
- Fast Fourier Transform of Time domain signal
- Peak frequency

**Comparative models**

- JONSWAP spectrum
- Inputs: speeds, heading angles, measurement positions...
- 2D-strip theory
- Significant vertical accelerations, peak response frequency

**Time of exposure**

**MSI curves**: percentage of sick people onboard according to the time of exposure

**MONOHULL**

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms
MONOHULL – Preliminary design (1)

- Same displacement than the SWATH
- Axe bow hull form – seakeeping behaviour
- Rough structural design and weigh estimation – vertical position of the centre of gravity

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

MONOHULL – Preliminary design (2)

<table>
<thead>
<tr>
<th></th>
<th>Lightship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight [t]</td>
<td>58.42</td>
</tr>
<tr>
<td>LCG [m]</td>
<td>-3.50</td>
</tr>
<tr>
<td>TCG [m]</td>
<td>0.00</td>
</tr>
<tr>
<td>VCG [m]</td>
<td>2.45</td>
</tr>
</tbody>
</table>

+ tank definitions (full load case) => VCG = 2.48m

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms
Wave spectra

- JONSWAP spectra used to represent the North Sea.
- Extracted from experiment results.

- Linear waves theory in deep water, \( \lambda \approx 1.56 T^2 \).

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

MONOHULL – Results 8 knots

<table>
<thead>
<tr>
<th>[min]</th>
<th>SWATH</th>
<th>MONO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>12.5%</td>
<td>58.8%</td>
</tr>
<tr>
<td>70</td>
<td>45.8%</td>
<td>86.7%</td>
</tr>
<tr>
<td>120</td>
<td>50.4%</td>
<td>87.6%</td>
</tr>
</tbody>
</table>

- Head seas
- Wave period 8 seconds
- Worst vertical acceleration locations at stern for SWATH and bow for monohull

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Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

<table>
<thead>
<tr>
<th>Hull Form</th>
<th>1.5m</th>
<th>2.4m</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWATH</td>
<td>7.9 sec</td>
<td>4.8 sec</td>
</tr>
<tr>
<td>Monohull</td>
<td>5.4 sec</td>
<td>2.7 sec</td>
</tr>
</tbody>
</table>

Wave frequency = 5 sec
CATAMARAN – Preliminary design (1)

- Same length than the SWATH
- Lightship weight known, 72.8 tonnes
- Preliminary structural design-GL

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

CATAMARAN – Preliminary design (2)

<table>
<thead>
<tr>
<th>Waterline length</th>
<th>25.0m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam overall</td>
<td>13.0m</td>
</tr>
<tr>
<td>Maximum draft</td>
<td>2.7m</td>
</tr>
<tr>
<td>Max. Speed</td>
<td>18 kn</td>
</tr>
<tr>
<td>Full loaded displacement</td>
<td>97.2 t</td>
</tr>
<tr>
<td>Spacing of CL demihulls</td>
<td>7.0m</td>
</tr>
</tbody>
</table>

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms
### CATAMARAN – Results 5&10 knots

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

- **Head sea**
  - SWATH
  - CATAMARAN
  - SWATH 10kn
  - Catamaran 10kn

- **Quartering-bow**
  - 90%
  - 80.6%
  - 49.5%
  - 49.1%

- **Quartering-stern**
  - 88%
  - 49.3%
  - 20.5%
  - 14.7%

- **Beam sea**
  - 92%
  - 90%
  - 37.5%
  - 42.2%

- **94%**
- **51%**
- **12.5%**
- **4.5 times sicker**
- **1.8 times sicker**

### CATAMARAN – Results 8 knots

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms

- **Hs=2.4m - 8kn**
  - 56.6%
  - 94%
  - 51%
  - 12.5%

- **10 minutes**  **120 minutes**
  - 4.5 times sicker
  - 1.8 times sicker

- **Higher transversal metacentric height,**
- **Shorter natural periods of Catamaran**
CATAMARAN – Results 12 knots

- Head seas with peak frequency close to 5 seconds.
- Non-linear phenomenon, depends on wave frequency, wave height, speed.

GLOBAL RESULTS

- Twice more people sick on-board of catamaran and monohull than SWATH.
- More sensitive during the first 10 minutes than SWATH.
- Non linear phenomenon (Fp, Hs, U…)
- Speed reduction necessary for comparative ships.
CONCLUSIONS

- The purpose of the work has been reached
- Significant peak frequency of ships
- Displacements of catamaran and monohull are different
- Polar plot diagram to optimize the road and speed to reach similar time transfer between comparative ships and SWATH

ADDITIONAL WORK

- Considering more than just significant wave heights, financial impact
- Active stabilisation systems -> impact on pitch & roll gyradius
- Coupling Seakeeper with an optimization software
Thank you for your attention, dziękuję bardzo

Szczecin ≈ chtchetchine
[French pronunciation]

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MONOHULL – Results 5 & 10 knots

Comparison of motion sickness incidence of three crew transfer vessels with different hull forms