SHOPERA Workshop WP2&4: Summary of proposed Criteria and Assessment Procedure
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Vladimir SHIGUNOV
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[10 min]
# Additional SHOPERA Manoeuvrability Criteria

<table>
<thead>
<tr>
<th>Groups of Criteria</th>
<th>Functional Requirements</th>
<th>Criteria</th>
<th>Environmental Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>In extreme weather, open sea</td>
<td><em>Weather-vaning in bow seaway</em></td>
<td>1. <em>Keep heading in bow to bow-quartering waves</em></td>
<td>Severe [to extreme]</td>
</tr>
<tr>
<td>In increasing storm, coastal waters</td>
<td><em>Any manoeuvre, in wind and waves from any direction</em></td>
<td>2. <em>Keep course in waves and wind from any direction</em></td>
<td>Moderate</td>
</tr>
<tr>
<td>At low speed, restricted areas</td>
<td><em>Course-keeping at low speed</em></td>
<td>Course-keeping at reduced speed in strong wind</td>
<td>Strong wind, strong current, no large waves</td>
</tr>
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<td></td>
<td></td>
<td>4. <em>in shallow water</em></td>
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<tr>
<td></td>
<td></td>
<td>5. <em>In shallow water near channel wall or bank</em></td>
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<tr>
<td></td>
<td></td>
<td>6. <em>In shallow water during overtaking by a quicker ship</em></td>
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</tr>
</tbody>
</table>
Additional Criteria for Manoeuvrability: Summary

1. Keep heading in bow to bow-quartering waves: severe waves and wind
2. Keep course in waves and wind from any direction: moderate waves and wind
3. Keep speed of at least [4.0] knots in waves and wind from any direction: moderate waves and wind
4. Course-keeping at reduced speed in shallow water: strong wind and current
5. Course-keeping at reduced speed in shallow water near wall or bank: strong wind and current
6. Course-keeping at reduced speed in shallow water during overtaking by a quicker ship: strong wind and current
Assessment Procedure:
Full Scale Trials / Model Tests / Numerical Simulations

- **IMO Manoeuvrability Standards** are evaluated in full-scale trials => impossible in adverse weather conditions
- Direct evaluation of criteria in transient model experiments with self-propelled models in irregular waves and wind => impractical at the present technology state in industry:
  - Scale effects (wind forces, rudder forces)
  - Statistical predictions require many seaway realisations => too expensive
  - Only few facilities exist world-wide => impractical for routine design
  - Verification by the Administration is impossible => impractical for approval
  - Large variability of results (depending on steering time history) => impossible to verify results in marginal cases
- Direct numerical simulation of manoeuvres in waves => not mature enough yet for routine design and approval
- Alternative procedure: separate simple model tests / numerical simulations / empirical formulae for different effects
Assessment Procedure

- Oscillatory wave forces and moments can be neglected, because their time scale is much shorter than time scale of manoeuvre.

- Solution of steady equilibrium equations in horizontal under influence of time-average forces (wind, waves, manoeuvring, rudder, propeller ...).

- Any contribution can be defined individually, independently from other contributions, with different methods: simple empirical formulae, numerical methods, model experiments, ...

- Designers have freedom to choose methods depending on particular project needs.

- Administrations can check “suspicious” contributions separately, instead of requiring full re-evaluation program.

- Rule developers can replace/update any outdated method, formula or model for any component when necessary without revising the Guidelines.

\[
\begin{align*}
X_s + X_w + X_d + X_R + T &= 0 \\
Y_s + Y_w + Y_d + Y_R &= 0 \\
N_s + N_w + N_d + N_R &= 0
\end{align*}
\]
Analogy to MSC.1/Circ.1200

- The sense of the proposed practical assessment procedure is similar to *Alternative Assessment of the Weather Criterion*, ref. MSC.1/Circ.1200 and MSC.1/Circ.1227 (not hydrodynamically, but methodologically!)

- Note that capsize tests at zero forward speed in beam seaway (=Weater Criterion) are much easier to do than transient manoeuvres in seaway (both conditions control & statistics)

- Still, more accurate and more efficient procedure is used, based on series of separate simpler tests in well-controlled conditions to define separately different contributions in the analytical model:
  - drift in beam wind (=> steady equilibrium heel angle),
  - roll decay in calm water (=> roll damping),
  - roll in regular beam waves (=> effective wave slope),
  - results of which are put together in a simple mathematical model

- As *Alternative Weather Criterion* procedures are accepted by the industry, this analogy allows to hope that the proposed procedure will be accepted as well
### Example of Proposed Approach for Course-Keeping and Minimum Advance Speed Criteria

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Components</th>
<th>High-Level</th>
<th>„Level 2“ (MS Excel)</th>
<th>„Level 1“ (pocket calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm-water</td>
<td>X, Y, N</td>
<td>model tests [CFD]</td>
<td>semi-emp. formulae</td>
<td>simple emp. formulae</td>
</tr>
<tr>
<td>Wave drift forces</td>
<td>X,Y,N</td>
<td>model tests [potential methods] [CFD]</td>
<td>semi-empirical formulae for RAOs</td>
<td>simple empir. formulae direct for irregular waves</td>
</tr>
<tr>
<td>Wind forces</td>
<td>X,Y,N</td>
<td>model tests [CFD]</td>
<td>semi-empir. formulae</td>
<td>empirical data [Blendermann or Japan method]</td>
</tr>
<tr>
<td>Shallow, bank, overtaking</td>
<td>Y,N</td>
<td>model tests [potential methods] [CFD]</td>
<td>semi-empirical formulae</td>
<td>empirical formulae</td>
</tr>
<tr>
<td>Rudder forces</td>
<td>X,Y</td>
<td>model tests [CFD]</td>
<td>semi-empirical method</td>
<td>empirical method</td>
</tr>
<tr>
<td>Propeller model</td>
<td>T -&gt; J,n,P_D</td>
<td>model tests potential methods CFD</td>
<td>open-water propeller curves</td>
<td>simplified methods difficult (change of prop. point in waves)</td>
</tr>
<tr>
<td>Engine</td>
<td>PD available</td>
<td>static model?</td>
<td>static model?</td>
<td>static model (engine diagramm)</td>
</tr>
<tr>
<td>Putting forces together</td>
<td>X,Y,Z</td>
<td>equilibrium in horizontal plane</td>
<td>equilibrium in horizontal plane: reduced number of cases</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

ToDo:

- Level 1 methods
- Level 2 methods
- Specifications for model tests: for contributions where ITTC procedures do not exist or should be updated
- Try to get through IMO Level 3 numerical methods for as many contributions as possible (difficult!)
Contact

Vladimir Shigunov
vladimir.shigunov@dnvgl.com
+49(0)40361495624

www.dnvgl.com

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