WP1
Environmental conditions and requirements for different ships
Task 1.1 Met-ocean description
WP1: Objectives

- Provide **met-ocean description** for the project
- Define **ship sizes** for ship types considered in the project
- Conduct **risk analysis of marine accidents** related to maneuvering in adverse weather conditions
- Propose **safety criteria** to be addressed by the project based on a critical review of the current EEDI as well as operational experience from ship operators and other project partners.
WP1: Output

NOW:
Existing EEDI Requirements

END OF PROJECT:
• Updated EEDI requirements
• Improved SoA of numerical tools
• Optimisation for safety & efficiency

WP1
Met-ocean data
Accident statistics
Analysis of criteria

WP2
Adjustment of numerical tools

WP3
Experiments

WP4
Validated numerical tools
Simplified models
Formulations for rules (Level 1)
Intact stability tools

WP5
Level 1 methods
Optimisation studies

WP6
Know-how & tools
Case Studies

WP7
Dissemination
Exploitation
Submission

WPS
Recommendations

15 Oct. 2015
Phase 1
Phase 2
IMO has taken the initiative to regulate the greenhouse gas (GHG) emissions from ships by introducing the Energy Efficiency Design Index (EEDI) in the IMO Resolution MEPC.203 (62), being the first regulation in this respect.

Introduction of EEDI represents a major step forward in implementing the regulations on energy efficiency of ships.

It has brought serious concerns regarding the sufficiency of propulsion power and of steering devices to maintain the manoeuvrability of ships in the adverse conditions.

Ship designers might choose to lower the installed power to achieve EEDI requirements.

The investigations carried out by IACS led to development of first draft guidelines for consideration by IMO in 2011, IMO MEPC 62/5/19, which resulted in 2012 Interim Guidelines, IMO MEPC 64/4/13, updated as 2013 Interim Guidelines in 2013, IMO Res. MEPC.232 (65), where adverse weather conditions to be used in assessment of ship manoeuvrability are proposed.
To avoid negative effects, such as under-powered ships, a provision was added to regulation 21 in Chapter 4 of MARPOL Annex VI, stating:

“For each ship to which this regulation applies, the installed propulsion power shall not be less than the propulsion power needed to maintain the manoeuvrability of the ship under adverse conditions as defined in the guidelines to be developed by the Organization.”

At MEPC 65 the 2013 Interim Guidelines for determining minimum power to maintain the manoeuvrability of ships in adverse conditions were adopted (17 May 2013).

For 2013 Interim Guidelines

- Possibility for 2 levels assessment
- Definition of adverse conditions
- Definition of “minimum power lines” (assessment level 1) for bulk carriers and tankers including combination carriers)
- Definition of “required ship speed of advance” (for assessment level 2)
  - Minimum navigational speed (4.0 knots)
  - Minimum course-keeping speed (defined as function of rudder area, ship length, breadth and draft, ship frontal windage area and lateral windage area)

For final guidelines (to be defined)

- Applicability to other ship types
- Verification and possible re-definition of adverse conditions
- Redefinition of “minimum power lines”
- Definition of safety criteria and standards
1.1 "Adverse conditions" mean sea conditions with the following parameters:

<table>
<thead>
<tr>
<th>Significant wave height $h_s$, m</th>
<th>Peak wave period $T_p$, s</th>
<th>Mean wind speed $V_w$, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>7.0 to 15.0</td>
<td>19.0</td>
</tr>
</tbody>
</table>

JONSWAP sea spectrum with the peak parameter of 3.3 is to be considered for coastal waters.

1.2 The following adverse condition should be applied to ships defined as the following threshold value of ship size.

<table>
<thead>
<tr>
<th>Ship length, m</th>
<th>Significant wave height $h_s$, m</th>
<th>Peak wave period $T_p$, s</th>
<th>Mean wind speed $V_w$, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 200</td>
<td>4.0</td>
<td>7.0 to 15.0</td>
<td>15.7</td>
</tr>
<tr>
<td>$200 \leq L_{pp} \leq 250$</td>
<td>Parameters linearly interpolated depending on ship’s length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than $L_{pp} = 250$</td>
<td>Refer to paragraph 1.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Several questions were raised:
- Should adverse met-ocean conditions also include other ocean zones not only coastal waters?
- Should other met-ocean parameters be included e.g. current?
- How adverse conditions relate to field data and other data sources?
- What ship accident statistics is showing?
- Do numerical calculations and model tests confirm these conditions?

Adverse conditions to be analyzed from three perspectives:
- Met-ocean description
- Ship accident statistics and interviews of ship masters
- Numerical simulations and model tests.
WP1: Work Content & Partners

- Task 1.0. Technical Management (DNV)
- Task 1.1. Met-ocean description (legacy DNV, IST, EVFH, legacy GL)
- Task 1.2. Identification of ships and risk analysis of relevant marine accidents (NTUA, GL, DNV, LR, IST, RINA, DAN, FNK, CAL)
- Task 1.3. EEDI and safety criteria (legacy GL, DNV, NTUA, LR, IST, UDE, RINA, DAN, FNK, CAL)

<table>
<thead>
<tr>
<th>WP/Task</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>12</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTUA</td>
<td>4.0</td>
<td>3.0</td>
<td>7.0</td>
<td>2.0</td>
<td>4.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
<td>26.0</td>
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<tr>
<td>GL</td>
<td>0.2</td>
<td>5.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
<td>0.5</td>
<td>8.3</td>
<td></td>
<td>7.8</td>
</tr>
<tr>
<td>DNV</td>
<td>3.3</td>
<td>0.3</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
<td>0.5</td>
<td>10.0</td>
<td></td>
<td>8.3</td>
</tr>
<tr>
<td>LR</td>
<td>0.7</td>
<td>2.5</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.8</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
<td></td>
<td>10.0</td>
</tr>
</tbody>
</table>

30-Oct-14
Task 1.1 Met-ocean description
(DNV, IST, GL, EVFH)

- Met-ocean description alone cannot define adverse weather conditions, ship analysis is needed. Steering and propulsion abilities of ships are challenged by the met-ocean environment but in different way depending on a ship type and size.

- Met-ocean description is geographic region and location dependent as well as season and ship route dependent.

- Different type of met-ocean data may give different met-ocean description due to their accuracy.

- 2013 Interim Guidelines are limited to significant wave height $H_s$, spectral wave period $T_p$, the mean wind speed $U_{10}$ and the wave spectrum, and are proposed coastal waters.

- More complete met-ocean criteria would need to include wind directional spreading, gust, wave energy spreading, wind sea and swell, tide (regarded by some researchers as a current component) and current, the met-ocean characteristics which may be of importance for ship manoeuvrability.
The first-phase SHOPERA investigations resulted in selection of three distinct situations requiring different adverse weather criteria:

- manoeuvring in the open sea
- manoeuvring in coastal waters
- low-speed manoeuvring in restricted areas.

These three scenarios would require different adverse weather criteria. To proposed them both measured and hindcast data have been used in the analysis in Task 1.1.

Locations considered:
- The deep water location – the North Atlantic
- The coastal channels giving access to the port of Antwerp, Scottish waters and the port of Leixões.

Met–ocean description needs to included relations between the met–ocean parameters, joint probabilities.
Deep water

- In most of situations is probably sufficient to keep a favourable heading with respect to wind and waves, and accepting some drifting with wind and waves. However, in some situations in increasing storm severity maintaining manoeuvrability maybe an issue. Tide and current may need also to be considered.

- A question would be: how often dangerous situations may occur?

- The North Atlantic the most severe wave climate (see Cardone et al., 2014), IACS Recommendation 34 represents the North Atlantic.

- The North Atlantic characterised by intense ship traffic.
Task 1.1 Met-ocean description
Ship routes in the North Atlantic

- Density of VOS reports on the considered area
- Accuracy of the VOS data: VOS, ERA40, HIPOCAS
- Bad weather avoidance

Vettor & Guedes Soares (2014)

Vettor & Guedes Soares (2015)
Wind

According to Tucker and Pitt (2001) the following relation for PM spectrum between the significant wave height derived from the wave spectrum $H_{m0}$ and the mean wind speed $U_{10}$ (m/s) at a height of 10 m over the sea level is proposed to be used:

$$H_{m0} = 0.0246U_{10}^2$$

For the JONSWAP spectrum

$$H_{m0} = 0.0163X^{0.5}U_{10}$$

where $X$ is the fetch in km and $U_{10}$ in m/s.

From hindcast data for West Shetland

$$\mu_w = U_c \Gamma(1+1/k)$$
Task 1.1. Met-ocean description
Adverse Conditions

- Waves – North Atlantic
  - Data sources:
    - Visual observations; IACS R.34
    - Instrumental data
    - Numerically generated data
  - Visual observations - GWS data (1986)- the last 28 years is missing. Impact on extremes; the 100-year $H_s$ reported is beyond 18-19 m in the North Atlantic. IACS $H_s =$17.23 m

- Visual observations

- Resolution of the wave model

Grigorieva & Gulev (2006)

Bitner-Gregersen and Toffoli (2015)
Deep water – The North Atlantic wave spectra

Deep water – The North Atlantic steep sea states

- $\gamma > 4.0$, the wave steepness $S_{Tz} = H_s / (1.56 T_z^2)$ values higher than 0.067 (corresponding to $k_p H_s / 2 \approx 0.10$, where $k_p$ is wavenumber at spectral peak) can trigger modulational instability responsible for generation of abnormal waves (called freak or rogue), see Onorato et al. (2009), Waseda et al. (2009).
- Bitner-Gregersen and Toffoli (2012) have shown that such sea states may occur in deep water.

- Ship meeting rogue wave; CFD calculations (Guo and Vartdal, 2015)

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Full Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all (Loa)</td>
<td>[m]</td>
<td>92.2</td>
</tr>
<tr>
<td>Length between perpendiculars (Lpp)</td>
<td>[m]</td>
<td>84.8</td>
</tr>
<tr>
<td>Breadth (B)</td>
<td>[m]</td>
<td>21.0</td>
</tr>
<tr>
<td>Depth (D)</td>
<td>[m]</td>
<td>9.6</td>
</tr>
<tr>
<td>Summer Draught (T)</td>
<td>[m]</td>
<td>7.6</td>
</tr>
</tbody>
</table>

$H_s = 2.0 \text{ m}$
Task 1.1 Met-ocean description
(DNV, IST, GL, EVFH)

- Location dependent, usually instrumental data exist
- Access to the port of Antwerp

Measuring network:
winds, waves, tide, current

- Scottish waters, the port of Leixões
Coastal waters

Empirical and fitted distributions of Hs and T hs and wave period for (left) the coastal access channel to Antwerp and (right) Scottish waters.

➢ In the Scottish waters most frequent mean wave direction is SW and NE, while in the Antwerp channel NW. The port of Leixões placed in the East North Atlantic coast is not so protected as the Antwerp channel.
Port of Antwerp

The JONSWAP $\gamma$ parameter resulting from average spectra near Belgian coast as a function of significant wave height (Truijens, 1992).

- Recent investigations of Winterstein and Haver (2015) show that in shallow water the bottom topography will affect shape of the wave spectrum significantly. The TMA spectrum is recommended to be used.

- In the Scottish waters and the Antwerp channel current present.
Task 1.1 Met-ocean description
(DNV, IST, GL, EVFH)

Restricted waters

- Manoeuvrability at **low forward speed in strong wind and, perhaps, current, is critical for ships with large windage area**, such as container ships, cruise vessels and car carriers, but also for bulk carriers and tankers, during approaching to and entering ports.

- Low-speed manoeuvrability criteria require specification of the **wind speed** and, **perhaps current**. Quadvlieg and van Coevorden (2008) recommend wind speed of **20 knots for general use** and **30 knots for ferries and cruise ships**, as the wind speed at which the ship should be able to leave the quay.

- For **tug operations**, relevant for low-speed manoeuvrability criteria, **IMO recommendations**: **significant wave height up to 5 m, wind speed up to 39 knots and current up to 2 knots** as environmental limits for towing operations, could be adopted.
The analysis of hindcast and instrumental data have confirmed the earlier findings of the SHOPERA project, **met-ocean conditions vary significantly in deep and coastal waters.**

The proposed **2013 Interim Guidelines** do **not cover all critical situations**; they are limited to **coastal waters only and limited met-ocean parameters.** Further, the adverse conditions of the **2013 Interim Guidelines** may need also some revisions to reflect more satisfactory met-ocean climate.

**Ability of ships to maintain manoeuvrability** will **depend on the ship type.** Therefore further investigation of met-ocean characteristics identified in the present study in **numerical calculations and model tests are needed** to reach firm conclusions.
It should be noted that **met-ocean environment is geographic region** and **location dependent**.

The adverse weather conditions are **not able to cover all location specific features of met-ocean climate**, particularly for coastal waters and restricted waters.

Therefore apart from proposing adverse conditions **a notation** may need to be given requiring verifying met-ocean climate **on a case by case basis** to account satisfactory for shallow-water aspects of wave and current shallow water dynamics as well as associated wind conditions.
Task 1.1: Met-ocean conditions

Thank you for your attention