Marine Operations

Lecture at CESOS, NTNU, 14th August 2013,

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## Marine Operations themes

<table>
<thead>
<tr>
<th>Operational criteria versus design criteria</th>
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<tbody>
<tr>
<td><strong>General aspects</strong></td>
</tr>
<tr>
<td>Resonant motion</td>
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<tr>
<td>Dynamic amplification</td>
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<tr>
<td>Damped motions</td>
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<td>Impact loading</td>
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<td>Splash zone lifting</td>
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<td><strong>Vessel</strong></td>
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<tr>
<td>Vessel motions</td>
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<tr>
<td>Natural periods of vessels</td>
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<tr>
<td>Encounter frequency</td>
</tr>
<tr>
<td><strong>Weather criteria</strong></td>
</tr>
<tr>
<td>Limiting wave height and Operational window</td>
</tr>
<tr>
<td>Uncertainties in weather forecasting</td>
</tr>
<tr>
<td>Weather windows</td>
</tr>
<tr>
<td><strong>Risk</strong></td>
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<tr>
<td>Risk in Marine Operations</td>
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<tr>
<td>HSE and Marine Operations</td>
</tr>
<tr>
<td>Risk and cost benefit analysis</td>
</tr>
<tr>
<td><strong>Installation tasks, cold climate aspects</strong></td>
</tr>
<tr>
<td><strong>Station keeping</strong></td>
</tr>
<tr>
<td>DP versus mooring</td>
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<tr>
<td>Anchoring</td>
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<tr>
<td>Mooring analysis</td>
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</tbody>
</table>
1) The issue

- Marine operations require special weather conditions
  - Wave heights (normally considered)
  - Wave periods (often not considered)

- Notice the vessel’s Response Amplitude Operator
  - Amplification of the motion at the eigen frequencies of the vessel
  - We often use a linear relationship between the response and the wave (height) multiplied with the RAO value
  - The vessel’s eigen frequencies change with velocity (encounter frequency)
The issue 2

- Marine operations require special weather conditions
  - Wave heights (normally considered)
  - Wave periods (often not considered)
- Operations:
  - We have therefore to wait for appropriate weather conditions which will last for the duration of the operation
  - Waiting on weather is an impotent issue, who will pay?
  - Weather statistics will be used to estimate best time for the operations (summer season weather)
  - Weather forecasts are used to decide on when to start the operations
  - For operations exceeding 3 days, seasonal statistics are used
- Survival
  - Also the survival weather condition must be assessed
Weather window, typical distribution

- Large wastage of offshore work time is reported just by waiting for the weather window during the installation phase.

http://www.we-at-sea.org/docs
Weather window length, typical Hs distribution
Weather forecast uncertainty (Ref: yr.no)

Sannsynlighetsvarsel for Trondheim

Nedbør (blå):
50% sannsynlighet
30% sannsynlighet

Temperatur (grå):
50% sannsynlighet
30% sannsynlighet

Langtidsvarselet er relativt sikkert når det er liten spredning i de grå feltene (de er smale) og de blå søylene (de er korte).

Langtidsvarselet er usikkert når det er stor spredning i de grå feltene (de er brede) og de blå søylene (de er lange).
DNV-OS-H101 - Operation Periods

2) From: DNV Presentation, DNV-OS-H101 Marine Operations, General

\[ T_R = \text{Operation reference period} \]
\[ T_{POP} = \text{Planned operation period} \]
\[ T_C = \text{Estimated maximum contingency time} \]
Operational Limiting Criteria

- The $\text{OP}_{\text{LIM}}$ (Limiting operational environmental criteria) shall never be taken greater than the minimum of:
  - The environmental design criteria.
  - Maximum wind and waves for safe working- or transfer conditions for personnel.
  - Equipment (e.g. ROV and cranes) specified weather restrictions.
  - Limiting weather conditions of diving system (if any).
  - Limiting conditions for position keeping systems.
  - Any limitations identified, e.g. in HAZID/HAZOP, based on operational experience with involved vessel(s) etc.

- The forecasted (monitored) operational criteria - $\text{OP}_{\text{WF}}$
  - is defined as $\text{OP}_{\text{WF}} = \alpha \times \text{OP}_{\text{LIM}}$. 
The alpha factor for waves is defined by 5 Tables, below “Base Case”:

<table>
<thead>
<tr>
<th>Operational Period [h]</th>
<th>Design Wave Height [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H_s = 1$</td>
</tr>
<tr>
<td>$T_{POP} \leq 12$</td>
<td>0.65</td>
</tr>
<tr>
<td>$T_{POP} \leq 24$</td>
<td>0.63</td>
</tr>
<tr>
<td>$T_{POP} \leq 36$</td>
<td>0.62</td>
</tr>
<tr>
<td>$T_{POP} \leq 48$</td>
<td>0.60</td>
</tr>
<tr>
<td>$T_{POP} \leq 72$</td>
<td>0.55</td>
</tr>
</tbody>
</table>

The other tables take into account combinations of
- Wave monitoring
- Weather forecast level
- Meteorologist at site
3) ISO Standard and DNV Offshore Standards

- In December 2009 the ISO standard 19001-6, Marine Operations was issued.
- This standard has together with the VMO Rules been specified as reference documents in many offshore development projects.
- The ISO 19001-6 standard has quite many requirements and guidelines of general nature.
  - It could in many cases be difficult both to split between requirements and guidelines and also to understand how to fulfill the requirements.
  - The VMO Standard gives more detailed requirements and guidance for many marine operation aspects, and could hence be used as guidance on how to fulfill the ISO 19001-6 requirements.
DNV Offshore Standards

- **Offshore Service Specifications** provide principles and procedures of DNV classification, certification, verification and consultancy services

- **Offshore Standards** provide technical provisions and acceptance criteria for general use by the offshore industry as well as the technical basis for DNV offshore services

- **Recommended Practices** provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards.

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**OFFSHORE STANDARD**
DNV-OS-H101

*Marine Operations, General*
*OCTOBER 2011*

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**OFFSHORE STANDARD**
DNV-OS-H102

*Marine Operations, Design and Fabrication*
*JANUARY 2012*
DNV Marine Operations

- DNV-OS-H101 Marine Operations, General
- DNV-OS-H102 Design & Fabrication
- DNV-OS-H201 Load Transfer
- DNV-OS-H203 Rig Moves
- DNV-RP-H101 Risk Management in Marine and Subsea Operations
- DNV-RP-H102 Marine Operations during Removal of Offshore Installations
- DNV-RP-H103 Modelling and Analysis of Marine Operations
- DNV-RP-H104 Ballast, Stability, and Watertight Integrity - Planning and Operating Guidance

See also:
Standards, a disclaimer

- ISO standards have to be purchased, several standards are linked. The costs can be very large
- The ISO standards are often general and put up principles. They serve as reminders of what to do
- The International companies are very strong and do NOT want prescriptive rules
- The DNV Documents are freely available
- The documents give very specific recommendations and are easy to understand and interpret
- The DMV documents are NOT textbooks and a thorough understanding of Marine Technology is necessary to understand the DNV documents
- Designs that satisfy the DN documents are normally accepted by authorities
RECOMMENDED PRACTICE
DNV-RP-H103

Modelling and Analysis of Marine Operations

APRIL 2011

This document has been amended since the main revision (April 2011), most recently in December 2012. See “Changes” on page 3.
Risk analysis

• Qualitative risk analysis
  – Accept criteria
  – Hazid
  – Implementation of barriers

• Quantitative Risk analysis
  – Fault tree analysis
  – Event tree analysis
  – Risk figure (the number’s game)
  – Risk reduction identification

• Cost benefit analysis
  – Discussion with management regarding risk reduction implementation
Reoccurring deficiencies

1. Deficient risk assessment and understanding of risk,
2. Insufficient information regarding risks, extrapolation from other areas/ similar operations are not always possible,
3. There is no risk in “my project”
4. Deficient distribution of responsibility and lines of communication,
5. Lack of implementation of required safety barriers
6. Deficient hand-over / communication
7. Procedures not followed,
8. Deficient follow-up by operator, etc.
Improving resilience of marine operations

1. Facilitate improved understanding of hazard management by all personnel,
2. Propose a clear distribution of responsibilities for hazard management,
3. Propose provision of so called “faint signals” (Hollnagel et al. 2006) of the potential weaknesses in the hazard management system,
4. Identify specific hazardous aspects of working in arctic conditions and suggest management procedures to secure that the necessary barriers are present during executions of marine operations in cold climate regions.
5. Improve weather forecasting services in cold climate areas
Resilience requires two types of foresight

1. The first comes from learning from the past and present experience. This includes evaluation, learning and dissemination of industry generic and facility specific incident data, and keeping alive existing knowledge. This is needed to identify potential failure modes and consequences (e.g. risks due to operating in non-chartered waters).

2. The second type of foresight is associated with processing of “faint signals”. These signals can include symptomatic events, suspected trends and “gut feelings (Hollnagel et al. 2006). This is needed to identify potential “non obvious” failure modes and consequences (e.g. sinking in harbour due to ballast procedure short cuts)
### Risk estimation

#### Risk matrix estimation criteria

<table>
<thead>
<tr>
<th>Increasing Likelihood (Upper and Lower Values) &gt;</th>
<th>Increasing Likelihood (Median Values) &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; Increasing Severity</td>
<td>Increasing Likelihood &gt;</td>
</tr>
<tr>
<td>People</td>
<td>Environment</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extremely unlikely</th>
<th>Very unlikely</th>
<th>Unlikely</th>
<th>Probable</th>
<th>Frequent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
</tbody>
</table>

#### Examples:

- **Minor injury**
  - People: Extremely unlikely
  - Environment: Very unlikely
  - Assets: Unlikely
  - Reputation: Probable
  - Severity: Slight effect
  - Likelihood: <10^-6
  - Risk: A1

- **Loss time accident**
  - People: Very unlikely
  - Environment: Unlikely
  - Assets: Probable
  - Reputation: Frequent
  - Severity: Minor effect
  - Likelihood: 10^-7
  - Risk: A2

- **Single or few serious injuries**
  - People: Unlikely
  - Environment: Probable
  - Assets: Frequent
  - Reputation: Extreme
  - Severity: Major effect
  - Likelihood: 10^-5
  - Risk: A3

- **Single or few fatalities**
  - People: Probable
  - Environment: Frequent
  - Assets: Extreme
  - Reputation: Extreme
  - Severity: National effect
  - Likelihood: 10^-1
  - Risk: A4

- **Many fatalities (5 or more)**
  - People: Frequent
  - Environment: Extreme
  - Assets: Extreme
  - Reputation: Extreme
  - Severity: International Effect
  - Likelihood: >1
  - Risk: A5
## Risk evaluation for increased resilience

### Barrier acceptance criteria

<table>
<thead>
<tr>
<th>Evaluated Risk</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acceptable</strong></td>
<td>Requires a minimum of one effective primary barrier in place for all threats</td>
</tr>
<tr>
<td></td>
<td>Requires a minimum of one effective primary barrier in place for each identified consequence</td>
</tr>
<tr>
<td><strong>Tolerable (ALARP)</strong></td>
<td>Requires a minimum of two effective primary barriers in place for all threats</td>
</tr>
<tr>
<td></td>
<td>Requires a minimum of one effective primary barrier in place for each identified consequence</td>
</tr>
<tr>
<td></td>
<td>Requires a minimum of one effective secondary barrier all barrier failure / decay modes</td>
</tr>
<tr>
<td><strong>Intolerable</strong></td>
<td>Requires a minimum of three effective primary barriers in place for all threats</td>
</tr>
<tr>
<td></td>
<td>Requires a minimum of two effective primary barriers in place for each identified consequence</td>
</tr>
<tr>
<td></td>
<td>Requires a minimum of one effective secondary barrier all barrier failure / decay modes</td>
</tr>
</tbody>
</table>
Improved comprehension of hazards
Hazard Bow Tie
Types of barriers

- Threat
- Consequence
- Barrier decay/failure mode
- Hardware (engineered) barrier
- Liveware (operator) barrier
- Software (procedural) barrier
- Unknown (non-existent) barrier
Improving barrier integrity
Barrier failure model

Primary barrier

Threat - Direct cause of failure

Barrier decay mode 1 - Underlying cause of failure

Secondary barrier 1 - Control of decay mode 1

Secondary barrier 2 - Control of decay mode 2

Barrier decay mode 2 - Underlying cause of failure

H Hazard

H.02 Initiating event (accident)
Conclusions

- **Marine Operations**
  - Allowable weather criteria depend on:
    - Vessel characteristics
    - Operation characteristics
  - Determination of operational criteria
    - Uncertainty in forecast, alpha factor
  - Waiting on weather
    - A management decision
  - Risk analysis
    - Hazard identification
    - **Qualitative** analysis
    - Identification of barriers
    - Quantitative analysis
    - Management’s attitude to **quantitative** analysis