Risk management of winter traffic in the Gulf of Finland

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Marine Technology

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Aim and scope
Decision support

1. Analysis of appropriate risk reducing measures for the winter navigation system in the Gulf of Finland. Focus on accident prevention.

2. Analysis of potential for accidental oil spills in winter navigation operations in the Gulf of Finland. Focus on pollution response capacity needs.
Motivation

Gulf of Finland – Oil transport

Increase in oil transport to and from Russia
Methodology:
Formal Safety Assessment

“A rational and systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks.”

# Formal Safety Assessment
## Outline of the concept

<table>
<thead>
<tr>
<th>Section</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>System description</td>
<td>• What is the purpose of the analysis?</td>
</tr>
<tr>
<td></td>
<td>• Which parts of the system are analyzed?</td>
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<tr>
<td>Scope</td>
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<tr>
<td>Hazard Identification</td>
<td>• What can go wrong?</td>
</tr>
<tr>
<td></td>
<td>• Scenarios</td>
</tr>
<tr>
<td>Risk Analysis</td>
<td>• How likely is it?</td>
</tr>
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<td></td>
<td>• Probabilities</td>
</tr>
<tr>
<td>Risk control options</td>
<td>• What can we do about it?</td>
</tr>
<tr>
<td></td>
<td>• How much does it help?</td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td>• At what cost?</td>
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<tr>
<td></td>
<td>• Do the benefits outweigh the costs?</td>
</tr>
<tr>
<td>Recommendations</td>
<td>• Decision criteria</td>
</tr>
<tr>
<td></td>
<td>• Prioritized actions</td>
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</tbody>
</table>

Step 0: System description

Ice concentration and drift

Mean ice thickness

Ridge ice thickness

Compressive region
Step 0: System description
Finnish-Swedish winter navigation system

**Focus of the analysis**
Limit to influence of RCOs on operator performance

**Ice class regulations (1)** provide information about specific engine output, strength hull and design, propeller shafts and gears, rudder and steering, and other requirements. (Trafi, 2010).

**Additional requirements (5)** complement the demanded requirements for navigating under ice conditions, including vessel loading and transport methods, positioning of vessels propeller, etc.

**Ice services (4)** provide the needed information to activate the traffic restrictions (2) of the system, the services encompass a monitoring of ice conditions and ice developments on a daily basis.

**Traffic restrictions (2)** are aimed to ensure the safety of vessels and natural environment in the zone, and to reduce the time of vessels waiting for icebreaker assistance.

**Icebreaker assistance (3)** is provided (when required) for those vessels navigating independently.
Step 0: System description

Beset in ice

Convoy

Towing
Step 1: Hazard Identification
Winter Navigation Accidents
(Type of accidents during Independent Navigation)
Step 1: Hazard Identification
Winter Navigation Accidents

Type of accidents during IB Operations

- Collision: 95%
- Propeller damage: 5%
Steps 2 to 4: Risk Management Model

Risk perspective

Risk assessment model
Risk control options
Costs*

Risk Management Model
Risk perspective

- Risk assessment is the systematic consideration of uncertainties U regarding the occurrence of events A and their consequences C, in light of available background knowledge BK.

- Risk = Uncertainty about consequences
  Risk = (A, C, U | BK)
Risk Management Model
Independent navigation

Bayesian Network framework
Risk Management Model

HUMAN ERROR

- Encounter situation
  - Vessel collided
    - Collision angle
  - Maneuvering Space
  - Collided Area

Potential spill size (Tankers)
- Actual spill size (Tankers)
- Potential spill size (Other vessels)
- Actual spill size (Other vessels)

- Exposure to collision
- Damage Extent (Tankers)
- Damage Extent (Other vessels)
  - Vessel size
  - Vessel Type
  - Loading conditions
  - Traffic direction

- Human error
  - Available time
  - Training and preparation
  - Collaboration quality
  - Collab

- Collision
  - Yes
  - No

- Improve the SMS
  - Improve Organizational Safety Culture
  - Improve emergency drills
  - Improve the operational procedures
  - Improve e-Nav support
  - Improve the designation of personnel on the bridge
  - Improve time management
  - Improve planning skills
  - Improve navigational training
  - Improve communication
  - Adequacy of Organization
  - Available procedures and plans
  - NMI and operational support
  - Available time
  - Training and preparation
  - Collaboration quality

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• Human error quantification CREAM 2nd generation Human Reliability Assessment
• Cognitive failure probabilities are influenced by performance shaping factors
RMM: Independent Navigation

Background knowledge (2)

- Ice conditions based on accident cases, data from Automatic Identification System (AIS) and operative ice model data (HELMI)
- Expert elicitation, models for assess the impact of collision and operational videos for impact conditions.
RMM: Independent Navigation

Background knowledge (3)

- Definition of **traffic conditions** based on AIS data, cargo flow analysis
- Definition of **ship characteristics** based on cargo layout data, cargo and bunker tank sizes

<table>
<thead>
<tr>
<th>DWT, t</th>
<th>Cargo tank arrangement scheme</th>
<th>$DH_1$, m</th>
<th>$Z_1$, m</th>
<th>$L$, m</th>
<th>$B_s$, m</th>
<th>$d_s$, m</th>
<th>$D_s$, m</th>
<th>0.98$V_\Sigma$, m$^3$</th>
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<tbody>
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<td>8.30</td>
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<td>8.30</td>
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<td>2.32</td>
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<td>16.8</td>
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</tbody>
</table>
Risk Management Model

RCOs

Adequacy of Organization
Available procedures and plans
MMI and operational support
Available time
Training and preparation
Collaboration quality

Detect
Assess
Act

Human error

Collision situation
Vessel collided
Collision angle
Speed
Manoeuvring Space
Collided Area

Damage Extent (Tankers)
Damage Extent (Other vessels)

Potential spill size (Tankers)
Actual spill size (Tankers)
Potential spill size (Other vessels)
Actual spill size (Other vessels)

Vessel size
Vessel Type
Loading conditions
Traffic direction

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Results: Effect of RCOs

<table>
<thead>
<tr>
<th>RCOs</th>
<th>Percentage of improvement (reducing human error) estimated by the experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequacy of the Organization</td>
<td>Finland</td>
</tr>
<tr>
<td>1  Improve Organizational Safety Culture</td>
<td>6%</td>
</tr>
<tr>
<td>2  Improve the Safety Management System</td>
<td>6%</td>
</tr>
<tr>
<td>3  Improve personnel’s satisfaction</td>
<td>4%</td>
</tr>
<tr>
<td>Available plans and procedures</td>
<td>4%</td>
</tr>
<tr>
<td>4  Improve the Emergency Drills</td>
<td>0%</td>
</tr>
<tr>
<td>5  Review and improve the operational procedures</td>
<td>0%</td>
</tr>
<tr>
<td>MMI and Operational support</td>
<td>0%</td>
</tr>
<tr>
<td>6  Improve the process for designing responsibilities on the bridge</td>
<td>15%</td>
</tr>
<tr>
<td>7  Improve the electronic navigation (e-nav) support on the bridge</td>
<td>12%</td>
</tr>
<tr>
<td>8  Improve/modify the ship bridge design</td>
<td>10%</td>
</tr>
<tr>
<td>Available time</td>
<td>10%</td>
</tr>
<tr>
<td>Training and preparation</td>
<td>10%</td>
</tr>
<tr>
<td>9  Improve time management</td>
<td>10%</td>
</tr>
<tr>
<td>10 Improve navigational training</td>
<td>17%</td>
</tr>
<tr>
<td>11 Improve planning skills with training</td>
<td>0%</td>
</tr>
<tr>
<td>12 Improve safety management and risk management training</td>
<td>17%</td>
</tr>
<tr>
<td>Collaboration quality</td>
<td>10%</td>
</tr>
<tr>
<td>13 Improve communication on the bridge</td>
<td>6%</td>
</tr>
</tbody>
</table>

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Results:
Probability of oil spill by Operations

Probability of oil spill from Tankers

<table>
<thead>
<tr>
<th>Amount of oil spill</th>
<th>IN</th>
<th>Convoy</th>
<th>Towing</th>
<th>Cutting loose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tankers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 1000 tons</td>
<td>0,2 %</td>
<td>0,1 %</td>
<td>0,0 %</td>
<td>0,0 %</td>
</tr>
<tr>
<td>1000 - 5000</td>
<td>0,5 %</td>
<td>0,2 %</td>
<td>0,0 %</td>
<td>0,0 %</td>
</tr>
<tr>
<td>5000 - 15000</td>
<td>0,4 %</td>
<td>0,2 %</td>
<td>0,0 %</td>
<td>0,0 %</td>
</tr>
<tr>
<td>&gt; 15000</td>
<td>0,3 %</td>
<td>0,3 %</td>
<td>0,0 %</td>
<td>0,0 %</td>
</tr>
</tbody>
</table>

Probability of oil spill from bunkers

<table>
<thead>
<tr>
<th>Amount of oil spill</th>
<th>IN</th>
<th>Convoy</th>
<th>Towing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunkers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 1000 tons</td>
<td>0,2 %</td>
<td>0,2 %</td>
<td>0,0 %</td>
</tr>
<tr>
<td>1000 - 5000</td>
<td>0,5 %</td>
<td>0,5 %</td>
<td>0,0 %</td>
</tr>
<tr>
<td>&gt; 5000</td>
<td>0,1 %</td>
<td>0,1 %</td>
<td>0,0 %</td>
</tr>
</tbody>
</table>

Note:
Higher spill sizes overestimates due to limitations of underlying engineering models.
Conclusions

- Uncertainty-based risk management model developed
- Integration of knowledge sources to get holistic view

Recommendations:
- Focus on improved navigational training
- Focus on improving safety management training
- Focus on developing e-navigation tools

Oil spill risk analysis:
- Spills are unlikely, but possible (ca. P=0.02 / winter)
- Spills most likely in range 1 – 5000 tonnes
- Higher spills are unlikely, but not impossible
Thanks for your attention!

The study was carried out as part of the project:

WINOIL

This project is co-funded by the European Union