EMSA 3
A STUDY ASSESSING THE ACCEPTABLE AND PRACTICABLE RISK LEVEL OF PASSENGER SHIPS RELATED TO DAMAGE STABILITY
Content

- Objectives and schedule (EMSA)
- Risk based damage stability, risk from watertight doors and update of CAF (DNVGL)
- Development of grounding (UNITS)
- Sample ships designs and use in CBA (Meyer Werft)
- Questions
Objectives and scope

Provide further information for decision making:

- What is an acceptable and practicable risk level for passenger ships (focus on collisions);
- Whether the current grounding regulatory framework is sufficient (double bottom requirement);
- How can the additional risk of watertight doors and other openings be taken into consideration in passenger ship design.
Schedule

- Project running according to schedule;
- Interim reports delivered (uploaded to EMSA’s website);
- Final reports of these tasks to be published at the end of March.
Schedule

1st task
Collision damage stability
Feb 2015

2nd task
Risk from watertight doors
Feb 2015

3rd task
Risk from groundings
Feb 2015

4th task
FSA compilation
3 months (July 2015)

• Information papers are expected to be submitted to MSC 95 (task 2 & 3);
• Additional information will be submitted to SDC3 as it becomes available;
• Final report to be published in September and submitted to SDC3.
Members of the consortium

Shipyards:
- EUROYARDS, representing: Meyer Werft, Fincantieri, MeyerTurku (ex STX-Finland), STX-France

Designers/Consultants:
- Knud E. Hansen AS & Safety at Sea

Operators:
- Carnival Cruise, Color Line, Royal Caribbean & Stena Line

Universities:
- National Technical University of Athens, University of Strathclyde & University of Trieste

Software developer:
- Napa OY

Classification Society:
- DNV GL
Task 1 – Description of work (1 of 2)

- Assess individual and societal risk to passengers and crew for the world fleet when assumed to be in compliance with SOLAS 2009;
- Determine risk evaluation criteria for five different transport modes as well as values for CAF (VPF) in use. Update limits for societal risk.;
- Suggest update of CAF (VPF);
- Revisit Hazids for cruise and Ropax carried out in SAFEDOR;
Task 1 – Description of work (2 of 2)

- Develop a collision damage risk analysis;
- Design 6 passenger ships in compliance with current regulations;
- Investigate Risk Control Options (RCO) and carry out Cost-Benefit-Assessment;
- Propose a formulation level of required index R.
Risk level of current fleet

- Studies based on:
  - Updated risk models collision and grounding
  - Additional risk models for (contact) flooding, fire & explosion based on the SAFEDOR FSAs.
  - Updated by using accident frequencies for the period from 2000 to 2012.
- Risk quantified for three reference ship sizes of each ship type (cruise and RoPax):
  - FN-diagram
  - PLL
  - Fatalities per hour
  - Fatalities per journey
  - Fatalities per distance
Update of VPF / CAF

Based on parameters:

GDP

e: life expectancy at birth

w: portion of life spent in economic production

HALE: Health Adjusted Life Expectancy

Two values recommended used in EMSA III:

4 mill USD and 8 mill USD
Updated collision risk model from GOALDS

Example cruise

Updated (merged Ropax and Cruise) -> no effect on risk

Updated (merged limited waters/en route) -

Accident frequency 2000-2012 per ship year
Uncertainties in the risk model

- Uncertainties are taken into account for:
  - Initial frequency for collision
  - Probability for being struck
  - Probability for collision in terminal areas
  - Probability for water ingress
  - Fatality rates
Some notes:

- The risk to persons on board (PLL) depends linearly on the initial accident frequency;
- Occupancy also linearly influences the risk;
- The fleet at risk and consequently the number of casualty reports for RoPax are significantly higher than for cruise ships:
  - 1 additional accident for RoPax: 1.9%
  - 1 additional accident for Cruise: 5.9%
Task 2 – Description of work

- Collect operational data of watertight doors for 2 Cruise ships and 2 RoPax for at least two weeks
- Propose a method that approximately estimate the risk from watertight doors
- Apply the method on the initial sample ship designs
- Study of RCOs; reducing number of watertight doors or re-categorisation
- Carry out CBA
- Recommendation for decision making
WTD – parametric model

Parametric formulation based on:

Categorisation of doors:
  - Probability for being open
  - Closing time

Volumes connected by the WTD(s)

Total volume of watertight hull
Task 3 – Work description

- Identification of historical raking damages
- Suggest modifications to SOLAS 2009
- Apply the suggested methods to the sample ships
- Study RCO
- Carry out CBA
- Recommendations for decision making
Status & Objectives

Current status:

✓ SOLAS2009 probabilistic framework: damages due to collision;

✓ Safety in case of grounding, within SOLAS2009, is handled by Regulation 9:
  • Minimum double bottom height; or
  • Direct calculations (unusual bottom arrangements) considering deterministic bottom damages;

Objectives of the study:

✓ Focus on passenger vessels;

✓ Develop a probabilistic framework for assessing damaged ship survivability following a grounding accident;

✓ Account also for grounding damages extending partially or totally above double bottom, taking into account long and shallow (raking) damages;
Types of damage taken into account

Bottom damage (Type B00): penetration in vertical direction

Side damage (Type S00): penetration in vertical direction
Bottom damage (Type B00)

Probabilistic model of damage characteristics (basis: GOALDS for non-full vessels)

- Damage length
  - Dimensionless longitudinal position of forward end of damage. Non-full vessels.

- Position of forward end
  - CDF [f]

- Damage penetration
  - Dimensionless transversal extent of potential damage (potential damage width). Non-full vessels.

- Damage width (uniform transversal position)
  - CDF [f]

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**Side damage (Type S00)**

Probabilistic model of damage characteristics
(development and analysis of a database of accidents within the project)

- Damage side: 50% PS, 50% SB

- Probabilistic model for lower limit and vertical extent of damage

In addition:

- Damage penetration

- Position of forward end

- Damage length
Approach for determination of A-index

- The development of a zonal approach based on analytical "p-factors" (as in SOLAS2009) was found to be impractical;

- A different approach was followed, which is based on the determination of "p-factors" through direct generation of hull breaches;

- Survivability in damaged condition is measured through the SOLAS2009 "s-factor";

- The attained index is determined by using the three draughts specified by SOLAS2009: $d_s$, $d_p$, $d_l$;

- Attained indices are defined, for bottom ("B") and side ("S") damages, in line with SOLAS2009:
  - Bottom: $A_{GR,B} = 0.4 \cdot A_{GR,B,s} + 0.4 \cdot A_{GR,B,p} + 0.2 \cdot A_{GR,B,l}$
  - Side: $A_{GR,S} = 0.4 \cdot A_{GR,S,s} + 0.4 \cdot A_{GR,S,p} + 0.2 \cdot A_{GR,S,l}$
### Approach for determination of A-index

#### Generation of sample of breaches
- Geometrical model of damage
- Probabilistic model of damage characteristics

- Generation of breaches
- Identification of damaged rooms for each breach

#### Determination of "damage cases"
- Grouping of breaches involving the same (set of) room(s)

- Damage cases with associated "p factors"

#### Survivability assessment based on static stability calculations
- Static stability calculations
- Survivability factor - "s-factor"

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A-index
# Software implementation

<table>
<thead>
<tr>
<th><strong>Grounding damage study</strong></th>
<th><strong>Notes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calculation setup</strong></td>
<td></td>
</tr>
<tr>
<td>Ship model arrangement</td>
<td>A</td>
</tr>
<tr>
<td>Calculation hull</td>
<td>DAMHULL</td>
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<tr>
<td>Compartment connection</td>
<td>WTCOMP</td>
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<tr>
<td>Opening arrangement</td>
<td>DAM.OPENINGS</td>
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<tr>
<td>Maximum moment definition to use for s(mom)</td>
<td></td>
</tr>
<tr>
<td>Calculate s acc. to SLF55 for ROPAX</td>
<td></td>
</tr>
<tr>
<td>Manually set main dimension parameters</td>
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</tr>
<tr>
<td>Length of the ship</td>
<td>234.443</td>
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<tr>
<td>Minimum X</td>
<td>-8.936</td>
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<tr>
<td>Breadth</td>
<td>32.2</td>
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<tr>
<td>Draught</td>
<td>7.2</td>
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<tr>
<td>Grounding type</td>
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<td><strong>S00 groundings</strong></td>
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<tr>
<td>S00 source</td>
<td>GENERATE</td>
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<tr>
<td>Number of damages to generate</td>
<td>10</td>
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<tr>
<td>S00 output CSV table</td>
<td>C:/NAPA/TEMP/EMSA3_CSV/E3_DEMO7.CSV</td>
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</tbody>
</table>

- Generate damages
- Initial condition group
  - IALL
Example test application in case of bottom damages

Within the project the methodology is being applied, for both bottom and side damages, to real designs.

The application so far indicates the practical feasibility of the approach, but the analysis is still ongoing.

An example is shown here on a notional box-shaped vessel with the following characteristics:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>100m</td>
<td>d_s</td>
<td>4.0m</td>
</tr>
<tr>
<td>Breadth</td>
<td>16m</td>
<td>d_p</td>
<td>3.6m</td>
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<tr>
<td>Total height</td>
<td>10m</td>
<td>d_l</td>
<td>3.0m</td>
</tr>
<tr>
<td>Assumed number of passengers</td>
<td>750</td>
<td>Height of double bottom</td>
<td>1.6m</td>
</tr>
<tr>
<td>Number of zones</td>
<td>10</td>
<td>Number of rooms</td>
<td>37</td>
</tr>
</tbody>
</table>
Example test application in case of bottom damages

PROFILE

Forward zone

Z=8

Central zone

Z=4

Aft zone

Z=0.4
Example test application in case of bottom damages
Conclusions (1 of 2)

✓ A probabilistic approach has been developed for safety assessment of passenger vessels in damaged condition, following grounding;

✓ The approach considers bottom damages and side damages;

✓ Geometrical/probabilistic model for bottom damages: GOALDS(as basis) + improvements ;

✓ Geometrical/probabilistic model for side damages: fully developed within this project (database of accidents + statistical analysis) ;
Conclusions (2 of 2)

✓ Damages extending partially or totally above the double bottom are embedded in the modelling (side damages);

✓ Long and shallow (raking) damages are embedded in the modelling (side damages);

✓ The approach has been implemented within NAPA;

✓ Applications on real designs and consequent analysis is ongoing, and results so far indicates the practical feasibility of the approach.
EMSA3 Sample ships and design teams
Sample ships - Cost Benefit Assessments

- Sample ships selected to fill the Gaps from GOALDS
- Good presentation of the all size of ships
- Actual designs selected
  - 2 cruise ships
  - 4 RoPax
- Complying with latest rules (SOLAS2009, SRtP, Stockholm agreement)
- For RoPax new s-factor used
Overview EMSA III  Sample ships

<table>
<thead>
<tr>
<th>Yard/Designer</th>
<th>Type</th>
<th>Length bp (m)</th>
<th>B (m)</th>
<th>T (m)</th>
<th>GT</th>
<th>Number of persons</th>
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</thead>
<tbody>
<tr>
<td>MW</td>
<td>Large cruise</td>
<td>294.6</td>
<td>40.8</td>
<td>8.75</td>
<td>153400</td>
<td>6730</td>
</tr>
<tr>
<td>Fincantieri</td>
<td>Small cruise</td>
<td>113.7</td>
<td>20.0</td>
<td>5.30</td>
<td>11800</td>
<td>478</td>
</tr>
<tr>
<td>Meyer Turku</td>
<td>Baltic RoPax</td>
<td>232.0</td>
<td>29.0</td>
<td>7.20</td>
<td>60000</td>
<td>3280</td>
</tr>
<tr>
<td>STX-France</td>
<td>Med RoPax</td>
<td>172.4</td>
<td>31.0</td>
<td>6.60</td>
<td>43000</td>
<td>1700</td>
</tr>
<tr>
<td>KEH</td>
<td>Small RoPax</td>
<td>95.5</td>
<td>20.2</td>
<td>4.90</td>
<td>7900</td>
<td>625</td>
</tr>
<tr>
<td>KEH</td>
<td>Double ender</td>
<td>96.8</td>
<td>17.6</td>
<td>4.30</td>
<td>6245</td>
<td>610</td>
</tr>
</tbody>
</table>

- Various Risk Control options under investigation
- Changes depending on design options (breadth, freeboard, subdivision etc)
- Constant business model
  - No significant change of capacity or speed
Cost-Benefit Assessment

- Calculation of costs RCOs based on:
  - Life-cycle costs transferred to Net Present Values
  - 30 years life time
  - Costs:
    - Investment Costs
      - Building costs due to enlarged ship (steel, interior systems)
      - Cost impact due to changed equipment (engines, propulsion, thrusters etc)
    - Operational costs
      - Mainly fuel costs
      - Increased maintenance costs
    - Revenue
      - Small adjustments of income
      - Reduced probability of total loss
Fuel oil price development

- Data published by EIA energy outlook have been used as basis for estimating the future trends.

- The current prices for HFO and MGO; 600 USD/t and 900 USD/t, have been obtained using the average reported prices for 2013 and 2014 (until now) in Rotterdam using Clarkson Intelligence as a source.

- The price of LSHFO is obtained based on a 20/80 distribution of the HFO and MGO price. This is the distribution that is required in order to obtain a content of 0.5 % sulphur.

- Price of LNG is taken as 94.1% of the MGO cost. This is a standard assumption used in analysis based on the LNG supplier’s standard way of pricing where it is referred to that the cost of the LNG should correspond to 80% of the use of MGO.
Cost effectiveness

- Based on risk model and netCAF limits (4 Mio$ and 8 Mio $) maximum cost limits are defined
- Easy way to check cost effectiveness for RCOs
- 5% and 95% confidence intervals included
Thank you for your attention!

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