EMSA OP/10/2013

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

- Introduction and overview of the EMSA III studies (Odd Olufsen)
  - Formal Safety Assessment, Risk Models for collision and grounding (Rainer Hamann)
  - Sample ships; design and risk control options (Odd Olufsen)
  - Grounding and combined assessment (Odd Olufsen)
  - Impact assessment (Rainer Hamann)
  - Conclusions and discussion points (Odd Olufsen)
Members of the consortium

- **Shipyards:**
  - EUROYARDS, representing: Meyer Werft, Fincantieri, Meyer Turku, 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
Overview of tasks in the EMSA III project

- Risk acceptance criteria and risk based damage stability
- Evaluation of risk from watertight doors
- Evaluation of risk from grounding
- Damage stability calculations of GOALDS design
- Impact assessment
- Combined assessments
Overview of tasks in the EMSA III project

- Update risk acceptance criteria for FSA
- Verify if current risk level of passenger ships is in ALARP region
- Develop risk model for collision focusing on damage stability
- Evaluate risk from watertight doors
- Develop model for evaluating damage stability with respect to grounding
- Develop risk model for grounding focusing on damage stability

- Develop passenger ship design with increased damage stability regarding collision and grounding accidents -> RCOs
- Cost-benefit assessment of RCOs: CN, GR and CN+GR
- Impact assessment
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- Final remarks (Odd Olufsen)
Risk Analysis II

- **Focus:**
  - Passenger ships, i.e. cruise, passenger, RoPax and RoPax-Rail
  - Ships in compliance with current damage stability requirements (reference)
  - Consider only damage stability of ships
  - Optimise designs with respect to damage stability
  - Evaluate the designs with respect to cost-benefit
- **Update of collision risk model**
- **Development of new grounding/contact risk model**

**Risk models**

**Cost-Benefit A.**

**Recommendation**

**RCOs**
High-level event sequence for collision casualties of passenger ship
- Considers main factors influencing the risk to persons on board
High-level event sequence for grounding and contact casualties of passenger ship

- Contact casualties with potential of penetrating hull and subsequent water ingress
- Only consequences with respect to persons on board are in focus
Cost-benefit assessment

- Risk models are used to determine risk reduction by increased damage stability.
- Risk models are based on experience and numerical models.
- For cost-benefit assessment so-called cost thresholds were calculated by means of risk models, i.e. calculating risk reduction (difference between A-Indices of reference and novel design) and monetary value per avoided fatality.
IMO EG FSA

- EMSA III study was reviewed by IMO EG FSA:
  - The study is for ships ≥ 400 person on board
  - The validity of input data was accepted as well as the expertise of experts participated in the study
  - The essential results are confirmed by an independent analysis

"The group agreed that the study was adequately conducted in accordance with the FSA Guidelines"
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EMSA3 Sample ships and design teams
Design variations

- For each sample ship design variations (RCOs) have been developed
- Following modifications have been applied in different combinations
  - Change of breadth and freeboard
  - Improvement of watertight subdivision
  - Different hull form
  - Buoyancy boxes on the car deck
  - Subdivided LLH
- For each RCO the change of A and costs have been calculated
Calculation assumptions

- SOLAS2009 is used as calculation base
  - Assumptions as in Explanatory Notes
  - For RoPax additional new S-wod according SLF55 calculated
  - Draught range based on loading conditions
  - A-class boundaries considered in flooding stages
- Assumptions:
  - The business model is kept constant
    - No significant change of capacity (cargo, cabins)
    - Operational profile kept the same (distance, turn around time)
  - Same methodology to calculate weight and stability
  - Simplified but realistic cost estimations
  - GM limit curve defined based on loading conditions
  - Margins to GM curve are kept constant
- No detailed internal watertight integrity considered
  - Projects are on basic design level
  - No detailed routing of pipes and ducts
Cost-Benefit Assessment

- Cost Benefit Assessments for sample ships are based on:
  - **Investment Costs**
    - Building costs due to enlarged ship (steel, interior systems)
    - Cost impact due to changed equipment (engines, propulsion, thrusters etc)
    - Financing costs
  - **Operational costs**
    - Mainly fuel costs
    - Increased time in port may cause increased speed $\rightarrow$ higher fuel costs
    - Increased maintenance costs
  - **Revenue**
    - Small adjustments of income
    - Reduced probability of total loss results in less costs for scrap
- All costs are calculated in Euro and converted in USD based on exchange rate of 1.35 USD/Euro
- Changes of costs to the society or industry in general due to changed probability of large accidents have not been accounted for
- The assessments have been carried out for:
  - Mean values,
  - all costs reduced by 20 % and
  - all costs increased by 20 %
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 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.

- The latest reduction of fuel prices (MGO 540 USD/t, HFO 300 USD/t) has not been accounted for.
Baltic RoPax – Meyer Turku & Color Line

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<tr>
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<th>T (m)</th>
<th>GT</th>
<th>Number of persons</th>
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Baltic RoPax – Meyer Turku & Color Line

- Global changes (beam, new hullform subdivided double hull on bulkhead deck)
- Effect of LLH

<table>
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<tr>
<th>Phase</th>
<th>Version</th>
<th>Description</th>
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<tr>
<td></td>
<td>A</td>
<td>Reference design</td>
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<td>Phase 1</td>
<td>B (Option 1)</td>
<td>Breadth increased by 40 cm</td>
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| Phase 1 | C (Option 2) | Breadth increased by 20 cm  
Freeboard increased by 20 cm |
| Phase 1 | D (Option 3) | Breadth increased by 40 cm  
Freeboard increased by 20 cm |
| Phase 1 | E (Option 4) | Breadth increased by 40 cm  
Freeboard increased by 40 cm |
| Phase 2 | F (Option 5) | As version D (opt. 3)  
subdivided double hull on bulkhead deck |
| Phase 3 | I (Option 6) | As version F (opt. 5)  
impact of LLH |
| Phase 3 | J (Option 7) | As version F (opt. 5)  
Subdivided Car Deck |
| Phase 3 | K2 (Option 8) | As version F (opt. 5)  
No Lower Hold |
| Phase 4 | L (Option 9) | As version F (opt. 5) + 40 cm more breadth  
Breadth increased by 80 cm  
Freeboard increased by 20 cm  
subdivided double hull on bulkhead deck |
Baltic RoPax – Meyer Turku & Color Line

<table>
<thead>
<tr>
<th>Phase</th>
<th>Version</th>
<th>Description</th>
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<tr>
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<td>D (Option 3)</td>
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<tr>
<td>1</td>
<td>E (Option 4)</td>
<td>Breadth increased by 40 cm, Freeboard increased by 40 cm</td>
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<tr>
<td>2</td>
<td>F (Option 5)</td>
<td>As version D (opt. 3), subdivided double hull on bulkhead deck</td>
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<td>3</td>
<td>I (Option 6)</td>
<td>As version F (opt. 5), impact of LLH</td>
</tr>
<tr>
<td>3</td>
<td>J (Option 7)</td>
<td>As version F (opt. 5), Subdivided Car Deck</td>
</tr>
<tr>
<td>3</td>
<td>K2 (Option 8)</td>
<td>As version F (opt. 5), No Lower Hold</td>
</tr>
<tr>
<td>4</td>
<td>L (Option 9)</td>
<td>As version F (opt. 5) + 40 cm more breadth = Breadth increased by 80 cm, Freeboard increased by 20 cm, subdivided double hull on bulkhead deck</td>
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<tr>
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<th>D opt 3</th>
<th>E opt 4</th>
<th>F opt 5</th>
<th>I opt 6</th>
<th>J opt 7</th>
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<td>0.0858</td>
<td>0.0716</td>
<td><strong>0.0826</strong></td>
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Ungraded
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Approach for determination of A-index for Grounding

**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"

**A-index**
GROUNDING
Large cruise vessel – Meyer Werft & Carnival

- All grounding RCOs are cost effective
- Some RCO do not comply with SOLAS2009 anymore

<table>
<thead>
<tr>
<th>Version</th>
<th>G2</th>
<th>G3</th>
<th>K3</th>
<th>K4</th>
<th>M1</th>
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<th>I3</th>
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<tbody>
<tr>
<td>Description</td>
<td>reference version</td>
<td>as G2 with wt decks</td>
<td>opt. Version for collision</td>
<td>as K3 with wt decks</td>
<td>double hull increased DB height</td>
<td>as M1 with wt decks</td>
<td>Increased beam, increased freeboard</td>
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Effects of taking grounding into account in the CBA

Attained Index A (collision) for Risk control Options with and without including the effect from grounding.
Suggested level of R if considering collision only

\[ R = 1 - C1 \times \frac{5000}{2.5 \times N + 15225} \]

\[ C1 = 0.8 - \frac{0.25}{10,000} \times (10,000 - N) \]

N is the number of persons onboard without consideration of type of LSA
Alternative when grounding is accounted for in the CBA

\[ R = 1 - \frac{C1 \times 6200}{4 \times N + 20000} \]

\[ C1 = 0.8 - \frac{0.25}{10000} \times (10000 - N) \]

N is the number of persons onboard without consideration of type of LSA
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Impact Assessment

- EU impact assessment enlarges the scope in order to cover all “relevant” effects, e.g. additionally to FSA
  - Environmental impact: air pollution, climate change, noise, avoided pollution
- For EMSA III study the impacts of new damage stability requirements for passenger ships were investigated by means of the developed RCOs
- Impact investigation considered all costs quantified in the FSA cost-benefit assessment
- Furthermore investigated, the effects with respect to
  - to environment considering also up- and downstream
  - collision and grounding accidents (e.g. search and rescue, wreck removal)
- Quantification of impacts in terms of Euro and mainly based on information from
  - Studies (EU, EPA ...
  - Project partners
  - Literature research
Impact Assessment

- Positive impacts, e.g.
  - Loss of human life: already considered in CBA
  - Loss of ship: considered in CBA
  - Loss of cargo: for RoPax, small fraction of ship newbuilding price
  - Environmental pollution (fuel oil, cargo): not quantified due to lack of suitable data
  - Wreck removal: considered as a multiple of newbuilding price
  - Loss of reputation/revenue: too uncertain to be considered in IA
  - SAR: not directly related to accident (service provided independent of number of accidents)
Impact Assessment

- Negative impacts
  - Newbuilding costs -> CBA
  - Fuel consumption -> CBA
  - Air pollution: relevant impact for all designs with increased fuel consumption, sensitive to fuel type
  - Climate change: relevant but smaller than air pollution
  - Harbour fees: depending on changes and ship dimensions and calculation basis, relevant only for ships with frequent harbour calls
  - Revenue/benefit: higher CAPEX and OPEX can lead to increased ticket prices or reduced benefit, with possible shift to other transport modes (RoPax). No impact expected for cruise. Too uncertain to quantify.
  - Noise: noise reduction can increase design costs. Too uncertain to quantify.
Impact Assessment: results

Overview of single impact costs for Mediterranean RoPax ship RCOs
Conclusions from impact assessment

- When the external costs are internalised the CAF value is generally increased
- Supports the conclusions from the CBA carried out according to IMO FSA Guidelines
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Final remarks

- The reports prepared in the study include information and recommendations for future use in research and development.
Content and Information

- Risk acceptance criteria and risk based damage stability (Task 1 reports):
  - Part 1:
    - risk acceptance criteria of various transport modes
    - methods and setting the value of preventing a fatality (VPF)
    - update of the current FN criteria
  - Part 2:
    - update of Hazid
    - collision risk model
    - sample ships presentation
    - risk control options (RCO for sample ships)
    - cost benefit assessment (CBA)
Content and Information

- Risk from watertight doors (Task 2 report)
  - model for assessment of vulnerability due to WTD
  - risk control options WTD arrangement (e.g. number and category)

- Risk from grounding (Task 3 report)
  - probabilistic models for bottom and side damage
  - risk model grounding and contact damages
  - new software
  - sample ship calculations and RCOs
**Content and Information**

- **Combined assessment; collision, watertight doors and grounding (Task 4 report)**
  - combined CBA of RCO develop for collision and grounding respectively
  - recommendations for level of R

- **Impact assessment in compliance with the EC IA guidelines (Task 5 reports)**
  - Part 1
    - Impact assessments of RCOs developed in previous tasks.
  - Part 2
    - Comparison between IMO FSA and the EC IA

- **Damage stability calculations of GOALDS RoPax Designs (Task 6 Report)**
  - Attained index A based on formulation of s agreed at SLF55.
Thank you for your kind attention

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SAFER, SMARTER, GREENER

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