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EMSA OP/10/2013

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

18 January 2016

Ungraded

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)

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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

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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

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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)

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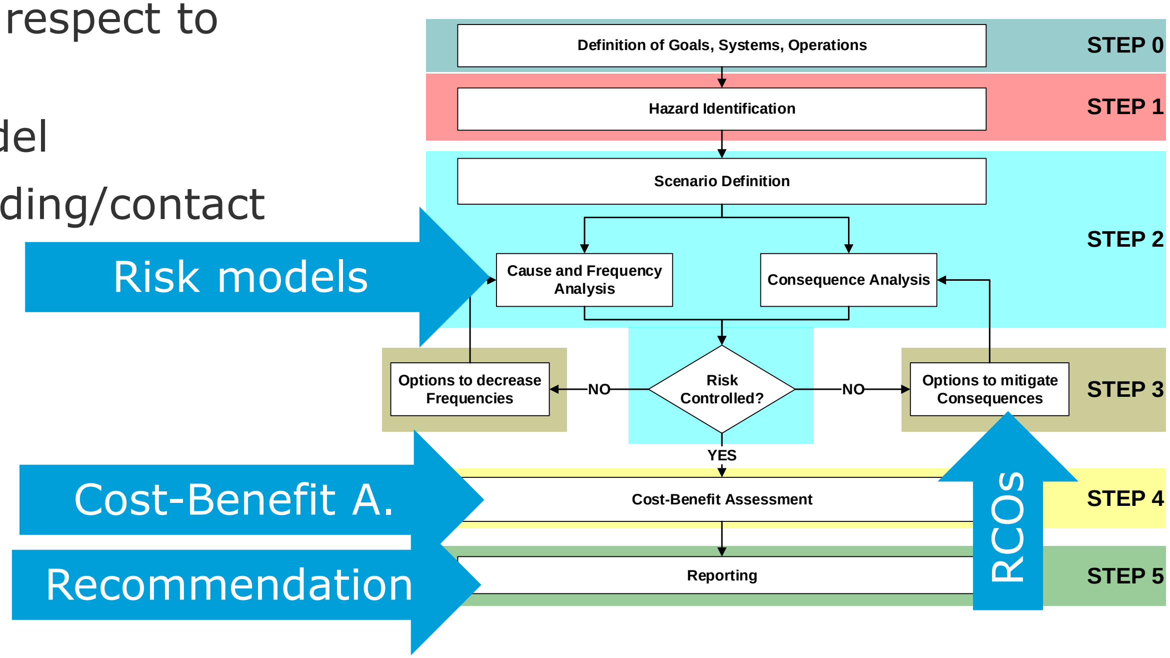
Risk Analysis II

- 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



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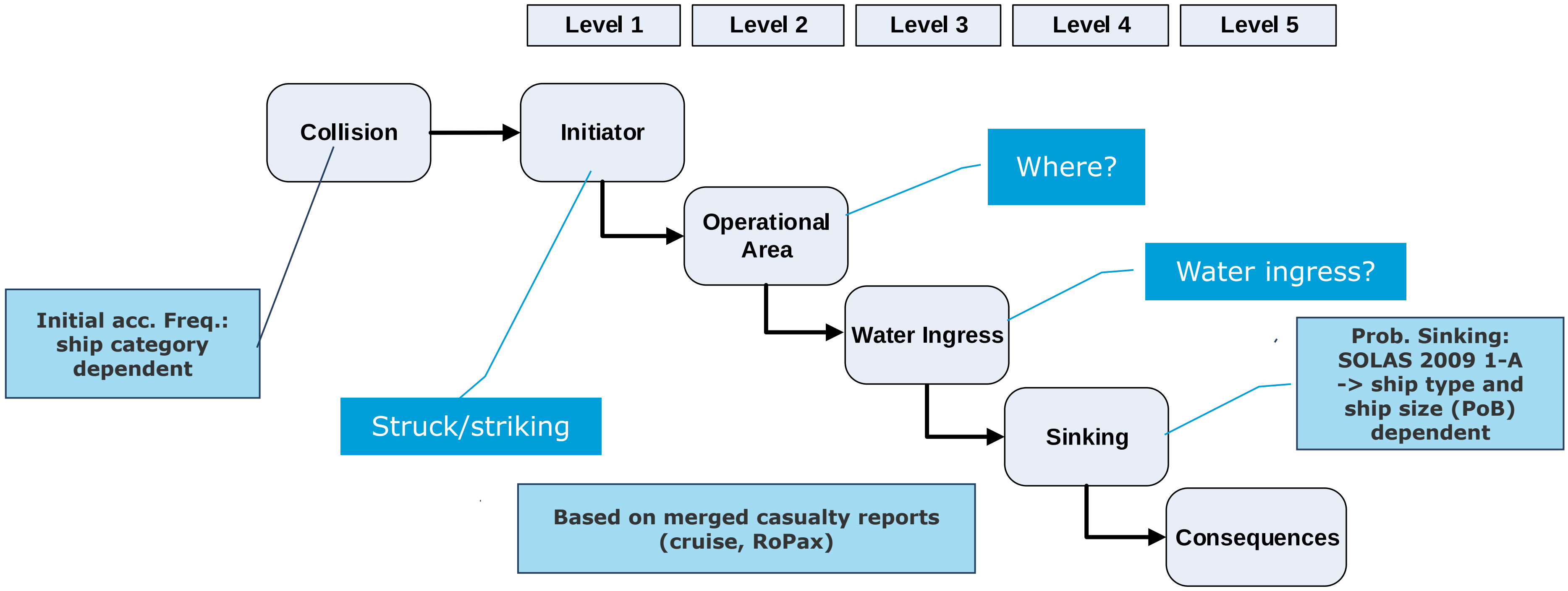
Risk Model: Collision



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

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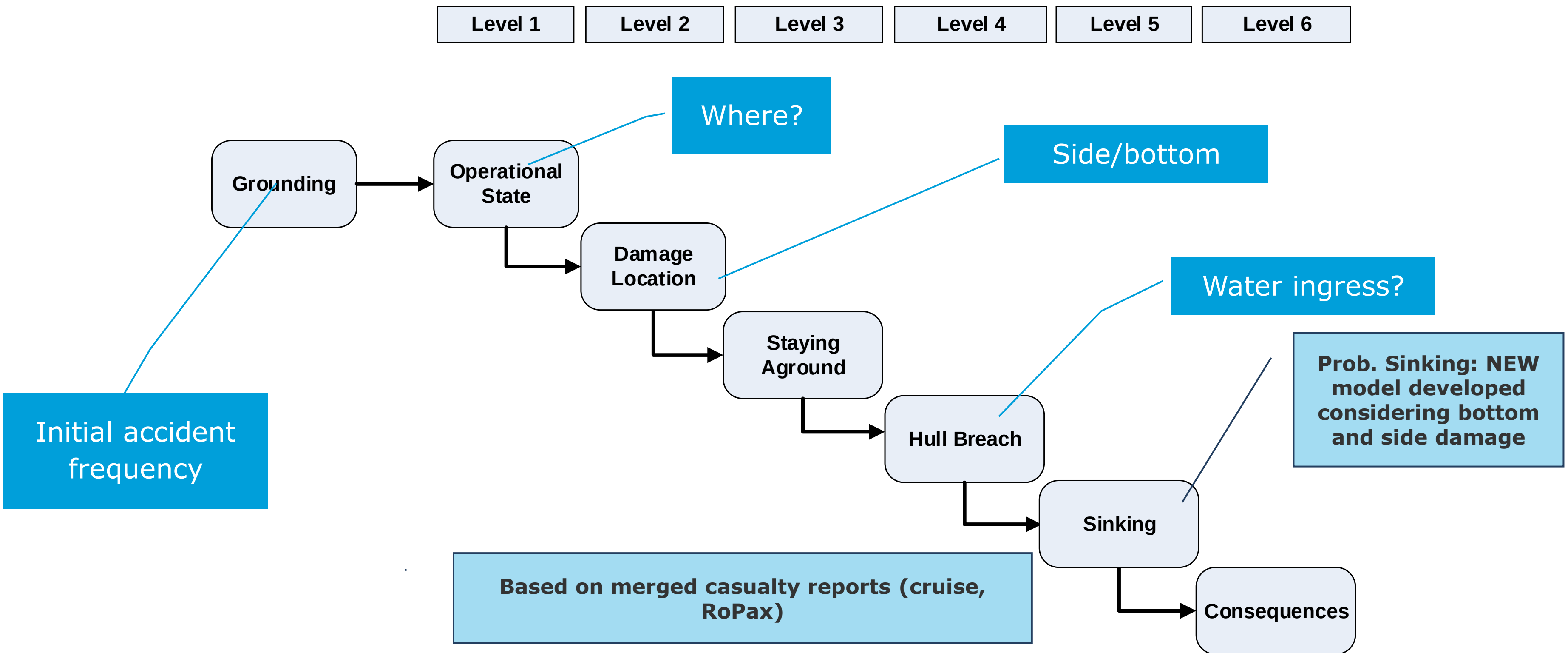
Risk Model: Grounding



- 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

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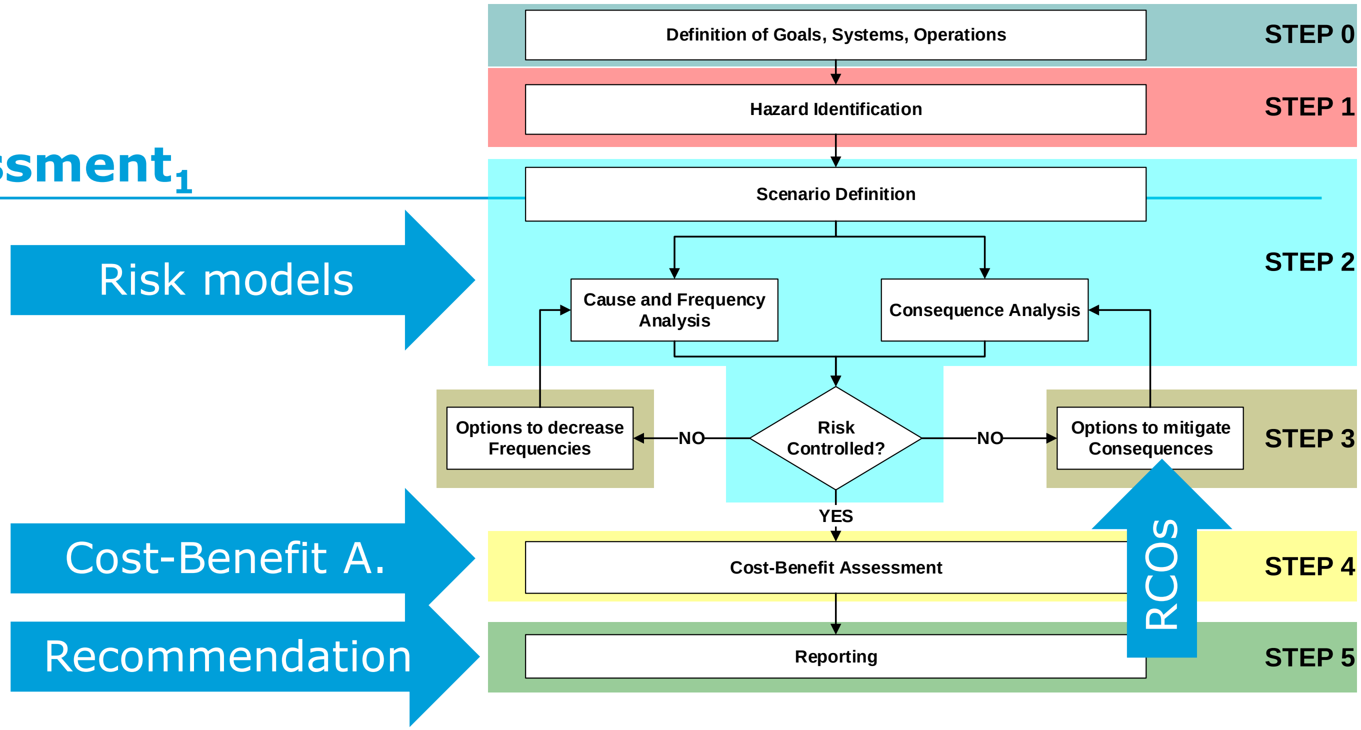
Cost-benefit assessment$_1$



- 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

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IMO EG FSA

- EMSA III study was review 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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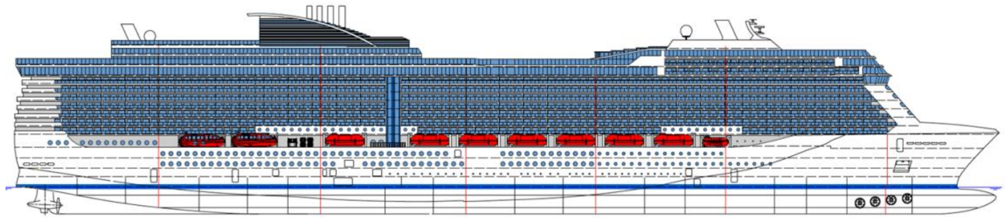
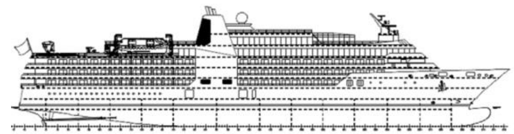
EMSA3 Sample ships and design teams

MEYER WERFT
PAPENBURG 1795



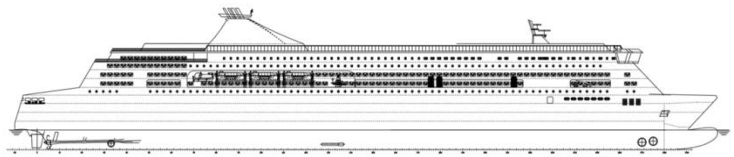
CARNIVAL
CORPORATION & PLC

FINCANTIERI S.p.A.



RoyalCaribbean
INTERNATIONAL

MEYER TURKU
SHIPYARD 1737



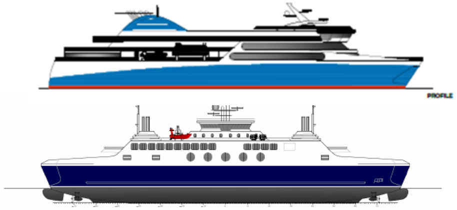
ColorLine

stx France

Stena Teknik
CARE, INNOVATION & PERFORMANCE

ColorLine

KNUD E. HANSEN A/S
NAVAL ARCHITECTS DESIGNERS MARINE ENGINEERS
~Since 1937~



Stena Teknik
CARE, INNOVATION & PERFORMANCE

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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 → 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 %

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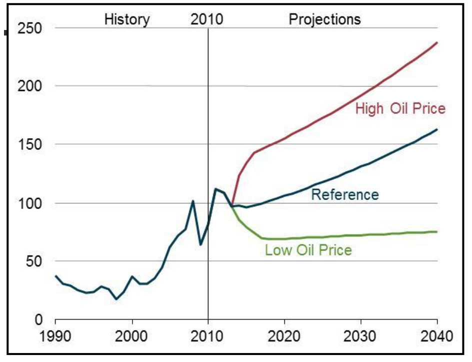
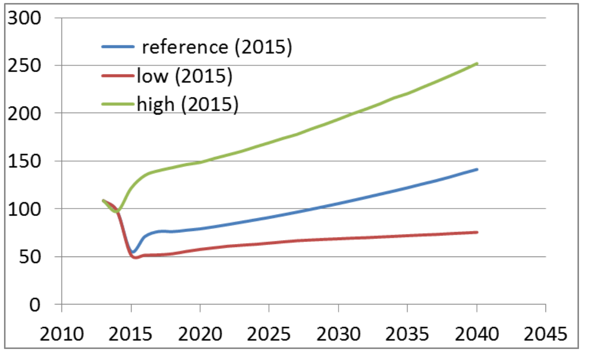
Fuel oil price development

- 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.

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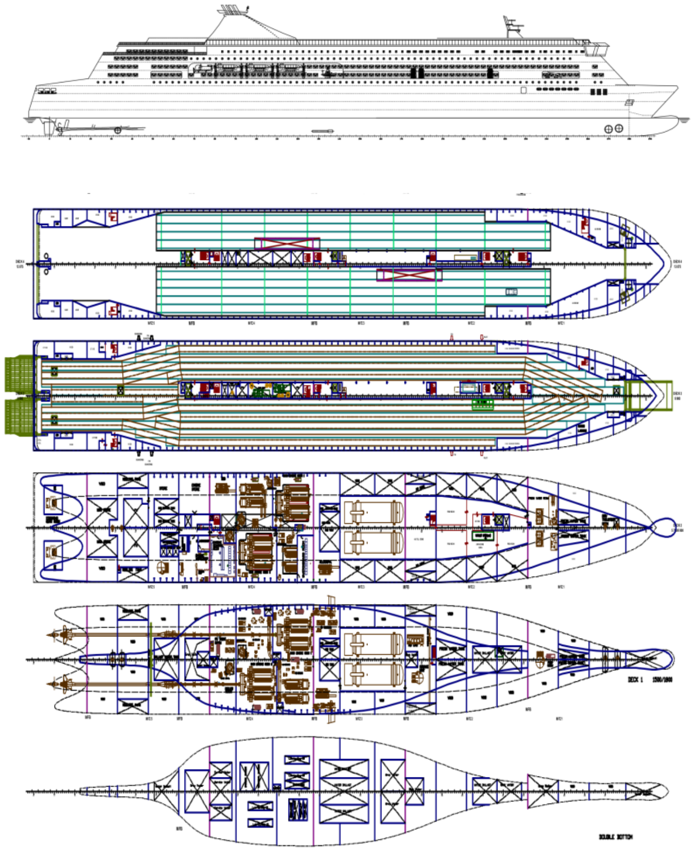
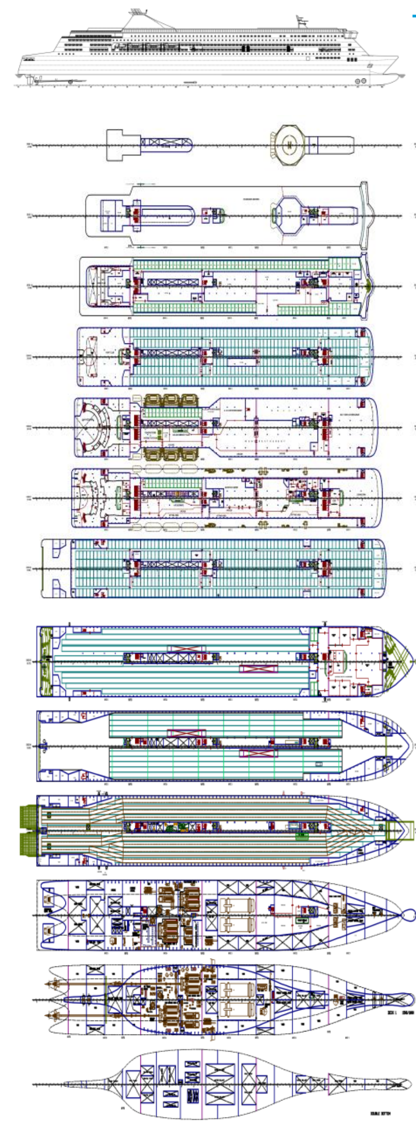
Baltic RoPax – Meyer Turku & Color Line





	Length bp (m)	B (m)	T (m)	GT	Number of persons
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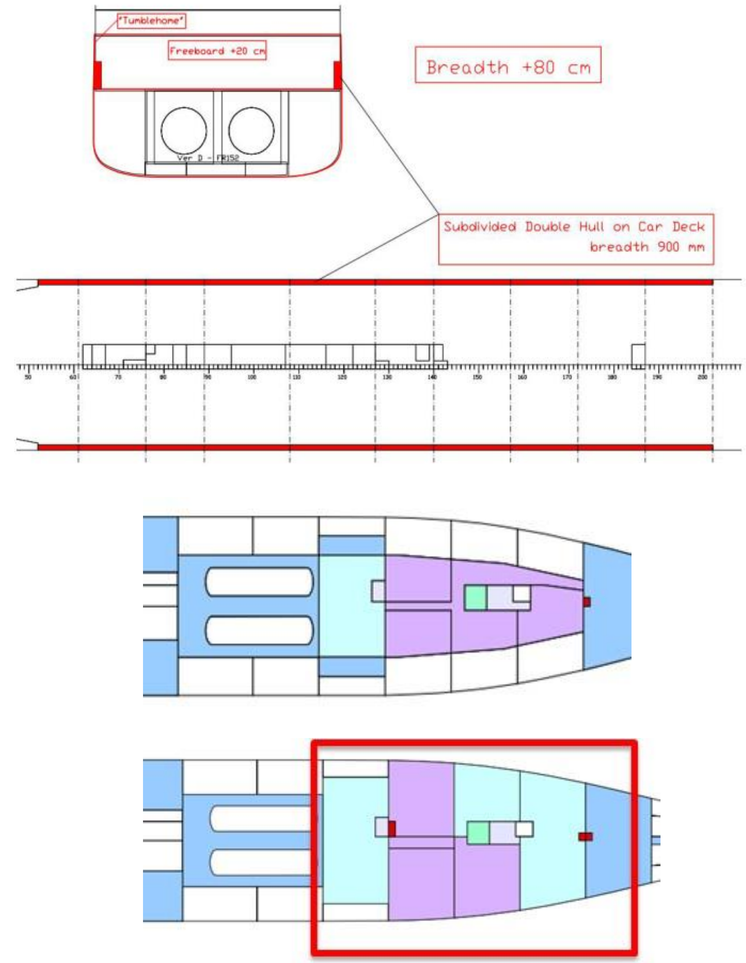
Baltic RoPax – Meyer Turku & Color Line

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

Phase	Version	Description
	A	Reference design
Phase 1	B (Option 1)	Breadth increased by 40 cm
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



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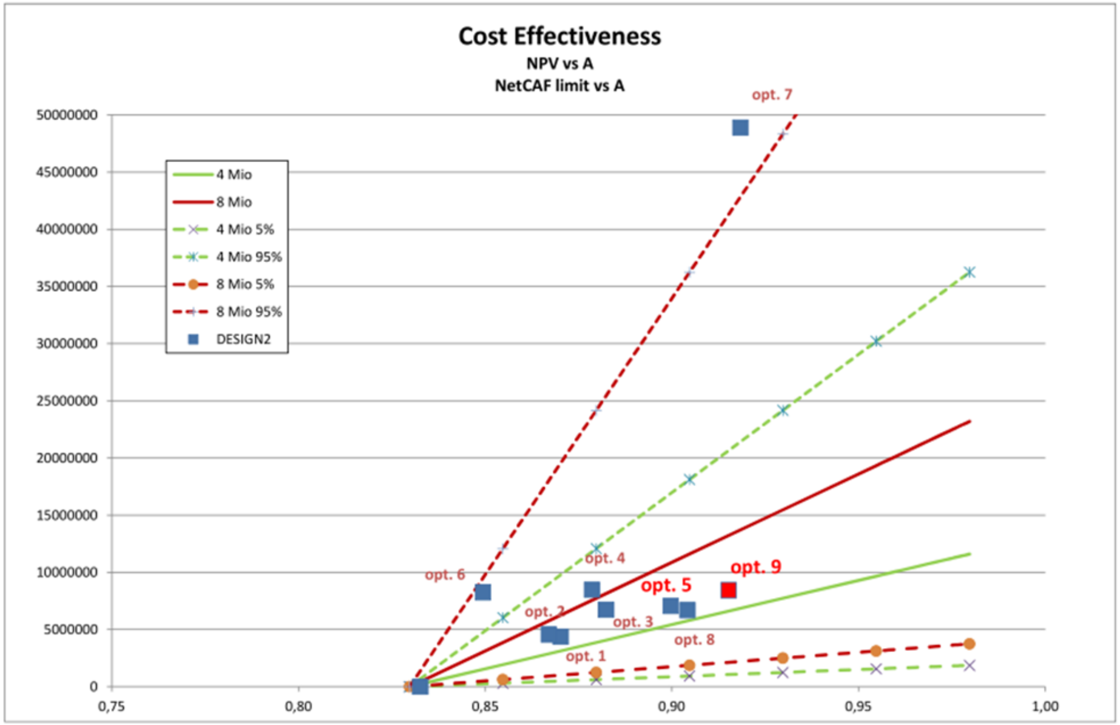
Baltic RoPax – Meyer Turku & Color Line



Phase	Version	Description
	A	Reference design
Phase 1	B (Option 1)	Breadth increased by 40 cm
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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
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Version	A	B opt 1	C opt 2	D opt 3	E opt 4	F opt 5	I opt 6	J opt 7	K2 opt 8	L opt 9
required index R	0.8300	0.8300	0.8300	0.8300	0.8300	0.8300	0.8300	0.8300	0.8300	0.8300
attained index A_{SLF55}	0.8326	0.8703	0.8670	0.8824	0.8786	**0.8997**	0.8494	0,.184	0.9042	**0.9152**
Change in A	0.0000	0.0377	0.0344	0.0498	0.0460	**0.0671**	0.0168	0.0858	0.0716	**0.0826**

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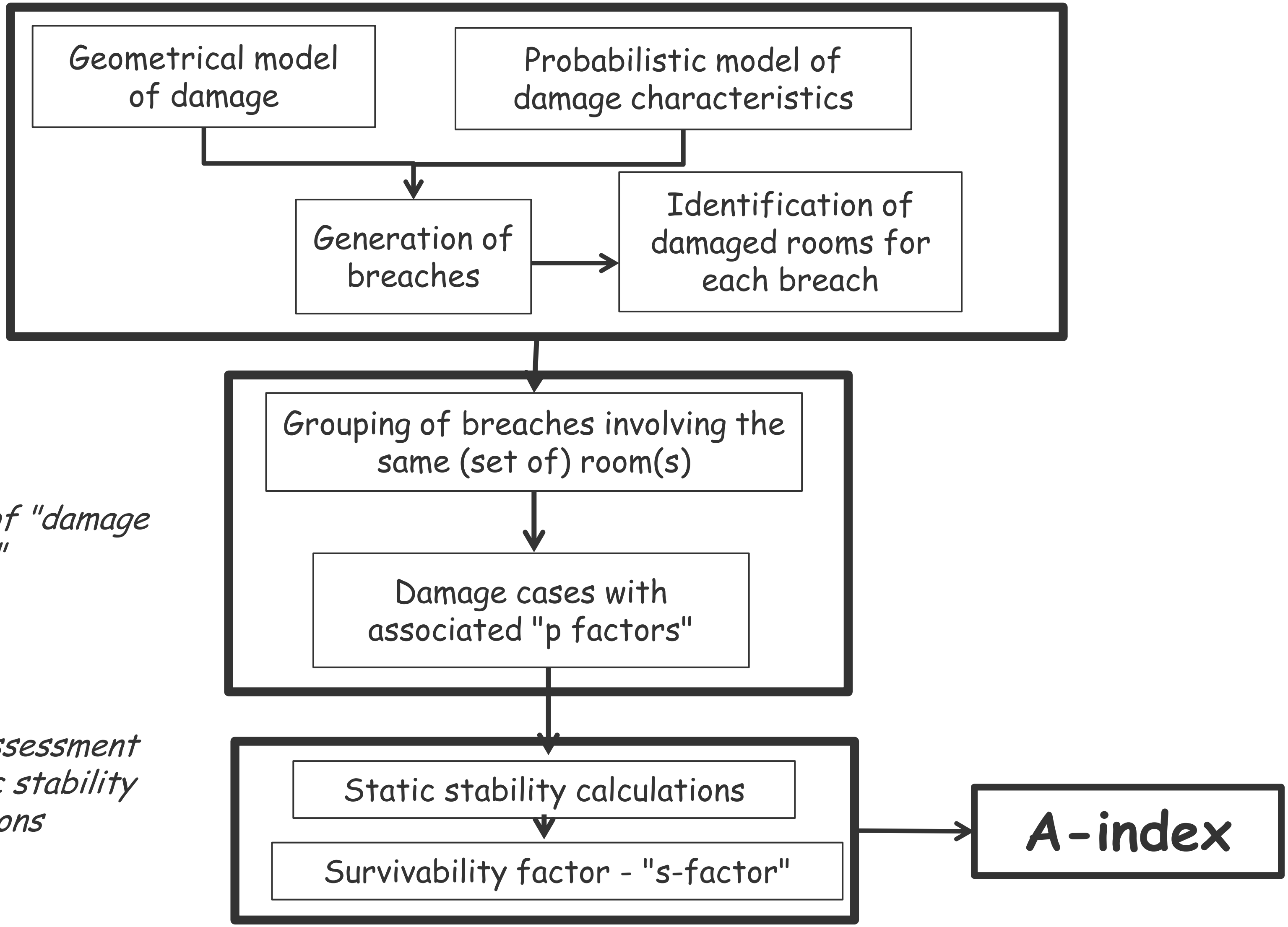
Approach for determination of A-index for Grounding

Generation of sample of breaches

Determination of "damage cases"

Survivability assessment based on static stability calculations



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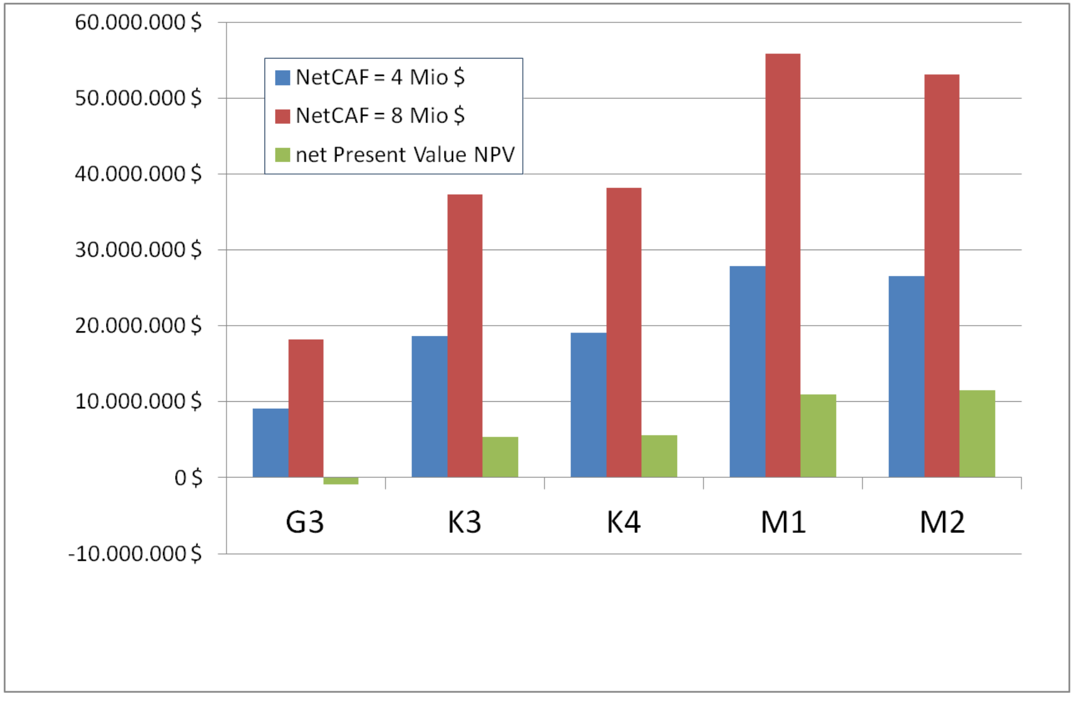
GROUNDING
Large cruise vessel – Meyer Werft & Carnival

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



Version	G2	G3	K3	K4	M1	M2	I3
Description	reference version	as G2 with wt decks	opt. Version for collision	as K3 with wt decks	double hull increased DB height	as M1 with wt decks	Increased beam, increased freeboard
SOLAS2009	0.8626	0.8643	0.8754	0.8792	0.8529	0.8747	0.9288
A Grounding	0.9142	0.9336	0.9543	0.9551	0.9736	0.9707	0.9513

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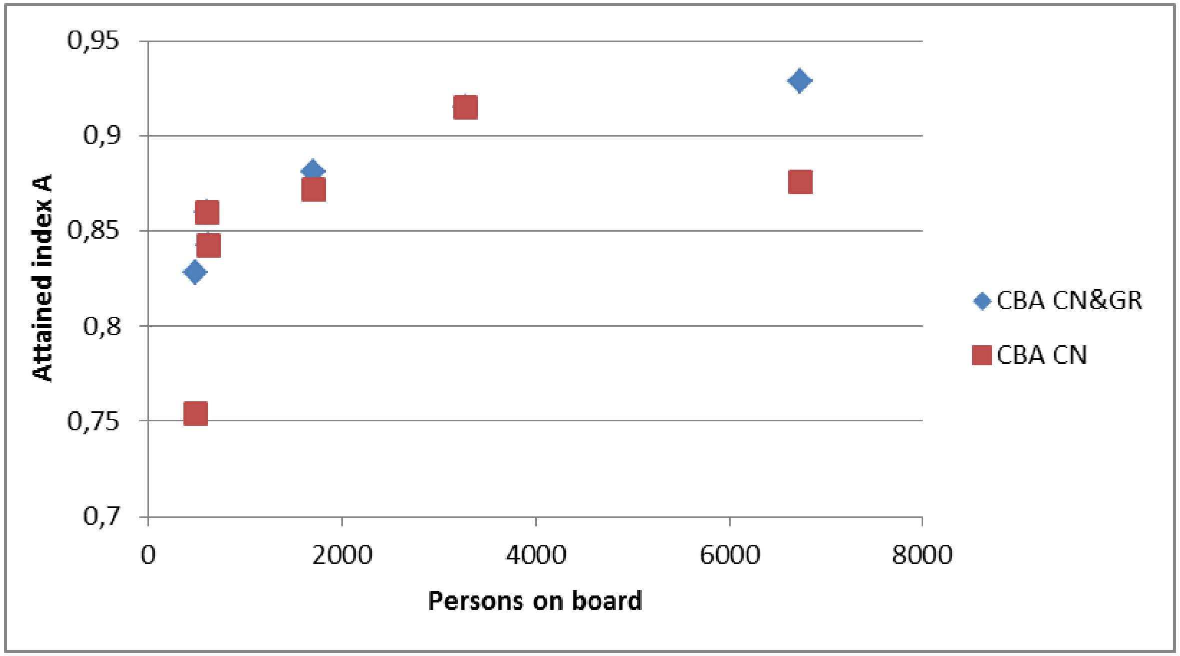
Effects of taking grounding into account in the CBA

Attained Index A (collision) for Risk control Options with and without including the effect from grounding.



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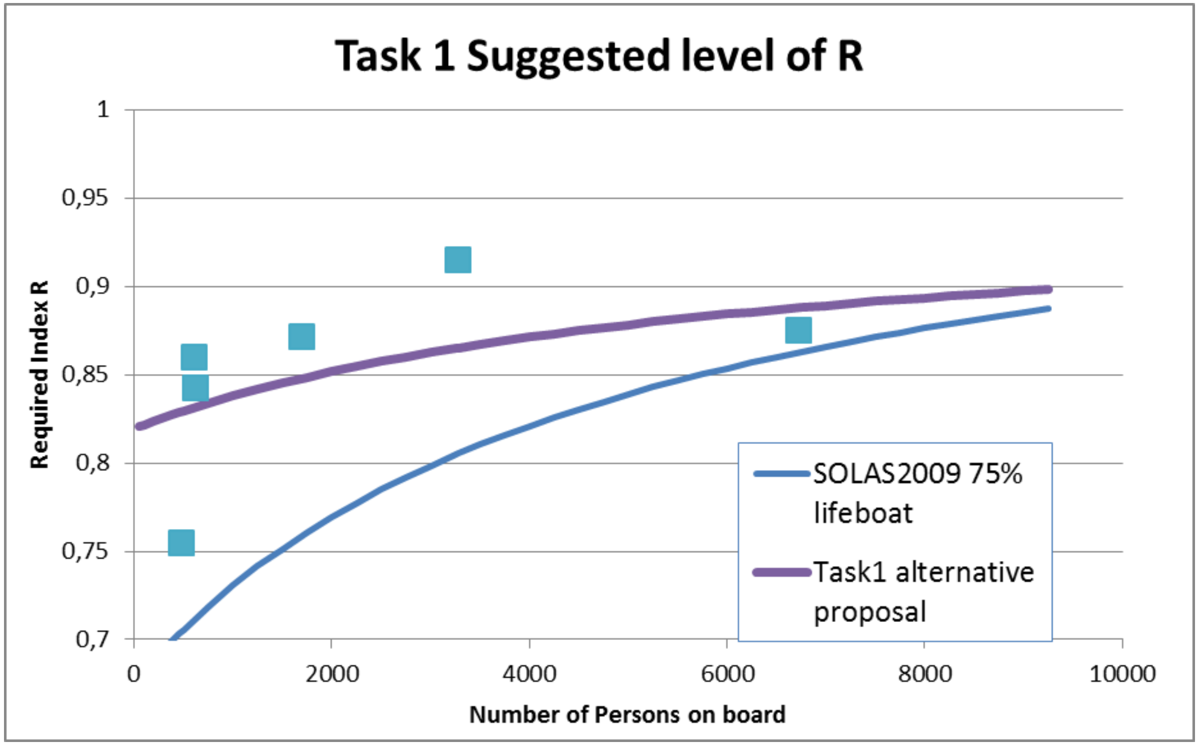
Suggested level of R if considering collision only



$$R = 1 - C1 * \frac{5000}{2{,}5 * N + 15225}$$

$$C1 = 0.8 - \frac{0.25}{10{,}000} * (10{,}000 - N)$$

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

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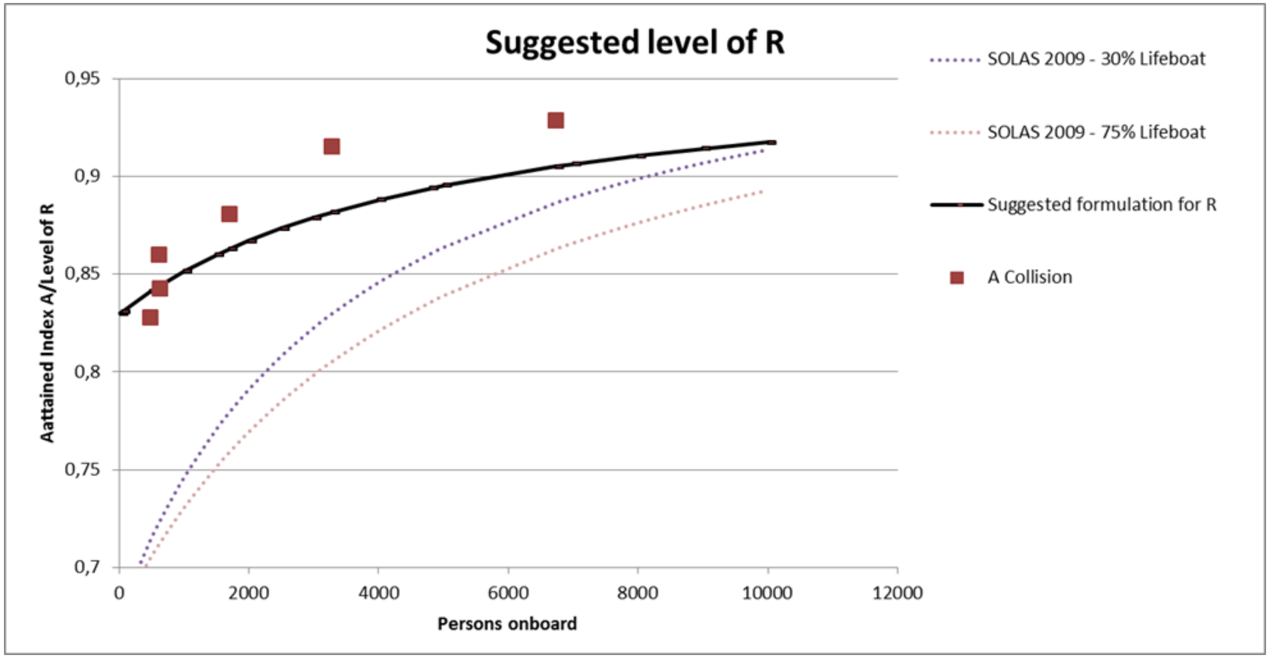
Alternative when grounding is accounted for in the CBA



$$R = 1 - \frac{C1 * 6200}{4 * N + 20000}$$

$$C1 = 0.8 - \frac{0.25}{10000} * (10000 - N)$$

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

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Impact Assessment$_1$

- 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

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Impact Assessment$_2$

- 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)

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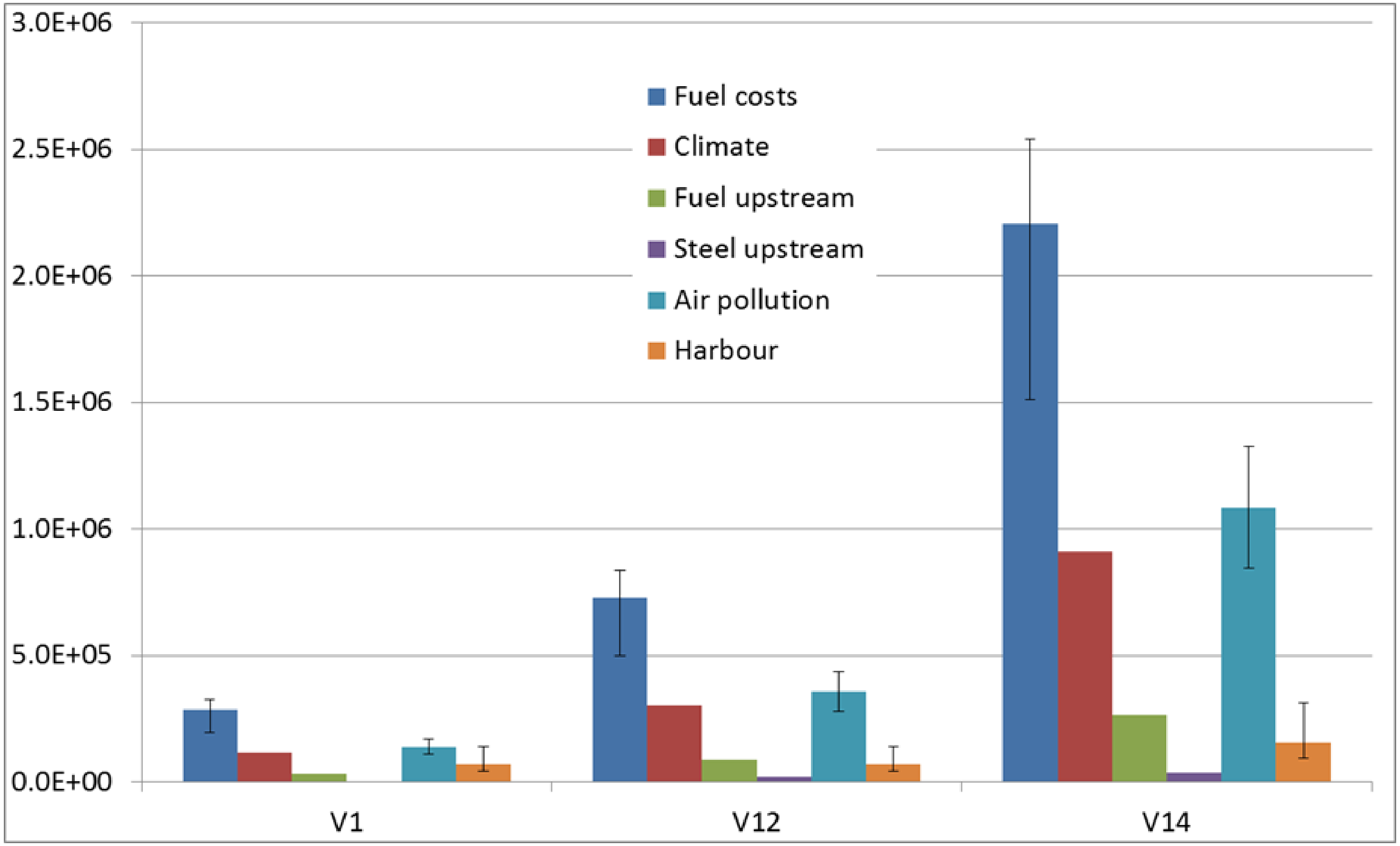
Impact Assessment$_3$

- 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$_5$: results



Overview of single impact costs for Mediterranean RoPax ship RCOs

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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.
- The reports can be downloaded from EMSA webpage http://www.emsa.europa.eu/damage-stability-study.html

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Content and Information$_1$

- 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)

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Content and Information$_2$

- 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$_3$

- 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.

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Thank you for your kind attention

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