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MARITIME

EMSA 3

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

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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

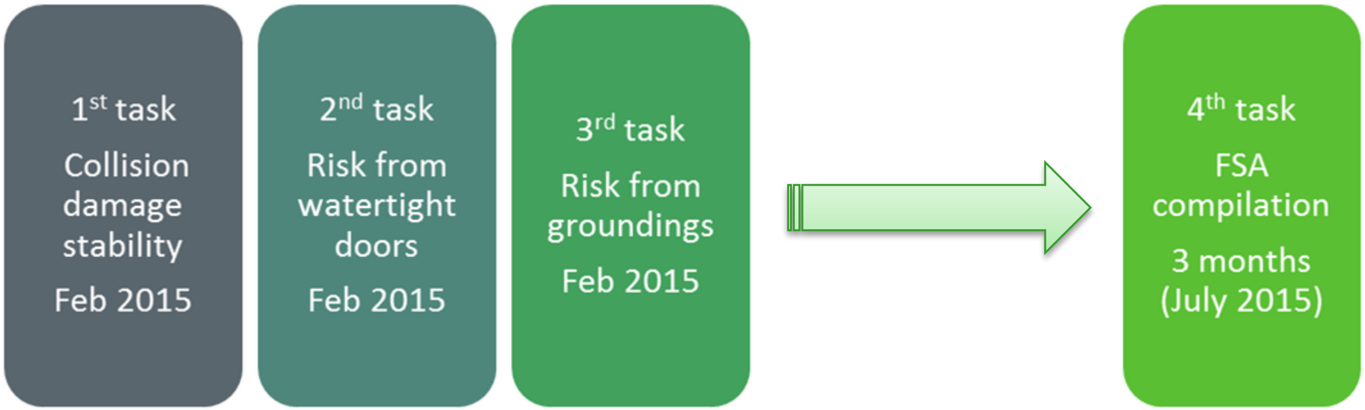
- Provide further information for decision making:
  - What is an acceptable and practicable risk level for passenger ships (focus on collisions);
  - Whether the current grounding regulatory framework is sufficient (double bottom requirement);
  - How can the additional risk of watertight doors and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

Schedule

1st task	2nd task	3rd task
Collision damage stability	Risk from watertight doors	Risk from groundings
Feb 2015	Feb 2015	Feb 2015

- 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



- 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;

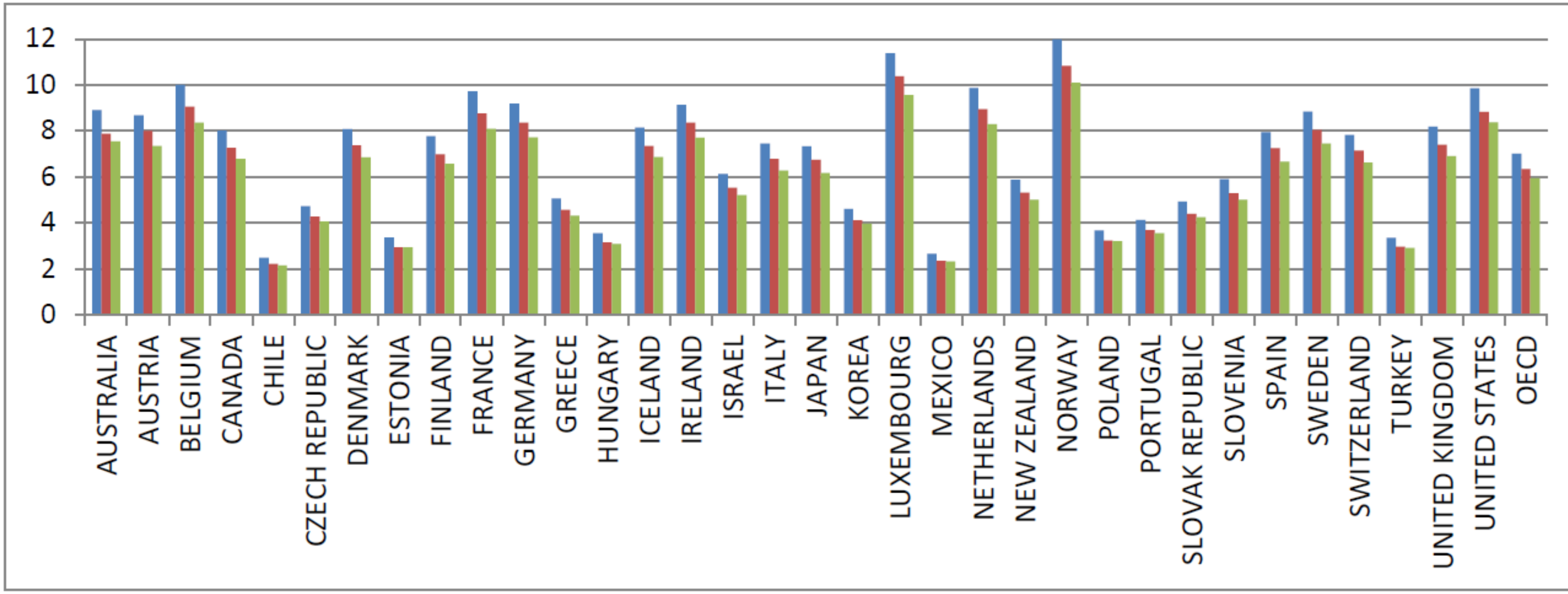
Task 1 – Description of work (2 of 2)

- 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

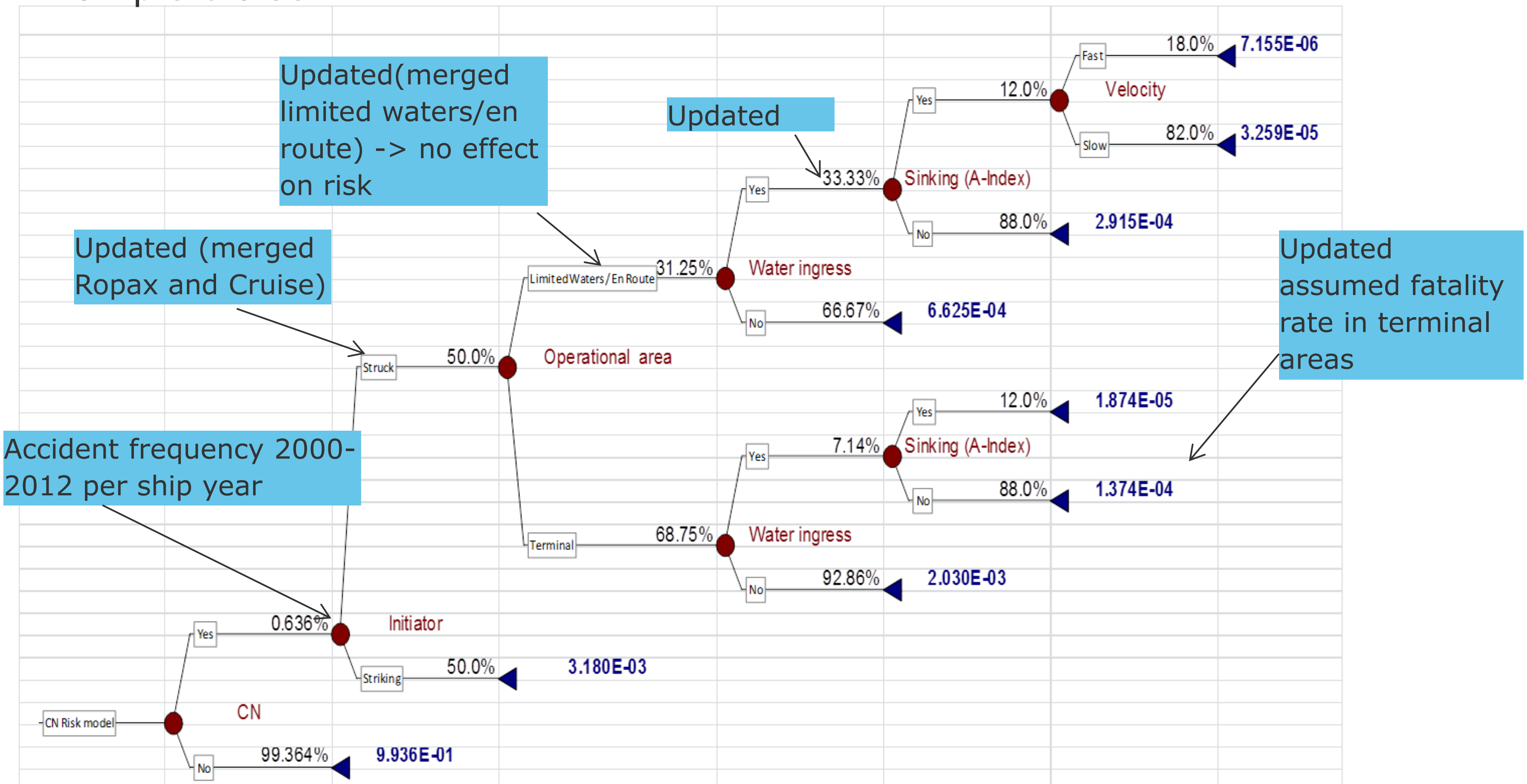
HALE: Health Adjusted Life Expectancy

Two values recommended used in EMSA III:

4 mill USD and 8 mill USD

Updated collision risk model from GOALDS

Example cruise



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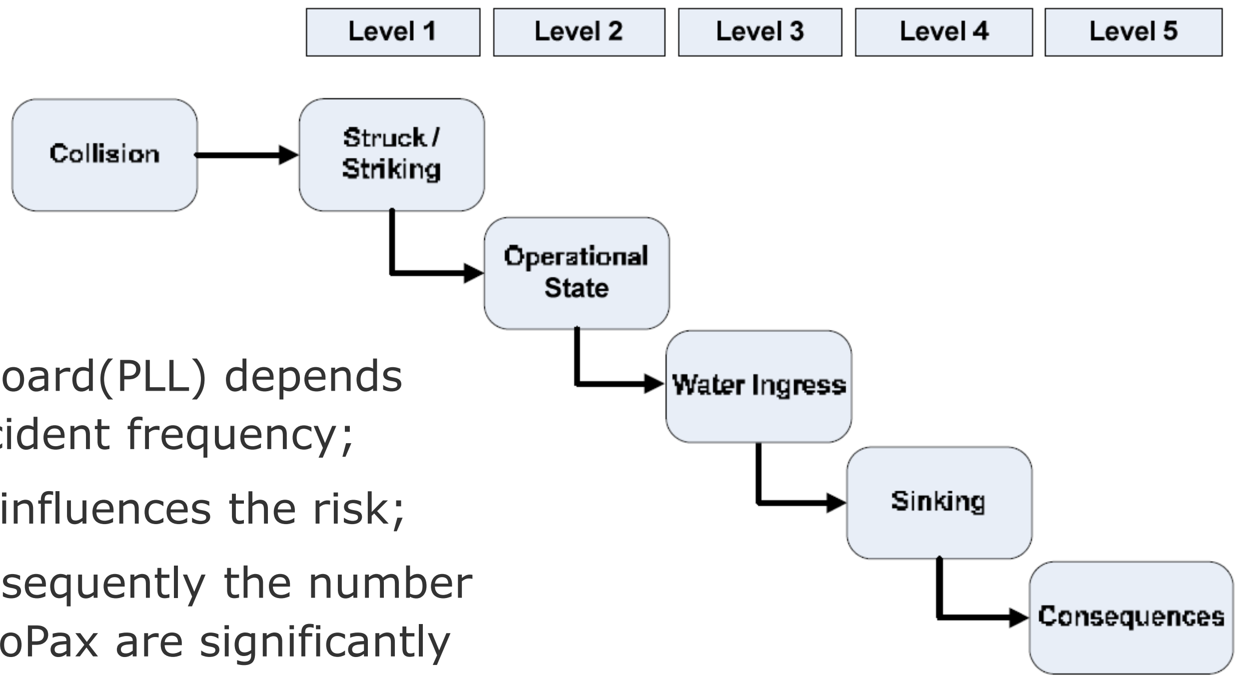
Uncertainties in the risk model

- 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

Sensitivity analysis



- 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:

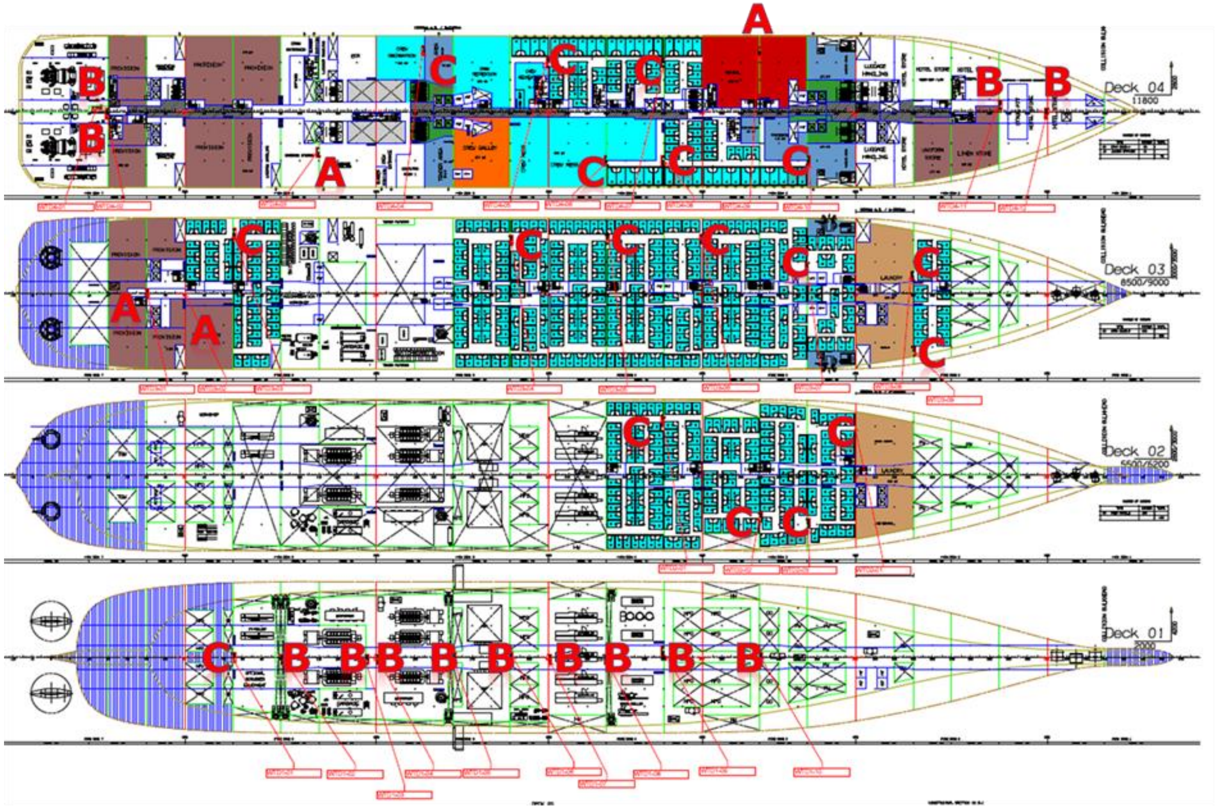
Categorisation of doors:

-Probability for being open

-Closing time

Volumes connected by the WTD(s)

Total volume of watertight hull



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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:

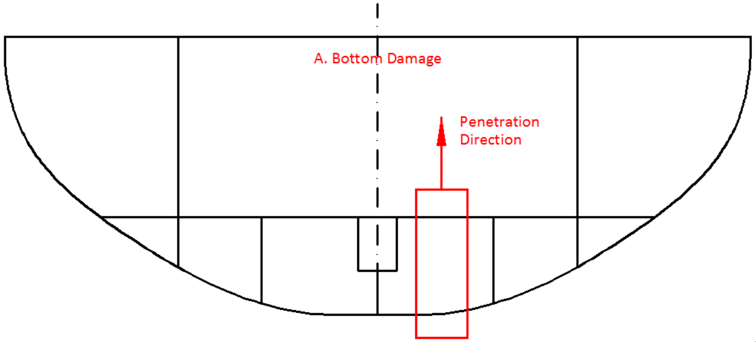
- ✓ SOLAS2009 probabilistic framework: damages due to collision;
- ✓ Safety in case of grounding, within SOLAS2009, is handled by Regulation 9:
  - Minimum double bottom height; or
  - Direct calculations (unusual bottom arrangements) considering deterministic bottom damages;

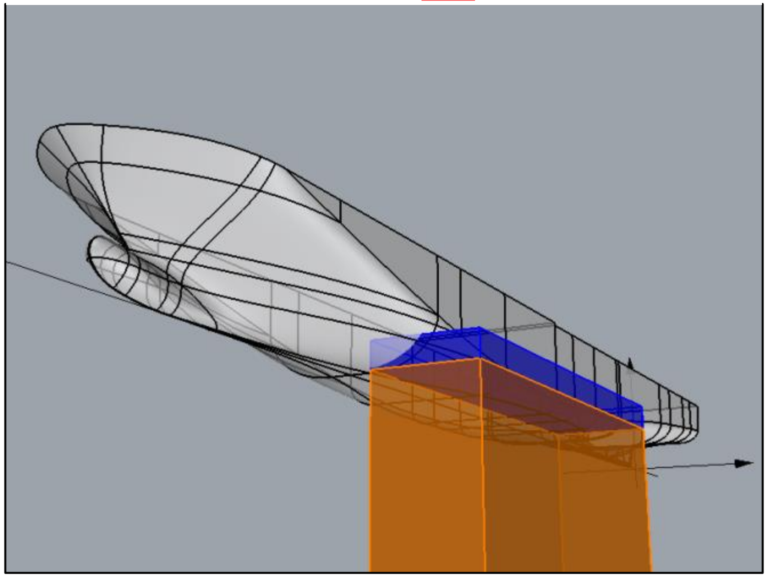
Objectives of the study:

- ✓ 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;

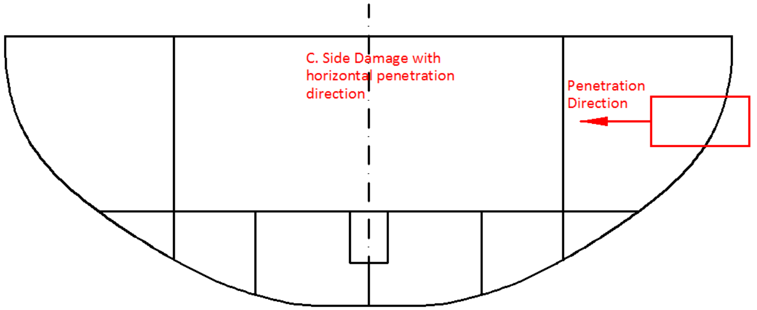
Types of damage taken into account

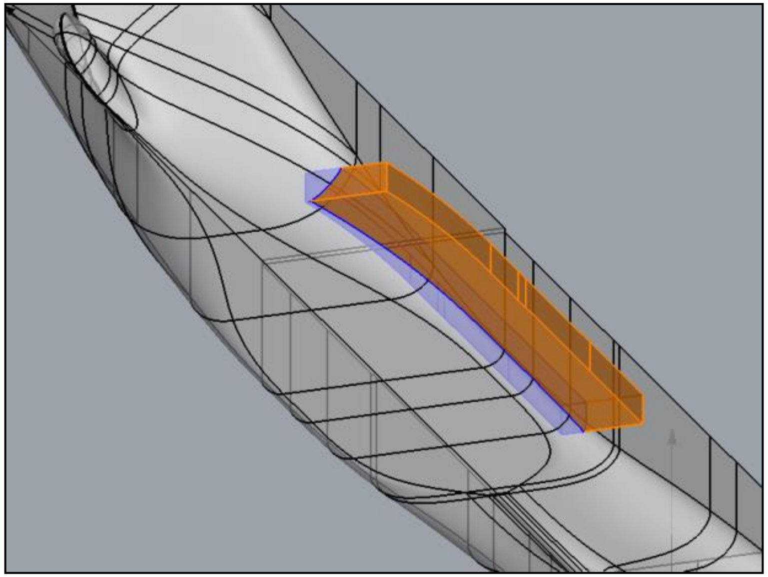
Bottom damage (Type B00): penetration in vertical direction





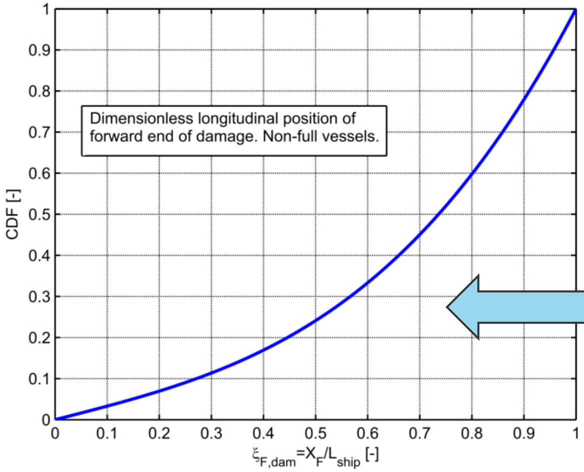
Side damage (Type S00): penetration in vertical direction





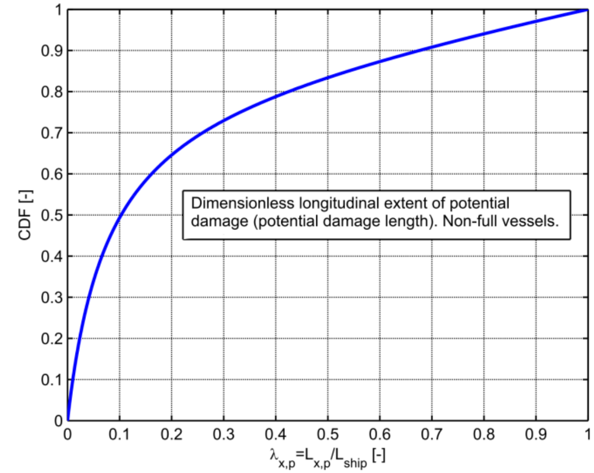
Bottom damage (Type B00)

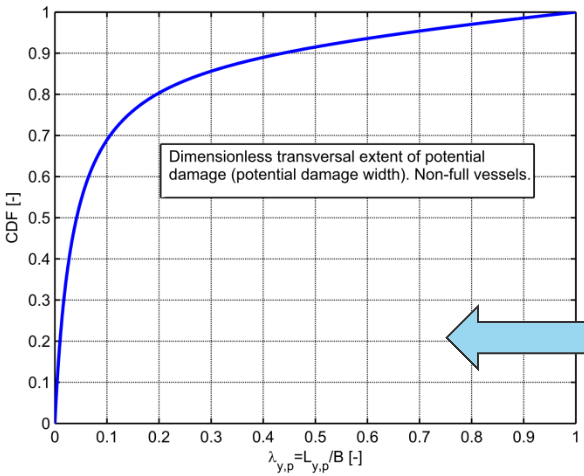
Probabilistic model of damage characteristics
(basis: GOALDS for non-full vessels)



Position of forward end

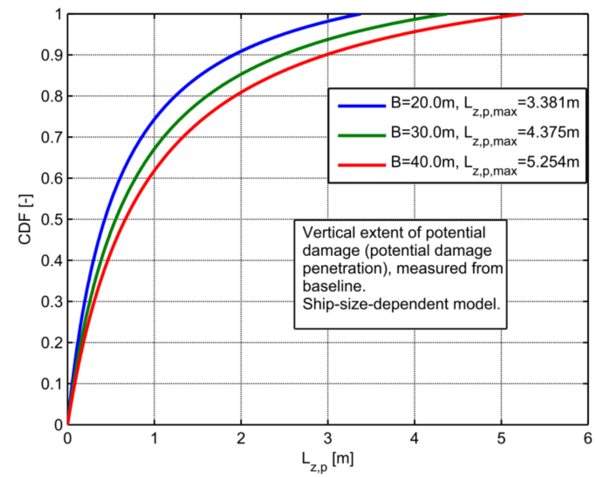
Damage length





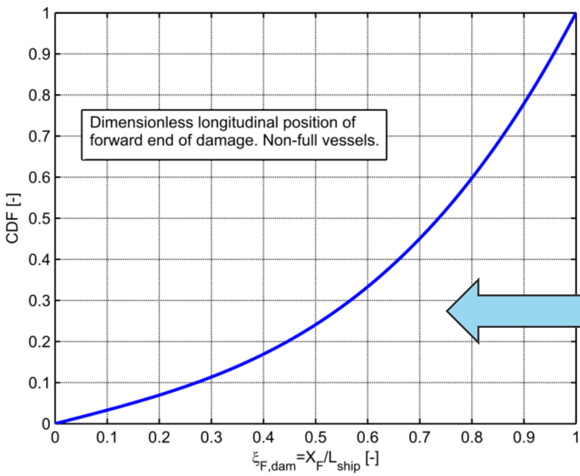
Damage width
(uniform transversal position)

Damage penetration



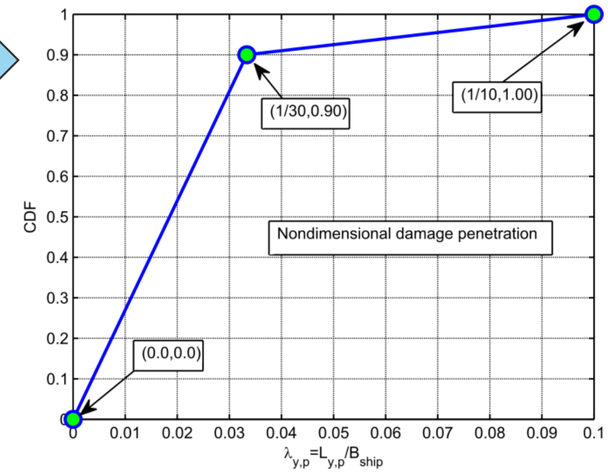
Side damage (Type S00)

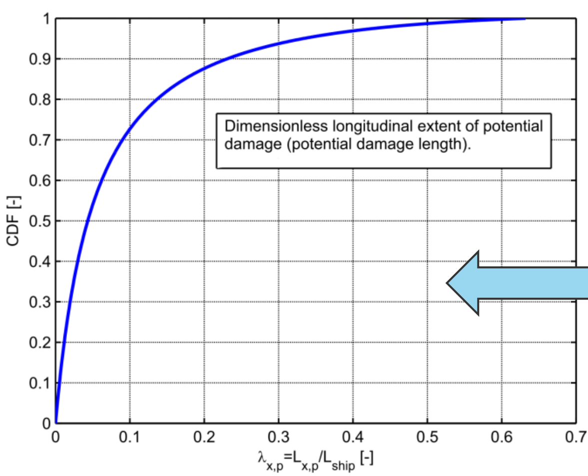
Probabilistic model of damage characteristics
(development and analysis of a database of accidents within the project)



Position of forward end

Damage penetration





Damage length

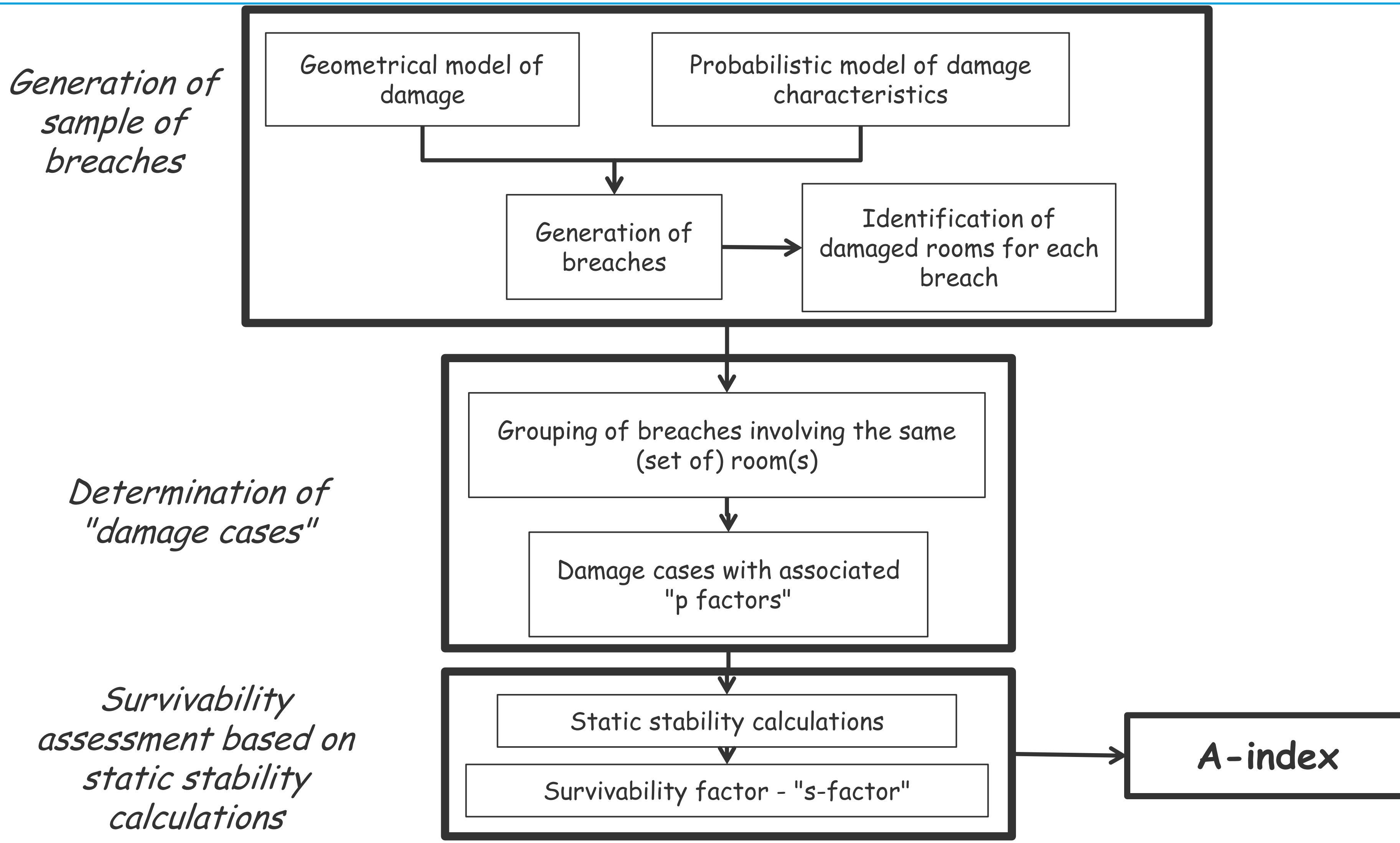
In addition:

- Damage side: 50% PS, 50% SB
- Probabilistic model for lower limit and vertical extent of damage

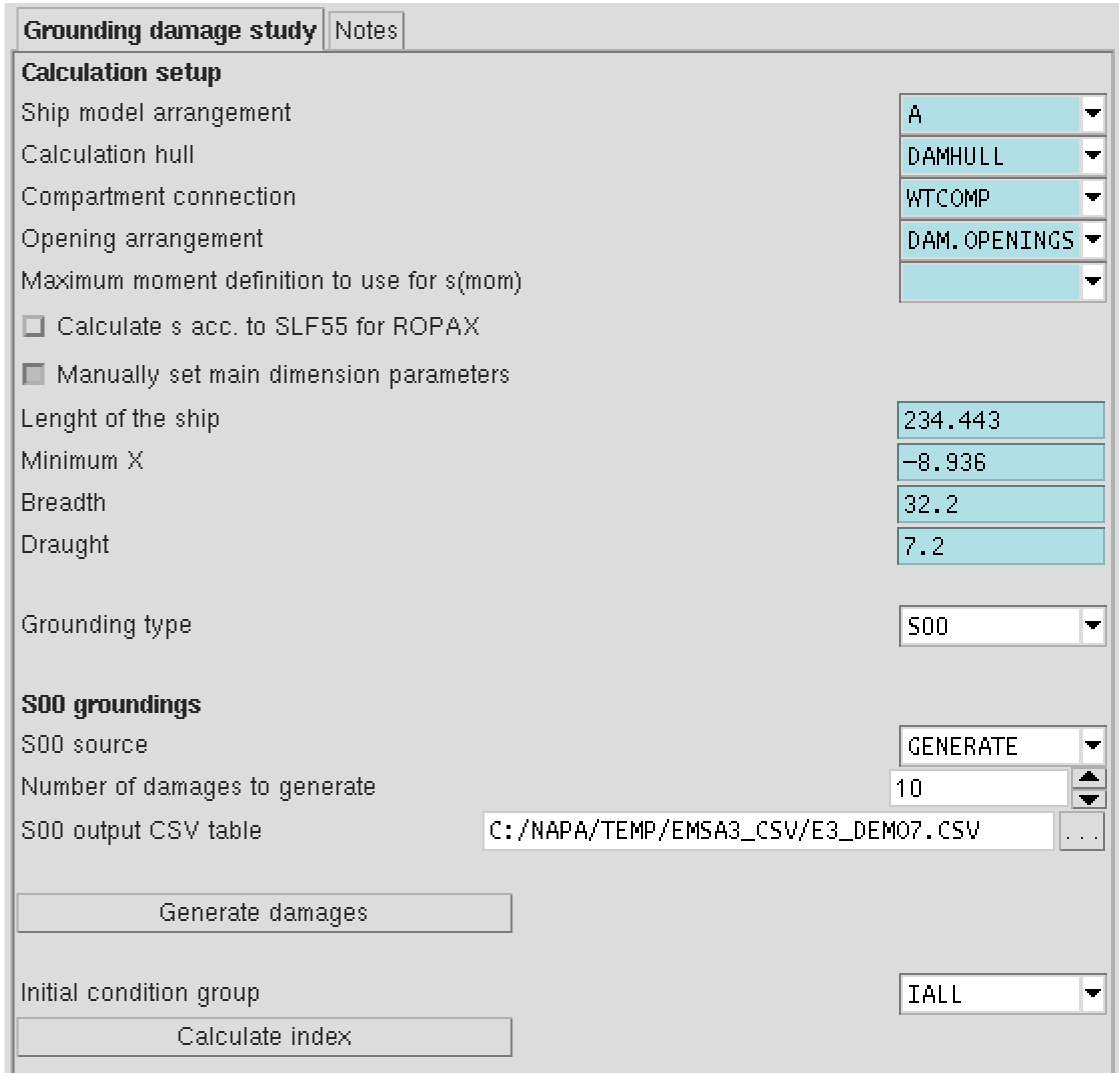
Approach for determination of A-index

- ✓ 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



Software implementation



Example test application in case of bottom damages

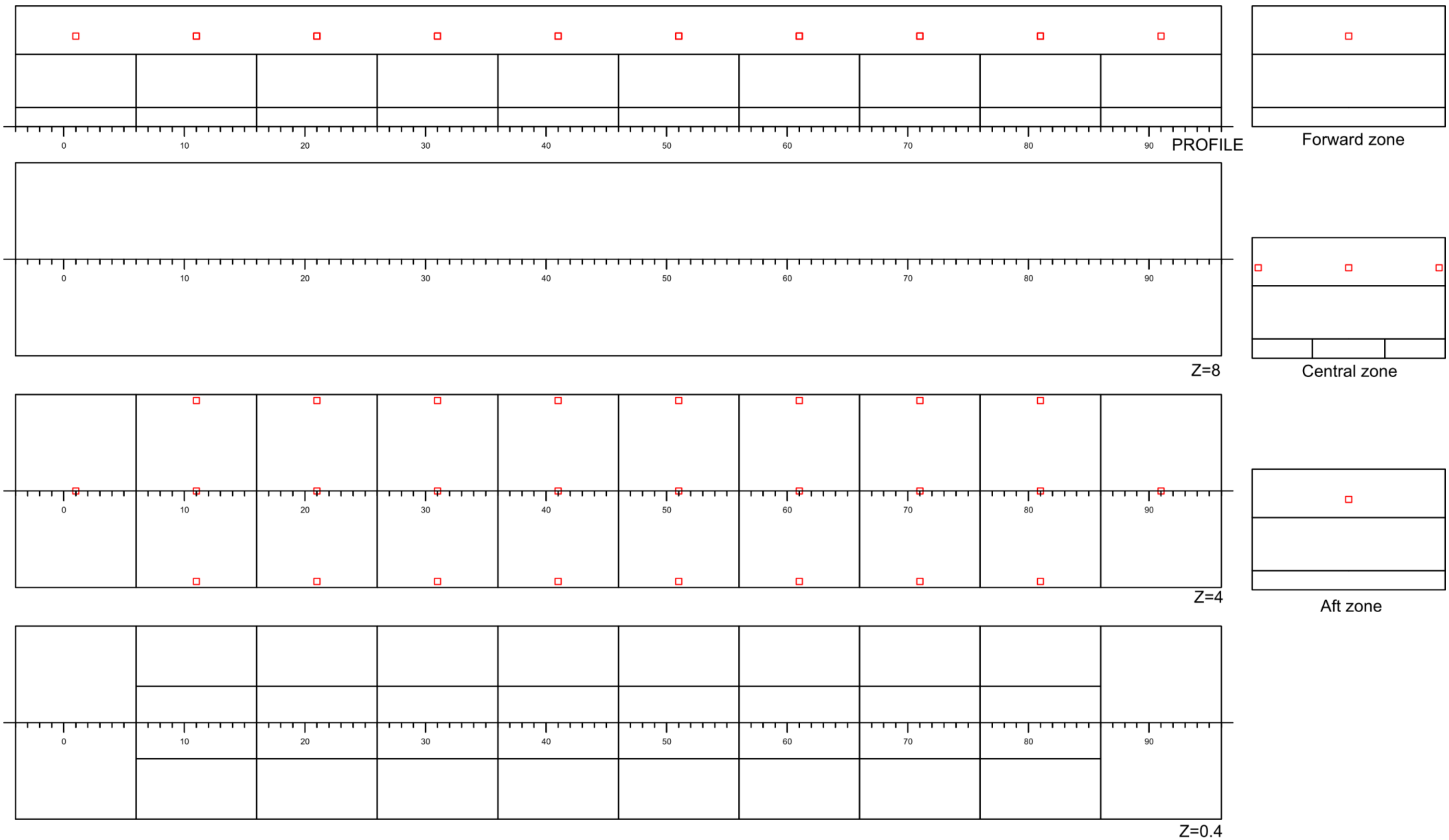
Within the project the methodology is being applied, for both bottom and side damages, to real designs.

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

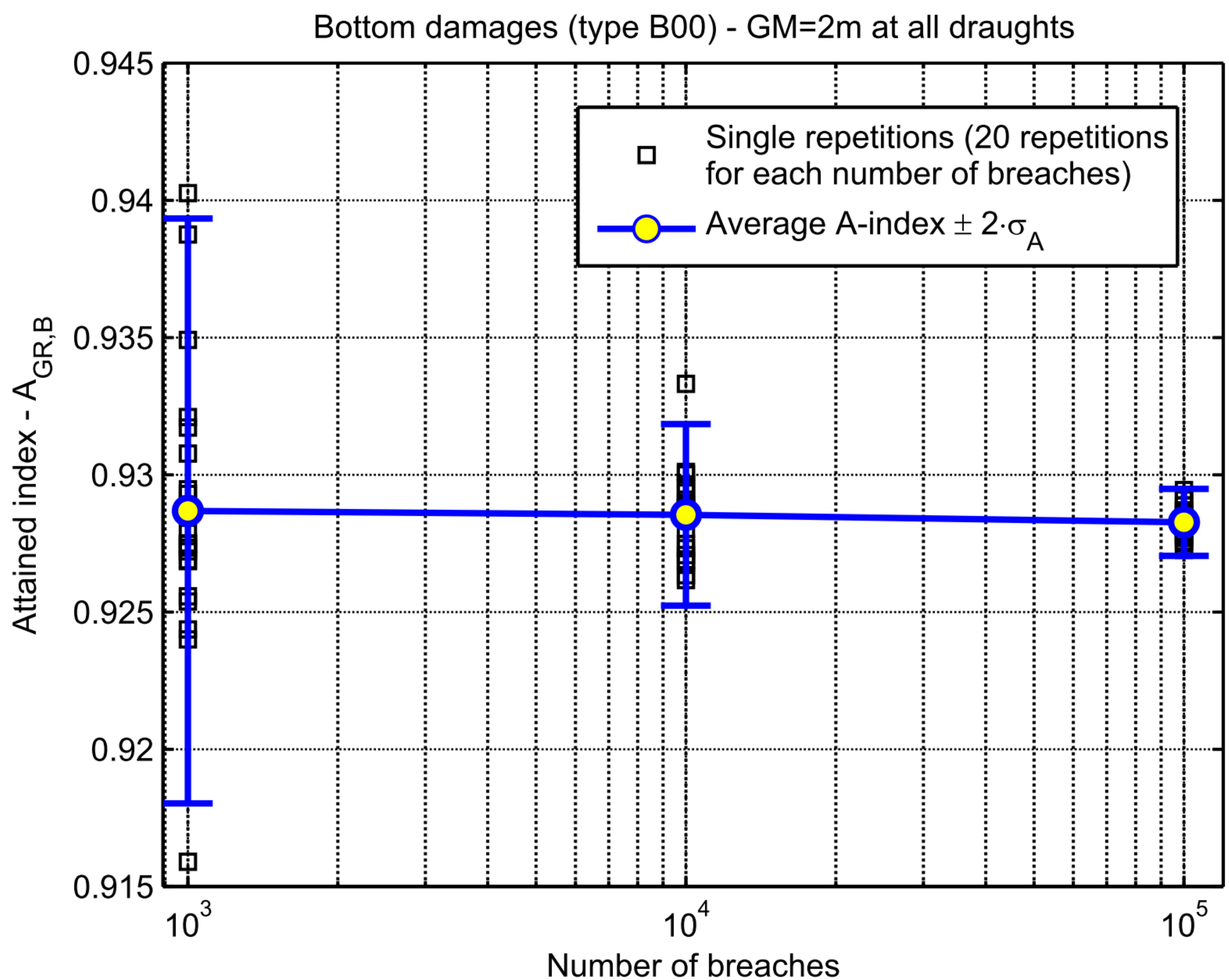
An example is shown here on a notional box-shaped vessel with the following characteristics:

Length	100m	d_s	4.0m
Breadth	16m	d_p	3.6m
Total height	10m	d_l	3.0m
Assumed number of passengers	750	Height of double bottom	1.6m
Number of zones	10	Number of rooms	37

Example test application in case of bottom damages



Example test application in case of bottom damages



Conclusions (1 of 2)

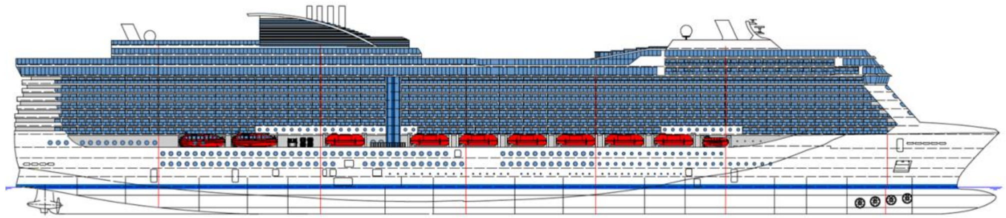
- ✓ A probabilistic approach has been developed for safety assessment of passenger vessels in damaged condition, following grounding;
- ✓ The approach considers bottom damages and side damages;
- ✓ Geometrical/probabilistic model for bottom damages: GOALDS(as basis) + improvements ;
- ✓ Geometrical/probabilistic 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.

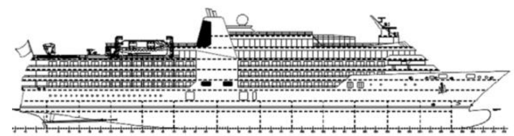
EMSA3 Sample ships and design teams

MEYER WERFT
PAPENBURG 1795



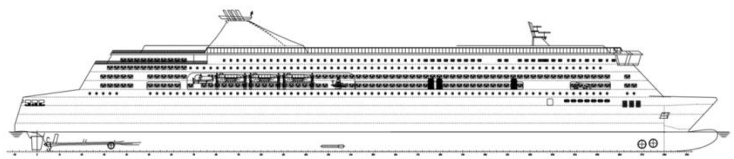
CARNIVAL
CORPORATION & PLC

FINCANTIERI S.p.A.



RoyalCaribbean
INTERNATIONAL

MEYER TURKU
SHIPYARD 1737



ColorLine

stx France

Stena Teknik
CARE, INNOVATION & PERFORMANCE

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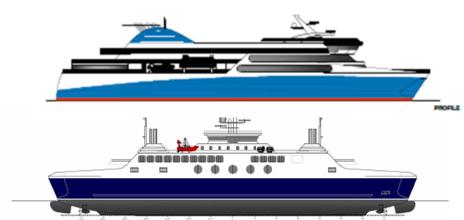
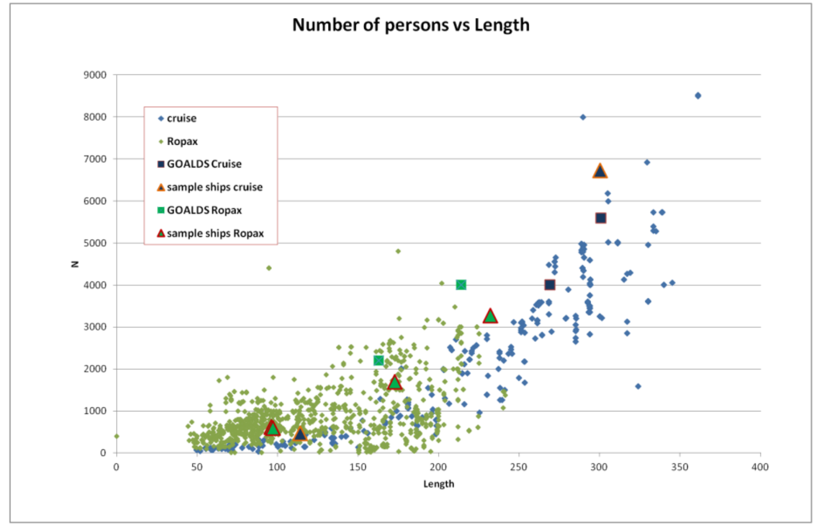
KNUD E. HANSEN A/S
NAVAL ARCHITECTS DESIGNERS MARINE ENGINEERS
~Since 1937~

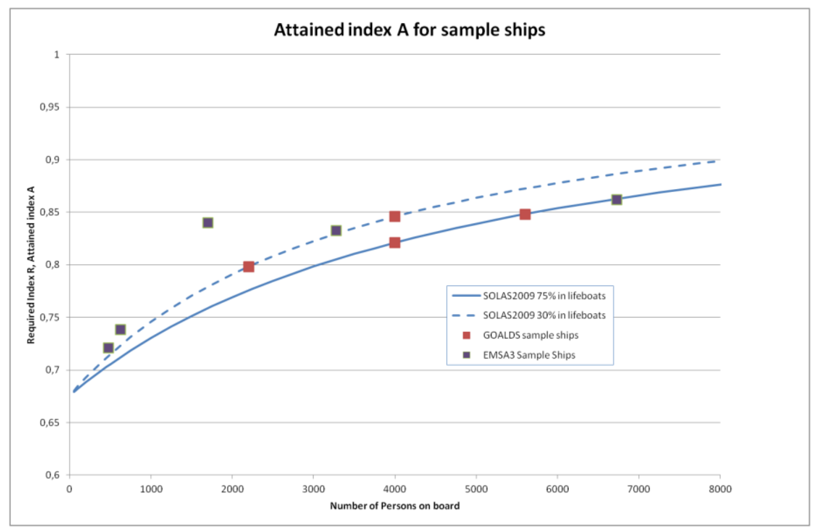


Stena Teknik
CARE, INNOVATION & PERFORMANCE

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





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Overview EMSA III Sample ships

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

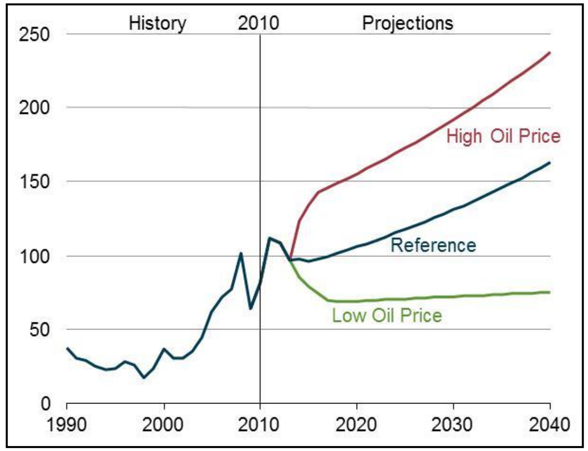
- Various Risk Control options under investigation
- Changes depending on design options (breadth, freeboard, subdivision etc)
- Constant business model
  - No significant change of capacity or speed

Cost-Benefit Assessment

- Calculation of costs RCOs based on:
  - Life-cycle costs transferred to **N**et **P**resent **V**alues
  - 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

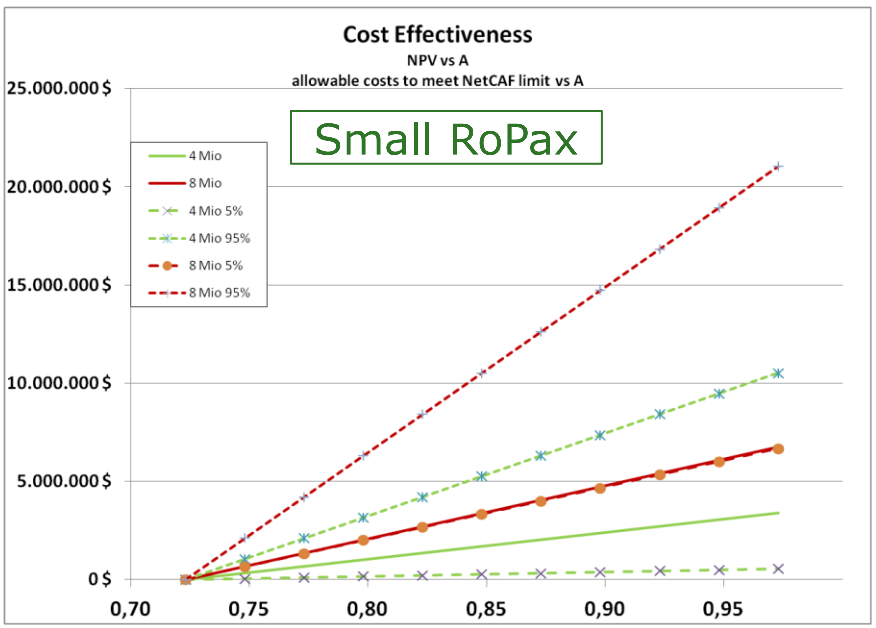
- Data published by EIA energy outlook have been used as basis for estimating the future trends.

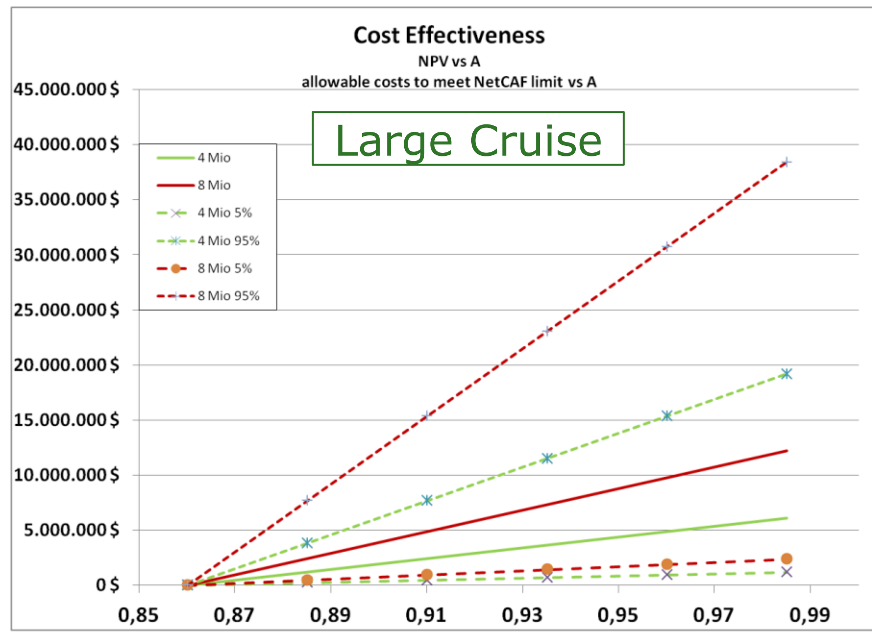


- The current prices for HFO and MGO; 600 USD/t and 900 USD/t, have been obtained using the average reported prices for 2013 and 2014(until now) in Rotterdam using Clarkson Intelligence as a source.
- The price of LSHFO is obtained based on a 20/80 distribution of the HFO and MGO price. This is the distribution 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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