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1 Scope-Agenda

The present report is the summary of presentations of the 1st year Open Workshop of the Integrated Project SAFEDOR, funded by the European Commission. The workshop is being held at the headquarters of the International Maritime Organization in London, on 14 February 2006.

The proceedings of the full presentations will be sent to the participants after the workshop and be available upon request on a CD-Rom through the Royal Institution of Naval Architects, London (safedor@rina.org.uk).

The Agenda of the Workshop is as follows:

8:00	Registration	
10:00	Introduction to the workshop	A. Papanikolaou
10:10	Overview of SAFEDOR and 1 st year activities	P. Sames
10:30	Risk-Based Design concept	D. Vassalos
11:00	Approval Process for Risk-Based Design and Risk Evaluation Criteria	Benedikte Wentworth, Rolf Skjong
11:30	Risk-Based Structural design	T. Hørte
11:50	FSA studies on selected ship types (Cruise Ship & LNG)	Ole Vidar Nilsen, Erik Vanem
12:30	Lunch	
14:00	Design tools for safety performance prediction: overview of WP2 activities	J. J. Jensen
14:30	Innovative safety-critical technologies: overview of WP3 activities	K. C. Ehrke
15:00	Validation and application for innovative ship designs: overview of WP6 activities	F. Del Castillo de Comas
15:30	Panel discussion with Steering Committee	
16:00	End	

2 Welcome - Introduction to the Workshop, by A. D. Papanikolaou, Ship Design Laboratory – National Technical University of Athens

It is with great pleasure that I welcome you all to the SAFEDOR 1st year Open Workshop jointly organised by the SAFEDOR consortium and the Royal Institution of Naval Architects (RINA). Members of the SAFEDOR consortium will present and discuss their 1st year research work in this public workshop. We all expect, besides the pure dissemination of valuable information in the forefront of developments in risk based design, the active response and discussion of the conducted research by workshop participants representing the whole maritime industry

This 1st Open Workshop of SAFEDOR inaugurates a series of follow-up SAFEDOR dissemination events:

- The SAFEDOR Midterm Conference, in spring 2007
- The 2nd Open Workshop of SAFEDOR, in spring 2008
- The SAFEDOR postgraduate training course on risk-based design, operation and regulations (addressing maritime industry professionals), in spring-summer 2008
- The SAFEDOR Final Conference, in spring 2009.

We are very pleased to see you all here, especially those of you who have come from overseas. SAFEDOR's vision is optimistic, by aiming to entirely integrate safety into all maritime sectors; the conducted research of SAFEDOR is in the heart of needs of the maritime industry, that's why your interest is greatly appreciated, while at the same time your participation should be rewarded by the provided information on latest developments in this most important to the maritime industry area.

Topics to be addressed at the present workshop by renowned speakers from the SAFEDOR consortium are:

- Overview of SAFEDOR 1st year activities
- Risk-Based Design concept
- Approval Process for Risk-Based Design and Risk Evaluation Criteria
- Risk-Based Structural design
- FSA studies on selected ship types (Cruise Ship & LNG)
- Design tools for safety performance prediction
- Innovative safety-critical technologies
- Validation and application for innovative ship designs

I wish to acknowledge the financial support of the European Commission for the SAFEDOR dissemination events, the organizational support of the Royal Institution of naval Architects and our host, the International Maritime Organisation.

Last but not least, I would like to express my sincere thanks to all the speakers, the delegates and all workshop participants. I am sure this workshop will greatly contribute to the effective dissemination of up-to-now acquired knowledge on Risk-Based Design and enable the sharing of experiences and visions towards safer and more competitive shipping tomorrow.

3 Overview of SAFEDOR 1st year activities, by P.C. Sames (Germanischer Lloyd)

3.1 Objectives and current status of SAFEDOR

SAFEDOR aims to improve maritime safety and the competitiveness of the maritime industry. Safety will be improved by integrating safety into the design process as one additional objective and the integration of enhanced tools into a design environment. Competitiveness will be improved through a proposal for a modernized regulatory framework and development of new ship designs.

3.2 WP2: Design tools for safety performance prediction

Work package 2 focuses on the development and enhancement of tools to predict the safety performance of ships in extreme and accidental conditions. As a start, focused hazard identifications have been performed and requirements for tools predicting the probability of accidents and their immediate consequences were specified. Five topics are dealt with: fast and accurate flooding prediction of complex compartment configurations, prediction of failure of hull girder, prediction of capsizing probability, prediction of collision and grounding probability taking into account system and human failures, and prediction of fire events for cargo and passenger ships.

3.3 WP3: Innovative safety-critical technologies

Work package 3 addresses safety-critical technologies such as power distribution system, navigation and life saving. First steps were related to the specification of a new tool to automatically generate fault trees for rapid safety assessment of complex systems. A novel bridge layout is being specified taking into account available state-of-the-art work station equipment including wireless connections. A range of life saving concepts is studied, each tailored for the vessel size, service and operating area.

3.4 WP4: Risk-based regulatory framework

Work package 4 focuses on Formal Safety Assessment studies for four ship types. These are being completed within the first 15 months of SAFEDOR and may be submitted to IMO for review. In addition, the blueprint for a modernized regulatory framework is developed. Already, the high-level approval process for risk-based ships is drafted including top level acceptance criteria related to life and environment.

3.5 WP5: Risk-based design integration

Work package 5 has developed in year 1 the concept for risk-based ship design. This includes a high-level process description and decision-making approaches. It is recommended to use cost-effectiveness as criterion to assess design changes with respect to safety performance. A survey is ongoing to identify available and needed tools to enable full risk-based design started.

3.6 WP6: Validation and application for innovative ship designs

Work package 6 started with producing eight innovative ship designs: two cruise vessels, three RoPax, one gas tanker, one oil tanker and one container ship. Focus is on ship designs that are believed to be safer, but for some formal reason, cannot be approved today. Alternatively, innovative ships may be as safe as today with reduced building costs and / or improved earning potential. All eight concepts were completed and are now refined into design studies. Here, full risk analyses will be performed to evaluate risks and to assess risk-control options.

To complete the picture, work package 1 manages the project and work package 7 is in charge of the training/dissemination/exploitation activities and organised this 1st year public SAFEDOR workshop.

4 Risk-Based Design Concept, by D. Vassalos (Universities of Glasgow and Strathclyde, The Ship Stability Research Centre)

This EU FP6 Integrated Project is aimed at integrating safety research in Europe and beyond and to drive RBD to full implementation ranging from concept development to approval. Considering the above, adopting a risk-based design methodology that embraces innovation and promotes routine utilisation of first-principles tools will lead to cost-effective ways of dealing with safety and to building and sustaining competitive advantage, particularly so for knowledge intensive and safety critical ships; knowledge intensive as such ship concepts are fuelled by innovation and safety critical as with such ship designs safety is indeed a design "driver".

To this end, accounting for safety effectively and rationally, necessitates that first and foremost a consistent measure of safety must be employed and a formalised procedure of quantification adopted, namely, risk and QRA (Quantitative Risk Analysis), respectively. Secondly, such analysis must be integrated in the design process in a way that would allow the designer to target safety objectives through risk prevention/reduction measures, systematically and rationally alongside traditional design objectives pertaining to performance, cost and earnings. For this to be workable, however, considering the complexity of what constitutes safety, a clear focus to identify the key determinants of ship safety, the “safety drivers” to be addressed in the design stage is required. These should comprise both normal ship operation as well as emergencies. Adopting a rational process (such as FSA) and accounting for all available experience and knowledge that affects ship safety as it is known today points towards the consideration of accident categories and ensuing scenarios as the only workable route to achieve such a focus. This, in turn, makes it obvious and necessary, to utilise first-principles frequency estimation and consequences analysis tools (safety performance prediction tools) for all such cases where innovation is an essential element in ship design.

Thirdly, for safety to be truly integrated in the design process and hence achieve optimal design solutions, it would be necessary to explore trade-offs between safety and other factors by utilising overlaps between functionality, performance and safety at parameter level. Considering the level of computations that might be necessary to address all pertinent safety concerns and the effect of safety-related design changes on functionality and performance and associated trade-offs, creating suitable parametric models as well as having access to fast and accurate first-principles tools are of paramount importance in the optimisation process.

In summary, “Risk-Based Design” is meant to imply the following:

- It is a formalised design methodology
- It enables safety to be dealt with in a systematic and all embracing way by treating safety as a design objective in the design process (through risk analysis)
- It opens the door to innovation and offers competitive advantage to the maritime industry by facilitating cost-effective safety; without Risk-Based Design optimal design solutions are not possible.
- Adopting a Risk-Based Design Framework is synonymous with promoting rational decision making; in this respect such an approach can support and guide the rule development process.

This presentation starts with an outline of conventional ship design, proceeding to highlight the innovation potential that can be afforded by adopting a risk-based design methodology and to explain the underlying concept. By way of demonstration, (large) passenger ship safety is addressed by adopting a risk-based framework to directly deal with contemporary issues of the corresponding IMO Working Group and to emphasise the need to adopt a systematic and rational approach in ship design, operation and in rule making.

5 Approval Process of Risk-Based Design and Risk Evaluation Criteria, by B. Wentworth & R. Skjong (Det Norske Veritas)

5.1 WP4-Risk-based regulatory framework

The operation of merchant shipping is international, specialised and complex, currently governed by comprehensive rules and regulations developed by national and international authorities to provide a basis for common action. Legislation governing ship and environmental protection has progressed over time through a number of stages but in the main assurance of safety has always been sought through regulating widely existing best practices in ship design, construction and operation, following a process of continuous amendment that is normally a reaction to and stimulated by major accidents. As a result, such process is addressing ships of the past or at best existing ships, the proposed reactive measures are normally fixes with a narrow focus, hence unsuitable for novel designs and more so for really innovative ship concepts. In the latter case, rule making must follow risk assessment of any such concept through a formal process (such as FSA) at generic level, addressing proactively and systematically all pertinent issues to support decision making and recommendations to ensure risk reduction to as low as reasonably practical level whilst accounting for other design priorities and constraints. To this end, the more quantifiable and the

more scientifically sound the information used is, the more rational the decision-making and the ensuing rules become and the more cost-effectively safety can be achieved.

In addition to being able to produce quantifiable information for novel designs, there is a need to address a number of major gaps before we can allow this process to run its course. This includes: making explicit the knowledge the current implicit safety level in existing rules (addressed through FSA studies on the selected ship types within SAFEDOR); formalising a risk-based regulatory framework for approval purposes; documenting the ensuing framework for adoption. This will require considerable effort, as would the attempt to inculcate in this process all the major stakeholders of the ship safety regime.

Added to the above, it must be emphasised that prescriptive regulations may constrain innovation. Removing prescriptive regulation by nurturing and supporting the development of goal-based standards, is the safest way of promoting much needed innovation in the maritime industry.

The primary objective of WP4 is to promote an alternative risk-based regulatory framework in shipping that allows linking performance optimization with risk minimisation as a means to providing solutions to increase the safety and security of waterborne transport cost-effectively. On this basis WP4 aims to perform FSAs for the selected ship types in SAFEDOR, to make explicit the current implicit safety levels in existing rules and regulations, to develop necessary documentation for a risk-based regulatory framework that could promote the new regulatory framework at regulatory level.

5.2 Approval Process for Risk-Based Design

The main objective is to develop a high level description of the whole approval process in cases of risk-based design.

As the first task, the project team has developed a high-level draft proposal for the approval process. The draft version describes the process, the documentation, the use of criteria, tools and methods, criteria for acceptance and non-acceptance. Obviously, the draft version will be lacking references to documentations that will be developed later in the project. The document is being developed early to communicate clearly to all participants in SAFEDOR what will be the requirement to risk-based design, thereby influencing the direction of development. Towards the end of the project, this document will be updated, and form the basic high-level reference document for the approval engineer. The final version will then contain references to relevant detailed documentation from the other tasks.

5.3 Risk Evaluation Criteria

The main objective is to develop high-level risk acceptance criteria for use in shipping, in FSA studies and for Risk-Based Design.

This presentation describes a general philosophy for deriving the criteria for tolerable/ALARP/intolerable regions of risk, and the R ("Reasonable" in ALARP), as well as deriving criteria for the most common ship types, and at least the ship types that are dealt with in SAFEDOR. It should be noted that these issues are already under debate at IMO, and SAFEDOR may contribute to bringing this debate to a conclusion. Within the safety area the criteria must cover the loss of life (individual and societal risk), injuries and ill health. In addition a method must be derived for dealing with environmental risk issues relating to accidental releases. The project includes considerations of risk perception and human element issues, which is very important in all risk communication. This is of particular importance related to emerging risks, such as security, piracy and terrorism.

6 Risk-Based Structural Design, by T. Hørte (Det Norske Veritas)

6.1 Example of Risk-Based Structural design

This presentation contains an example of how structural design rules are derived and justified based on internationally agreed and standardized methods and tools commonly referred to as Structural Reliability Analysis (SRA) and limit state design. The



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14th February, 2006

example is the hull girder vertical bending moment Ultimate Limit State (ULS) for tankers. The approach used demonstrates how FSA, including cost effectiveness assessment, may be used to derive target reliabilities for relevant failure modes.

Standard Structural Reliability Analysis (SRA) has been used to derive a Rule formulation in a partial safety factor format for the Hull Girder Ultimate Capacity as an explicit control of the most critical failure mode for double hull tankers. The SRA analysis provides the opportunity to quantify partial safety factors as a function of safety level. Reference is made to the Joint Tanker Project for these results:

www.itprules.com/background/Section_09_01_03_05.pdf

A risk control measure has been identified in terms of a design parameter. The design parameter in this example relates to strengthening of the deck structure so that the vertical bending moment capacity is increased. This provides the link between the resulting rule and structural dimensions to the level of safety.

The cost effectiveness analysis provides the relationship between the target reliability and the life cycle cost, and demonstrates that an optimum can be identified. The cost model includes costs of the risk control measure (deck strengthening) and the costs associated with failure. Consequences to property, life and environment are considered, and the impact of each of them on the optimum target reliability is illustrated.

Whilst a Rule itself may be very difficult to verify, the FSA/SRA analyses may be subjected to review and verified. The example therefore also provides a proposal for how to verify the rules, an issue that is currently debated in the IMO Goal Based Standards correspondence group.

7 FSA studies on selected ship types (Cruise Ship & LNG), by O. V. Nilsen & E. Vanem (Det Norske Veritas)

FSA has been developed as a tool for supporting the decision making process at IMO. It should make decision making procedures more rational and provide a proactive and holistic approach, thus reducing the number of ad-hoc proposals and implementations, and giving less room for politics in the decision making process.

FSA should also encompass both technical and operational aspects, taking into account the influence of human factors on accidents in shipping.

FSA should provide reliable information on hazards, risks, risk control options, their costs and benefits, in a rational, structured and auditable manner, in order to improve the decisions regarding the management of the risks identified.

FSA is a risk based approach consisting of five inter-related steps:

1. Identification of hazards
2. Assessment of the risks arising from the hazards identified
3. Identification of options to control the risks
4. Cost/benefit assessment of the risk control options
5. Recommendations for decision-making, based upon the information derived in the previous steps.

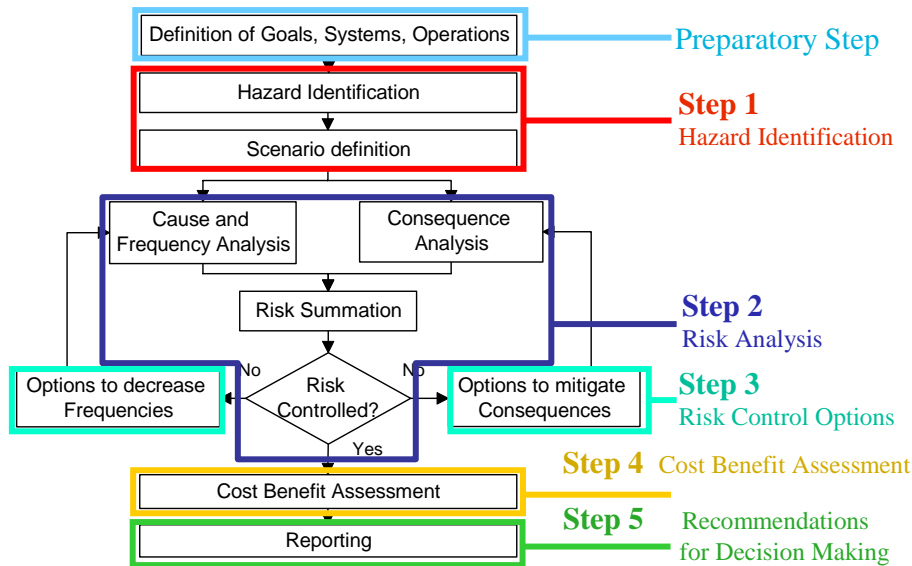


Figure 1 FSA Approach

The safety of an aspect under consideration is assessed by evaluating the risk accompanied with this aspect, e.g. a specific operation. The decision upon the acceptability of that risk is done by employing risk acceptance criteria.

In SAFEDOR four FSA studies are being carried out:

- FSA for cruise ships
- FSA for RoPax
- FSA for gas tankers
- FSA for container ships

All FSAs have completed the first 2 steps of the FSAs. The FSAs on Cruise ships and gas tanker are presented at the present Workshop.

8 Design Tools for Safety Performance Prediction, by J.J. Jensen (Technical University of Denmark)

8.1 WP2 Overview and Key Findings

Risk-based design demands advanced tools to predict the safety performance of a given ship design. It is the specific objective of work package 2

- To develop and / or refine such advanced design tools
- To enable integration of the tools into a design environment
- To evaluate risk and the effect of risk-control options

with the aim to provide tools for fast and reliable evaluation of various risks associated with failure of the ship or its subsystems. Thereby, WP6 dealing with design of actual ship project will be assisted to

- make a fast screening of various scenarios in order to identify the important ones
- make a detailed analysis of those scenarios thereby identified
- suggest appropriate risk control options

8.2 SP2.1: Fast and accurate flooding prediction

The primary goal of this subproject is to devise a robust methodology capable of modelling realistically the behaviour of a damage ship in severe seas during progressive flooding that may lead to sinking/capsizing. It is also within the scope of this

subproject to evaluate a number of identified risk control measures that can be considered at early stages of the design process to improve ship survivability in critical scenarios.

A review of the pertinent literature on stochastic methods for non-linear processes has been performed, including the available research on predictions of water ingress and egress and, the damaged ship response and survivability in random wave environment. The main findings are:

- The existing deterministic SOLAS regulations are simplistic, as they ignore the environment from the assessment.
- The latest regulations building on probabilistic concept of subdivision do not seem to be adequate, as they still rely on traditionally-derived static stability characteristics of the ship.
- The time domain simulations are too slow for routine applications, as well as they are still not quantitatively accurate in modelling dynamics of damaged ships.
- Model experiments are too expensive and time consuming for use in the design process.

It seems that the only technique to comprehensively consider complex relationship between specifics of the damage, ensuing instantaneous water ingress, its spread through the architecture of the internal subdivision, the environment, ship loading conditions and the ship response, is that of model experiment or numerical simulation, until proper understanding of this relationships is established, and subsequent simpler generic models are developed.

This subproject is linked to other subprojects as illustrated in the Figure 2. These links must be kept in focus to fulfil the overall goals of WP2.

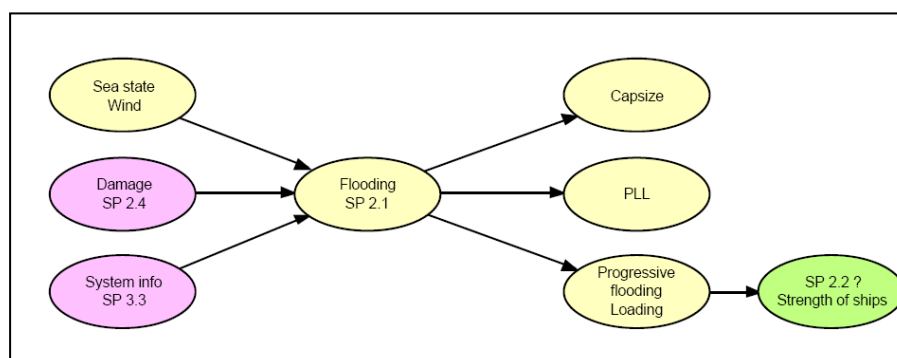


Figure 2 Interaction diagram for SP2.1

8.3 SP2.2: Probabilistic assessment of the strength of ship structures

The primary goal of this subproject is to apply structural reliability analysis to calibrate a design equation for the limit states corresponding to: hull girder collapse due to global bending moments. With increased computational capacity it is now possible to link state-of-the-art first principle analysis tools for load effects and capacity into probabilistic analysis models. Structural Reliability Analysis can then efficiently be used for the calibration of design codes to a consistent reliability level. In addition, cost-effectiveness analysis is used to evaluate the target reliability level and risk control options.

Firstly, two ships were selected as case vessels; i.e. a large tanker for oil (VLCC) and a large liquefied natural gas (LLNG) carrier. All relevant data for the ships were collected and made available to the group. These test ships have been subjected to hydrodynamic analyses in order to calculate the response amplitude operators (RAOs) of the hull girder bending moment for the intact case and for some selected cases of flooded and heeled condition. This task is completed for the VLCC and almost completed for the LLNG. The effect of flooding on the still water bending moment is also calculated.

Hull girder bending moment capacity calculations have been carried out, where also the effect of damages is taken into account. This task is completed for the VLCC and ongoing for the LLNG. The so-called "model correction factor" is used for the capacity assessment in the reliability analysis. A successful example application of this approach has been demonstrated on a plate buckling problem.



A reliability analysis model has been defined in which the results from the hydrodynamic analysis (RAOs) and the capacity calculation are utilised. In the case of damaged condition, it is a challenge to identify the most likely critical scenarios. In order to do this, work with a Bayesian network model is ongoing, where distributions of the damage size and location will be established. The intention is to use this model as a screening tool to find the appropriate conditions to be subjected to a more detailed reliability analysis. This tool is expected to be useful for this type of screening evaluations also for other ship sizes and types.

In parallel with this work on loads, capacity and structural reliability analysis, work related to the concept of “risk-based structural design” has been carried out. This presentation demonstrates how FSA (Formal Safety Assessment), including cost effectiveness assessment, may be used to derive target reliabilities taking into consideration consequences to property, life and environment. The link between the resulting rule and structural dimensions to the level of safety is illustrated.

This subproject is linked to other subprojects as illustrated in the Figure 3. These links must be kept in focus to fulfil the overall goals of WP2.

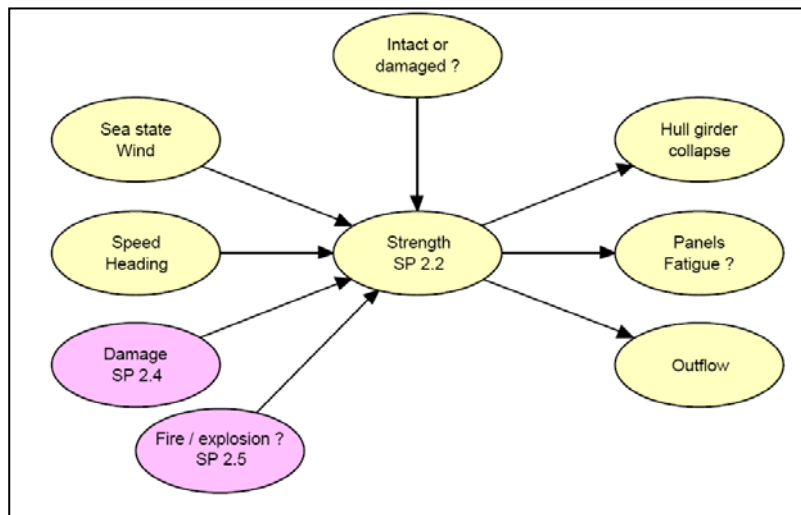


Figure 3 Interaction diagram for SP2.2

8.4 SP2.3: Probabilistic assessment of intact stability

The primary goal of this subproject is to develop and evaluate the necessary elements of a probabilistic framework aimed at quantifying the probability of capsizing (or of exceeding specified extreme motion levels) for any given ship. As there is no unique solution to this problem, several probabilistic approaches will be compared. This includes stochastic wave data, which serves as input to existing, state-of-the-art large-amplitude ship motion codes, suitable for modelling intact ship capsizing in extreme seas. In addition, possible risk control options are identified and assessed from a ship design and operation perspective.

This subproject is linked to other subprojects as illustrated in the Figure 4. These links must be kept in focus to fulfil the overall goals of WP2.

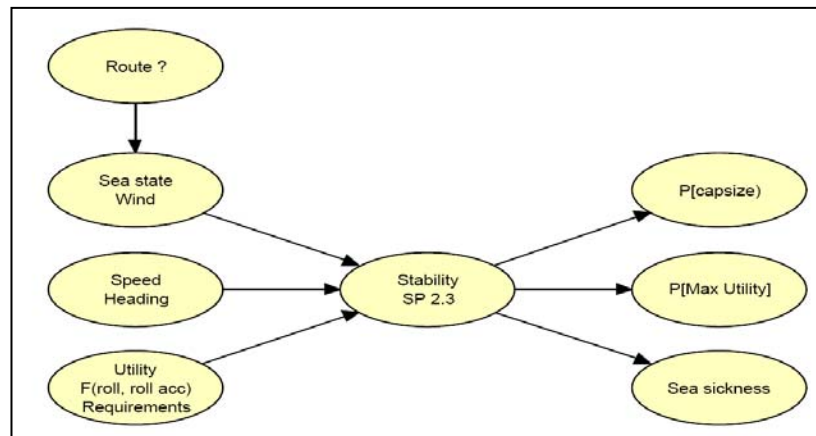


Figure 4 Interaction diagram for SP2.3

8.5 SP2.4: Prevention of collision and grounding events

The primary goal of this subproject is to provide a methodological approach that is capable of predicting the probability of collision and grounding events taking into account ship systems, environment and people by estimating the causation factor, with due account to the integrated bridge system; the probability of disabled ship as function of ship type; the probability of a disabled ship drifting towards objects etc. and effectively assessing the resulting damage distributions following collision and grounding. Suitable Risk Control Options that affect the probability of collision or grounding are identified and evaluated.

The goal of Task 2.4.2 is to analyse the role of the crew in a collision or grounding event. The focus is on emergency response actions that is to say the ship under power is assumed to be already on a collision route. The links among the human element (the crew) and the other context and organizational elements (bridge equipment, operational conditions, level of fatigue etc.) has been analysed and assessed using the framework proposed by Hollnagel (1998).

It has been decided to switch to a more naturalistic approach to the operator model mostly relying on the use of the Expert Judgement provided by the Leader of the Subtask 2.4.1 for identifying main elements of performance in relation to collision and grounding scenario. In consequence of the discussion the "scenario" part of the network had to be modified in order to:

- consider a node (replacing OOW Task node) representing the surveillance status;
- consider "time to take action" node (very short, short, medium,...) which influences the human reliability;
- take into account the apparent collision angle (ahead, side), this implies to consider the width of sectors to consider for the watch.
- consider the different times (detection, interpretation, planning, execution).

The modification of the scenario determined major changes in the operator model as well. A new network was then outlined, without fully considering the underlying probability distribution just to display the main elements identified and the possible relation among them. A unified model for Task 2.4.1, 2.4.2 and 2.4.3 is now being built using BBN for the representation of the scenario, the different bridge layout effects and the operator actions involved. The causation model is broken down into objects for the scope of clarity, each object is a Bayesian Network representing part of the bigger picture (Scenario, Detection, Planning of action etc.) connected to each other through the input-output nodes, see Figure 5.

This subproject is linked to other subprojects as illustrated in Figure 6. These links must be kept in focus to fulfil the overall goals of WP2.

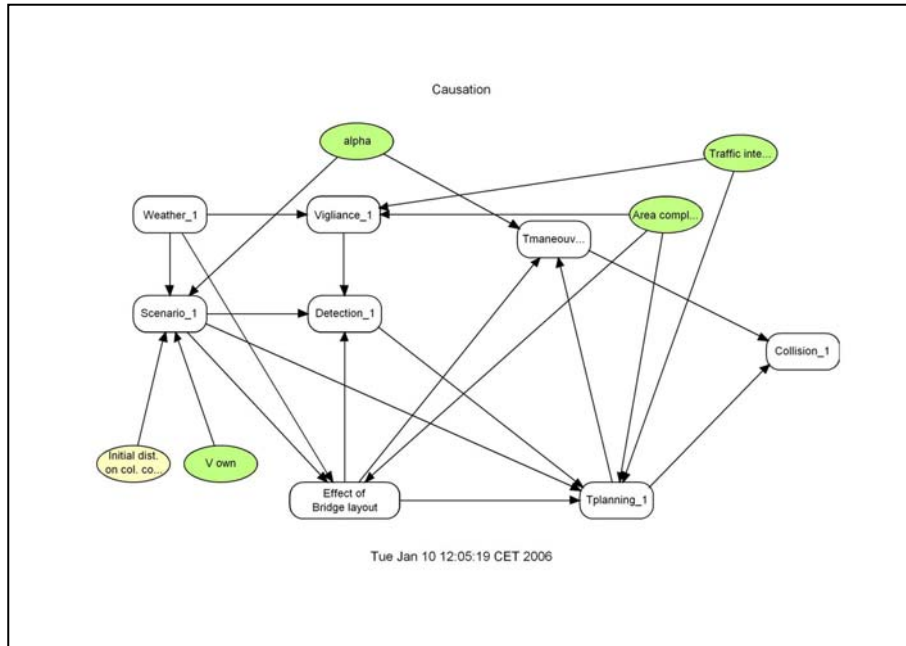


Figure 5 Causation model for collision and grounding events

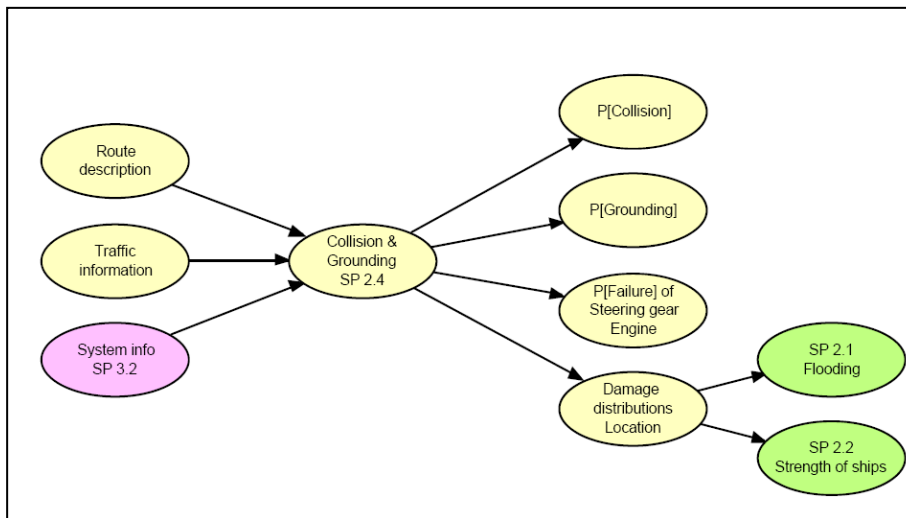


Figure 6 Interaction diagram for SP2.4

8.6 SP2.5: Prevention of fire and explosion events

The primary goal of this subproject is to identify ship design issues that can be addressed with new and/or alternative design and arrangements for which fire protection is an important design factor. The project also intends to develop and demonstrate a risk assessment methodology encompassing first-principle fire engineering science, the implementation of which will allow the achievement of the fundamental fire safety objectives implicit in the new SOLAS regulations, namely, prevention of the occurrence of fire and explosions, containment and suppression of fire and smoke and the provision of adequate and readily accessible means of escape for passenger and crew.

Fire and explosions constitute one of the accident categories that most contribute to the risk to ship operations. Fire safety is also one of the few areas where current ship safety regulations define explicit safety goals and functional requirements in addition to allowing an alternative performance-based approach to demonstrate safety equivalence. In this context, SP2.5 is aiming at exploring the potential for using alternative fire safety approaches with a view to identifying gaps and making developments to fill identified gaps in two areas: (i) human life safety and (ii) cargo (container) safety. The first step in this

direction was taken by conducting a task denominated Qualitative Design Review (QDR) and was the focus of the activities during the first year.

The QDR on cargo fire safety was approached with a review of fire accidents/incidents statistics associated with container vessels. Subsequently design and construction issues related to Container and Ro-Ro vessels were reviewed with a view to defining the potential for fire risk reduction by design. Cargo transported in containers was analysed with a view to gain insight into fire development potential in containers. A hazard identification session and a Failure Mode and Effect Analysis (FMEA) was conducted with a view to identifying specific container-vessel-related fire scenarios and potential fire risk control measures. Two specific situations were identified in need of quantitative fire engineering calculations.

The QDR on human life safety was approached in the same manner as above, namely, review of fire accidents/incidents statistics for passenger vessels and hazard identification (HAZID) sessions. The HAZID session for a RoPax vessel carried out within WP4 was included. The HAZID reports for other passenger vessels were used also as input. The objective is also to identify critical design scenarios for evaluating human life safety in fires. The qualitative information and limited statistical information is used to build a "diagnosis" tool based on Bayesian Network technology that can be used for design purposes (within WP6).

This subproject is linked to other subprojects as illustrated in Figure 7. These links must be kept in focus to fulfil the overall goals of WP2.

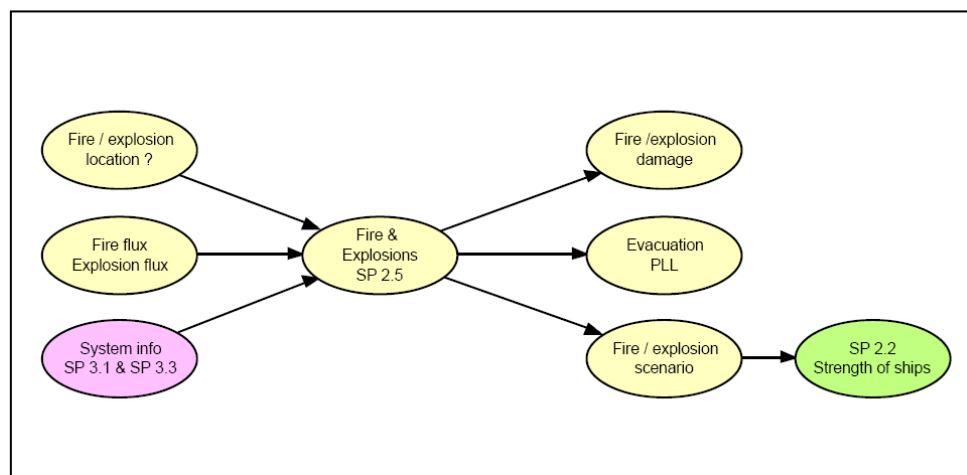


Figure 7 Interaction diagram for SP2.5

9 Innovative Safety-Critical Technologies, by K. C. Ehrke (SAM Electronics)

9.1 WP3 Overview and Key Findings

Design changes having influence on the risk level are called risk-control-options (RCOs) in risk-based design. Innovative products can be powerful RCOs. Therefore, it is the objective of work package 3

- To develop innovative technologies to support safe operation
- To develop specific tools which support safety (in the related RCOs under evaluation)
- To evaluate their risk-reducing potential

WP 3 focuses on specific innovative and safety-critical technologies that will improve the safety of ships. Three issues known to be safety critical have been selected for improvement through the work in this work package that will look into the performance of certain systems and procedures adopted onboard ships and seek way to improve them by incorporating the risks at the design stage. It targets some of the prescriptive limitations imposed by the rules and regulations in force today and exposes their limitations and will propose solutions that are both safe and cost effective. All subprojects focus on practical known important risk control options.

If successful some of the solutions found could be immediately applicable, and this is one of the reasons that operators are strongly represented in this work-package. Thus the effectiveness is being demonstrated in reality. The work has been divided into 3 subprojects:

9.2 SP 3.1: *Innovative tool for safety critical ship systems*

This subproject pursues two main objectives:

- Development of a tool suitable to support the safety analysis of ship systems, i.e. electric power distribution systems, that are developed using simulation techniques and may not comply with current rules.
- Development of techniques and tools that enable the designer to automatically evolve an initial functional design model in which there is no replication of components to a design with appropriate replication schemes that minimize the additional cost of replication while achieving given reliability requirements.

First the system design is started with the development of a model for the electrical power bus system. This model simulates the system behaviour for a range of operating conditions. In a second step, a computerised algorithm exploits the structure of the model to determine how the manually specified local failures propagate through material and connections and cause functional failures at the outputs of the system. This global view of system failure is captured in a set of fault trees. Finally, standard fault tree analysis techniques are used for processing the synthesised fault trees and to determine whether the design meets given safety and reliability requirements.

9.3 SP 3.2: *Innovative concepts for safer navigation*

The main objective of this subproject is, to combine new technologies as used by the office industry (flat screen, wireless networks, integration of all controls) with new safety concepts for redundant workstation operation in such a way, that

- a clear and easy to overlook operator working place is achieved
- all workstations are working fully redundant
- every application respective every ship operation task can be performed from any workstation
- for the first time SOLAS RegV/A Reg15 principles for bridge design are applied and tested

It is expected, that the new design will improve the usage as follows:

- Increased safety of operation with fail safe system configuration
- Increased safety of operation with user friendly system handling
- Reduced equipment costs with multipurpose workstations
- Reduced space requirements giving more design freedom in free view from all positions

The advantages for vessel operators are faster and more reliable information during critical passages.

9.4 SP 3.3: *Innovative life saving for passenger ships*

The principal aim of this subproject is to develop and validate, using risk based methods, a matrix of life saving appliances (LSA) solutions, here also called risk control options that are consistent with the type of vessel and operational envelope. This will allow designers to choose the most effective means to solve the LSA issues currently facing them. By considering all phases of the evacuation and abandonment, it takes a holistic approach to the area of life saving appliances, and will link the provision of LSA to the survivability of the vessel by considering LSA as a mitigating measure in the abandon ship process. It will look at a number of LSA solutions ('packages') and link the importance given to LSA to the likelihood that it will need to be used. This will be done by utilising risk assessment methods. It will look at the complete evacuation process from muster to recovery and will concentrate on solutions that incorporate and improve on aspects related to the human element. The specific objectives of this subproject are:

- To link LSA requirements to ship survivability
- To remove unintentional effects of LSA regulation that effectively limit the number of passengers / size of passenger vessels
- To challenge all European LSA manufacturers to suggest innovative solutions for abandonment of large passenger ships.

After the first project year all three subprojects SP 3.1 to 3.3 have nearly finished the user requirements and specification phase. This presentation is focusing on first results of this phase.

For SP 3.1 the key findings are given by a new tool for failure analysis of electrical power bus systems.

For SP 3.2 the key findings include a new concept for describing bridge architectures by a reference model and a first set of end-user requirements.

For SP 3.3 a new concept for an inflatable lifeboat with reduced space required on-board has been developed.

10 Validation and Application for Innovative Ship Designs, by F. Del Castillo de Comas (Navantia)

10.1 WP6 Overview and Key Findings

The principal objective of WP6 of SAFEDOR is to focus on innovative ship designs that are expected to be as safe as or safer than current ships, but for formal reasons cannot be approved under the current rules, class and/or flag regulations.

SAFEDOR has identified a series of 8 innovative ship designs that are expected to meet with above mentioned objective. In addition this work package, by the use of the new developed methods and tools, aims to:

- test the feasibility of the proposed risk-based design approach
- challenge some regulations that restrain innovation
- develop a common understanding for risk-based approaches by implementing it
- eventually sustain competitiveness of European maritime industry by producing prototype designs
- gain experience that can be used to refine the documentation of risk-based regulatory framework and for the training

The eight (8) innovative ship designs identified correspond to five different ship types: Cruise Vessel (2), Ropax (3), LNG carrier (1), Containers Ships (1) and Oil Tankers (1). The 8 design teams (chosen from 18, following an open call) comprise leading ship owners, major ship yards, main marine equipment suppliers/manufacturers, design/consulting offices and major European Classification Societies. The titles of the selected designs (WP6 subprojects) are:

- SP6.1: Innovative cruise ship – Post-Panamax size.
- SP6.2: Cruise Vessel
- SP6.3: Fast Full Displacement Ferry
- SP6.4: The 13th Passenger
- SP6.5: Lightweight composite sandwich superstructure for a Ropax vessel
- SP6.7: Risk-based design for shortsea LNG vessel
- SP6.8: Innovative open top container vessel
- SP6.9: Safe and Competitive Oil Tanker - Aframax Size

For each innovative design the work has been divided into 3 phases:

- Design Concept
- Design studies (Project Definition)
- Functional design phase

10.2 Phase 1: Design concepts

This phase defines the concept and determines the feasibility.

It has been already carried out for the 8 innovative designs during the first year of SAFEDOR. For each one of them a outlined specifications of the developed concepts, a identification of the rules that need to be challenged and the means of overcoming rule constraints to offer an acceptable level of safety cost-effectively has been developed.

10.3 Phase 2: Design studies (Project Definition)

This phase refines the design concept with the production of the technical definition of the ship, including feasibility, reliability, economic studies and risk and safety assessments.

It is being carried out for each innovative design during the second year of SAFEDOR and will produce all necessary documents required to evaluate each design regarding the achievement of conceptual targets. In particular the following documents will be generated: a detailed specification, general arrangement drawing, line drawings, hull definition, preliminary scantlings, weight and centre of gravity calculations, intact and damaged stability and survivability calculations, risk analysis related to the developed concept, approval documents list; economic impact study and safety and environmental impact study.

At the end of this phase, an evaluation and project selection process will be carried out with the objective of:

- selecting the best 2 design for the next phase.
- improving the design quality
- performing an intermediate evaluation of the obtained results

The evaluation criteria for selecting the best design studies will be based on main SAFEDOR objectives: (1) Relevance for SAFEDOR, (2) Economic impact, (3) Innovation, (4) Environmental impact and (5) Safety Impact.

10.4 Phase 3: Functional design phase

In this last phase the documentation for approval will be prepared and considered by the Classification Society for "approval in principle".

This phase will be carried out during the third and fourth year of SAFEDOR for the 2 innovative designs chosen at the end of phase 2. Design teams in this task will benefit from methods and tools developed in other WP of SAFEDOR.

The final documents for each design will include the final evaluation of environmental impact, the economic interest of the concept, safety cost-effectiveness and innovative aspects as well as all the agreed documentation for approval.

The final designs will be analysed and studied by the Classification Societies for "approval in principle", using approved procedures developed in WP4, especially in SP4.5 "Risk Based Regulatory framework".

In this presentation the main outcomes and key findings of the concept designs, will be summarized.