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Annual Public Report Year 4

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Title: SAFEDOR Annual Public Report Year 4

Abstract

SAFEDOR (2005-2009) is the first known large scale project worldwide that developed a risk-based regulatory framework for the maritime industry and corresponding design tools to facilitate first principle approaches to safety, addressing the complexity of a fully comprehensive system.

The conducted research work, which was completed in 2009, focused on strategies and technologies to improve maritime safety and, at the same time, the competitiveness of the involved stakeholders. A systematic and all-embracing approach to ship safety has been developed that leads to optimising of safety and an effective use of both critical technologies and the wealth of information amassed over years in ship design. Gained knowledge has been applied to innovative ship design and approval, as well as improved safety-critical technologies.

The SAFEDOR Public Report Year 4 intends to provide an overall summary of the conducted research activities and outline the way ahead.

Summary Report:

Introduction

The aim of SAFEDOR is to improve the safety of maritime transportation and to increase European maritime industries' competitiveness through the integration of safety as design objective into ship design and risk assessment into the approval frameworks.

State of the Art

The SAFEDOR approach is a novel approach to a transparent and consistent methodology for Risk-based Ship Design and Approval.
Safe design—that effectively minimizes the likelihood of accidents and mitigates their consequences—has long been a priority in many industries; to mention but a few, such as Civil, Offshore, Aeronautics, Nuclear, Systems, Hydraulic, Water Resources & Environmental Engineering. Risks cannot be completely eliminated but at least be consistently reduced to a level that can be tolerated by all concerned—by facility staff, company management, surrounding communities, the public at large, industry and government agencies.
Therefore, methods of risk and reliability analysis in various engineering disciplines, developed during the last decades, are becoming more and more important as decision support tools in engineering applications.

State of the Market

Presently core technical elements governing the operation of seagoing ships are established by regulations of the International Maritime Organization (IMO). In addition, rules governing the construction of ships are established by Classification Societies. As a consequence, ship design is significantly constrained by these rules and regulations.

SAFEDOR aims to provide additional design freedom for ship and systems and an appropriate approval process that introduces safety as additional objective – additional to standard performance requirements like speed, capacity, endurance etc. - and by proposing a modernised regulatory framework to facilitate risk analysis as additional element of the approval process. This way, the regulator imposes boundary conditions directly on the targeted safety performance of the ship with quantified risk acceptance criteria and the ship designer decides how to achieve the prescribed level of *safety cost-effectively. Thus, a path to approve novel ships beyond the current regulatory constraints is offered.*

Value added to SAFEDOR

The outcome of SAFEDOR comprises the integration of all operational, technological, environmental and human related factors concerning safety at sea throughout the entire vessel life cycle; the demonstration of the potential of risk-based frameworks for safety assessment techniques, integrated design environments and optimisation of ship operation processes for safe and economic shipping.

With risk-based approaches firmly established in the maritime industry, ship owners will be able to realise innovative ships and maritime transport solutions - challenging current rules - relating to, e.g., new layouts or use of new materials and systems. With the novel approval process, implementation of novel and risk-based ships will be faster and more reliable.

The benefits for shipyards arise from the fact that yards acquainted with risk-based approaches are among the first to respond to the increasing demand from ship owners to realise risk-based ships. In addition, production costs are expected to be reduced through application of risk-based approaches.

Marine equipment manufacturers will benefit through enabling new and optimised systems incorporating new functions and materials. Understanding and applying risk-based approaches will be a competitive advantage. The key asset of risk-based designed ships will be the knowledge to prove compliance with risk acceptance criteria, which results in new opportunities for patenting innovative solutions.

Achievements

REGULATORY FRAMEWORK

Within the project SAFEDOR, elementary building blocks for a risk-based regulatory framework for shipping were developed. These comprise the approval processes for ships and ship systems, risk evaluation and acceptance criteria at ship and functional level and requirements for documentation and qualification. In addition, six formal safety assessment (FSA) studies were conducted; five of them have been already to IMO and were partly reviewed in May 2009 during the meeting of the Maritime Safety Committee (MSC 86). Thus, work performed in SAFEDOR towards a modern and risk-based regulatory framework will eventually affect the way risk is managed within rule making at IMO level.

METHODS& TOOLS

Within SAFEDOR, several engineering tools to predict the safety performance of a vessel in extreme and accidental conditions were newly developed or refined. These tools address the main accident categories, namely collision & grounding, fire & explosion, intact and damage stability, systems' failures. Two benchmark studies on the validation of software tools for the assessment of intact and damage stability were completed.

SHIPS AND THEIR SYSTEMS – IMPLEMENTING NEW KNOWLEDGE

Eight design teams developed innovative ship concepts at the beginning of SAFEDOR. Two of these concepts, namely the 'Composite Superstructure' and the 'ROPAX of enhanced Survivability' have been further elaborated to the preliminary design stage. Work within SAFEDOR also addressed development of innovative focusing on areas with high impact on safety, such as an innovative bridge layout, a novel system to distribute electrical power and several new concepts for life saving appliances.

QUALIFIED ENGINEERS

A number of dissemination and training measures were planned from the beginning of SAFEDOR to enhance knowledge on risk-based approaches within the maritime industry and to add stimulus towards developing a new safety culture. SAFEDOR attracted a large number of people to the annual public conferences. In addition, annual public reports and presentations were provided together with fact

sheets for main stakeholders. Two training courses were organised with one focusing on regulators and the second one on PhD students and young professionals from all the industry. To complement the material for students and experienced engineers alike, besides the offered training course material, a handbook on risk-based ship design was published, which is being offered commercially by SPRINGER Publishers. Finally, the SAFEDOR consortium was very active in publishing results of the project in scientific conferences and peer reviewed journals, namely close to 200 publications with direct acknowledgement of SAFEDOR or related to the SAFEDOR objectives were published by SAFEDOR partners over the project period.

This executive summary may be published outside the SAFEDOR consortium.

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Contents

1 Introduction

SAFEDOR (2005-2009) is the first known large scale project worldwide that developed a risk-based regulatory framework for the maritime industry and corresponding design tools to facilitate first principle approaches to safety, addressing the complexity of a fully comprehensive system.

The conducted research work, which was completed in 2009, focused on strategies and technologies to improve maritime safety and, at the same time, the competitiveness of the involved stakeholders. A systematic and all-embracing approach to ship safety has been developed that leads to optimising of safety and an effective use of both critical technologies and the wealth of information amassed over years in ship design. Gained knowledge has been applied to innovative ship design and approval, as well as improved safety-critical technologies.

The SAFEDOR Public Report Year 4 intends to provide an overall summary of the conducted research activities and outline the way ahead.

2 IP SAFEDOR

SAFEDOR is an Integrated Project responding to the need of the EU maritime industry for evermore-innovative solutions for better quality, cleaner and safer transport.

SAFEDOR constitutes the culmination of eight (8) years of EU-wide concerted effort to foster radical shift from the current maritime safety regime, through the activities of the thematic network SAFER EURORO ("Design for Safety"). SAFEDOR has pooled together an accolade of leading expertise from across the whole maritime spectrum to pursue its vision of strengthening the competitiveness of the EU maritime industry by enhancing safety through innovation. This entails development of a holistic approach that links risk prevention / reduction to ship performance and cost, with safety treated as a lifecycle issue and a design objective, implying focus on risk-based operation and need for risk-based regulations within an integrated risk-based design framework, utilising routinely first-principles tools. This all-embracing system is the key to attaining optimum design solutions and it acts as catalyst to pan-European cooperation with strong structuring and integration effects. SAFEDOR produces a series of prototype ship designs to validate and implement this novel approach and ascertain its practicability. To accelerate transition from conventional to risk-based design, the wider maritime community is inculcated through a rigorous knowledge management, training and dissemination system of all technological, methodological and regulatory developments whilst continuing to nurture, enthuse and fuel a maritime safety culture [1].

Innovation in the transportation industry has to a significant extent been driven by safety. Ship safety has until recently been driven mainly by individual events. Each major catastrophic accident has led to a new safety regulation and subsequent design measures imposed by the International Maritime Organization (IMO) and the classification societies. The integrated project SAFEDOR introduces a risk-based design methodology and regulatory framework that systematically embraces design knowledge and innovation, thus offering economic benefits and competitive advantage to the European maritime industry.

The SAFEDOR project officially started on 15th February 2005, when the kick-off meeting was held at Germanischer Lloyd (GL), in Hamburg. Fifty-three -53- project partners from all sectors within the European maritime industry are participating in the project, the duration of which is until January 2009[1].

SAFEDOR Objectives

Risk-based ship design and approval will satisfy the European maritime industries' need to deliver ever more innovative transport solutions to their customers. Risk-based ship design and approval will also satisfy the European society's need to have increasingly safer transport. SAFEDOR research activities distinctively addresses both aspects and, thus, deliver the foundation for Europe to sustain world-leadership in safety-critical and knowledge-intensive ships, maritime services, products, equipment and related software. A vision was formulated to present these two goals of SAFEDOR:

ENHANCE SAFETY THROUGH INNOVATION
TO STRENGTHEN THE COMPETITIVENESS OF THE EUROPEAN MARITIME INDUSTRY

SAFEDOR provides solutions for both key issues for the European maritime industry. Increasing safety and security of maritime transport cost-effectively is achieved by treating safety as design objective and not as a constraint as in current ship design. Increasing the competitiveness of European industry is achieved by systematic innovation in design and operations encouraged by modernizing the maritime regulatory system towards a risk-based framework.

Strategic research objectives are formulated to meet the outlined vision, these being:

- Develop a risk-based and internationally accepted regulatory framework to facilitate first principles approaches to safety.
- Develop design methods and tools to assess operational, extreme, accidental and catastrophic scenarios, accounting for the human element, and integrate these into a design environment.
- Produce prototype designs for European safety-critical vessels to validate the proposed methodology and document its practicability.
- Transfer systematically knowledge to the wider maritime community and add a stimulus to the development of a safety culture.
- Improve training at universities and aptitudes of maritime industry staff in new technological, methodological and regulatory developments in order to attain more acceptance of these principles.

SAFEDOR objectives and the approach are summarised in Figure 1 showing the two development tracks – one related to risk-based ship design and one related to risk-based ship approval – and the validation and application activities.

[1] The project was extended to the end of April 2009, to allow for the organization of the SAFEDOR final conference on April 27-28, 2009 (IMO, London).

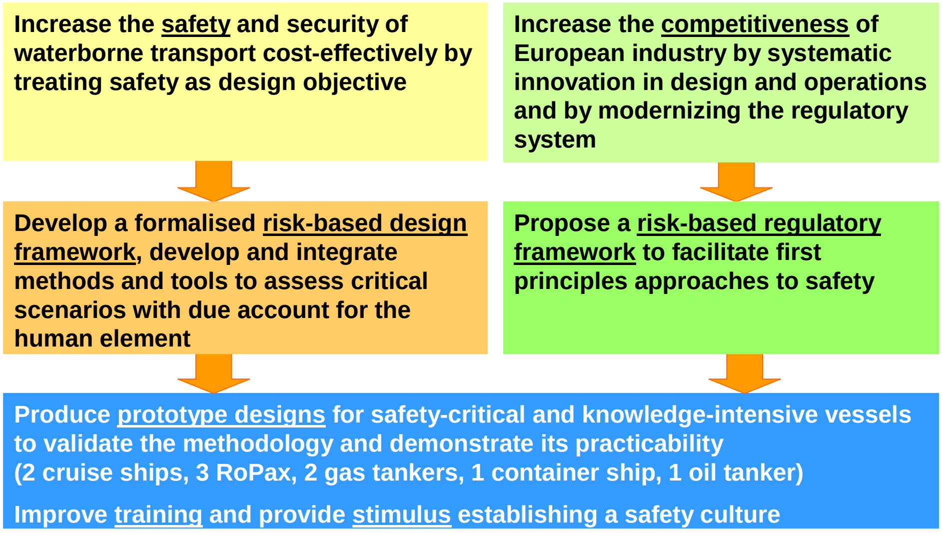

Figure 1: SAFEDOR Objectives & Approach

Figure 2 presents the structure of SAFEDOR development activities and shows the planned timeline.

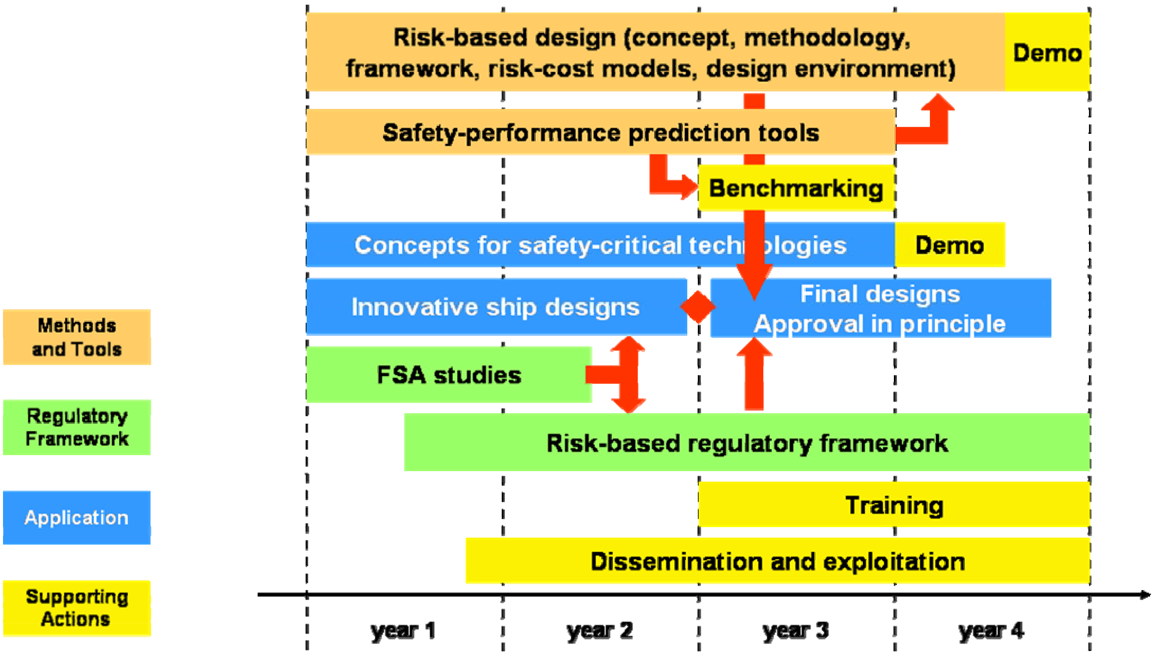

Figure 2: SAFEDOR Road Map

SAFEDOR Focus

As introduced above, SAFEDOR development activities focus on risk-based ship design (which is an enhanced ship design process), approval of risk-based ships (which requires an enhanced approval process and a modernised regulatory framework), and sample designs to prove the practicability of the developed risk-based approaches.

Risk-based ship design requires a novel process to incorporate safety as an objective, sophisticated methods and tools to assess ships in extreme and accidental scenarios with due account for the human element and improved knowledge on cost elements in construction and operation of ships. Optimisation of ship designs also needs integration of available tools. SAFEDOR addresses all of the above.

Approval of risk-based designed ships requires a new approval process, which takes into account the rule-challenging character of the innovative ship. Qualitative and quantitative assessments of innovative concepts are required and knowledge on current risk levels is needed to establish suitable risk acceptance criteria. High-level FSA studies of ship types deliver just this piece of information. SAFEDOR addresses these elements and develops a proposal for a modernised regulatory framework to facilitate the above.
Application of the newly gained knowledge to complete ship designs and to selected safety-critical technologies (navigation and life saving) is the third pillar of SAFEDOR. Eight ship designs were developed focusing on aspects that improve safety and / or economics but for some formal reason cannot be approved today.

3 SAFEDOR Structure

To ensure an effective control of the project, the work programme is broken down into a number of work packages (WP) which in turn are divided into Subprojects (SP) and Tasks (TK). Individual partners have been allocated responsibility for technical co-ordination within the respective WPs, SPs and TKs. In summary, SAFEDOR comprises 7 work packages, 32 subprojects and 221 tasks [2].
Risk-based design entails the systematic integration of risk analysis in the design process targeting risk prevention/ reduction as a design objective. An essential pre-requisite to undertaking this is the availability of fast and accurate first-principles tools. This is addressed in work package (WP) 2 of SAFEDOR. Also knowledge of the effect of design changes/measures to enhance safety cost-effectively (considering all major hazards and ensuing accident categories and scenarios) is crucial. This issue is addressed in a number of work packages (FSA studies in WP4, implementation of first –principles tools in WP2 and in WP3). To pursue this activity effectively, it is necessary to provide an integrated design environment (IT platform) to facilitate and support a holistic approach to ship design (WP5) that enables appropriate trade-offs and advanced decision-making, leading to optimal ship design solutions. The next essential step (design approval) necessitates the development and consolidation of a risk-based regulatory framework to set conditions for design approval that would allow linking ship design performance optimisation with risk minimisation (WP4). To embed the risk-based design process into the heart of the maritime industry, design teams are assembled representing a large sector of the EU shipping and shipbuilding industries to pursue the design (from concept to approval) of innovative ship types that cannot be approved under the current prescriptive rules (WP6). Finally, a knowledge management, training and dissemination system is put in place to maximise benefits by targeting all the stakeholders of maritime safety and to exploit RTD results by systematic evaluation, consolidation and marketing (WP7) [1].

4 SAFEDOR Partnership

The SAFEDOR Consortium comprises 53 organisations from 14 European countries and represents all stakeholders of the maritime industry, namely ship owners, ship yards, maritime equipment manufacturers, engineering consultants, research institutes, software developers, university departments, classification societies and one flag state. The following list provides the 53 participants alphabetically; in brackets the relevant country is indicated.

1. Germanischer Lloyd AG (DE): IP Coordinator

2. Aker MTW Werft GmbH (DE)
3. Alpha Ship Design ApS (DK)
4. Aker Yards St. Nazaire (FR)
5. Altair Special Maritime Enterprise (GR)
6. ANSYS Europe Ltd. (UK)
7. AVEVA AB (SE)
8. British Maritime Technology (UK)
9. Brodrene AA AS (NO)
10. Carnival plc (UK)
11. Centro per gli Studi di Tecnica Navale (IT)
12. Color Line Marine AS (NO)
13. Columbus Shipmanagement GmbH (DE)
14. D'Appolonia S.p.A. (IT)
15. Danish Maritime Authority (DK)
16. Deltamarin Ltd (FI)
17. Det Norske Veritas AS (NO)
18. DFDS A/S (DK)
19. Fincantieri - Cantieri Navali Italiani S.p.A. (IT)
20. FiReCo AS (NO)
21. Flensburger Schiffbau-Gesellschaft mbH & Co. KG (DE)
22. Fr. Fassmer GmbH und Co. KG (DE)
23. FRESTI (PT)
24. GKSS Forschungszentrum Geesthacht GmbH (DE)
25. Harland & Wolff Heavy Industries Ltd (UK)
26. Instituto Superior Tecnico (PT)
27. ITI Ges. f. ingenieurtechnische Informationsverarbeitung mbH (DE)
28. Leif Hoegh & Co. AS (NO)
29. Lloyd's Register (UK)
30. Lund, Mohr and Giaever-Enger Marin AS (NO)
31. Maritime Research Institute Netherlands (NL)
32. Maritime Simulation Rotterdam b.v. (NL)
33. Martec S. p. A. (IT)
34. Meyer Werft (DE)
35. Napa Ltd (FI)
36. Navalimpianti S.p.a. (IT)
37. Navantia, S.A. (ES)
38. National Technical University of Athens (GR)
39. Peter Dφhle Schiffahrts-KG (DE)
40. RFD Beaufort Limited (IE)
41. RINA SPA (IT)
42. Royal Caribbean Cruise Line (UK)
43. Safety at Sea Limited (UK)
44. SAM Electronics GmbH (DE)
45. Sirehna (FR)
46. Snecma Moteurs (FR)
47. SSPA Sweden AB (SE)
48. Stena Rederi AB (SE)
49. Technical University of Denmark (DK)
50. Umoe Schat Harding AS (NO)
51. University of Hull (UK)
52. Universities of Glasgow & Strathclyde (UK)
53. V. Ships (UK)

The percentage of various affiliation groups participating in SAFEDOR is shown in the following figure:

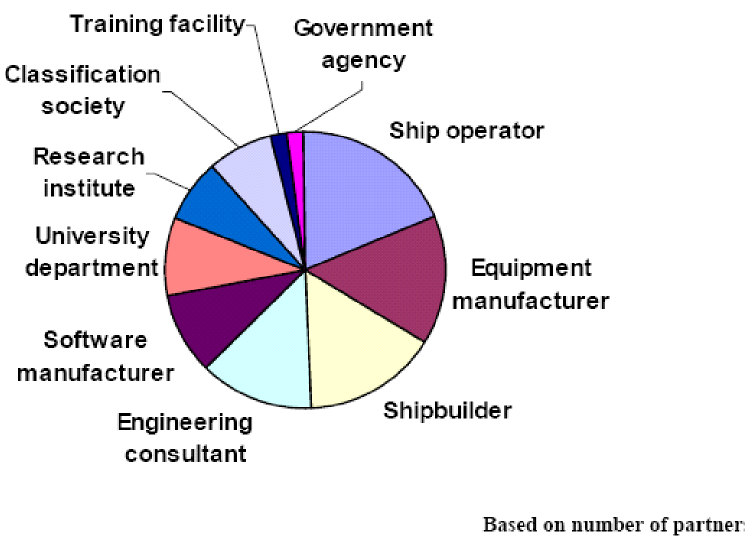

Figure 3: SAFEDOR Partnership

5 Work performed – Results achieved

Regulatory framework

Within the project SAFEDOR, elementary building blocks for a risk-based regulatory framework for shipping were developed. These comprise the approval processes for ships and ship systems, risk evaluation and acceptance criteria at ship and functional level and requirements for documentation and qualification. In addition, six formal safety assessment (FSA) studies were conducted; five of them already being submitted to IMO with an expected review in May 2009 during the meeting of the Maritime Safety Committee (MSC 86). Thus, work performed in SAFEDOR towards a modern and risk-based regulatory framework will eventually affect the way risk is managed within rule making at IMO level.

The approval processes for risk-based ship and ship systems both aim to provide a basis to be used by approval authorities to ensure that novel and risk-based designs are handled in a safe and efficient manner and to make the approval process these designs more transparent and reliable. The key element of the newly proposed approval processes is an intermediate step called the “Preliminary Approval” which concludes the first phase of the process.

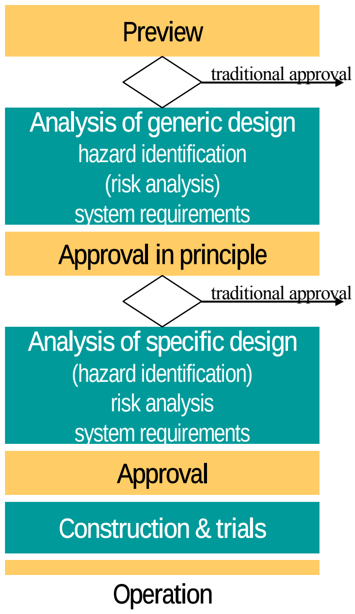

Figure 4: SAFEDOR risk-based approval process

The preliminary approval allows the client to demonstrate that an independent third party attests to the novel or risk-based design which may be useful with respect to project partners. A summary of the novel approval process with all relevant details is being submitted to IMO (MSC 86).

High-level risk evaluation criteria for use within risk-based design and approval were also presented. These criteria include individual and societal risk acceptance criteria, a cost-effectiveness evaluation criterion related to life saving and appropriate background information to update the criteria. In addition, a new cost-effectiveness evaluation criterion related to environmental protection was developed: Cost of Averting a Ton of Oil Spilt (CATS). This new criterion should primarily be used to assess design changes of oil tankers with respect to their cost effectiveness – under the assumption that risk associated with oil transport by tankers is inside an ALARP area. Alternatively, one could use this criterion to enhance the cost-effectiveness evaluation related to life saving by subtracting expected difference in oil outflow times CATS from the differences in costs for a design option. The concept of CATS was intensely discussed and extensions relating to spill size and spill location were suggested. A correspondence group was established between recent Maritime Environmental Protection Committee (MEPC) meetings and the basic idea of CATS was recently agreed (IMO 2008). Continued discussions now focus on the correct value of CATS and whether an ALARP area would be needed for its application.

Risk evaluation criteria at ship system and function level are presently not publicly available. An unpublished report from SAFEDOR lists such criteria and proposes a general procedure to derive lower-level risk evaluation criteria. This procedure builds upon a risk model for the considered system or function and uses high-level cost-effectiveness criteria to derive target reliabilities, availabilities or failure probabilities. The procedure was successfully applied to hull girders in intact and damaged condition and a fuel oil system.

The FSA studies were performed to deliver high-level risk models, identify risk control options and to document the current level of risk per ship type and followed the FSA guidelines (IMO 2002 and IMO 2007). At the moment of writing, five FSA studies have been submitted to IMO addressing container vessels, LNG tankers, oil tankers, cruise vessels and RoPax ferries. One FSA study on dangerous goods on open-top container vessels is currently being finalized. The submitted FSA studies show that all the societal risk profiles of considered ship types are in the ALARP area and, therefore, cost-effective risk control options should be implemented. The FSA studies for the oil tanker, the cruise and RoPax vessels list a number of such measures for consideration by rule makers.

Designer's toolbox

Risk-based design is an extension of the traditional design process in that it integrates assessment of the safety performance into the design process. Prevention and / or reduction of risk (to life, the environment and property) are embedded as a design objective, alongside conventional design objectives (such as speed, capacity, etc). SAFEDOR developed this design framework offering an enhanced decision-making to balance traditional objectives – performance and cost – with the new objective – minimize risk.
An overview of the elements of the risk-based design framework and the principal linkage between safety performance predictions tools addressing main accident categories is presented in the figure below:

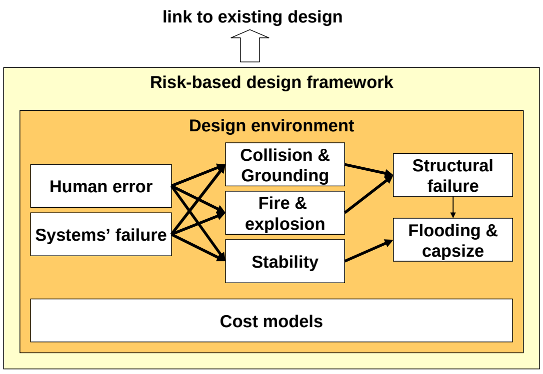

Figure 5: SAFEDOR risk-based design framework and toolbox

Within SAFEDOR, several engineering tools to predict the safety performance of a vessel in extreme and accidental conditions were newly developed or refined. These tools address the main accident categories, as shown in figure above. The following developments were performed to date:
- A Bayesian network was extended to evaluate changes in the causation factor driving from enhanced training and advanced bridge equipment for collision and grounding.
- A new Bayesian network was established to predict the probability of propulsion and manoeuvring systems' failure. However, lack of sufficiently validated data on components limited validation.
- A new technique to create fault trees and FMEA tables from system descriptions inside a standard system simulation package was developed. Enhancements include entering annotations to systems and components related to failure modes.
- A new approach to assess fire in cargo holds was applied by introducing a Bayesian network to evaluate probabilities and consequences of container fires.
- A methodology to assess fire safety for passenger ships was developed which offers a probabilistic approach to fire safety similar to the probabilistic approach to damage stability.
- A structural reliability analysis of a damaged ship structure showed that the damaged condition – following a collision – is not a dimensioning case for the hull girder of a tanker.
- The probability for intact capsize was predicted with two newly developed algorithms. A validation of the new methods using dedicated experimental data is ongoing.
- A new method was developed to predict the probability density function for the time to capsize for RoPax ferries. The new method is extremely fast – which allows integration into a design environment - and is still considered to be sufficiently accurate. Validation is ongoing.

Ships and their systems

Eight design teams started developing innovative ship concepts when SAFEDOR began. Concepts addressed technological, economical and safety aspects for two cruise vessels, a fast full displacement RoPax ferry, a hybrid RoRo/RoPax vessel, a lightweight composite sandwich superstructure for a RoPax ferry, a short-sea LNG tanker, an open-top container vessel and an oil tanker. A formal selection of the best designs by a panel resulted in two winning designs which were given additional resources to refine their concepts and prepare for preliminary approval.

The first winning design was the lightweight composite sandwich superstructure for a RoPax ferry which exemplifies the use of risk-based approaches to demonstrate safety compliance. The risk model incorporated results from full scale fire tests and advanced computer simulations to show that the risk level for passengers is smaller than for passengers on conventional ferries when appropriate risk control options are implemented. The second winning design was the fast full displacement RoPax ferry which exemplifies the optimization potential for risk-based design and demonstrated the potential of a newly developed tool to predict flooding. The risk assessment of a novel subdivision concept also introduced blisters (inflatable buoyancy units above design waterline) as potential powerful risk control options.

Work within SAFEDOR also addressed development of innovative systems focusing on area with high impact on safety, such as an innovative bridge layout, a novel system to distribute electrical power and several new concepts for life saving appliances.
The novel system to distribute electrical power (primary power bus) was integrated into a RoPax ferry design and analyzed with respect to its safety compliance.
The final step following an accident may be life saving and rescue if the vessel needs to be abandoned. SAFEDOR developed three novel life saving appliances, each focusing on a different scenario and related different survival ranges. The long-range solution focused on a novel launching system to facilitate safe embarkation. The medium-range solution considered a novel onboard stowage to reduce space allocation. The short-range solution addressed safe access and stowage for a complementary life saving system – similar to life rafts.

Qualified Engineers – The core of SAFEDOR's success

SAFEDOR started its ambitious path with a partnership comprising 53 European organizations which represent all stakeholders of the maritime industry. In total, about 300 persons were involved at various stages of SAFEDOR and, thus, the knowledge was spread effectively. Indeed, this was one of the reasons for the large partnership of SAFEDOR. Although most partners were building on a decade of intensive research into ship safety, it turned out that some skills were not available as expected and more training was needed.

Qualification requirements for engineers involved in risk-based ship design and approval was distinctly addressed within SAFEDOR. Depending on the process step and level of involvement, four target groups were identified as follows: design engineers, approval engineers, operators and inspectors. The steps in risk-based design and approval were assigned required qualification levels and these were compared with available initial qualifications. A required entry level qualification and desired qualification upgrades were identified for all involved stakeholders as staring point for a personnel training activity.

A number of measures were planned form the beginning of SAFEDOR to enhance knowledge on risk-based approaches within the maritime industry and to add stimulus towards developing a new safety culture. SAFEDOR attracted a large number of people for the annual public conferences. In addition, annual public reports and presentations were provided together with fact sheets for main stakeholders. Two training courses were offered with one focusing on regulators and the second on PhD students and young professionals from all the industry. To complement the material for students and experienced engineers alike, a handbook on risk-based ship design is being commercially offered (Papanikolaou 2009).

6 Knowledge Management, Dissemination and Training

Summary description of workpackage objectives

Future competitiveness of the European maritime industry depends on proper management of acquired innovative knowledge and the availability of qualified employees. For the risk-based design approach to be successfully implemented in practice a training of professionals should be performed and results of SAFEDOR should be widely disseminated. Quality of results should be checked and benchmarking studies will be performed to quantify the impact of the conducted research.

Therefore, the main objectives of WP7 are:
- Knowledge transfer from the research conducted within the SAFEDOR IP in a systematic manner to the wider maritime community and to promote the application and implementation of the work undertaken
- Training improvement at universities and aptitudes of maritime industry staff in new technological/methodological and regulatory developments
- Effective dissemination of SAFEDOR IP results
- Benchmark studies performance for selected topics
- Rational assessment of SAFEDOR IP results

To meet the outlined objectives, three subprojects have been defined as follows:
- Training, including the development and delivery of postgraduate training modular course
- Dissemination Activities
- Assessment and Exploitation of Project Results and Benchmarking

Within the last year of the project, dissemination activities, as well as activities on assessment and exploitation of results and benchmarking, were active according to plan.

Contact

The WP-7 Leader is the National Technical University of Athens – Ship Design Laboratory (http://www.naval.ntua.gr/sdl), represented by Prof. A.D. Papanikolaou (tel. +30 210 772 1416, Fax: +30 210 772 1408, email: papa@deslab.ntua.gr

Training and Dissemination Activities Year 4

Training

This subproject started in year 3. It consists of two tasks, namely the “Development of postgraduate training modular course” and the “Training course to professionals”.

The planned training course on Risk-based design, operation and regulation was held in Lyngby/Copenhagen, at the Denmark Technical University (DTU) on 25-27 August 2008. The course addresses an extended number and background of prospective participants from the whole spectrum of the maritime industry. Public information about the course was released through SAFEDOR Newsletter No. 4 (February 2008) and was complemented by a separate leaflet of DTU/ DCAMM.

Dissemination

The primary goal of this subproject is the efficient dissemination of SAFEDOR results by:

- the organisation of a series of conferences and workshops,
- the printing of newsletters and public annual reports and
- the compilation and printing of a handbook on Risk-Based Design.

In this reporting period, dissemination of results was attained via the ongoing elaboration of the following tasks:

- SAFEDOR Year 3 Seminar
- Newsletters issues 5 and 6
- Public report Year 4
- Handbook on risk-based design
- Final plan for using and disseminating the knowledge
- Final Conference (end of year 4)

The SAFEDOR Year 3 seminar was successfully held on 5-6 May 2008, at the premises of the University of Strathclyde in Glasgow. It was jointly organised by NTUA-SDL, on behalf of the SAFEDOR consortium and the Ship Stability Research Centre (SSRC) of the Universities of Glasgow and Strathclyde. The first day of the workshop was focused on Risk Based Design and Operation, while the second day on Risk Based Approval along with some emerging issues using Risk Based Design. The seminar addressed latest developments and results of SAFEDOR on risk-based ship design, operation and regulation and attracted a number of about 70 delegates representing satisfactorily the whole maritime industry. Representatives from many countries around Europe and from overseas participated. It is very important that the SAFEDOR knowledge and results were disseminated to an audience both from inside and especially outside the SAFEDOR consortium.

The SAFEDOR Final Conference was successfully held on 27-28 April 2009, at the headquarters of the International Maritime Organisation (IMO) in London. It was jointly organised by NTUA-SDL on behalf of the SAFEDOR consortium and the Royal Institution of Naval Architects (RINA), subcontracted by the SAFEDOR WP7 Leader (NTUA). The first day of the conference was focused on Risk Based Framework, Systems availability, Fire Safety, Navigational Safety, and Risk-based Design, while the second day on Technologies & Tools, Damage Survivability and Rescue. Demonstrations of software tools were planned for both days of the conference. The conference addressed the concluding results and the latest developments SAFEDOR four year research on risk-based ship design, operation and regulation. It was attended by a large number of professionals from the whole spectrum of the maritime industry, both from within and outside the SAFEDOR consortium, the European Commission and mass information media. The conference was a successful SAFEDOR dissemination event, as it attracted a fully satisfactory critical number of about 150 participants and besides the pure dissemination of valuable knowledge in the progress of developments in risk-based design, it updated the conference delegates representing satisfactorily the whole maritime industry.

Knowledge generated in SAFEDOR formed the basis for the edition and publication of a book on “Risk based Ship Design – Methods, Tools and Applications”, A. D. Papanikolaou (Ed.), Springer-Verlag, ISBN 978-3-540-89041-6. The book was first released in February 2009 during the SAFEDOR kick-out meeting and is considered a major result of the SAFEDOR project. The book is the first published in the area of risk-based design and achieved very high publicity thanks to the renowned publisher. The book, which is co-authored by renowned experts from the SAFEDOR consortium, facilitates the transfer of knowledge emanating from the research conducted within the SAFEDOR project to the wider maritime community and nurtures inculcation upon scientific approaches dealing with risk-based design and ship safety. It describes methods, tools and application of risk-based ship design and aims to provide an understanding of the fundamentals and details of the integration of risk-based approaches into the ship design process (http://www.springer.com/engineering/mechanical+eng/book/978-3-540-89041-6).

Assessment and Exploitation of Project Results and Benchmarking

In this reporting period, assessment and exploitation of results were attained via the ongoing elaboration of the following tasks:

- 2nd SAFEDOR Benchmarking study

The 2nd SAFEDOR International Benchmark Study on Numerical Simulation Methods for the Prediction of Parametric Rolling of Ships in Waves (http://www.naval.ntua.gr/sdl/sibs) was organized within the SAFEDOR - SP 7.3.9; it was announced in July 2008 and completed in February 2009. Thirteen qualified institutes worldwide from both inside and outside SAFEDOR, that have been established as developers of relevant simulation methods and computer programs, participated in the study, which was coordinated by NTUA-SDL.
The study on the simulation of a containership in waves under conditions of parametric roll resonance assessed first the overall performance level of the benchmarked simulation codes. Numerical simulations were compared with available and newly conducted model experiments for a series of 20 specified benchmark tests. The study leads to the conclusion that the mean overall performance level of benchmarked codes is low with notable divergence between the individual numerical estimations, while an improved and satisfactory efficiency was observed when taking into account the performance of the best performing and more mature methods.

Published results

Synoptically, during its fourth project year, SAFEDOR produced the following results that have been made available to the public:

- SAFEDOR Book : Papanikolaou A. (ed.), 2009, "Risk-based Ship Design – Methods, Tools and Applications", SPRINGER, ISBN 978-3-540-89041-6, February 2009.
  http://www.springer.com/engineering/mechanical+eng/book/978-3-540-89041-6

- Benchmark on Intact Stability-Parametric Roll
  http://www.naval.ntua.gr/sdl/sibs

- Newsletter Issue 5: SAFEDOR FSA Studies (October 2008)
  http://www.safedor.org/resources/SAFEDOR_Newsletter_October2008-Issue5.pdf

- Newsletter Issue 6: SAFEDOR Research Overall Results & Outlook (March 2009)
  http://www.safedor.org/resources/SAFEDOR_Newsletter_March2009-Issue6-v2.pdf

- Fact sheet for owners
  http://www.safedor.org/resources/SAFEDOR-I-SC-2009-03-18-GL-fact-sheet-for-owners.pdf

- Fact sheet for yards
  http://www.safedor.org/resources/SAFEDOR-I-SC-2009-03-18-GL-fact-sheet-for-yards.pdf

- Fact sheet for suppliers
  http://www.safedor.org/resources/SAFEDOR-I-SC-2009-03-18-GL-fact-sheet-for-suppliers.pdf

7 Conclusions and Way Ahead

With the regulatory framework for shipping changing towards a more goal-based style and new regulations addressing fire safety, damage stability and - in the near future - life saving appliances advanced by IMO, the design solution space available to the ship designer is expanded. Ship designers have now available increasingly sophisticated methods and tools supporting advanced and risk-based ship design and including safety as additional objective into the design process. Risk evaluation criteria are eventually becoming explicit and accepted also at maritime administrations and enable a holistic decision-making. Taken together, all necessary elements and the frame are now available to produce innovative ships with enhanced economics and increased safety.

Although the further development of the Goal-based Standards (GBS) at IMO using the risk-based Safety-Level Approach (SLA) is not progressing fast, a clear trend is seen towards using risk analysis in design, approval and rule-making. In this respect, the planned review of the FSA studies conducted by SAFEDOR at IMO (MSC 86 in May 2009) is seen as a large step towards documenting risk levels for shipping at IMO. In parallel, industry has started using the risk-based approach developed in SAFEDOR in a number of new commercial and research projects. And the European maritime industry has identified the implementation of risk-based frameworks as key priority towards 2020.

Risk-based ships are sailing today and their operational aspects are aligned with the current regulatory framework treating risk-based elements as equivalents. Details and reasons for the acceptance of the equivalent are to be communicated to IMO and circulated to IMO Member States. With the advent of more design aspects of a ship becoming risk-based, there is a clear need to ensure complete documentation of all risk-based elements of a ship together with the process and criteria of acceptance should be carried onboard. In addition, a proper summary addressing the concerns of surveyors and port state control officers should be drafted.

The short-term plans of the SAFEDOR consortium on the way ahead will be besides the implementation of developed refined concepts, the further elaboration of risk-based ship design and assessment procedures in specific safety critical areas, like survivability in case of flooding (damage stability of passenger ships) and fire safety. In this respect, three ongoing FP7 RTD projects are being launched within 2009, namely FLOODSTAND (kick-off: April 2009), FIREPROOF (kick-off June 2009) and GOALDS (planned kick-off September 2009). All above projects were initiated and are co-ordinated by major SAFEDOR consortium partners and a large number of SAFEDOR partners participating in them are anticipated to further refine the introduced concepts, in accordance with the original aims and objectives of SAFEDOR.

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9 List of SAFEDOR Publications in Year 4

During the last project year**,** results of SAFEDOR were presented at a variety of international conferences and scientific journals. The following list of publications is divided into three sections, namely:

- publications with acknowledgement of SAFEDOR
- publications relevant to SAFEDOR in a broader sense, but not developed as SAFEDOR activity
- IMO submissions/publications

<u>Publications with acknowledgement of SAFEDOR</u>

1. Breinholt Christian, Ehrke Karl-Christian, Pavaut Carole, Sames Pierre C., Skjong Rolf, Strang Tom and Vassalos Dracos, 2009, "SAFEDOR – The Implementation of Risk-Based Ship Design and Approval", 10th International Marine Design Conference, IMDC 2009, Trondheim, Norway, May 2009.
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SAFEDOR Publications – Submissions to IMO

IMO Submissions 2008

- MSC 85/17/1 (2008) Formal Safety Assessment; FSA – Cruise vessels, submitted by Denmark.
- MSC 85/INF.2 (2008). Formal Safety Assessment; FSA – Cruise ships; Details of the Formal Safety Assessment, submitted by Denmark.
- MSC 85/17/2 (2008) Formal Safety Assessment; FSA – RoPax ships, submitted by Denmark.
- MSC 85/INF.3 (2008). Formal Safety Assessment; FSA – RoPax ships; Details of the Formal Safety Assessment, submitted by Denmark.
- MEPC 58/17/2 (2008). Formal Safety Assessment; FSA – Crude Oil Tankers, submitted by Denmark.
- MEPC 58/INF.2 (2008) Formal Safety Assessment; FSA – Crude Oil Tankers; Details of the Formal Safety Assessment, submitted by Denmark.

IMO Submissions 2009

- MSC85/5/10 GOAL-BASED NEW SHIP CONSTRUCTION STANDARDS, Alternative to the GBS verification process – Consequences for SOLAS amendments, Submitted by Norway
- MSC86/5/3 GOAL-BASED NEW SHIP CONSTRUCTION STANDARDS, Guidelines on approval of risk-based ship design, Submitted by Denmark
- MSC86/5/4 GOAL-BASED NEW SHIP CONSTRUCTION STANDARDS, Alternative to the GBS verification process, Submitted by Canada, Norway and Sweden
- MSC86/INF.4 General Cargo ship Safety – FSA – Initial Step. Submitted by IACS. (Authors: R Skjong and M Dahl (DNV), R Hamann (GL)
- FP53/5/3 MEASURES TO PREVENT EXPLOSIONS ON OIL AND CHEMICAL TANKERS TRANSPORTING LOW-FLASH POINT CARGOES, Formal Safety Assessment on the installation of inert gas systems on tankers of less than 20,000 dwt. Findings and a possible way forward, Submitted by Norway (Authors: M Thomas and R Skjong, DNV)