SAFEDOR

design, operation and regulation for safety

Integrated Project 516278
in the sixth framework programme of the European Commission

http://www.safedor.org

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Contents Issue No. 2

Editorial

The SAFEDOR Consortium is pleased to welcoming you as a reader of the 2nd SAFEDOR Newsletter, which appears bi-annually and intends to inform about research activities and relevant progress of the SAFEDOR Project. More detailed public domain information about the SAFEDOR project is provided in the Annual Public Reports. The first and (*shortly*) the second year report, as well as other public domain results are available on-line (http://www.safedor.org).

The SAFEDOR newsletter addresses readers from organisations from the whole spectrum of the maritime industry: flag state and government administrations, classification societies, designers, operators, researchers, educators, and practitioners of risk-based design. This second issue of the SAFEDOR newsletters aims to acquaint you with SAFEDOR activities developing innovative ship designs, presenting some main achievements of the project during the second year of activity.

Design Activities in Brief

The principal objective of SAFEDOR design activities is to develop innovative ships that are equally safe or safer than today, while exhibiting reduced building costs and/or improved earning potential, but for formal reasons cannot be approved under the current rules, class and/or flag regulations. These activities build on newly developed -within other SAFEDOR workpackages- methods and tools, and aim to:

- test the practicability of the proposed risk-based design approach,
- challenge some regulations that restrain innovation,
- develop a common understanding for risk-based approaches by implementing it,

- gain experience that can be used to refine the documentation of risk-based regulatory framework and for the training, and
- sustain competitiveness of European maritime industry by producing prototype designs.

SAFEDOR has invested massively into embedding the risk-based design process into the heart of the EU maritime industry by assembling a series of design teams (comprised of leading ship owners, major ship yards, main marine equipment suppliers /manufacturers, design/consulting offices and one major European classification society) to pursue innovative ship designs, which cannot formally be approved by existing regulations. Eight –8– different design studies (*each one conducted under the umbrella of an individual subproject*) have been developed during the first two years of the project for the following ship types:

- Cruise ship – Post-Panamax size
- Cruise vessel
- Fast full displacement ferry
- The 13th Passenger
- Lightweight composite sandwich superstructure
- Short sea LNG vessel
- Container vessel
- Oil tanker – AFRAMAX-size

For each one of the above ship types, a Preliminary Design Study has been elaborated during the first project year. All designs were refined during the second year and are now documented by a set of reports comprising a Design Study, an Economic Impact Study and a Safety & Environmental Impact Study. All innovative ship designs went through an evaluation process aiming at selecting the two best designs for further development in the next year.

Some details of the innovative ship designs are presented in the following.

Innovative Ship Designs

➢ Cruise ship – Post-Panamax size

Design Problem

Post-Panama ships are very large and technologically complex vessels – continuously growing in size, very profitable and with high economic value for the European Industry.

The opportunity for adopting a goal-based design on this shiptype has not been systematically explored. A performance-based design approach may play an important role in this process. Of course, ship designers may still take advantage of some SOLAS regulations offering the explicitly opportunity of proposing “equivalent” design solutions, but the difficulty in this approach is that safety levels and the required performances should be determined and agreed before assessing the equivalent level of safety of any alternative design.

In order to treat safety as a design objective, it is necessary to establish a performance - based regulatory framework.

Design Focus

Using a Post-Panama cruise ship as reference (130,000 GRT), the focus is to design, through performance-based methodology, a new Post-Panama Cruise vessel with design solutions looking for a better client satisfaction and an adequate safety level referred to the design goals.

At the same time, the focus is to assess if a performance-based design is more effective than a conventional design, based upon prescriptive rules and regulations, and if there is a sensible cost variation, which may influence the decision.

Design Concept

The design study of this subproject is summarized in the following:

- Definition of main commercial goals: range of operation, speed, payload, use of public spaces, operational flexibility, logistics etc.
- Definition of main safety goals: Stability (based upon a "platform optimisation" concept and the possible use of side sponsons), Fire prevention (innovative lay-out of large public spaces and stairway enclosures), Evacuation and Abandonment (including compatibility with innovative Life Saving Appliances), Bridge design and equipment to prevent collisions.
- Analysis of regulatory framework.
- Setting of vessel functional requirements to meet the defined goals.
- Identification of Alternative Design and Performance Criteria to meet these goals.
- Preliminary Cost-Benefit analysis.
- Development of vessel specific design features, to be assessed by means of performance-based criteria.

Innovations Aspects

Specific intentions of this design concept were to introduce among other things:

- At least a public space exceeding the current size limits required by SOLAS
- Reconsideration of the prescriptive limits for fire load and material certification in public spaces.
- Type, arrangement, position and configuration of innovative Life-saving Appliances.
- Use of stairway enclosures as assembly stations (Safe Area).
- Platform optimisation, based upon the new probabilistic damage requirements, including also a comparison between the IMO Weather Criterion standard methodology and the alternative assessment.
- Improved navigation / bridge equipment to prevent collisions

➢ Cruise vessel

Design Problem

At present, the safety of any vessel is defined with reference to strict prescriptive rules, all derived and created over many years with a constant feedback from incidents and accidents. However, the rules have primarily been written for passenger liners and not for actual tourist cruise ships, which are designed for a higher number of people onboard.

The increase of size required to introduce amended rules to SOLAS imposing further restrictions to the design and layout of future cruise ships: Fire-Zone length, Position and types of lifesaving appliances, Type of fire doors, Margin Line.

In addition, pollution of the environment in case of fire, grounding or collision needs to be addressed.

Design Focus

The focus was to design a Cruise Liner with Risk-Based tools and methods which will be safer than existing ones, in terms of passenger safety and which shall be designed with reduced incidental damages to the environment in case of grounding and collision comparing with existing vessels; And at the same time, to design a cruise vessel more attractive to the cruise industry with maximum exterior cabins, very large public rooms, which can be used as its own lifeboat.

Design Concept

The design study of this subproject is summarized in the following:

- Selection of a benchmark vessel
- Selection of a novel concept design.

From the start, the goal has been to create a vessel, which in all respects will be safer than the present ones, and the results of the first phase seems to be indicative that this goal can be fulfilled.

The development of the Concept Vessel has required a certain input from the industry. This has led to a very thorough investigation and testing of extremely large mobile fire barriers.

Innovations Aspects

Specific intentions of this design concept were to introduce among other things:

- Innovative and novel layout with very large fire-curtains, fire zones and watertight compartments
- balconies in all passenger cabins
- an upper structure working as a lifebelt in case of very large damages
- Transversal and longitudinal Cross flooding through valve operate trunks
- Novel machinery location, etc.

➢ Fast full displacement ferry

Design Problem

The principal objective of SP 6.3 was to focus on innovative fast full displacement ferry designs that are expected to provide as high or higher a safety standard as today's solutions.

The developed designs were anticipated to have features, which for formal reasons cannot be approved under the current rules, class and/or flag regulations.

Design Process

Safety provision in ship design process has been based to date on the compliance with a set of prescriptive regulations.

When the safety is no more defined by means of compliance with prescriptive rules, designers have new freedom to search novel solutions, i.e. perform Risk-Based design.

The chance of loss (=risk) were studied with the following means:

– Simplified FMEA (*Failure Mode Effect Analysis*) in respect of loss of vital ship systems in case of collsion and flooding in way of machinery rooms.
– Risk Model in respect of loss of human life in case of collision and flooding.

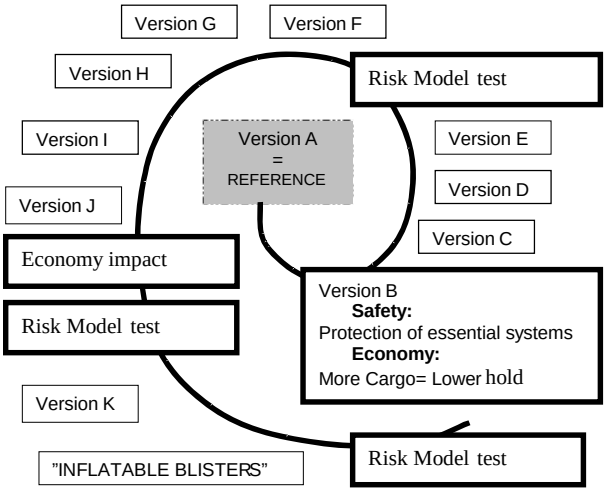

Figure 1: Risk-Based Design Spiral

Ten variations of the novel watertight arrangement were developed and assessed. The impact on cargo capacity, damage stability / attained subdivision index were calculated for all design versions. Versions E, J and K were analysed in more detail with available elements of the risk model provided by another SAFEDOR subproject on Fast and Accurate Flooding Predictions.

The economic impact was analysed in detail for versions E and J. For each

of the design versions two alternative cargo configurations were considered in economic impact calculations:

– Maximum car capacity =hoistable car decks on two deck levels as in the reference vessel.
– Maximum trailer capacity = one hoistable car deck removed.

Design Concept

The design team selected an existing fast full displacement ferry design with L_{OA} 186 m, trailer lane capacity of 1960, and passenger capacity of 2200 passengers, as a state of art vessel. Among the numerous alternative approaches, the following three solutions were selected to be further studied:

- Increase the cargo capacity with lower hold combined with novel type of watertight arrangement.
- Novel watertight compartment arrangement, in order to protect vital ship systems.
- "Inflatable reserve buoyancy" built on the hull for enhanced survivability.

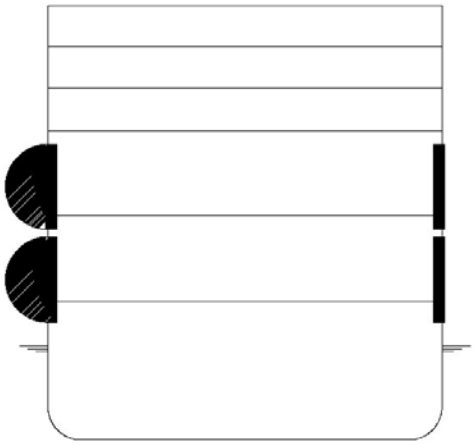

Figure 2 : Principle of inflatable blisters

Figure 2 shows the principle of the blister. On the left side the blisters are deployed, on the right the blisters are in stored position.

The "inflatable reserve buoyancy", composed of numerous autonomous systems, will deploy automatically when a vessel exceeds some critical angle of heel or submerges under water. Since no data on such product have been found to date, the study addressed the impact on the ship survivability only.

Innovations Aspects

A set of innovative designs was developed with the following characteristics:

- Improved earnings (~1 year payback, ~6% net earnings).
- Cleaner transport (~7% lesser emissions per unit).
- Dramatic 90% risk reduction possible in collision and flooding.
- 45% increase in system's availability in collision and flooding in machinery area.

The developed design concept challenges the following rules:

- MSC Resolution 194 (80) the SOLAS II-1, Regulation 6.1 on the attained index of subdivision, not met.
- MSC Resolution 194 (80) SOLAS II-1, Regulation 9 on the extent of the double bottom, not met.
- SOLAS III, Regulation 21.1.2. 1 on provision of life boats, either MES system only or no LSA at all considered.
- SOLAS II-2, Regulation 9.2.2.1.2 on fire zones.

Although all of the new solutions challenge a series of current regulations, it has been shown, that some of them prove less risky than a design fully compliant with the deterministic legislation regime without any economic compromise, or indeed enhancing their commercial attractiveness and environment-friendliness.

The design process applied throughout this subproject, albeit still rather limited in the extent due to the lack of relevant tools, has allowed clear demonstration of the implementation

of the SAFEDOR philosophy of "risk-based" design.

➢ The 13th Passenger

Design Problem

Existing rules and regulations do not explicitly reflect the risks, which a ship or its passengers are exposed to. In the case of damage stability and fire safety, most rules apply if more than 12 passengers are to be transported. No matter whether the vessel is designed for 13 or 2500 passengers, the requirements are more or less the same.

Consequently, the transport of a small number of passengers is economically of limited interests.

Specific intentions of this project are to identify in qualitative terms the safety level of present vessels with 12 passengers and to design an innovative one as safe as the SOLAS vessel but more cost- efficient.

Design Focus

The focus is to design a RoPax ferry for about 50 passenger, using risk-based principles and not-SOLAS requirements, which will be as safe as a design using SOLAS but more cost-efficient. In addition, a novel system to distribute electrical energy was investigated.

The main aim addressed is to develop a design concept for a RoPAX vessel carrying more than twelve, but not more than fifty passengers, based on an existing modern RoRo ship.

Design Concept

To fulfil the aims without the constraints of prescriptive SOLAS and Class Rules, a risk-based approach is chosen. The major tasks addressed during the concept design definition are:

- Selection of a reference design.
- Issuing a specification for the modification of the reference vessel.
- Making an initial cost estimate for a vessel according to the rules.
- Identification of relevant rules and their intention.
- Identification of hazards, which are threatening the safety of passengers.
- Identification, in qualitative terms, of the safety level of a vessel of 12 passengers according to rules and regulations.
- Identification of differences in risk between reference vessel and modified vessel using a qualitative, risk-based approach
- Identification of main risk contributors for the modified vessel.

➢ Lightweight composite sandwich superstructure

Design Concept

The aim is to provide documentation of the risks and benefits of a composite superstructure in a passenger ship. The design goal is to develop a commercially attractive design solution that exploits the advantages offered by lightweight composite structures. To achieve this, it is necessary to demonstrate that the composite design is safe.

The design study of this subproject is summarized in the following:

- Definition of goals
- Analysis of SOLAS safety objectives and functional requirements
- Identification of rules challenged by new design
- Adoption of a pragmatic approach to reach the objective
- Identification of hazards and critical fire scenarios
- Development of fire risk model
- Selection of an application case

- Establishment of an electronic geometry model of superstructure (identical to existing steel design)
- Extraction of FE model of composite module
- Definition of Composite materials and scantlings

Figure 3: Design case showing composite module

Design Problem

The state of the art prior to this project is that economic lightweight design solutions and fire protection systems are suitable for HSC and Naval Ships. However, merchant ships (except HSC) have to satisfy requirements of SOLAS convention that prevent the use of composites.

Specific intentions of this project were to carry out a risk based design approach in order to allow introduction of lightweight composite structures in superstructures of merchant ships and to provide benchmark examples for application of fire safety engineering and methods.

Design Focus

The focus is to develop an economic lightweight composite sandwich design concept for a superstructure on a passenger ship through developing a fire risk model and to provide a quantitative measure of the fire risks associated with the new design concept and the economic benefits expected from using it.

➢ Short sea LNG vessel

Design Problem

There is a growing market for small-scale LNG distribution in Europe (and Asia). Small LNG carriers may be economical with two cylindrical cargo tanks (type C). That permits the transport of LNG pressurised.

The LNG vessel is developed in order to transport LNG for short distances from small-scale LNG factories/storage tanks to small-scale end-customers, in such way boil-off reliquification is not required. Instead, a thermal oxidiser could be installed.

This scenario permit to challenge some rules in particular:

- Structural Solutions – IGC rules using the new CNG (Compressed Natural Gas Carriers) class rules which permit to used equivalent bottom solutions if they can be shown by calculations or tests to offer the same protection to the cargo tank against indentations and the same energy absorption capabilities as conventional double bottom design.
- Gas combustion unit – No code exist for small vessels
- Machinery Solutions – ICG Code: gas dangerous areas

Design Focus

The focus is to develop a short sea LNG vessel which can distribute gas to small scale customers with a structural solution optimised using the principia of safety equivalency establish in the CNG rules; and to test the implementation of new LNG equipments as power connector, gas combustion units, medium pressure pneumatic cargo valve actuators, argon, since a safety and economic point of view.

Design Concept

The design study of this subproject is summarized in the following:

- Knowledge Exchange between the partners.
- Analysis of state of the art.
- Development of a preliminary business case to identify market drivers and constraints. Requirement profile
- Selection of a reference vessel.
- Analysis of present rules and regulations.
- Identification of innovations which could be integrated and tested out within the framework of the basic design including their economic profitability.
- Identification of rules challenged by new design.
- Establishment of design concept: Development of a short sea LNG vessel which can distribute gas to small scale customers with a structural solution optimised using the principia of safety equivalency established in the CNG rules.

Innovations Aspects

This design incorporate the following innovations

- Power connector – ICG Code: no rules at all
- Medium pressure pneumatic cargo valve actuators
- Use of Argon as inert gas

➢ Container vessel

Design Problem

Open top feeder ships are potentially regarded as an effective transport means for short sea shipping service where cargo-handling times are the crucial driving forces. But open top container ships are still the exception. The reason for this is likely that these vessels have quite significant rule-based economic disadvantages: A bigger tonnage and therefore higher operation costs.

Design Focus

The focus is on the creation of a low gross tonnage, highly competitive and equivalent safe open-top container vessel through challenging current rules where necessary to make it more competitive.

Design Concept

The aim of this subproject is to design and promote an innovative open top feeder containership. These ship designs will have the same or higher overall safety level as existing standard ships, although they do infringe certain mandatory (safety) rules and / or regulations.

Figure 4: Open Top Containership

The design study is summarized in the following:

- Knowledge exchange on open top container vessels: Design implications, identification of market drivers and constraints, market prospects
- The legal environment: Existing rules and regulations, guidelines, specific requirements
- Identification of market entry barriers and ways to overcome these, respectively which rules and/or regulations will be addressed (and challenged) to achieve a competitive advantage.
- Design outline of the innovative open top container design

➢ Oil tanker – AFRAMAX-size

Design Problem

The transportation of oil by tankers involves a very high risk since the consequences in case of accidents can be catastrophic. Although the frequency of accidents has been substantially reduced in the post-90 period, there is not reduction in spilled tonnes rates (by ship year) in the same period. A series of IMO regulations concerning the prevention of incidents and accidents have contributed to this improvement, however the state of affairs is yet not satisfactory. Public have zero tolerance for oil spill and associated pollution.

Double Hull design is not the only improvement taken place in improving safety of tankers. Many others have into force during last 26 years, but not all regulations are cost effective. Using a risk assessment methodology, regulations can be justifiably introduced to improve the safety of tanker designs and operation.

The intention of this subproject is, taking as reference (state of art vessel) a double hull tanker, to challenge some rules of the MARPOL 73/78 and SOLAS II-2 Part b, relative to general layout of the vessel, cargo tank size, tank length limitation, capacity of the segregated ballast tanks, and, among others:

- to get a greater overall oil outflow performance
- to increase cargo capacity
- to improve cargo handling

Design Focus

To evolve a Double Hull concept, as it is publicly and politically set to be the norm, with the following safety goals:

- Reduction of potential of medium to large amount oil spills significantly.
- Eliminate small size oil spills due to operational incidents/accidents.
- Significantly reduced ballast water exchange and their effects.

Design Concept

This task discusses the background of AFRAMAX tankers and proposes a highly competitive oil tanker design concept challenging some requirements of current regulation.

- More cost-effective to build and operate,
- In line with modern safety expectations.

In order to develop an oil tanker design in concept level, having the above key objectives in mind, the following activities were carried out:

- Identification of basic functionality and performance requirements.
- Identification and reporting of basic safety expectations.
- Identification of rules that govern tanker design: overview of rules and regulations, in particular rules concerning tank configurations.
- Development of design specification: design objectives, functional requirements and design criteria.

Figure 5: AFRAMAX Tanker

The implemented case study focused on the multiobjective optimisation of an AFRAMAX tanker by genetic algorithms, considering a variation of only the main cargo block parameters to demonstrate the potential of best performing designs with respect to

both environmental impact and transport economy.

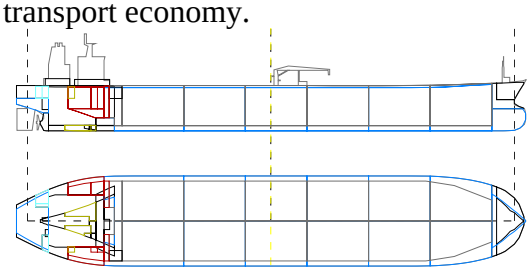

Figure 6: Case Study Vessel: AFRAMAX Tanker

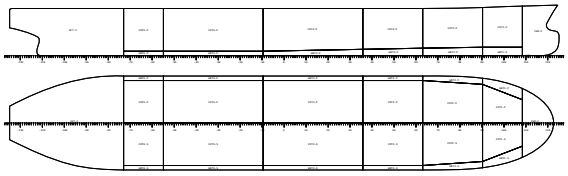

Figure 7: Identified 'Pareto Optima' Design (DH alternative- *ID.141*)

Evaluation Process

The design subproject evaluation was performed through a transparent assessment by a formed evaluation panel on 14-15 December 2006. The evaluation panel was comprised by all members of the Steering Committee and four independent experts from the maritime industry. The evaluation panel concluded on a "joint summary statement".

During the evaluation, the designs were ranked using pre-defined "evaluation criteria".
These criteria were:

- Economic impact: The degree to which the proposed design offers reduced costs and / or improved earning potentials.
- Safety impact: The degree to which the proposed design contributes to safer transport.
- Environmental impact: The degree to which the proposed design contributes to cleaner transport.
- Feasibility: The degree to which the proposed design is technically and politically feasible.
- Rule challenge: The degree to which the proposed design deviates from prescriptive rules.
- Quality of analysis and documentation.

Winning Designs

The two highest assessed design projects were:

- Lightweight Composite Composite Superstructure,
- Fast Displacement Ro-Pax Ferry

These two designs will continue with their detailed design study and eventually, a preliminary approval will be considered by the involved class societies and flag states.

Lightweight Composite Composite Superstructure

The proposed use of composite construction for superstructures for passenger ships was considered to be innovative and with a high economic impact. At the same time it was challenging the current regulations, whilst providing sufficient arguments that safety would not be compromised.

The documentation of the design will be updated to enable a more accurate estimation of economic impacts. The main challenge is to properly address all the issues required for the design approval. In this sense, the description of the design needs to be detailed enough for approval in principle.

Fast Displacement Ro-Pax Ferry

The proposed design followed the holistic approach advocated in SAFEDOR and demonstrated how risk-based design can be implemented focussing on system availability and survivability.
The main focus of the development has been a novel type of watertight

arrangement with long lower hold, for increased likelihood of systems availability in case of a collision and a solution with inflatable buoyancy blisters for enhanced survivability.
The proposed "life-belt" concept of inflatable reserve buoyancy offers significant safety advantage, although it requires further investigations to demonstrate its feasibility.

Conclusions

For the next generation of innovative ship types, there seems to be no alternative to risk-based design, operation and regulation.

By incorporating safety as a design objective, the two winning designs have demonstrated to achieve – in principle – the same safety level at lower cost, or to increase the safety at the same cost. And, with fast and accurate performance prediction tools – already being developed through SAFEDOR- the total design process time can be shortened and the objective quality of the design is improved. Thus, incorporation of safety as a design objective makes possible the development of innovative ship designs representing clear progress beyond state of the art.

With the two winning innovative designs, SAFEDOR will demonstrate that it is feasible to sustain the competitiveness of the European maritime industry, increasing the actual leadership of European shipbuilding in the segment of knowledge-intensive and safety-critical vessels with economic interest for Europe.

Furthermore, increased safety levels will result in safer and more environmentally friendly navigation. In this respect, it could be argued that there is a real chance in having to show tangible success at large scale (in the form of a unique ship design) deriving through the activities performed in the final design studies and the preliminary approval of the selected designs.

Dissemination Activities

A series of SAFEDOR dissemination events are planned for years 2008-2009, namely:

- The 2nd Open Workshop of SAFEDOR, in spring 2008
- The SAFEDOR postgraduate training course on risk-based design, operation and regulations, in spring-summer 2008
- The SAFEDOR Final Conference, in spring 2009.

For further information, please refer to the available brochures at http://www.safedor.org , as well as to the sequential issues of the present newsletter.

SAFEDOR

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