Safety at Speed - S@S

DESIGN FOR SAFETY METHODOLOGY
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CONTENTS

ANNEXES

1. EXECUTIVE SUMMARY SUITABLE FOR PUBLICATION

Deliverable 550 outlines the Design for Safety philosophy in relation to the wider Marine Industry. It then focuses in on how Safety at Speed fits into this philosophy and the impact it may have on the sector.

The annexes are included to give the user an understanding of how the mechanics of each model works and how to apply the S@S design tool and associated models to real life design processes.

2. THE BACKGROUND TO DESIGN FOR SAFETY

The concept of "Design for Safety" stems from a desire to allow greater flexibility in marine design. This flexibility is required to allow for improved performance of the craft in operation, whether that means a reduction in the maintenance costs or increased passenger numbers strict prescriptive rules limit the design space available to the naval architect, thus preventing the full potential income being reached.

To achieve this flexibility, "total" approaches to safety have been developed where safety sits a long side the other design characteristics. This means that as well as designing for a speed and capacity the naval architect designs to minimise the risks to an acceptable level.

The traditional safety approach is demonstrated in the figure below:

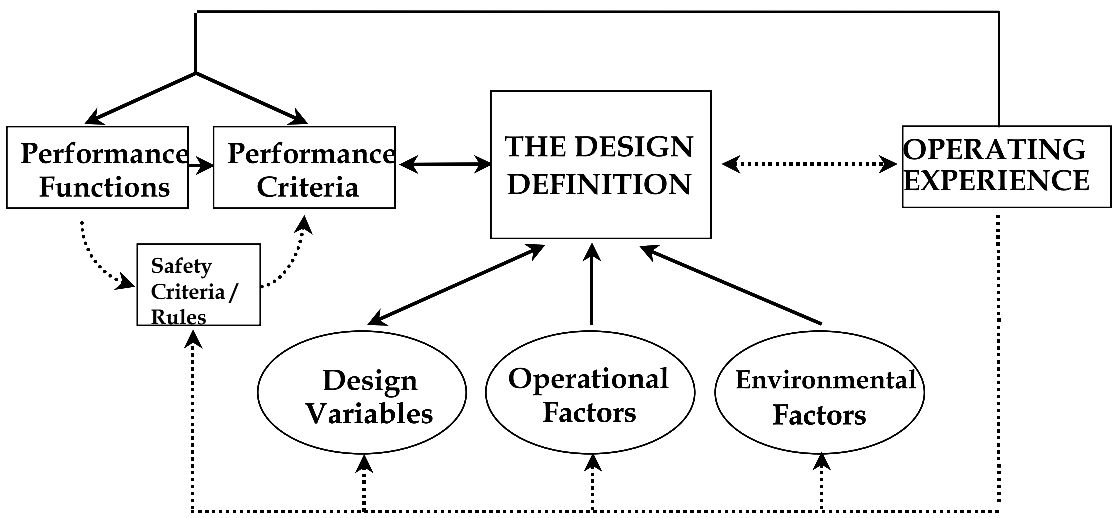

Figure 1 – Traditional prescriptive rule approach to design

This approach is an add-on to the design process. In other words it just checks that the design meets the rules after the design has been formulated. This limits how flexible the design can be as it either passes or fails.

This is not an accurate description of safety and so in the early to mid nineties the marine community evolved, for the marine industry, the concept of as low as reasonably practicable.

Code		Definition
U	**Unacceptable**	Risk cannot be justified on any grounds
A1	**ALARP 1**	Tolerable only if risk reduction is impractical or if penalties are disproportionate to the improvement gained
A2	**ALARP 2**	Tolerable if penalties of reduction would exceed the improvement gained
N	**Negligible**	No need for detailed working to demonstrate ALARP

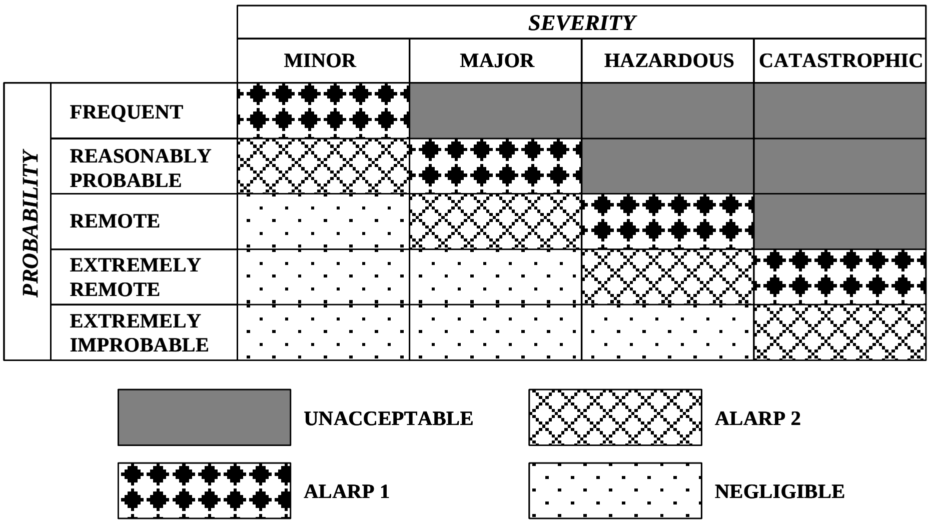

Figure 2 Qualitative levels of risk [International Maritime Organisation, 1995]

This gave regulators and designers the ability to discriminate between different risks in a way that was not possible before. Once it was recognised that there are different levels of risk it was possible to start introducing flexibility into the rules. In addition to this "Formal Safety Assessment" was introduced. This gave five steps for ensuring the safety of a vessel.

1. identification of hazards;
2. evaluation of risks;
3. identification of risk control options (RCO);
4. cost benefit analysis of RCO;
5. recommendations for decision-making

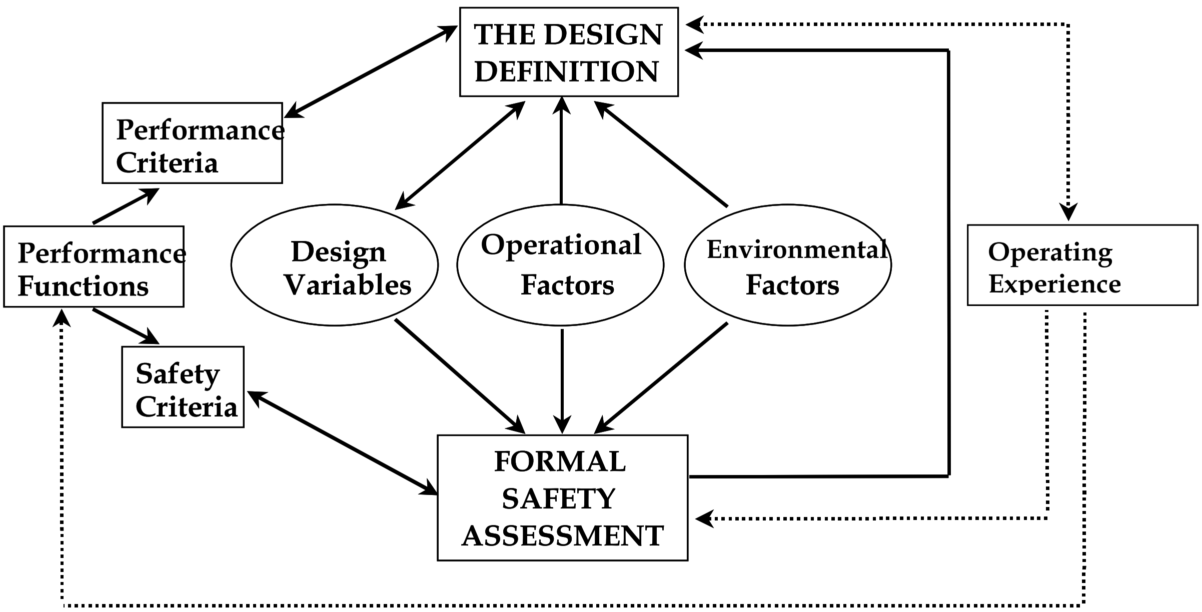

Figure 3 - New design process

This represented a fundamental shift in dealing with safety as the regulations went from constraints on the vessel to characteristics of the design, in the same way the structural properties were a design characteristic.

However, FSA proved more difficult to implement than anticipated due to the resources required to execute it, for example, for each vessel a complete hazard identification exercise had to be completed. The added flexibility could lead to some improvements in design quality in terms of safety and economic performance but the design costs were excessive.

3. DESIGN FOR SAFETY CONCEPTS

"Design for Safety" aims to integrate safety cost-effectively in the ship design process. The need to adopt "total" and flexible approaches for improving safety is now appreciated by all concerned. FSA showed that safety is a global concept and fragmented attempts to tackling it tended to produce biased, incomplete and ineffective solutions.

To overcome the resource demand of FSA, an integrative and holistic approach that links safety performance prediction through the use of appropriate predictive "tools" and technological innovation, risk assessment deriving from risk-based methodologies and design is adopted, as illustrated in Figure 1.

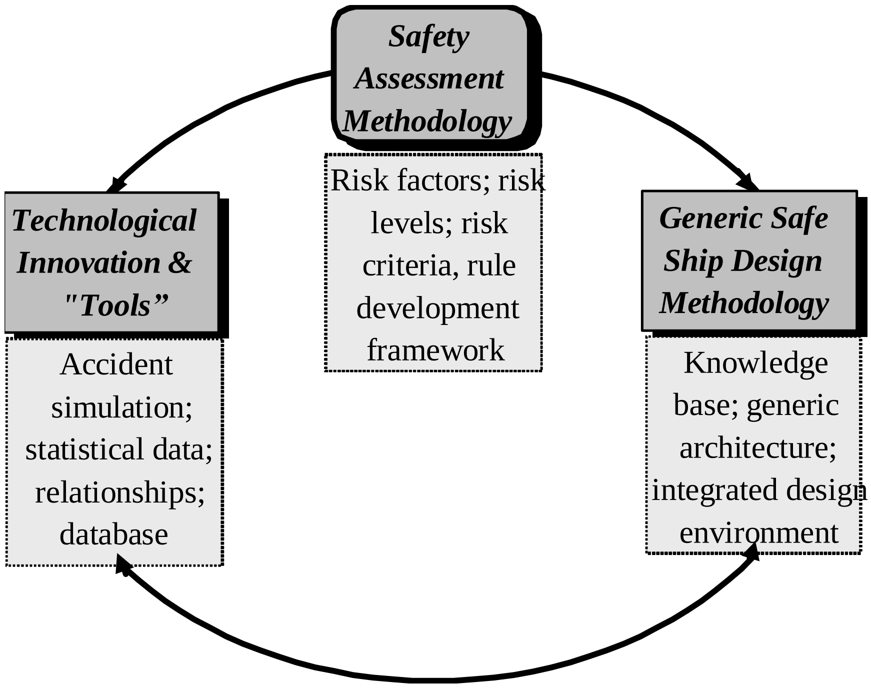

Figure 1- Design for Safety Philosophy

The underlying theme is that safety assessment will enable safe-ship-designing to be formalised as a process within an iterative procedure that allows a two-way dynamic link between tools and design, where design constraints are defined or filtered by the process of safety assessment and indeed assurance. The procedure, on the one hand, gathers and assimilates technical information, prioritises safety issues, identifies practical and cost-effective safeguards and sets requirements and constraints for the design process.

On the other hand it provides feedback from the design process to stimulate validation and refinement of the tools, in the light of the experience gained from simulation, implementation, and/or practical applications. In this process, risk assessment "pulls" together developments on consequence analysis tools, design measures/parameters, systems design and approaches to preventing and mitigating risks. In risk-based design methodologies, cost-effectiveness of safety measures is used to achieve a balance between costs and safety optimally to render risks as low as reasonably practical, whilst accounting for other design priorities and constraints.

4. ADOPTING A RISK-BASED APPROACH IN SHIP DESIGN

Traditionally ship design has focused on balancing technical and economic considerations, with adherence to safety requirements being a design periphery at best, if not a design afterthought. Furthermore, within current ship design practice any safety-related consideration is treated with reference to prescriptive regulations, conformance to which is sought by performing deterministic assessments. In this manner, safety is imposed as a constraint to the design process of a ship, an undertaking that has resulted in the ill-based concept that investment in safety compromises returns.

On this background, the approach presently advocated comprises the following principal characteristics:

- Development of working design frameworks appropriate for various stages of the design process, with particular emphasis paid to the required design input and output for their effective application.
- Utilisation of predictive tools and techniques for assessment purposes, with the view to adequately take into account prevailing environmental conditions and vessel responses during the design process.
- Transfer of knowledge from the production and operational phases and utilisation within design in the form of input to the working frameworks applicable to the design process.

In so doing, safety is becoming a central life-cycle issue, addressed critically as early as possible within design. Appropriate coupling of typical risk assessment techniques with first-principles methods and tools offers the potential for these requirements, not only to provide design input and to be implemented within the design process, but also to assist in the development and assessment of the effectiveness of rules and regulations and in the proposal of appropriate criteria. In this respect, safety assurance is embedded within the ship design process, treated as it should as a core design objective.

Specific elements of the work content include the following:

- In applying first-principles/performance-based approaches, a number of appropriate numerical tools for incidents frequency-of-occurrence prediction and consequence analysis and modelling are deployed. This work is assisted by the updating and completion of the relevant technical data and accident statistics, in order to allow the delivery of comprehensive risk/cost models with reference to potential societal and economic consequences (losses/gains of human life, cargo, property, environment etc.).

- Models addressing the issue of socio-economic implications of shipping (from a organisational/managerial perspective), evaluating individual and societal levels of risk, cost and performance, and finally the way to achieving safety equivalency from a regulatory point of view are required. This information will be integrated into comprehensive risk models (e.g. fault and event trees), which reflect the seriousness of incidents occurring and their potential consequences, with the view to building the reference risk-based design framework.
- The risk-based design framework covers issues such as balance between effects on safety and performance of various risk contributors or choice of appropriate risk control options and the implementation of appropriate design trade-offs in a systematic manner.

Methods/procedures for establishing risk levels corresponding to the major hazards that may occur during operation and for decision making considering available risk control options (RCO) are developed, which influence ship costs and performance, in order to quantify trade-offs and perform optimisation among the RCO within a multi-criteria environment accounting for other design constraints and objectives. The effects of risk reducing design features on resistance, seakeeping, loading/unloading, stability, and so on, are determined by utilising relevant tools in the design process. Cost-effectiveness of safety enhancing design features or measures is used as a basis to achieve balance between costs, safety and performance optimally whilst rendering risks as low as reasonably practical.

5. SAFETY AT SPEED IN DESIGN FOR SAFETY

Safety at Speed has developed the concepts described above into an integrated tool which provides a framework for the quick evaluation of safety at the concept and preliminary design stages, which can fit into the design process as shown below:

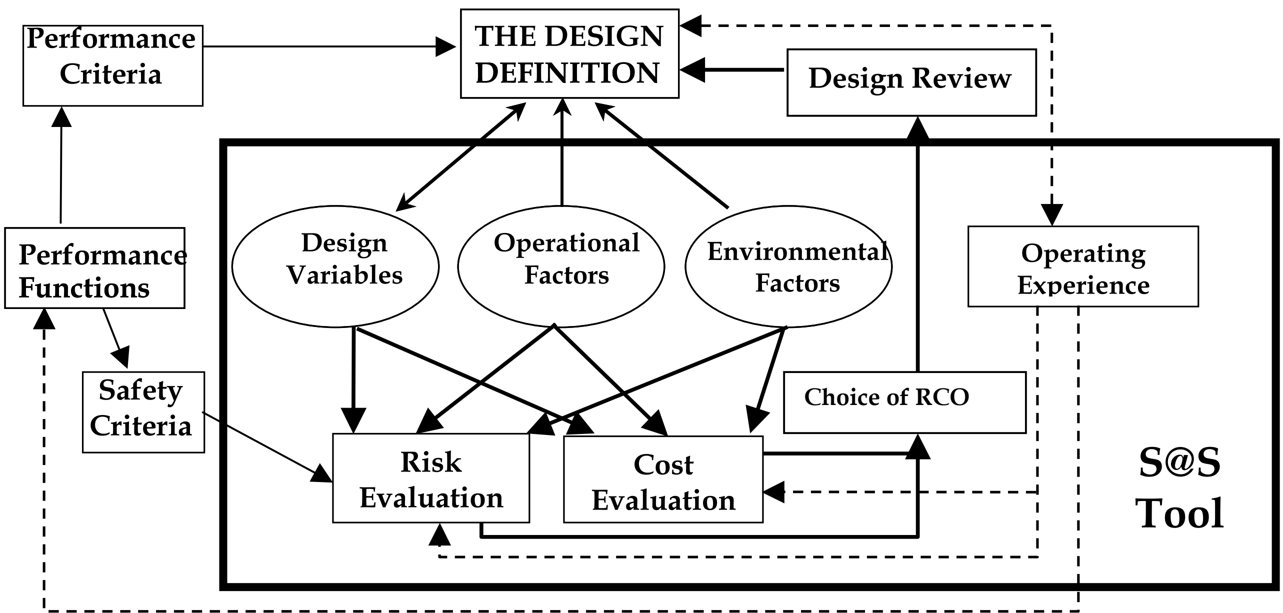

Figure 4 - Safety at Speed in the Design Process

The variables for the design, operation and the environment are captured in the parameters used by safety at speed. The risk evaluation is centred on a risk contribution tree, the combination of a fault tree and event tree. The cost evaluation uses a net present value model contained in the Cost model Spread sheet.

This can be used in a iterative process to achieve various goals depending on the needs of the client.

- Increase NPV while maintaining a level of safety;
- Maintain a minimum NPV whilst raising the levels of safety as high as possible; this is maybe the case where an accident would severely damage the company's reputation, for example an oil company;
- Examine effect of individual systems on total design.

To achieve the best results information flow between the designers and the owners /operators has to be outstanding. This is because, instead of designing ships for a generic environment, route and operational system, the vessel will be design specifically for a purpose or purposes. This means that the owners must give more details of what they require and what regime the vessel will be operated under. This will lead to a product that has been optimised for the use it was intended and therefore is fitter for purpose.

This may lead to vertical integration in the marine industry. In other words, owners may want to invest in design companies so they can develop a close relationship whilst keeping in house the extremely sensitive commercial information that is needed to make the most of the new design for safety frameworks, procedures and tools.

To get a better understanding of the how each individual model fits into this framework please refer to the appropriate user guide which are attached as annexes.

6. REFERENCES

1. Wang, J., 1994. "Formal safety assessment methods", PhD Thesis, Dept of Marine Technology, Newcastle University.
2. International Maritime Organisation, 1995, International Code of Safety for High Speed Craft, London.
3. International Maritime Organisation, 2000, International Code of Safety for High Speed Craft, London.
4. Vassalos, D., Oestvik, I. and Konovessis, D.: "Design for Safety: Development and Application of a Formalised Methodology", Journal of Ship and Ocean Technology, The Society of Naval Architects of Korea, Volume 4, Number 4, December 2000, pp. 1-18.
5. Vassalos, D., Oestvik, I. and Konovessis, D.: "Recent Developments and Application of a Formalised Design for Safety Methodology in an Integrated Environment", Transactions of the Society of Naval Architects and Marine Engineers (SNAME), Volume 108, 2001, pp. 419-445.
6. Konovessis, D. and Vassalos, D.: "Design for Damage Survivability - Development and Application of an Optimal Design Procedure", Proceedings of the Second International Conference on High-Performance Marine Vehicles (HIPER 2001), 2-5 May 2001, Hamburg, Germany, pp. 291-305.

7. Konovessis, D., Vassalos, D. and Guarin, L.: "Elements of an Integrated Risk-Based Design Methodology", International Conference Learning from Marine Incidents II, 13-14 March 2002, The Royal Institution of Naval Architects (RINA), London, 10 pages.
8. Cain, C., (2002), "Design for Safety: A practical approach and its implementation within the Royal National Lifeboat Institution", PhD Thesis, Dept. of Marine Technology, Newcastle University.
9. Birmingham, R., McGregor, J., Astrugue, J-C., (2003) " Development of a safety based design tool for High Speed Craft", IMDC'03
10. Konovessis, D., Vassalos, D. and Vassalos, G. C.: "A Risk-Based Framework for Safe Ship Design", Eight International Marine Design Conference (IMDC 2003), Athens, 5-8 May 2003
11. Delautre, S et al, (2003) " Application of risk based methodology to the preliminary design phase of a high speed craft", FAST '03