Integrated Tool for safer and cost effective design of High Speed Craft, A success story

Project Name: Safety@Speed

Partners:

Force Technology / Danish Maritime Institute (DMI)	DK
Bureau Veritas (BV)	FR
D'APPOLONIA S.p.A (DAP)	IT
Technical University of Denmark (DTU)	DK
American Bureau of Shipping – Europe Ltd. (ABS)	UK
Technical Research Centre of Finland (VTT)	FI
FINCANTIERI (FIN)	IT
Ship Stability Research Centre (SSRC)	UK
Duisburg Shallow Water Towing Tank (VBD)	DE
SIREHNA (SIREHNA)	FR
Maritime Engineering and Technology for Transport, Logistics and Education (METTLE)	FR
University of Newcastle (UNEW)	UK
National Technical University of Athens (NTUA)	GR
SEA CONTAINERS Ltd. (SEA)	UK
CETENA (CETENA)	IT

Website: www.safetyatspeed.org

The introduction of high speed passenger and vehicle ferries coincides with society's increased awareness of safety issues and greater aversion to risk. However the brief operational history of these vessels means that there is little experience to guide the designer toward safer features. Formalized safety methods have to be implemented in the design process. In that context, it was recognised by several research organisations that there was an opportunity to undertake research at the interface of the disciplines of design and safety, with high speed passenger ships (monohull vessels, with design speeds up to 45 knots) being the specific subject of the work.
The project "Safety at Speed", often abbreviated S@S was funded under the European Commission's Fifth Framework. The general purpose of the project was twofold first to develop a formalised methodology for design for safety of HSC using state of the art technique and tools, and to develop supporting tools and information, which will enable HSC designers to explore alternative design solutions at the preliminary design stage with regard to overall safety and through-life cost. Bureau Veritas and the University of Newcastle, with the support of FORCE Technology as the coordinator, provided the integration and technical management of the project.

Figure 1 Superseacat 3, S@S reference vessel

The tool should assist designers of High Speed Vessels at the preliminary design stage by enabling them to quickly model the risk and cost associated with their design choices with a minimum of input information. The tool should allow early evaluation of alternative design ideas, so several design solutions could be explored at the early stages in ship design, where creativity and innovation could be used to their maximum to achieve safety enhancements most cost-effectively, as considered over the life time of the ship.

The first stage in the development of the tool was the identification of the parameters (design and operational) that will affect the risk and cost levels of the design. About three hundred key parameters were found to be relevant for the study. They were organised and categorised by system: user defined, hull form and construction, general arrangement, motion characteristics, systems and procedural.
Setting the parameter values in the tool constitutes the first step of the design evaluation. For easy data entry the parameters have been formatted in simple tabular forms within the user interface.

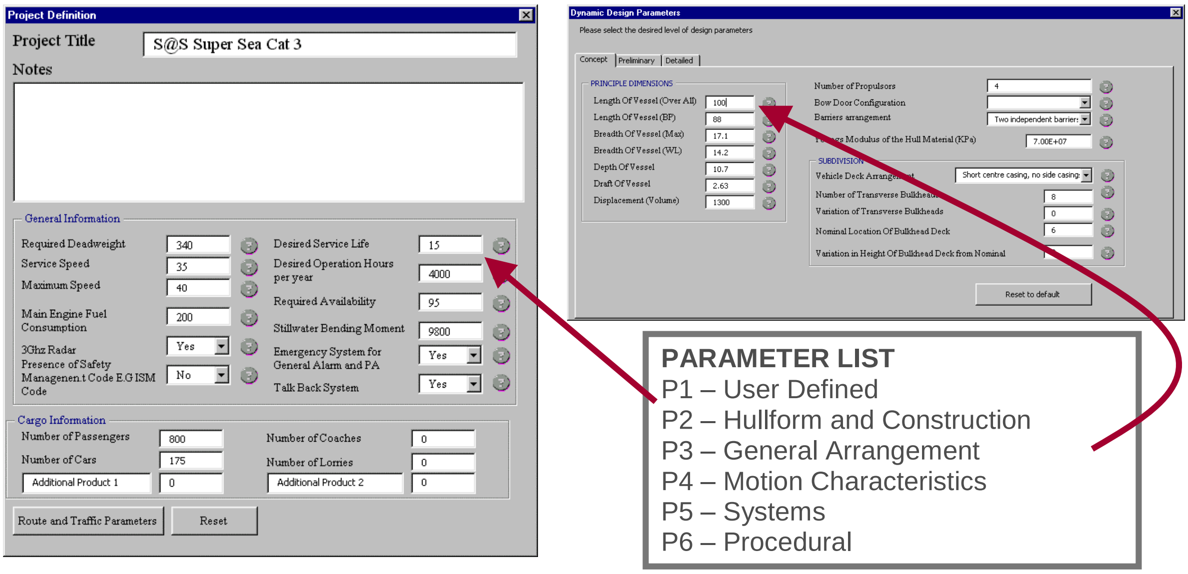

Figure 2 Parameters Interface

The rest of the calculation is a three steps process which enables successively the evaluation of the comfort, the risk and the cost level associated with the design. First the designer evaluates the comfort index associated with his/her design. This index is based on five characteristics of comfort: the level of motion sickness induced by the ship, the safety of footing on board, the level of vibration, the indoor climate and the noise level. Five modules were developed, each of these modules producing a comfort index, then they were integrated to issue only one comfort index for the overall considerations.

Then the designer starts the evaluation of the risk level. This risk level considers the various scenarios of accident that may be encountered by the vessel: collision & grounding, dynamic stability, foundering, fire and flooding. The logic is based on the risk contribution tree methodology, a method representing graphically the distribution of risk. Fault trees describe how a combination of basic events results in an accident occurring (“the top event”) and event trees represent the possible outcomes (“the end events”) by describing how the risk may progress.

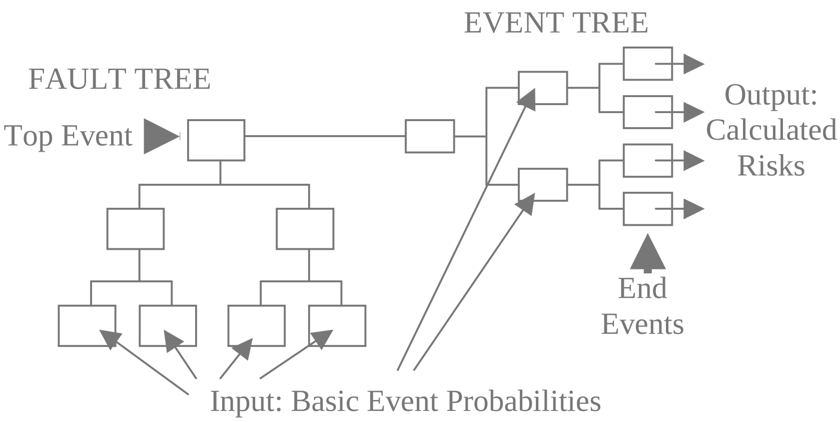

Figure 3 Risk Contribution Tree methodology

However the challenge of the model wasn’t to calculate the probabilities of the basic events. The real challenge of the project was to provide the designers with a simple set of procedures that takes as input the values of the relevant parameters, and that can calculate from these the probabilities of a specific basic event occurring.

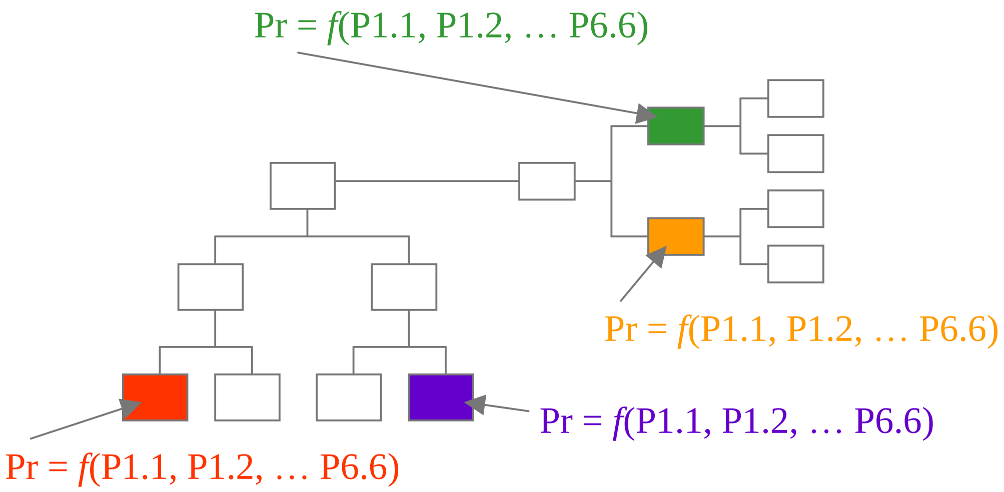

Figure 4 Evaluation of the Fault Tree/Event Tree

These procedures tackle different domains of expertise such as human factor, manoeuvrability, mechanical and automation system, seakeeping, dynamic stability, structural reliability, containment of fire, and containment of flooding…Sometimes it may be necessary to use several procedures to be able to evaluate all the basic events of one fault tree. Some of the relationships between the modules also require that the calculation process is performed in a certain order.

Finally the designer evaluates the cost associated with his/her design choices. The cost in the safety at speed tool is the sum of the build cost and the through life cost which counts for operational side of the vessel. The model also enables to evaluate the earning ability of the ship over her lifetime. Procedures were also developed for the cost evaluation, with reference to the key parameters. Some specific procedures were developed for the cost model, such as the prediction of the ship's availability or the power prediction.

The tool was built by integrating these two main models and the related various elements used for the calculations. The key parameters were the foundations on which was built the framework of the tool as they are the common inputs of all the modules.

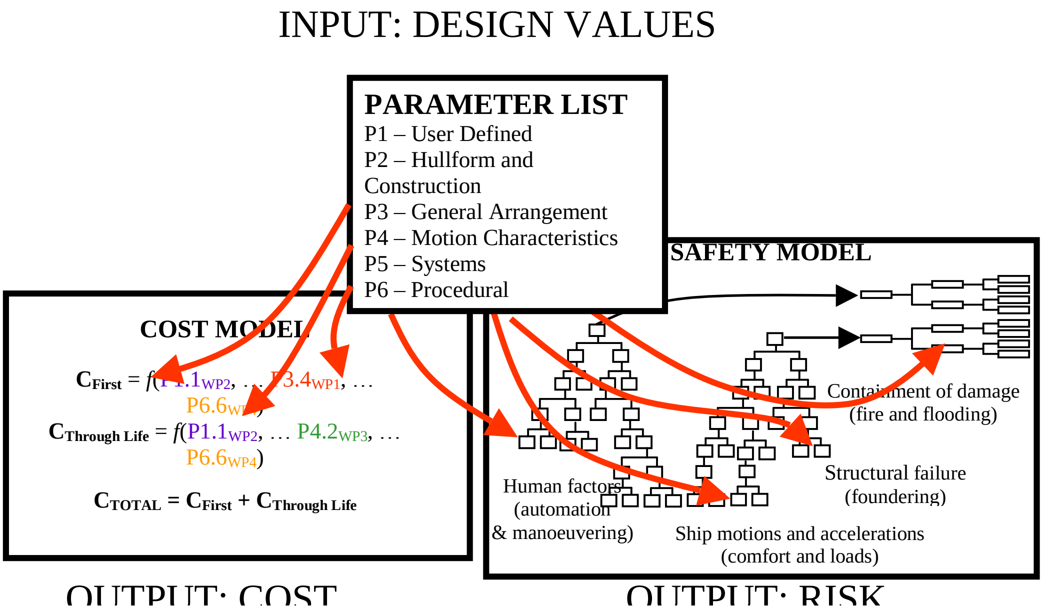

Figure 5 The Tool Logic

The development of the tool was supported by an iconic vision of a simple computer screen on which a set of sliders enable the designer to modify the values of his/her design and operational parameters and which gives as outputs the values of the risk and the cost level. Although simplistic this representation provided a common understanding within the project of the goal to achieve.

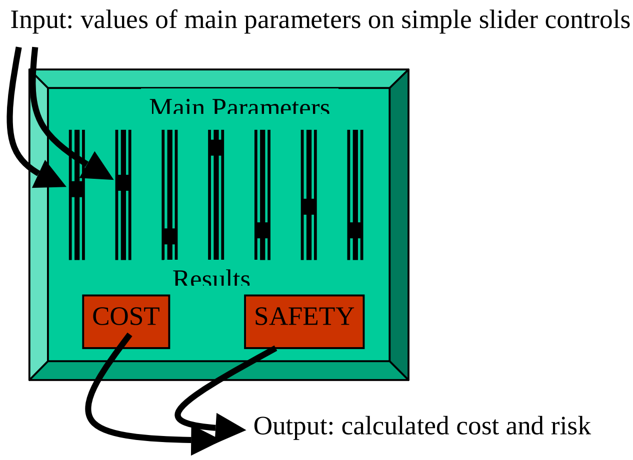

Figure 6 Iconic Vision

Today the S@S project tool is a semi-automated tool created with a user-friendly interface that includes sections representing the major calculations necessary to evaluate the risk and cost levels of a proposed design. The tool is composed of different interlinked applications; these relationships being managed by the main interface. Most of these applications have been implemented in excel workbook and coded in visual basic. However some of the module calculations are done in dll-files compiled with Compaq Visual Fortran programming language or use executable files.

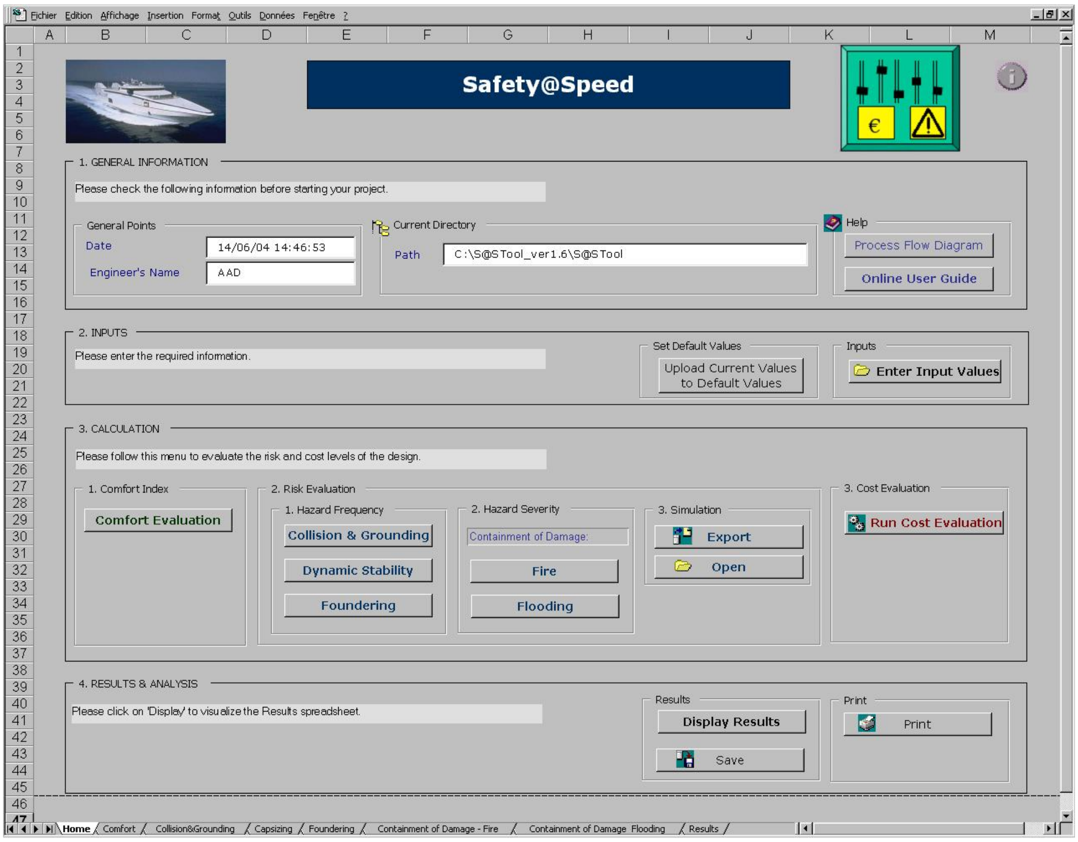

Figure 7 The S@S Tool Main Interface

The advantages of this implementation are quite straightforward. First Microsoft excel is a universal software available in most of the companies which do not require major investment or training. The modular structure of the tool enables a continuous improvement of the tool itself; a module can quite easily be replaced by a company own procedure.

The validation of the tool on an existing ship design was performed during the project. A case study involves several sequential steps. First the designer evaluates his/her design performance in terms of overall safety and through life cost. Then it is possible with the tool to identify the critical parameters that affect the risk (See Figure 8).

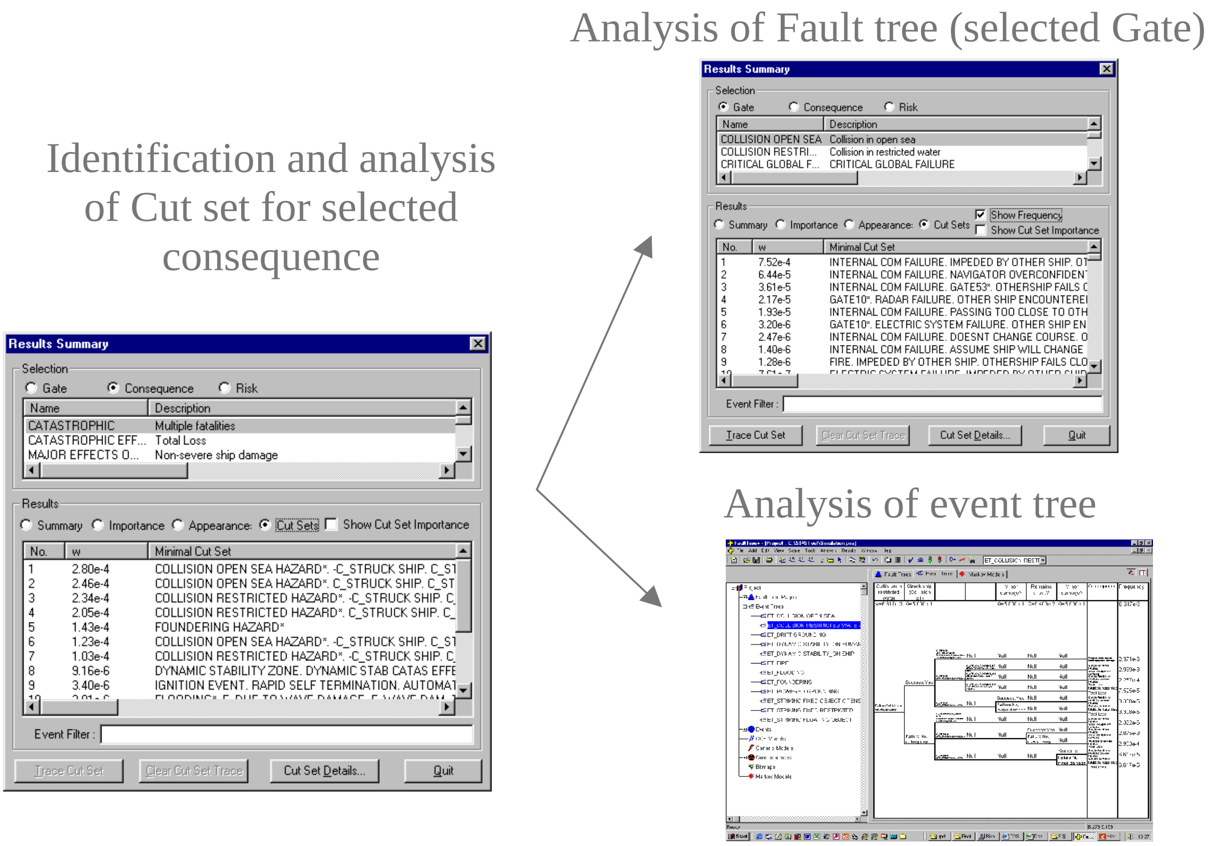

Figure 8 Identification of Risk Control Measures

From this, the naval architect can formulate alternative design solutions also called safety enhancement features and perform a second run of calculation to try the different configurations he/she imagined. Finally the designer will be able to compare the different design solutions and choose between them according to the risk and cost level associated with each design alternative.

Changed Parameters	Basic	Configuration 1	Configuration 3
L_{BP}	88 m	92,4 m	83.6 m
L_{OA}	100 m	105 m	95 m
B_{WL}	14,2 m	14,2 m	14.2 m
T	2,63 m	2,63 m	2.63 m
Δ	1300 m^3	1365 m^3	1234 m^3
C_b	0.396	0.396	0.396
LCG	35,20 m	36.96 m	33.44 m
N_{PT}	8	10	8
P	20550 KW	21200 KW	19850 KW
tp	5 mm	6mm	6
b	500mm	250mm	250
SCF* (Stress Concentration factor)	1.5	1.3	1.3
Number of passengers	800	860	740
Number of cars	175	189	161
Presence of paging system	No	No	Yes
Risk Level	$2.07\ 10^{-2}$	$1.21\ 10^{-2}$	$4.36\ 10^{-3}$
Cost (Net Present Value)	$2.07\ 10^{6}$	$2.\ 728\ 10^{6}$	$2.287\ 10^{6}$

Table 1 Alternative design solutions

The results of these three years of cooperative research are far beyond all expectations. The S@S tool is a flexible and cost-effective framework for the preliminary design of High Speed Craft enabling a designer to compare different alternative solution in terms of overall safety and through life cost. Today the intention is to extend the methodology both by increasing the scope to other vessel types, and by increasing the accuracy of the procedures, so enabling the tool to be used beyond the preliminary design phase.