Door mw. Ing. A. Gerritsen

Virtual Reality and Social Computing in Shipbuilding

More than 200 participants from shipyards, universities and software companies all over the world gathered in the Savoia Hotel in the city of Trieste, Italy, to share knowledge at the International Conference on Computer Applications in Shipbuilding (ICCAS). The conference took place from 20 to 22 September 2011 and was organized by the Royal Institution of Naval Architects (RINA). About 73 presentations were held in three streams. A wide range of subjects was discussed, in this article we try to give an overview of the trends and subjects that were presented.

Dr. C. Antonini, chairman of Fincantieri shipyards, gave a clear view on the world market in shipbuilding in his opening speech. He pointed out that to stay competitive in this market as a European shipbuilder we must concentrate on green technology, high-tech ships and efficiency. Computers and software can contribute to making the shipbuilding processes more efficient, although the integration of new software and traditional work processes is a challenge.

Findings in Academic Research and Shipbuilding Practice

At the beginning of ICCAS in 1973 only academic papers were presented, nowadays the papers come from shipyards (1/3), software companies (1/3) and academic research (1/3). Where the conference used to be only about software, now work processes and methods are also involved, because without implementation of the software and integrating them in the practice of the shipyard the software is useless.

Predicting a Ship's Operation

The operation of the ship can be predicted in several scenarios that are likely to happen. By these scenarios can be assessed if the ship will meet the requirements of operation. In addition, simulation of a ship's operation can provide naval architects with a greater and more in-depth understanding of the design drivers at the concept phase and support decision making. At the conference, different methods on using scenarios and simulation in the design stage were presented.
The University of Strathclyde and Safety at Sea Ltd developed a method to assess the ship's systems availability at a damage situation. With this the impact on a ship's operation can be assessed on safety to meet environmental regulations at an early design stage. The method takes into account the vessel's topology as well as the interdependency of systems. [50]

At the University of Rostock they use scenario methods to develop a detailed service profile considering economic and ecological constraints and the vessel's operating profile as well as the possibility of uncertain events like economic crises. For a ship design's development, which is most suitable to a specific operation task, they combined different techniques of forecasting, scenarios and statistical methods in one integrated approach. In figure 1 the general application flow of the intended approach is given [7].
The University of Michigan presented a paper in which the Markov Decision Process is used to model the evolution of ballast water legislation, product development across the ballast water management industry and stochastic degradation of the equipment's internal components. The objective is to devise a strategy that minimises cost over the vessel's lifecycle while still achieving performance requirements [72].
The Royal National Lifeboat Institution together with the University

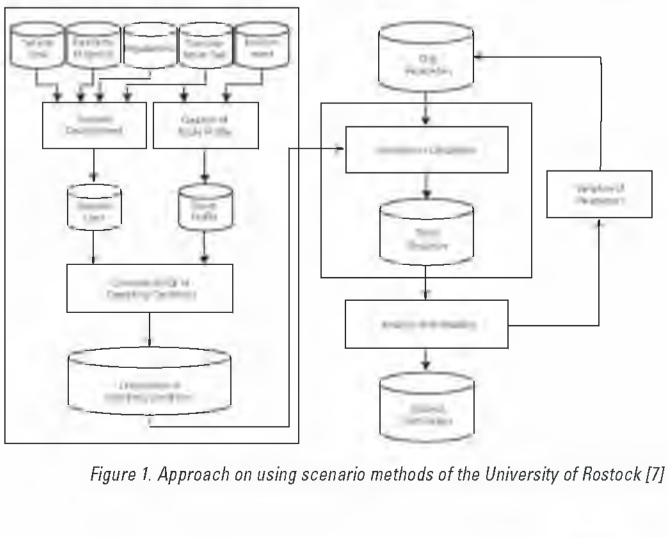

Figure 1. Approach on using scenario methods of the University of Rostock [7]

Annelinde Gerritsen is freelance scheepsbouwadviseur en redactielid van SWZ Maritime

of Southampton use (discrete) event simulation to develop through-life cost modeling alongside concurrent engineering in order to understand and reduce the total cost of owning and operating lifeboats over their whole lifecycle [71].
In South Korea a model is developed for advanced evacuation analysis using a cell-based event simulation model for human behaviour in a passenger ship. Total evacuation time is calculated via computer-based simulations, by considering each passenger's characteristics (such as age, gender, et cetera) and the detailed layout of the ship. In figure 2 a glimpse of the method is given [70].
Of course, simulators can also be used to predict a ship's operation. At CETENA in Italy simulators are used to evaluate naval ship's performance and capabilities in an early design stage. For example, landing craft manoeuvrability and helicopter landing operations are assessed in a simulator [47]. Even flight simulators can be used to evaluate the aerodynamics with helicopter landings and improve ship designs for helicopter operations [29].

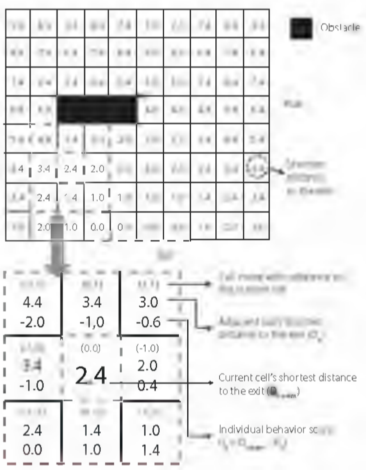

Figure 2.

A System of Systems

A ship's complexity is traditionally managed by using hierarchical structures in specifications and other documents. These structures are two dimensional "flat" lists of systems and components. However, a ship is more a "system of systems"; all the elements are connected to each other to form a whole. Systems and components have multi-dimensional relations to other systems and these relations are hard to manage in a two-dimensional list or a hierarchical structure. A ship's structure is more like a network and to manage a network of systems a relational database is a better suitable solution. Several research- and software companies have been working on this subject, like Intergraph [8] and PTC [11]. Navantia has especially developed a database for the electrical systems and used it in the highly demanding environment of submarine design [61]. At the TU Delft and the "Integral Cooperation" project in Holland they are working on a new functional system breakdown structure allowing users to have their familiar hierarchical overview, but it is more easily related to other structures and used for communication of data [23].

Concurrent Design and Engineering by People

A ship's design and engineering is first of all done by people, only they are capable of decision making and creativity in highly complex processes. These processes cannot be completely automated, however, these processes can be supported by software tools. To work concurrent in the design process spiral innovative solutions to optimise the design process's automation have been developed and implemented. Most of the solutions are focused on the optimisation of the design process by encouraging people to use creativity and cooperation. Where some try to convince the market by developing an integrated package on their own, others integrate existing design software and exchange design data automatically (more about this in the next chapter).
At the University of Michigan a method is used where design team members reason and communicate about sets of designs (Set Based Design SBD), supported by a "hybrid agent fuzzy logic" (HAFL) software tool. This design tool uses automation of certain aspects such as data collection and analysis while still allowing for input from human designers. The HAFL design tool breaks the SBD process into a hierarchical structure, with a Chief Engineering agent at the top of the structure and functional design agents beneath (for instance for Resistance, Seakeeping, Stability and Weight). Human design agents input preferences for design variables (such as Length, Beam, Deadrise, LCG and Displacement) that are described via a set of design values ranging from minimum to maximum values utilising any of the three linguistic terms Preferred, Marginal and Unpreferred. The Chief Engineering agent has the responsibility of controlling the time for the SBD process and then later narrowing the set-ranges of design variables based on results from the HAFL design tool. In this way, the effect of changes on design variables can be determined, decisions can be delayed and sets of design can be open longer [54].
Intergraph has been using an "Agile" method to review and capture shipyards design and construction standards into automated design rules, this method is used a lot in the ICT sector [12].

Concurrent Design by Software

Independently, at several places in the world, naval architects combined and connected existing design tools to integrate the design spiral's process and make data management more efficient and concurrent. In this way, many design options can be calculated and the design space can be explored. In Greece, formal explorations and exploitations were combined and connected in the software to investigate the design space and, subsequently, advance competing design proposals into certain directions. With the software that was developed about 2500 variants were realized and compared [50].
At the Innovero project in Holland a design platform is developed using a central design server where all the design data from different tools are gathered and managed. The designers can see the changes and development in the process in a user interface 'dashboard'. The Innovero Design Server informs the project team members during the project about pending design tasks and tasks to be

repeated due to changes made in any of the tasks of the project [65]. A similar platform is developed in Germany called the Spiral solution [48].

A lot of work has been done to optimise arrangement of ship compartments with knowledge-based systems. A ship is both an engineering system and an assembly of many spaces. This means that, to design an arrangement of ship compartments, it is necessary to treat not only geometric data, but also knowledge on topological relations between spaces and components of a ship [3]. In the Innovero project a method is also developed for modeling of the ship's internal geometry. This tool bridges the duality between volumes (spaces, compartments) and planes (bulkheads, decks) [65]. In line with this subject, the University of Michigan described how clustering signed complex networks can be used to identify groups of related spaces [41] and have developed an algorithm and software for intelligent ship arrangements [24].

Computational Fluid Dynamics offers the advantage to evaluate and compare different ship hull designs with respect to the hydrodynamic performance. Two papers were presented on using open source software (OpenFOAM) for CFD calculations [1] and [52].

Integrate or Exchange Data?

During the past decades engineers have made their tasks more efficient by developing software to automate their tasks. For separate calculations and data storage activities separate tools were created. Now the shipbuilding process is performed more concurrent and integrated, the software tools need to be integrated too. A lot of solutions to integrate software were presented.

One way of automation is exchanging data between tools, for example by using XML language for data exchange between shipyard and class association [32], share data by PDF documents [33] or using the JT language for data exchange [31].

Furthermore, a lot of data can be extracted from the CAD system and imported in the ERP or PLM system, since the CAD system is a "data rich" environment and the ERP system is "data poor" [4]. This is usually done by extracting bills of material (BOMs) from the CAD system an load it into the ERP system [30] [37]. At Sener in Spain they use a publishing mechanism to send information from the CAD to the ERP system [34]. In addition, a lot of other solutions for data sharing have been developed: At Sener they use a tool where people who are not necessarily IT experts can extract and use data from the existing systems in their own way [63]. In Taiwan a more integrated solution is developed where the different CAD, ERP and PLM databases are connected to each other [10]. Nupas-Cadmatic developed a smart database-centric client server system to communicate data of marine design and engineering projects to parties working all over the world on the same project [5].

The benefit of exchanging data is that all parties involved can continue working in their own familiar environment and they are independent and free to work in their own way. The disadvantage is that the information is still disintegrated and stored in different places, therefore, data inconsistency is not easily prevented, controlling and communicating change is difficult and the overview of information remains unclear.

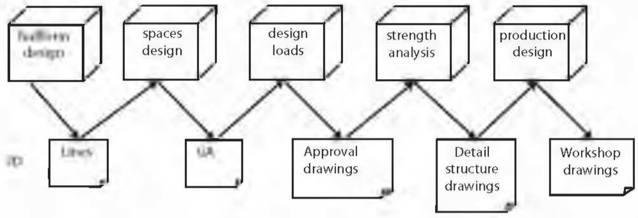

Figure 3. Switches from 2D to 3D [22]

Another way of integrating software is by using one single database where all the data is stored or combined. In this way, there is only one "single point of truth" and information can be followed during the process. By sharing data instead of exchanging, a deeper level of information is made available for all different users (user interfaces) of the application [8].

The Newcastle University Aveva did a lot of research and development on this subject, for instance, they introduced the "Integrated Shipbuilding Strategy" by using a "digital information hub" where all the businesses in the shipyard can connect to [36]. Additionally, the integrated schematics, engineering and 3D concept is something that Aveva has been actively developing for some time and is now practically reality [38].

From 2D to 3D to Virtual Reality and 4D

Traditionally, the ship design and engineering processes are depicted in 2D drawings. However, the design's technical analysis calls for 3D models. Because people are used to work in 2D, the transition to 3D takes time and still a lot of inefficient switches are being made between 2D and 3D in the design process, see figure 3 [22].

More and more the 3D model is being used for a variety of tasks in the shipbuilding process, like planning [59], paint quantity estimation [53] [22], block lifting simulation [20] and even hull inspection and maintenance in shipping companies [45]. With the use of the 3D model and algorithms outfitting and pipe routing can be automated, a lot of developments in this area were presented at the conference ([56], [57], [58], [65] and [64]).

The 3D model also makes it possible to explore the ship in virtual reality before it is built. In this way, the spaces and systems can be checked on safety, operability and maintainability and clashes are easier to detect [60]. eBrowsers are used to explore the 3D model [5].

With cameras in the construction area and status levels attached to the 3D model even "4D" can be created, where the viewer can follow the building progress [14].

In the ICCAS conference hall several software companies presented the possibilities of using the 3D model and virtual reality. With a joystick you can virtually walk through the ship (see picture).

The author "walks" through a ship model in the TechViz software

Design by Intuition

Designing a ship is a very complex and creative process. Intuitive ways of working can simplify this process and make it more natural for engineers. Aveva proposes a completely different approach to developing electrical engineering and design tools, by connecting the Single Line Diagrams directly to the database and use "drag and drop" to create those SLDs [35].

This company is even thinking further and sees a good role for "social computing" in maritime industry. More and more people (especially young people) use social networks such as LinkedIn and Facebook to communicate in communities. Shipbuilding is a highly collaborative activity and, moreover, an activity that requires the collaborative use of expertise and knowledge, therefore social computing for shipbuilding may be a good communication device. Updates on design and engineering information can be shared on the network and users get a direct feed of information on the subjects they are subscribed to, see figure 4 [40].

Figure 4. A possible interface for communication of ship data by using "social computing"[40]

Developments in the Far East

A lot of ships are being built in Japan, Korea and China nowadays and thus they have been working on optimising the production process a lot in those countries.

For the hull welding at sub-assembly stage, block assembly stage and in the dock advanced robot systems are being used in Japan and they continue on improving the use of robots [19].

Bending and forming of plates and profiles is a difficult process to automate. In China some positive developments have been made for digital bending of profiles [74] and doubly curved plates [75] and in Japan they check the accuracy of curved shell plates by laser scanner [17].

By considering the production process in the design stage more efficiency can be realized during the production stage. This is done, for example, by block division during design [49] and predicting the weld deformation during design [15].

Reducing loss of material and time in the production process is realised by using production simulation [68], application of an algorithm for effective workflow in pipe spool production [16], torch way optimisation [73] and monitor sub assembly of objects by video image processing and motion detection technologies [67].

Production optimisation analyses have also been done outside the Far East; the American universities worked on making sure there is constant work in progress (CONWIP) in block building [18] and Lean Manufacturing, which they analysed in cooperation with a University in Croatia [66].

More Interesting Subjects

In the area of shipyard management, the usage of PLM was treated [9], a paper on ship repair project control was presented [42] and the Technical Research Centre of Finland developed an innovation and engineering maturity model for global businesses to identify competence development [39].

At the Newcastle University Aveva Initial Design is used for teaching. By using this software the student can "play" with parameters of the ship and see what the effect on changing them is on the design [55].

More Information and Papers

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The next ICCAS conference will be in 2013 in Busan, Korea.

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