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VIRTUAL PROTOTYPE IN SHIP DESIGN

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Abstract: *Rapid evolving market and very short delivery times emphasise new requirement for shipbuilding process. In such environment computerised system with photo realistic and simulation capabilities such as virtual reality become valuable tools for high-speed creating and manipulating geometric and other characteristic of the craft. As a result the shipbuilding is trending towards the use of advanced 3D modelling, visualisation and simulation tools that enable the entire ship to be designed and developed in the pre-contract phase. The advantages of introducing virtual prototyping in shipbuilding are the same or even bigger than in the automotive or aerospace industry due to the fact that the final customer is known from the earliest phase of the shipbuilding process. Facilitating the virtual reality communication capability, different variations of the project can be studied and discussed among all parties included in the project in a more transparent and efficient mode. Savings due to application of virtual prototyping in shipbuilding goes through the complete building process, not jus the design only. Key technical and conceptual features of the virtual prototype are described. as well as its advantages over traditional CAD system. At the end, the paper outline the experience gained through the development of virtual prototype of luxury motor boat RB-12.*

Key words: virtual prototype, virtual reality, 3-D model

VIRTUALNI PROTOTIP U PROJEKTU BRODA

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Sažetak: *Brze promjene na tržištu i kratko vrijeme isporuke uvode nove zahtjeve na učinkovitost brodograđevnog procesa. U takvim uvjetima računalni sustavi sposobni za brzo izvođenje foto realističnih prikaza i simulacija iz područja virtualne stvarnost predstavljaju vrijedan alat za osnivanje i modeliranje geometrijskih i drugih značajki broda.Kao posljedica toga brodogradnja se kreće u pravcu prihvaćanja alata za 3-D modeliranje, vizualizaciju i simulacije koji omogućuju projektiranje i razvoj cijelog broda u predugovornim fazama projekta. Prednosti primjene koncepta virtualnog prototipa u brodogradnji su iste ili još i veće od onih u automobilskoj i zrakoplovnoj industriji zbog činjenice da je krajnji kupac u pravilu poznat od najranijih faza brodograđevnog procesa. Korištenjem mogućnosti bolje komunikacije putem virtualne stvarnosti, svim članovima projektnog tima omogućeno je analiuziranje različitih inačcia projekta na puno jednostavniji i učinkovitiji način. Uštede ostvarene zahvaljujući primjeni tehnologija izrade virtualnog prototipa zahvaćaju cijeli brodograđevni process, a ne samo njegov projektni dio. U članku se opisuju tehničke i koncepcijske značajke virtualnog prototipa, te njegove prednosti pred klasičnim CAD modelima. Na kraju se daje prikaz iskustva ostvarenog tijekom izrade virtualnog prototipa luksuzne motorne brodice RB-12.*

Ključne riječi: virtualni prototip, virtualna stvarnost, 3-D model

1. INTRODUCTION

Prior to construction, every ship must be designed, the construction operations must be planned, and the timely delivery of prime materials and equipment must be assured. These activities involve generation and manipulation of enormous amounts of information. Continuous flow of this information across the shipbuilding process is vital for the efficient realization of each shipbuilding project. The benefits of using CAD/CAE tools within the shipbuilding process are well documented and understood.

The development of CAD software commenced with the introduction of electronic two-dimensional design and drawing tools, which enabled documents to be quickly developed, changed and modified. These tools provided benefits ranging from reductions in design cycle time, increased design accuracy and reduced the time to produce drawings and documentation. While it did reduced the time to undertake required changes, in many cases, a significant reduction in the number of changes was not realised.

Three-dimensional software soon followed which enabled simple models to be created and designed. This provided the opportunity to modify and visualise complex geometric shapes. This change heralded the most significant advancement providing the opportunity to conduct prototype and component interactions of the design solutions prior to contracting or to committing to production.

With the development of accurate geometric (3-D) model the ability to conduct true design simulations has been advancing. As detailed in [1] the different levels and type of simulation activities and development which can be undertaken are:

- 3-D Model – this is the most basic form of simulation. These have been created for many years, often physically but more recently in digital form;
- Enhanced 3-D Models – the model enhancement to enable animation of component parts increases the value of visual simulation and provide verification of certain design objectives;
- Behavioural Characteristics – the extension of the concept to include physics based algorithms further enhance the simulation which enables the assessment and analysis of the model against performance;
- Real-Time Simulations – this adds time constraints to the behaviour characteristics to give time based analysis that reflects a true to life operation of the object and allows for interaction between simulated object and human operators;
- Discrete Event Simulation – uses the behaviour of the objects for accurate calculation of operational scenarios but it is interested in the logical sequence of events rather than the effects of time
- Human Factors Simulation – is conducted with the introduction of mankind model with behavioural algorithms that closely match human movements and constraints.

As a result the industry is trending towards the use of advanced 3D modelling and visualisation tools that enable the entire product to be designed and developed.

2. EVOLUTION OF VIRTUAL PROTOTYPING

The concept of virtual prototyping comes through US defence establishment efforts. It was established to answer two questions. First is the capability to prove functionality and manufacturability of new weapons systems prior to the commitment of large production resources, and the second as an answer to "near zero" production paradigm for maintaining and manufacturing proficiency without actually building products.

The Virtual prototyping has been successfully used in different industry. Boeing used virtual prototyping and manufacturing in the development and production of Boeing 777 airplane, the first airplane to be 100 percent digitally designed. Boeing was able to build plane without the benefit of drawings, mock-ups or development

fixtures. Automotive producer such as Chrysler, Ford or Volvo design and produce your new model of vehicles using virtual prototyping and virtual manufacturing.

As the nature of design in shipbuilding is little different from other manufacturing industry, new design methods such as virtual prototyping can be easily adopted and used in shipbuilding. Application of virtual prototyping in shipbuilding is enhanced on complex craft such as cruise ships [2], submarines and surface combatant due to their complexity and capability of virtual prototyping to visualize the design and enables the assessment and analysis of the model against performance requirements.

3. TODAY SITUATION

According to EU Commission State of the Art report on The Automation and Integration of Production Processes in Shipbuilding, 3D computer modelling technique in shipbuilding is generally not used at the project design stage [3]. Most of the models are specific for hydrodynamic, structural or piping design. Although three-dimensional design has been standard in shipbuilding for several years, 3-D models of complete vessels with all disciplines included are still rare.

Ideally, 3-D computer modelling technique should be applied at the start of the project, in pre-contract design phase. The same model then be extended into a real product when designing and engineering are proceeding.

However, still today 3-D design in shipbuilding is used almost only in the detailed design phase. In some rare cases, the use extends to earlier design phases: the best known examples are 3-D tools for hull form design and naval architectural calculations. When larger commercial vessels are considered, the major part of project design is still done with 2-D CAD systems [4].

In automotive and aerospace industries, 3-D tools and other modern methods like comprehensive product models are already a standard. Shipbuilding has been left out of this development due to several reasons, one of them being the very conservative nature of shipbuilding and the other very large and complex entities compared to, for example aircraft.

In today market situation, shipyards are concentrating on core business and outsourcing most of the support functions. This serves reducing the costs and balancing the use of capacity in the fluctuating market. In such circumstances, the product definition becomes essential for the shipyard, ship-owner, class and the subcontractors. For all of them, definition of the ship at the earliest possible stage becomes of vital importance.

Based on this requirements, a new design paradigm of integration of all necessary information starting form pre-contract phase of product process, by means of virtual prototype, becomes increasingly attractive in shipbuilding. Depend on time and financial resources 3-D model is designed and organized in a way that could serve ship development process form the first idea up to commissioning, its operation and decommissioning.

The first virtual reality ship models were prepared by spring-summer 1998, for a passenger cruise ship outline project by Deltamarine [3]. The main issue was to visualize the design of the exterior and the public spaces. From that experience, seven conclusions were taken [3]:

1. The number of required man-hours in preparing virtual model is not more than required for preparing arrangement drawings. Drawings can be extracted directly form the virtual prototype (4-D) model,
2. Visual presentation of any new idea, space or arrangement is easy and much more efficient than with drawings, rendering or even cartoon models.

3. Presentation and common meetings with the owner, yard, architect, consultant, subcontractor etc, are greatly simplified. Fly around and walk-through of the virtual ships as required in the meetings is possible.
4. Different alternatives can be display at the same time and fly around or fly-in can be made for both.
5. Minor changes can be made on the spot in the meeting concerning colours, lighting, furniture, as well as arrangement, structures, equipment, furniture, etc. Major changes may require working "overnight".
6. Visualisation of the changes and alternatives is immediate, decision-making become easier and more reliable.
7. Functionality of spaces can be easily checked with performance simulation in the virtual model using efficient simulation solutions. These can be ro-ro deck operations, or any kind of cargo operations, passenger flows, and escape simulations, luggage handling, galley, catering operations and similar.

All this can be done already before the shipbuilding contract is signed, and a lot of typical misunderstandings and mistakes can be avoided.

4. VIRTUAL PROTOTYPING AND TRADITIONAL CAD

Virtual technology gives the possibility for all people involved within the design, production, engineering, planning, procurement and maintenance departments, to review and test concepts in the pre-contract phase of the shipbuilding process. These tools therefore facilitate visibility and communication.

A virtual prototype represents a computer-based simulation of systems and subsystems with a degree of functional realism comparable to a physical prototype. Depends on time and financial resources virtual prototype of ship includes ship systems defined at various level of abstraction ranging form main geometrical to full geometrical and functional definition. In ideally situations virtual prototype operate as a true substitute for a physical prototype.

Virtual prototyping has certain advantages over traditionally CAD systems available in shipyards. Some of the advantages are:

- Optimisation of 3-D model of the ship for graphic performances with rendered or photo realistic images;
- Simulate the operations of equipment like throwing out anchor or turning of valve control, with resultant effect displayed;
- Ship owner can feel sense of space in the prototype model, validating thus their function and aesthetic appeals;
- Ship owner can accurately access spaces when verifying/inspecting the design.

5. CASE STUDY

The use of virtual technology have been demonstrated on the project of the luxury motor boat RB-12. The project was undertaken in 2001. and the craft was commissioned in the July of 2002.

The main task was to achieve favourable space utilization and avoid typical misunderstandings and mistakes regarding aesthetic appeals of exterior and interior details. Exterior and interior details of the arrangement of final design are given in fig. 1-6.

Simulations used in the RB-12 project includes 3-D model flight through and walk through animation of craft exterior and interior and simulation of door and anchor operation. Experience gain from RB-12 project confirm the conclusions regarding virtual prototype characteristics outlined in paragraph three.

Fig 1. Fore view on luxury motor boat RB-12

Fig 2. Wheelhouse view

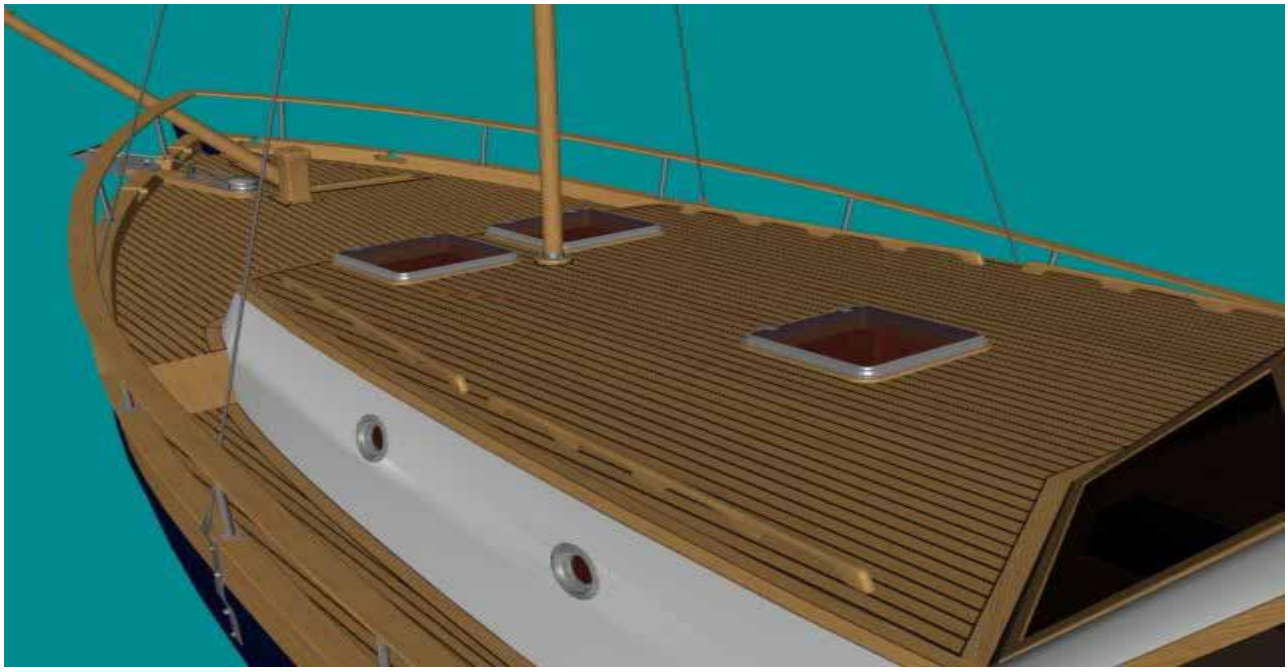

Fig 3. Fore deck view of RB-12

Fig 4. Kitchen of RB-12

Fig 5. Wheelhouse bridge of RB-12

Fig 6. Toilette of RB-12

Using virtual prototype of RB-12 we succeed to achieve concurrent alteration and modification of design in a very efficient manner. This enabled ship-owner and other design team members involved in the design process to conduct comprehensive analysis of general arrangement of the craft with full confidence. It includes design considerations regarding the craft exterior, with emphasising of the anchoring and mooring equipment arrangement on the bow and on the stern, as well as the interior accommodation spaces consisting of wheelhouse and saloon on the main deck, and two fore cabin, one side cabin, toilet, saloon, kitchen and saloon in the hull. Using virtual reality technology enables all the members of the design teams that all the detail of the arrangement to be quickly, easily and accurately expressed and viewed.

5. CONCLUSION

The virtual reality is based on the on the premise that the use of 3-D modelling and simulation concepts and tools can highlight the problem before main decision in the shipbuilding process regarding cost are committed.

The advantages of introducing virtual prototyping in shipbuilding are the same or even bigger than in the automotive or aerospace industry due to the fact that the final customer is known from the earliest phase of the shipbuilding process. Facilitating this fact, different variations of the project can be studied and discussed among all parties included in the project in a more transparent and efficient mode. Savings due to application of virtual prototyping in shipbuilding goes through the complete building process, not jus the design only.

Today for a passenger cruise ship the total number of design man-hours can vary up to 100 000 man-hours depending on the quality of basic design [1]. In dollars, this make $5-10 million. The effect of using virtual reality product model properly from the pre-contract phase in the project of complex ships such as submarines, surface combatants and passenger cruise ships and other complex ships is leading to even bigger impacts. This represent a huge potential for the design of complex or unique ships and boats, taking into account that the design activity for this type of craft is easily as much as 10 % of the total new-building cost.

REFERENCES

[1] Saber R: Potential Benefits Derived from Integration of Conceptual Design Tools for 3D Modelling & Simulation, 10th International Conference on Computer Applications in Shipbuilding, Cambridge, USA, June 1999.

[2] Zini A., Rocca A.: The Integration of Virtual Prototyping in Ship Design, Proceedings of 1st International Conference on Computer Applications and Information Technology in the Marine Industries (COMPIT 2000) Potsdam 2000.

[3] Andritsos F., Perez-Prat J.: The Automation and Integration of Production Processes in Shipbuilding, European Commission, Joint Research Centre, Institute for Systems, Informatics and Safety, June 2000., 99 pages.

[4] Aarnio M.: Early 3-D Ship Model Enables New Design Principles and Simulation, Proceedings of 1st International Conference on Computer Applications and Information Technology in the Marine Industries (COMPIT 2000) Potsdam 2000.


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