On Building 3D Support System in the Shipbuilding Process in Vietnam - From Concept to Deployment

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Abstract - From concept to deployment, the ship production process requires innovative solutions that will increase efficiency, lower costs, and provide support throughout the life cycle of the ship. World Shipyards experience with new ship construction and production have helped us to meet challenging requirements. The ship production service offerings include: ship design and assembly, materials planning and procurement, information management, etc. This paper will explain how to build the 3D support system for shipbuilding process in the small to medium sized shipyards in Vietnam.

Keywords - 3D Modelling; Support System; Digital Shipbuilding; Shipyard.

I. INTRODUCTION

According to the report of ECORYS [1], the global shipbuilding market has faced the next down cycle in recent years since the end of 2008. In addition, the world’s economic crisis also increased the strict competitive pressure for shipyards in the end of 2008. Most shipyards in Asia confront a lot of challenges in development strategies especially in Vietnam. Nowadays, progressive shipbuilders come from China, Japan, Korea, Singapore, Philippines, India, Russia and Brazil have non-stop to strengthen their advantages by applying new innovative technologies in their shipbuilding and ship design processes.

In South Korea, Seoul National University, Samsung Heavy Industry and some national institutes are funded to carry out the project “Integrated Digital Shipbuilding Technology for Development of High Value-added Ship” since 2001 [2]. In May of 2010, one of the world leading suppliers of 3D simulation-based systems and PLM solutions, Dassault Systèmes cooperated with the government of South Korea, and Keimyung University in setting up their Shipbuilding R&D Center at Keimyung University in Daegu [3]. This center supports both Korea’s shipbuilders and universities in developing and applying the new 3D simulation-based systems in production, design, and management processes. As a result of this project, Samsung Heavy Industries is an essential shipbuilder in South Korea has adopted DEMILIA solution to develop the next-generation simulation shipbuilding system since January of 2003 [4]. Hyundai Heavy Industries has also owned their digital shipbuilding technology via advanced 3D simulation-based solutions as AVEVA Marine, NAPA, Nastran, and Teamcenter, Technomatix (Fig. 1) [5].

China is recently one of the world leading nations in the order-book [1]. To build the ship with the low cost, higher quality and hand over ship faster to ship-owners, Chinese shipyards have adopted 3D simulation-based support systems from concept design through engineering to production, operation and maintenance. Yantai Raffles shipyard is a success paradigm in deploying 3D simulation-based systems of Dassault Systèmes (Fig. 2) [6].

Fig. 1 3D simulation-based machinery arrangement in Hyundai Shipyard [1]
Vietnam’s shipbuilders have to catch this new trend to survive in the world competitive environment. There are some shipbuilders intend to streamline the 3D simulation-based production systems. The PTSC Mechanical and Construction (PTSC M&C) under the Vietnam National Oil and Gas Group is one of typical examples in using AVEVA PDMS to design and simulate 3D model of 600 meter well head riser topside for the Pearl field since 2008 (Fig. 3) [8].

The evaluation of the essential 3D support systems of substantial shipyards in China and Korea will assist the director board of Vietnam’s shipbuilders comprehend the important role of Simulation-Based Design (SBD) and Computer Integrated Manufacturing (CIM) in the Product Lifecycle Management (PLM) solution. Hence, the board of shipyards can make the right decisions in bidding a project besides coordinating effectively the enterprise resources to not only optimize the profits, and but also enhance the shipyard’s competitive advantages compared with the neighbor nations as China, Singapore, Indonesia, Malaysia and Philippine.

II. 3D SIMULATION-BASED SUPPORT SYSTEMS IN PLM SOLUTION

The shipbuilding ecosystem is a very complex architecture including shipyard, ship owner, ship registration organization, design office, sub-contractor and supplier. As Fig. 4, the ship production project management is required to coordinating (1) ship engineering, (2) ship construction, and (3) ship maintenance and operation from project development through fabrication and erection to outfitting and accommodations [9]. Due to the practical network with highly collaboration in ship production processes, the project planning is the most pivotal step. The digital shipbuilding bases on the simulation, real time visualization, and high performance computing will reduce the time and avoid the error in the design and production planning. Besides that, the workflow, bills of material (BOM), Product Database Management (PDM) systems are essential parts in planning to control the cost overruns and avoid ship delivery delay. Hence, the BOM, PDM, and workflow integrated into PLM solution helps planners have the overview of the whole of project, and thus to make the right decision in planning.
In the stages of ship engineering and ship construction, the Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Aided Engineering (CAE) and Digital Mock-Up (DMU) technologies will be integrated into the SBD and CIM systems [9]. These support systems are available to improve the quality of design and shorten the stages of product development and manufacturing via reusing and analyzing the 3D models directly. In addition, the design and production data can be exchanged easily through standardized data as DWG, STEP and IGS.

Almost shipyards build the ship with the block erection process. Within each shipyard, they will own their shipbuilding process to be suitable with each ship type and factory environment. The Fig. 5 will analyze the typical ship production process using the block erection technology [10]. In the block erection sequence planning, the location and the time are two important factors. The SBD and CIM can simulate the 3D block construction in the real time, then support the operators make essential decisions about time and location to erect the block construction assembly. As a result, the shipbuilders can decrease the time and coordinate logically the enterprise resource as the human and the equipment.

The successful shipyards around the world increasingly choose essential component outsourcing to optimize the enterprise resource, thus to collaborate experts of many different sites and improving the shipyard capacity. In typical shipbuilding characteristics, the marine equipment supply chain and construction sites can place around the world. These above concerns will create the high pressure for the communication and coordination. The 3D simulation-based support systems in PLM solution will allow each member access on 3D models dynamically with suitable levels in real time to update any information of any stages of project. For example, if the ship owner wants to choose the other marine engine, immediately the ship designer will update information and modify the design, at the same time as the shipyard will receive the changes of drawing and send the new order to supplier.
To comprehend the advantages of applying 3D simulation-based support systems of PLM solution, the paper will briefly analyze two case studies involving Yantai Raffles shipyard of China and Samsung Heavy Industries of South of Korea. Besides that the paper will show the current situation of SBD and CIM application in Viet Nam.

A. Case Study: Yantai CIMC Raffles Offshore Ltd., China

Yantai CIMC Raffles Offshore Ltd has three shipyards, which are located in Yantai, Haiyang, and Longkou in Shandong province, China. It is known as the largest rig builder with nearly 4,000 employees and 8,000 sub-contracted workers in China. The shipyard in Yantai, also called Yantai Raffles shipyard (YRS), can positively design and build the Jack-ups with leg’s length over 120 m besides semi-submersible drilling rigs, and heavy derrick pipe-lay vessels.

With increasing development and high competitive pressure, YRS has to transform the original 2D CAD systems into the innovative 3D simulation-based support systems to streamline their design and production capacity. Since 2008, DS PLM solutions including CATIA, SIMULIA, DELMIA, and ENOVIA VPLM have usefully been implemented by YRS [11, 12].

YRS has deployed CATIA and SIMULIA to optimize their offshore structure design and shorten the product development time. Creatively, engineers of YRS used CATIA to design the world’s largest crane named Taisunalong with SIMULIA for optimizing their design via finite element analysis (FEA) as shown in Fig. 6. With 20,000 metric ton capacity of Taisun crane, YRS can build the huge oil rigs faster via transporting and erecting heavier structure blocks.

Particularly, full marine engineering module is integrated into CATIA as ship structure design, heating – ventilation – air condition (HVAC) design, piping design, electric system design, and outfitting design to help engineers and designers shorten the new product development time (Fig. 7). In addition, DMU technology in CATIA encourages engineers and designers visually simulate the block structure fitting sequence, kinematic characteristics, and even analyze workshop spaces to innovate suitably their design, and thus to meet customer’s demands.

On the other side, DELMIA provides 3D simulation-based manufacturing systems with visual environment and digital mock-ups technology to analyze the potential problems in real production condition and plan completely the shipbuilding processes especially in block erection and fabrication (Fig. 8). YRS’s managers can plan effectively enterprise resources, such as human power, material, and crane operation, especially in optimizing the shipyard space via DELMIA. YRS can satisfy customer’s demands by reducing the operation training cost through the maintenance procedure simulation with DELMIA.
The most important advantage of DS PLM solution is that suppliers, clients and YRS can track easily designs and update any information related with their project inside CATIA’s visual environment. Corresponding to full collaboration environment of ENOVIA VPLM, YRS can successfully enhance their shipbuilding capacity by controlling strictly the outsource activities of sub-contractors, cooperating logically equipment suppliers. Hence, all members of management board can cover all aspects of project, and make the right decisions in right time.

The new innovative 3D simulation-based support systems of DS PLM solution enable YRS to shorten the production process as much as 70% faster, and improve effectively the design capacity as much as 30%. According to \[16, 17\], DS PLM solution assists YRS optimizes their investment budget and increases the profitable income due to decreasing over two million man hours in building the semi-submersible platform. Besides that multiple partners can comprehend easily the design criteria by evaluating the 3D simulation-based models, thus to shortening the building time, reducing the unexpected production cost, and also restricting the unforeseen mistakes in practice production.

B. Case Study: Samsung Heavy Industries, South Korea

In 2001, Samsung Heavy Industries (SHI) was a member of the key national project in building a simulation-based digital shipyard. The essential goal of this project is to improve national shipbuilders’ competitive advantages. Since 2003 Samsung’s shipyard has effectively launched DELMIA digital manufacturing technology of Dassault Systèmes to build their simulation-based digital shipyard. As positive results, Geoje shipyard of SHI applied usefully DELMIA to optimize block erection procedures and also enhance the maintenance processes. The new technology is expected to save US$7.3 million a year by simulating all aspects of ship production processes in visual environment.

Up to now, SHI with around 13,000 employees can deliver more than 70 vessels every year. As stated by Intergraph, SHI implemented Smart Marine 3D solution of Intergraph for developing its 3D simulation-based design (SBD) system \[4, 13, 14\]. Recently, SHI has carried out the new projects of field development ship (FDS) design. The structure of FDS is such a complicated design that SHI has coped with difficult situations in design stage (Fig. 9). Smart Marine 3D provides state of the art digital solution to support marine engineers design the complex structures as bulbous bow design (Fig. 10) and systems as electrical, HVAC, and piping (Fig. 11). SHI owns advanced method of mega-block erection process to minimize the fabricated blocks and thus to shorten delivery time. SHI has to fabricate such complex mega-blocks and install marine equipment in pre-assembly stage. Material procurement planning plays a very essential role to secure the project schedule.

Fig. 8 3D simulation-based ship structure block erection process control \[12\]

Fig. 9 Drilling platform is built by Geoje shipyard \[14\]
To deal with above issues, Smart Marine 3D with cutting edge planning environment supports project managers can operate flexibly the overall project schedule through planning exactly the block assembly time, and controlling strictly fabrication procedures. Consequently, 3D simulation-based support systems enable SHI avoids the potential errors in design and manufacturing processes, and thus to save production cost and maximize ROI [15, 16, 17].

C. 3D Simulation-Based System Application in Vietnam

Back to Vietnam, most of engineers are similar to 2D CAD solutions especially in AutoCAD of Autodesk. Because 3D simulation-based solution in design and manufacturing is still so expensive and almost shipbuilders are small-middle size productivity and just focus on the market segment of ship construction and repair. However, some marine and offshore builders with huge investment and sustainable development recently shift from traditional 2D CAD systems into 3D simulation-based systems. Many 3DCAD/CAM/CAE solutions for shipbuilding industry are represented in Vietnam involving Maxsurf, AutoShip, Ship Constructor, AVEVA PDMS, Smart Marine 3D, Nupas-Cadmatic, Unigraphic NX, and CATIA. There are Maxsurf, AutoShip, Ship Constructor, and AVEVA PDMS have been trained by Vietnam’s universities graduating marine engineering, and naval architecture.

Ship Constructor software is popularly 3D simulation-based manufacturing solution in shipyards of Vietnam because it interfaces with AutoCAD and is introduced in major universities. One of successful stories, Hong Ha Shipbuilding Company (or Z173 factory under Ministry of Defense) implemented successfully Ship Constructor to design the new naval artillery ship [18, 19]. Saigon Shipbuilding Industry Co. Ltd used Unigraphic NX5 of Siemens to build 3D simulation-based models of piping and electric systems [20]. On the other software, Nupas-Cadmatic is used by Saigon Shipmarine shipyard to move forward 3D simulation-based design [21]. In offshore market, STX OSV shipyard and PTSC M&C have adopted AVEVA solution to maintain their competitive advantages with modern SBD and CIM systems [8, 22]. Intergraph solutions as Smart Marine 3D and Smart Plant 3D are also effectively applied by VIETSOVPETRO and PV Shipyard to build complex offshore structures in 3D visual environment [23, 24]. The proven successes indicated the new trend of 3D simulation-based support system application in Vietnam. More details can be read in [25, 26].

Fig. 10 3D simulation-based bulbous bow structure in Smart Marine 3D [17]

Fig. 11 Piping routing based on 3D simulation in Smart Marine 3D [17]
III. THE WAY TO BUILD THE 3D SIMULATION-BASED SUPPORT SYSTEM FOR THE SHIPBUILDING IN VIETNAM

Nowadays, principal offshore builders and shipbuilders in Vietnam cooperate closely with international customers or are directly invested by foreign groups as STX OSV, and TRIYARD SSY. As the results, each shipyard owns not only different CAD/CAM solutions but also complex modern management systems. In addition, there has also an issue that the chief employees of shipyards move their position into other shipyards. Both of these shipyards will waste time by training new employees again to adapt the new environment. These reasons require that the new SBD-CIM systems should be high flexibility, comfortable comprehension, and especially in meshing effectively with concurrent systems.

There are three ways to build the new shipbuilding simulation-based support system in Vietnam. The first way is that the SBD-CIM system will be developed by popular interactive programming languages such as Visual C++, Visual Fortran, and Visual Basic [10]. The advantage of suggestion, the shipyard can save investment cost by building the relationship with university to research and develop the suitable SBD-CIM system. Besides that, open source programming languages recently is powerful enough to develop successful SBD-CIM systems. For example, Aras Innovator is PLM solution based on open source developed by Aras Corporation [27]. It is the innovative trend that the SBD-CIM system can be operated totally on internet via cloud computing technologies.

As the Fig. 12, the input of new SBD-CIM system includes 3D models of ship, detailed production planning, and shipyard's production environment [2, 10]. All models can be created from advanced 3D CAD solution. The shipyard environment will easily be scanned by high-end 3D scan technologies. Production planning information is also integrated into SBD-CIM system via management tools as MS Project, which is well-known in the project management. The output of simulation based support systems can show the simulation, analysis, statistics, bill of material, and even prediction reports as collision prediction in block erection procedure, material and human resource prediction [2, 10]. Hence, the SBD-CIM system helps effectively the shipyard in ship lifecycle management, project management, and even production process control and evaluation (Fig. 13).

![Diagram of SBD-CIM system](image)

**Fig. 12** The schema of applying interactive programming languages to build the SBD-CIM system

<table>
<thead>
<tr>
<th>No.</th>
<th>Solutions</th>
<th>The advantages</th>
<th>The disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Based on interactive programming languages</td>
<td>Low investment cost</td>
<td>Long time to develop and implement</td>
</tr>
<tr>
<td>2</td>
<td>Using the SBD-CIM systems integrated into PLM solutions of famous vendors</td>
<td>Short time to implement</td>
<td>High cost</td>
</tr>
<tr>
<td>3</td>
<td>Developing the SBD-CIM packet for meshing into the current system</td>
<td>Take full advantage of the concurrent systems</td>
<td>Long time to develop</td>
</tr>
</tbody>
</table>

**Fig. 13** The advantages and disadvantages of solutions for developing the SBD-CIM system

On the other hand, to save time, the shipyard management board can consider the next generation of SBD-CIM systems integrated into total PLM solutions from famous vendors. In the third way, shipyard and universities can be care about the flexible simulation based support packets. The new packets will build depending on the programming language in the shipyard's concurrent CAD system.

In any cases, the shipyard should totally consider the shipyard’s whole capacity from design, production capacity to finance ability and even new projects in future.
IV. CONCLUSION

The global competitive environment is increasing strictly pushing Vietnam’s shipbuilder forward into the digital shipbuilding database management and 3D simulation-based technologies, and thus to (1) save man hours, and manufacturing cost, (2) optimize ROI rate, (3) decision making assistant, and (4) improve design, production, operation and maintenance capability. Intelligent PLM platform enables shipyards to achieve these essential goals in the next development strategies. Up to now, Vietnam lacks of research and analysis of intelligent PLM platform although 3D simulation-based design (SBD) and computer integrated manufacturing (CIM) has recently appeared in foreign-invested shipyards and government-owned groups. The analysis is one of series in project “Research and build digital simulation-based support system for shipbuilding industry” to assist marine and offshore builders of Vietnam comprehend the advantages of SBD and CIM especially in new PLM solution application.

Finally, marine and offshore builders in Vietnam should consider clearly new PLM solutions based on project budget, shipyard’s size, and employee ability. Hence, shipyard can choose the suitable PLM package to optimize ROI and advance the competitiveness.

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