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3D Simulation-based Support Systems in PLM Solution for Offshore and Marine Industry

Ajay D [1], Ajith Kumar M[2], Cibinesh R[3], Kumaresan S[4], Saravana Kumar R[5]

UG Scholar, Department of Marine Engineering,

PSN College of Engineering and Technology, Melathediyur, India

***Abstract* — From concept to deployment, the shipbuilding process re-quires innovative solutions that will increase efficiency, lower costs, and provide useful supports throughout the life cycle of the ship. World shipyards' experience with new ship construction and production help us to meet challenging requirements. This paper will evaluate the advantages of the 3D simulation-based support system implemented for the small to medium sized shipyards of Vietnam in the ship production process. Through the new simulation-based technology, Vietnam's shipbuilders can shorten the time to bide the new projects with the competitive price, build profitably the ship with the high quality, and obey strictly international regulations especially in handing over the ship on time.**

***Index Terms*— Support System; Shipbuilding; Product Lifecycle Management (PLM); Simulation-Based Design (SBD); Computer Integrated Manufacturing (CIM).**

I. INTRODUCTION

In accordance with (ECORYS, 2009) 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 has also increased the severe competitive pres-sure for shipyards in the end of 2008. Most Asian shipyards confront a lot of challenges in development strategies especially in Vietnam. Nowadays, progressive shipbuilders come from China, Korea, Japan, Singapore, Philippines, India, Russia and Brazil have non-stopped to strengthen their advantages by applying new innovative technologies to their shipbuilding and ship design processes.

In South Korea, Seoul National University, Samsung Heavy and some national institutes have been funded to carry out the project "Integrated Digital Shipbuilding Technology for Development of High Value-added Ship" since 2001 (Young J.S. et al, 2009). In May of 2010, one of the world leading suppliers of 3D simulation-based systems and PLM solutions, Dassault Systems cooperated with the government of South Korea, and Keimyung University in setting up their Shipbuilding R&D Center at Keimyung University in Daegu (Dassault, 2010). 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, an essential shipbuilder in South Korea, has adopted DEMILIA solution to develop the next-generation simulation shipbuilding system since January of 2003 (Dassault, 2003.) Hyundai Heavy Industries has also owned their digital shipbuilding technology via advanced 3D simulation-based solutions as AVEVA Marine, NAPA, Nastran, and Team center, Techno matix (Fig. 1) (Hyundai, 2011).

China is recently one of the world leading nations in the order-book. To build the ship with own 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's shipyard is a success paradigm in deploying 3D simulation-based systems of Dassault Systèmes (Fig. 2) (Dassault, 2008.).

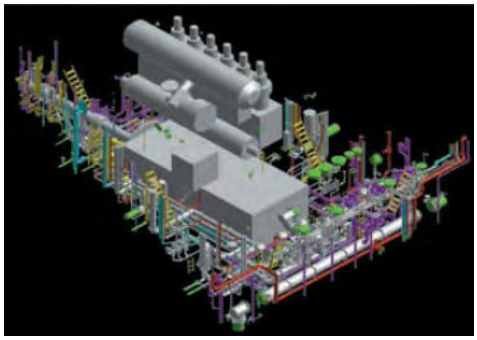

FIG. 1 3D SIMULATION-BASED MACHINERY ARRANGEMENT IN HYUNDAI SHIPYARD (Hyundai, 2011)

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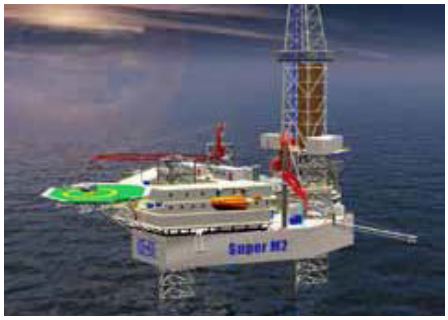

FIG. 2 3D SIMULATION-BASED MODEL OF JACK-UP OF YANTAI RAFFLES SHIPYARD (Dassault, 2008)

Vietnam's shipbuilders have to catch this new trend to survive in the world competitive environment. There are some shipbuilders intended 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 example 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) (AVEVA, 2009)

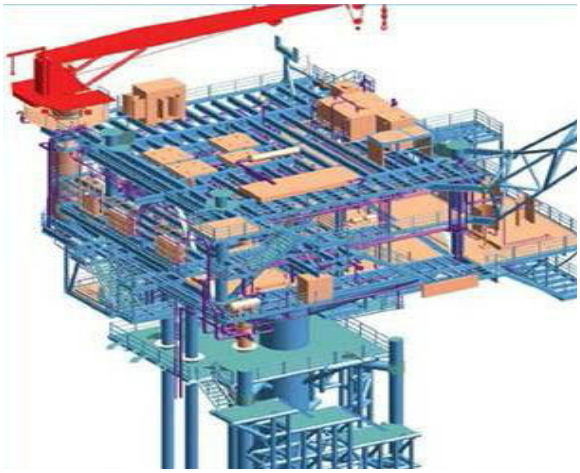

FIG. 3 600-METER WELLHEAD RISER TOPSIDE IS SIMULATED VIA AVEVA PDMS BY PTSC M&C (AVEVA, 2009)

The evaluation on the essential 3D support systems of substantial shipyards in China and Korea will remind the director board of Vietnam's shipbuilders of 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, but also enhance the shipyard's competitive advantages com-pared 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 shown, the ship production project management is required to coordinate (1) ship engineering, (2) ship construction, and (3) ship maintenance and operation from project development through fabrication and erection to out fitting and accommodations (Dassault, 2007). Due to the practical network with highly collaboration in ship production processes, the project planning is the most pivotal step. The digital shipbuilding based 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 to have the overview of the whole of project, and thus making 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 (Dassault, 2007). These support systems are available to improve the quality of design and shorten the time 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 (Hongtae K. et al. (2002)

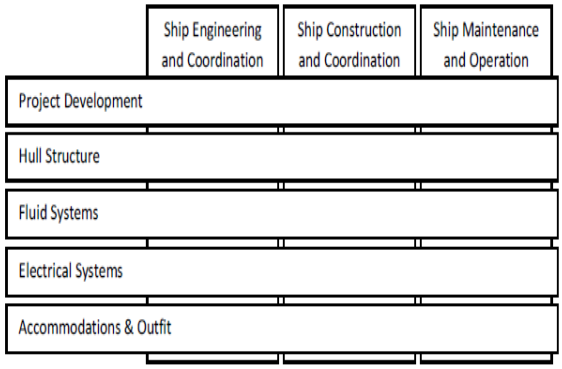

FIG. 4 PROJECT COORDINATION IN SHIP PRODUCTION PROCESS (Dassault, 2007)

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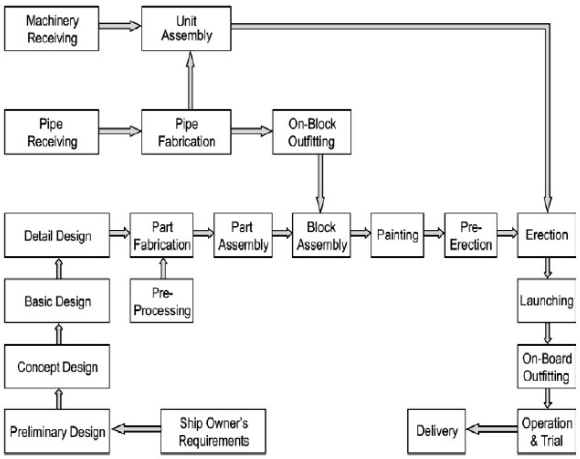

FIG. 5 THE SHIPBUILDING PROCESS USING BLOCK ERECTION TECHNOLOGY (Hongtae K. et al., 2002)

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. Fig. 5 will analyze the typical ship production process using the block erection technology (Hongtae K. et al., 2002). 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, and then support the operators to 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 equipment.

The successful shipyards around the world increasingly choose essential component outsourcing to optimize the enterprise resource, thus collaborating 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 high pressure for the communication and coordination. The 3D simulation-based support systems in PLM solution will allow each member to access 3D models dynamically with suitable levels in real time to update 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 using 3D simulation-based support systems of PLM solution, the paper will briefly analyze two case studies involving Yantai Raffles's shipyard (YRS) of China and Samsung Heavy Industries (SHI) 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 with three shipyards which are located in Yantai, Haiyang, and Longkou in Shandong province, China, respectively, is known as the largest rig builder with nearly 4,000 employees and 8,000 sub-contracted workers in China. The shipyard in Yantai, known as 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 have to transform the original 2D CAD systems into the innovative 3D simulation-based sup-port 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 (Dassault, 2008a) and (CIMC Raffles, 2012.)

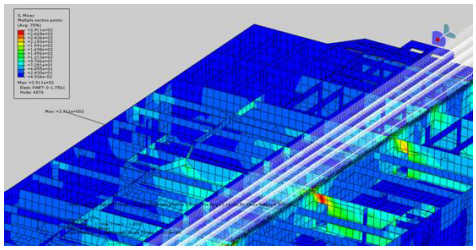
FIG. 6 3D SIMULATION-BASED FEA IN CATIA (CIMC Raffles, 2010)

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 to shorten the new product development time (Fig 7). In addition, DMU technology in CATIA encourages engineers and designers visually to simulate the block structure fitting sequence, kinematic characteristics, and even to analyze

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workshop spaces to innovate suitably their design, and thus meeting customer's demands.

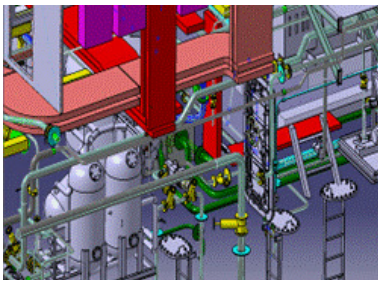

FIG. 7 COMPLEX SYSTEMS ARE SIMULATED BY CATIA (CIMC Raffles, 2010)

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). DELMIA enables YRS's managers to plan effectively such enterprise resources as human power, material, and crane operation especially in optimizing the shipyard space. YRS can satisfy customer's demands by reducing the operation training cost through the maintenance procedure simulation with DELMIA.

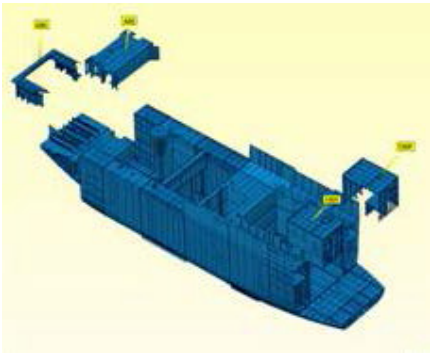

FIG. 8 3D SIMULATION-BASED SHIP STRUCTURE BLOCK ERECTION PROCESS CONTROL (CIMC Raffles, 2010)

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%, and improve effectively the design capacity as much as 30%. According to (SHI, 2012a) and (Intergraph, 2011a), DS PLM solution assists YRS to optimize their investment budget and increases the profitable income due to decrement 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 shortening the building time, reducing the unexpected production cost, as well avoiding 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 top objective of this project is to improve national shipbuilders' competitive ad-vantages. Since 2003 Samsung's shipyard has effective-ly 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 (Fig. 9.) As stated by Intergraph, SHI implemented Smart Marine 3D solution of Intergraph for developing its 3D simulation-based design (SBD) system, as mentioned in (SHI, 2012) and (Dassault, 2003 and 2006.) 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. Smart Marine 3D provides state of the art digital solution to support marine engineers on the design of 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 shortening 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 in securing the project schedule.

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FIG.9 DRILLING PLATFORM IS BUILT BY GEOJE SHIPYARD (Dassault, 2006)

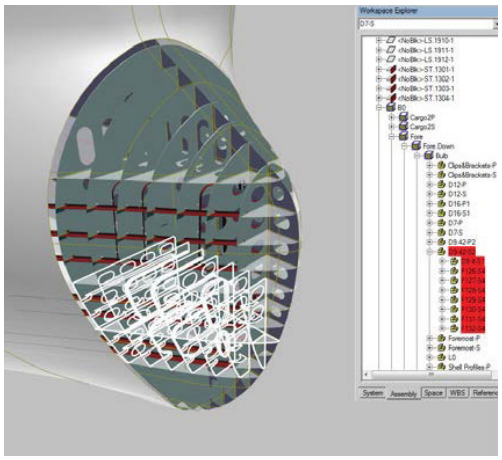

FIG. 10 3D SIMULATION-BASED BULBOUS BOW STRUCTURE IN SMART MARINE 3D (Intergraph, 2011)

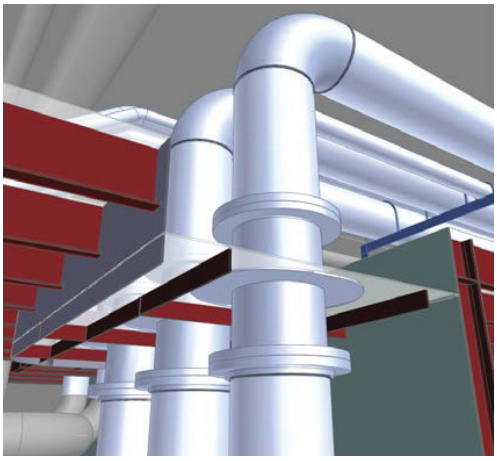

FIG. 11 PIPING ROUTING BASED ON 3D SIMULATION IN SMART MARINE 3D (Intergraph, 2011)

To deal with above issues, Smart Marine 3D with cutting edge planning environment is in favor of project managers who 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 to avoid the potential errors in design and manufacturing processes, and thus saving production cost and maximizing ROI (SHI, 2012a) and (Intergraph, 2011 and 2011a.)

III. 3D Simulation –Based System Application in Vietnam

Back to Vietnam, most of engineers are familiar with 2D CAD solutions especially in AutoCAD of Autodesk. Because 3D simulation-based solution in design and manufacturing is still so expensive and almost ship-builders are small or 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 to 3D simulation-based systems. Many 3DCAD/CAM/CAE solutions to shipbuilding industry are represented in Vietnam including Maxsurf, Auto Ship, Ship Constructor, AVEVA PDMS, Smart Marine 3D, Nupas Cadmatic, Unigraphic NX, and CATIA. There are Max-surf, AutoShip, Ship Constructor, and AVEVA PDMS which have been trained by Vietnam's universities on marine engineering, and naval architecture.

Ship Constructor software is a popular 3D simulation-based manufacturing solution in shipyards of Vietnam because it interfaces with AutoCAD and has been introduced in major universities. One of successful stories, Hong Ha Shipbuilding Company (or Z173 factory under Ministry of Defense) has implemented success-fully Ship Constructor to design the new naval artillery ship (Ship Constructor, 2012) and (Tuoitre_News, 2011).

Saigon Shipbuilding Industry Co. Ltd used Unigraphic NX5 of Siemens to build 3D simulation-based models of piping and electric systems. (SSIC, 2008.) For the other software, Nupas-Cadmatic is used by Saigon Ship marine shipyard to move forward 3D simulation-based design (SSMI, 2011.)

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 (AVEVA, 2009 and 2012.) 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 (Intergraph, 2009 and 2010.) The proven successes indicated the new trend of 3D simulation-based support system application in Vietnam.

IV. Conclusion

The global competitive environment increasingly pushes Vietnam's shipbuilder forward into the digital shipbuilding

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database management and 3D simulation-based technologies, and thus (1) saving man hours, and manufacturing cost, (2) optimizing ROI rate, (3) making right decision, and (4) improving 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 is lack of research and analysis on intelligent PLM platform although 3D simulation-based design (SBD) and computer integrated manufacturing (CIM) have recently appeared in foreign-invested shipyards and government-owned groups. The analysis as one of series in project "Re-search and build digital simulation-based support sys-tem for shipbuilding industry" helps marine and off-shore builders of Vietnam in comprehension on 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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AUTHORS BIOGRAPHY

Ajay D was born in 1995. He is currently a UG Scholar in PSN college of Engineering and Technology Tirunelveli, in the Department of Marine Engineering. His research interests include Based on Ship Steering Autopilot Based on ANFIS Framework and Conditional Tuning Scheme.

Ajith Kumar M was born in 1996. He is currently a UG Scholar in PSN college of Engineering and Technology Tirunelveli, in the Department of Marine Engineering. His research interests include Based on Ship Steering Autopilot Based on ANFIS Framework and Conditional Tuning Scheme.

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Cibinesh R was born in 1996. He is currently a UG Scholar in PSN college of Engineering and Technology Tirunelveli, in the Department of Marine Engineering. His research interests include Based on Ship Steering Autopilot Based on ANFIS Framework and Conditional Tuning Scheme.

Kumaresan S was born in 1996. He is currently a UG Scholar in PSN college of Engineering and Technology Tirunelveli, in the Department of Marine Engineering. His research interests include Based on Ship Steering Autopilot Based on ANFIS Framework and Conditional Tuning Scheme.

Saravana Kumar R was born in 1996. He is currently a UG Scholar in PSN college of Engineering and Technology Tirunelveli, in the Department of Marine Engineering. His research interests include Based on Ship Steering Autopilot Based on ANFIS Framework and Conditional Tuning Scheme.