ICCAS 2015: Abstracts

1. USE OF SIMULATION FOR COMPLEX SHIP MANOEUVRES AS APPLIED TO UNDOCKING OF QUEEN ELIZABETH CLASS AIRCRAFT CARRIERS

Doug Milne, Operations Support Manager, Babcock, UK

Floating a new build ship out of a dry dock is not usually a complex, operation. However the latest aircraft carrier for the Royal Navy did present a few unique challenges principally clearance visibility and access. This was a complex operation requiring a large and diverse team to work together in a carefully choreographed sequence to achieve success. Additionally this high profile project attracted considerable international interest and the event was widely covered in the media. In developing the plan for this manoeuvre the numerous technical issues had to be resolved and justification provided to some very senior people that the evolution could be safely completed.

This paper will discuss the contribution of simulation to this process. How both 2D and 3D simulations were used to identify potential issues and high risk elements. It will illustrate the how subsequent simulations were used to test the impact of alternative methods and equipment, and to establish the safe environmental limits for the operation. In addition the simulations were briefed to the ACA senior management and other interested parties providing confidence that the operation was safe and low risk.

It will demonstrate that simulation is an invaluable tool in the refinement of a process and for familiarisation and crew training for such unique events.

On the day the behaviour of the ship corresponded extremely well with the predictions from the simulator and *HMS Queen Elizabeth* exited her build dock without incident and to the planned timeline.

2. KEY CAD ENHANCEMENTS TO FIT SUBMARINE DESIGN REQUIREMENTS

Rodrigo Perez, Carlos Gonzalez, SENER, Spain

Naval submarines industry significantly differs from surface naval shipbuilding industry. This difference is visible in all phases of the process, from conceptual design to operation of the boats/vessels, passing through the construction itself.

Regarding the design phases, in the surface naval shipbuilding the conceptual and initial designs are driven, normally, by the operation costs of the ship, while the detail design is focused in reducing to the minimum the construction cost and timing. However, in the naval submarine shipbuilding the drivers at all stages are mainly the operability of the boat and its lifecycle, being operation and construction costs important but not essential. This difference implies different engineering and design processes, and affects the way of using the CAD/CAM/CAE applications and other IT tools (as for example PLM) supporting the design phases.

The intended paper describes the particularities of the design of naval submarines compared with surface naval vessels, and the way in which shipbuilding oriented CAD/CAM/CAE Systems can be adapted to these particularities. It also tries to highlight how the design of naval submarines can be improved by means of using such systems, and at the same time to explain how the technological improvements in this type of warships affect to the development and evolution of the CAD/CAM/CAE Systems.

Explicit reference in the paper is made to FORAN System, as it clusters the experience of SENER, a ship design company established more than 50 years ago, and the experience of several first class naval shipbuilders all around the world using this System.

3. WITHDRAWN

4. INFORMATION MODELLING FOR TRACKING MODIFICATIONS IN CLASSIFICATION PROCESS

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With the development of electronic and information technology, maritime systems nowadays are becoming more and more complex, and the degree of system integration keeps increasing. In comparison to pure-mechanical components and technical systems that have dominated maritime world for long time, quite distinctive challenges are observed with electronic devices and software based control solutions. Often they are not as mature as pure-mechanical systems and thus less reliable. Reasons for this are the fast pace of development, making solutions quickly outdated and being replaced by new solutions.

The combined effect of increasing system complexity and relatively short experience with modern complex maritime systems is a challenge for both the system manufacturers and classification societies. In approval processes for such systems, multiple iterations of system design modifications are normal cases rather than exceptions. Within the approval process the classification society is then challenged with version control, i.e. to identify and assess the impact of these changes on system reliability and safety. For integrated complex systems with a high number of components, functions, and

complex inter-relations, such an analysis is becoming significantly more time consuming, resulting in increased costs for both parties.

This paper presents an information-modelling concept for complex system design version control in a classification process. It introduces major supporting functions for tracking modifications and for analysing their impact on reliability and safety of a system. Besides the much improved work efficiency demonstrated in tests, the approach can also serve as a reference work for both, classification societies and manufacturers.

5. DESIGN DEFINITIONS OF FLIGHT DECK LAYOUT FOR HELICOPTER AVIATION OPERATIONS USING SIMULATION METHODS

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A brief synopsis of the theory and calculation of the ship motion simulation and Energy Index programs, are discussed. The Ship Motion Simulation (SMS) Model is derived from the relationship between the wave and ship motion spectrum. It incorporates seakeeping philosophy and applies various definitions of seaway spectral formulation, such as, Bretschneider. SMS defines a seaway, computes the hydrodynamic and hydrostatic forces imposed on a ship (defined as the product of its transfer function and the seaway) and calculates a resulting ship time history. The simulation is an extensive treatment of a floating object's response to the dynamic loads on its structure. The simulation establishes the forcing function (seaway) in the frequency domain, selects an appropriate definition of the ship transfer function or response amplitude operator (RAO), producing the ship response definition as a series of harmonic components. The transfer from the frequency domain to the time domain is next made by summing over time the series of harmonic components that produces ship motion time histories. The time histories are used to calculate aircraft deck limits, encountered deck forces and air vehicle motion limits. The method, verified at the RN Culdrose Test Centre, gives good performance and air loads correlation with apparent quiescent windows of deck motion. Warship configuration is being studied, amongst other issues, owing to hangar design which has indications of significant bluff body turbulent vortex shedding. These free-flow separations are associated with the presence of shear and turbulence greatly complicating the free-stream flow. Wake distortions are minimised when solid structures do not disturb the flow field. This correlates with lower ship motions. The theoretical approach is described. The monitoring system is based on the Landing Period Designator (LPD) energy index, which was integrated into the flight simulator at Culdrose. The system is a reliable means of recording ship motion parameters at the landing deck and in the hangar. A brief synopsis is presented summarising development, simulation and testing of the LPD helicopter recovery aid as applied during the simulator test. Measurements of instantaneous degree-of-freedom velocity and acceleration are reported, and preliminary comparisons are made with the LPD energy index evaluation during recovery.

6. SHIP MOTION PREDICTION USING SIMULATION – TECHNOLOGY DEVELOPMENTS AND RESULTS FROM A DEDICATED ROYAL NAVY SEA TRIAL

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An essential condition for the safe recovery of a manned or unmanned device to a “Mother” platform regardless of the seaway, is the necessity of fully defining the motions of the recovery platform with significant lead time or prediction. Quiescent Period Prediction (QPP) system achieves this by using a wave sensor system to measure the sea surface several hundred meters in advance of the ship. From the measured sea surface, a short term deterministic wave model can be constructed allowing the wave system to be propagated to the ship's location. The ability to fully define a ship’s motion as a function of a recovery device, greatly enhances the overall system operational capability whilst fundamentally reducing the inherent risks associated with platform manipulation in high sea conditions. The use of simulation is routinely considered in the UK, as an alternative to traditional approaches such as scale model testing and full scale sea trials, to predict the safety and performance envelopes of platforms and systems. The objective is to safely expand ship operating deck limits. This article describes the NATO Submarine Rescue System (NSRS) launch and recovery simulation model and the corresponding verification and validation data program testing the accuracy of the simulation modeling. Verification information is discussed regarding the sensor operation and interfaces collected during this trial, a QPP simulation design specification is being produced based on High Level Architecture (HLA) technics. Particular attention is applied to the latter portions of the Submersible Rescue Vehicle (SRV) recovery procedures in which there is a heightened risk of ship to ship collisions. In higher sea states, QPP offers the ability to identify when the ship motions are most favorable to

bring the vehicle into the dangerous recovery zone. In the development of the report topic, an overview of the theory and application is provided concerning dynamic interface analysis with the focus on encountered forces and vehicle to platform response stability.

7. DETERMINING SHIP OUTFITTING TASK PRIORITIES USING LATEST FINISH TIME DISTRIBUTIONS

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The outfitting process has become increasingly more important in recent years for shipyards building outfitting intense complex ship types, such as cruise ships, dredgers and offshore vessels due to the ever increasing complexity of such vessels. The outfitting process is often defined by disorganization, a lack of transparency and sub-optimization, all of which result in an inefficient outfitting process filled with unnecessary rework. These problems are worsened by an inherent difficulty in transferring the necessary skills to a new workforce. One proposed solution to alleviating these problems is to codify the outfitting process and develop methods which can enhance the abilities of existing outfitting personnel by automatically performing some portion of the required planning tasks. This paper examines the relationships constraining the different mounting tasks of the outfitting process to systematically develop task priorities. The task priorities are selected with the goal in increasing the controllability of the outfitting process and minimizing the potential for rework. To develop these priorities, the complex network of precedence relationships governing the outfitting process is first defined, and then priorities are assigned based on Latest Finish Time distributions created using Monte Carlo simulation. A test case of an auxiliary machinery room section of a recently delivered pipelaying vessel from Royal IHC is also presented to show the feasibility of the developed method. This paper is part of a larger effort to model the outfitting process of shipbuilding to facilitate efficient production and effective knowledge transfer.

8. OPTIMIZATION OF BALLAST WATER MANAGEMENT SYSTEM INSTALLATION PROCESS BY 3D ENGINEERING TECHNOLOGY

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To meet IMO's "International Convention for the control and management of Ships' Ballast Water and Sediments, 2014" that is expected to come into force in next few years, ship owners will be required to equip their new and existing vessels with BWMS (Ballast Water Management System) usually inside the engine room that is already very crowded with a number of pipes and machinery equipment. Currently, shipbuilding engineers have no choice but to visit the vessel several times in advance to understand the latest arrangement in the engine room and conduct 3D engineering using generic modeling software they are not familiar with.

The authors and other maritime stakeholders in Japan have developed a completely new system that supports smooth and effective installation of BWMS. In the new system, once the engineers scan the exact arrangement in the engine room with 3D laser scanners as a huge point cloud, a modeling software reproduces the situation of the engine room as a 3D model quickly. Since the software applies the standard rules of various ship components, such as pipes, valves or ladders, as constraint conditions in performing the data processing using least squares method, ICP, RANSAC or down sampling filter, the 3D model is created with high accuracy and less working load. And the 3D data is converted to the CAD format for the detailed engineering. This system is already used by major shipyards and designing companies and proved to be capable of shortening the installation term of BWMS drastically.

9. GENERATION AND SUPPRESSION OF DIMPLES IN MULTI-SQUARE-PUNCH FORMING PROCESS FOR DOUBLY CURVED SHIP HULL PLATE FORMING

Yijie Cai, Wuhan University of Technology, China

Multi-square-punch forming (MSPF) has been introduced into doubly curved ship hull plate forming industry as a novel kind of reconfigurable die. Traditional reconfigurable die employs height-adjustable hemisphere punches distributed in matrix style in pair to approach continuous upper and lower solid dies. The contact between die and workpiece is point-to-surface which lead to generating dimples and wrinkles on the workpiece. MSPF technology adopts rotary-square-punch (RSP) to construct the die surface transforming the contact to surface-to-surface avoiding those defects. RSP is constructed by a cuboid part directly contacts workpiece can approximate a more continuous and compact die surface with other cuboid parts and a hemisphere part can maintain a constant rotation center when RSP rotating in the base. Meanwhile the distribution of punches in upper and lower die are changed from symmetric to asymmetric. But there are still some dimples after experiment. To suppress dimples, numerical simulations on MSPF for fabricating pillow and saddle-shaped parts are bring about through Ansys LS/DYNA. In the forming system, upper and lower die are consisted by 21*21=441 and 22*22=484 RSP with a 125mm*125mm cuboid part contacting the workpiece separately. The height matrix of RSPs is calculated by software. The simulation result adopting dynamic-explicit algorithm shows dimples are caused by sharp

corners on cuboid part of RSP. Therefore, new simulations using the corrected RSP been chamfered are carried out. Result of those simulation shows generation of dimples are obviously suppressed. Finally, experiment shows adopting corrected RSP can suppress defects in MSPF process excellently.

10. COMPUTER AIDED STRUCTURAL DESIGN OPTIMIZATION IN SELECTION OF A T-SECTION WITH UNIFORM STRENGTH

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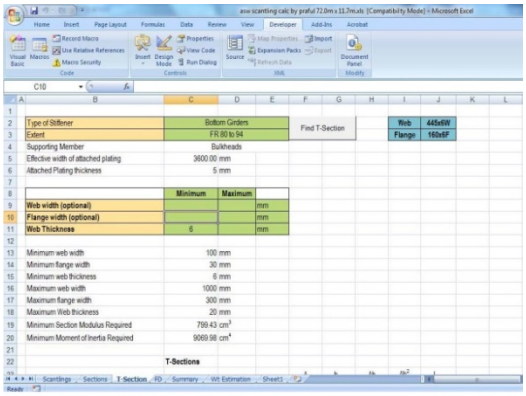
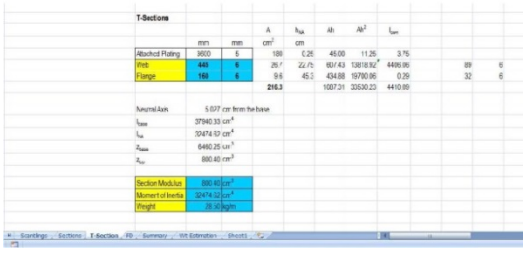
The structural design procedure followed by most designers revolves around the Classification Society requirements of section modulus, moment of inertia or shear area of the structural member under consideration. This paper describes a computer-aided method, which uses advanced features of Microsoft Excel, to arrive at an optimum scantling of a T-section, for a required section modulus and/or moment of inertia. The parameter of optimization is the sectional area (and hence the weight); incorporating principles which regulate the proportions and forms of sections to ensure uniform strength of the section; i.e. both shearing strain and bending strain are considered and the web and flange begin to yield simultaneously.





The program uses in-built features of Microsoft Excel, vis-à-vis the basic functions of computation and the powerful Solver Add-in for optimizing the selection of the T-section stiffener. The automation and iteration procedure has been programmed using Excel Visual Basic for Applications (Excel VBA) and has been integrated into the program to perform iterative selection with the click of a radio button.

In many instances, the designer would want to impose a minimum/maximum restriction on the web height, flange length and/or web/flange thickness. The program also incorporates an optional input of these data from the user. On click of the radio button, the solver algorithm is run, incorporating the user-imposed restrictions, computing the scantlings for a T-section with uniform strength and minimum weight. A screenshot of the program, customized for the structural design of a specific vessel, is shown above.

11. ENERGY SIMULATION FOR WASTE HEAT RECOVERY SYSTEMS

Jörg Lampe, DNV GL SE, Germany

Traditionally, energy efficiency approaches were based on the optimization of individual components of the energy system. More recently, with the rapid evolution of numerical simulation for energy flow on ships, design and operational solutions can be assessed by considering the complete energy system. In this paper, the authors present an updated version of the Ship Energy Systems library within the software SimulationX - a Waste Heat Recovery (WHR) system has now been integrated. The goal of the library is to model the thermodynamic behaviour of the entire on-board energy system, including e.g. main and auxiliary engines, pumps, turbines and heat exchangers. The WHR elements include a single- or dual-level Heat Recovery Steam Generator (HRSG), a power turbine, steam turbine, and combined power and steam turbine among others. The energy recovered by the WHR can be used to meet electrical demands, and/or added to the powertrain via a shaft motor. The main characteristics and benefits of the WHR tool are illustrated via simulations and results. Total extra power produced, fuel consumption and costs will be compared for a standard energy system with and without heat recovery.

12. ANALYSIS OF PROPELLER WAKE FIELD FOR TWISTED RUDDER DESIGN

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Interest in high fuel-efficiency is growing because of new environment regulations. Consequently, many kinds of energy saving devices (ESDs) have been developed and applied in order to reduce hydrodynamic resistance of hull or increase propeller efficiency. Since such performances are highly related to a flow around a hull and its appendages, it is essential to predict the flow characteristics around hull precisely in the early design stage.

This paper examines hydrodynamic characteristics, especially propeller wake field, based on CFD (Computational Fluid Dynamics). To validate the computational method, the CFD results were compared to an experimental data which measured the propeller wake field of 174,000 CBM twin skeg type LNG carrier model ship by using stereoscopic particle image velocimetry (SPIV) system in Hyundai Maritime Research Institute (HMRI) and we found that the present CFD method provided reliable results. A twisted rudder was designed in consideration of the propeller wake field flow by using the CFD technique.

A CFD analysis on the designed twisted rudder has been carried out and the results were compared to an experimental data which was conducted at the towing tank in HMRI. We found that the designed twisted rudder showed improved efficiency of about 1% relative to a symmetry rudder.

14. REMANUFACTURING IN SHIP REPAIR – A REVIEW OF POSSIBILITIES.

Kim Jansson, VTT Technical Research Centre of Finland, Finland

Remanufacturing is an industrial process in which used products are restored to "*like new"* condition. This means that the remanufacturers claim that the remanufactured product or component should meet the specifications of a new product or component, both in performance and appearance.

Ship repair is an industry branch not very often addressed in the "Remanufacturing" community. A complete ship cannot be remanufactured; it is too large a unit. However a ship contains a very large amount of different types of components and structures that very well can be the object for remanufacturing activities. There are many forms of ship repair activities, starting from small scale voyage repairs and on-board repair to planned dry-docking, ship overvault, large scale retrofit and refurbishment, all the way to complete ship conversion. Additionally in some occasions emergency and damage repair on short notice may be needed. The ship repair business domain involves various special characteristics, it is to a large scale labour intensive, with short delivery times involving a variety of products, working methods and partners. Additionally ship repair sometimes involves environmentally hazardous material usage.

The presentation discusses how remanufacturing could be applied in the different types of ship repair activities. The yard can take different roles in the remanufacturing value chain and reverse logistics operations, for example collector of part to be remanufactured, independent remanufacturer involving disassembly, cleaning, reconditioning etc., and the role of customer for remanufactured products. The presentation reviews challenges and opportunities of applying the remanufacturing concept in the domain. The paper also elaborates on the forms of networked remanufacturing organisations.

15. TOOL FOR EVALUATION OF OPERATING ECONOMY AND ECOLOGY IN SHIP CONCEPT DESIGN

Saara Hänninen, Risto Tuominen, Susanna Kunttu *(VTT Technical Research Centre of Finland Ltd) and* ***Mia Elg*** *(Deltamarin Ltd)*

Alongside the pure economic performance, the ecological performance has become an important aspect of interest that needs to be accounted in ship design. This reflects both the environmental regulations in the maritime sector getting more demanding, as well as the positive marketing value of the more sustainable technology and operation perceived by the shipping industry. Consequently, there is a need to consider both economic and ecological aspects early on in the vessel design process to effectively guide the selections that are made between technical design and operating alternatives in each particular ship project.

In this paper, we introduce a simple tool aimed to support ship concept design and discussions between a shipping company and the ship designers on alternative solutions for ship machinery. The tool supports systematic comparisons and informed trade-offs between design and operating alternatives considering both economic and ecological impacts of the decisions. The effects of these alternatives on vessel performance, fuel-economy, and ecological impacts in terms of exhaust gas emissions can be quickly simulated to find the best valued solutions. The present tool implementation allows *preliminary analyses* with initially available data and estimates regarding the considered case, as well as *advanced analyses* when more specific data are available to facilitate more detailed views.

Tool functionality and usage will be described and demonstrated with examples based on real vessels. Finally, directions for potential future tool developments are briefly discussed.

16. RESEARCH ON INFORMATION MATCHING CORRELATION TECHNOLOGY FOR THE MANUFACTURING ASSEMBLY OF HULL ASSEMBLAGE

ZhiChao Chen, Jiangsu University of Science and Technology, China

In order to meet the requirements of fine management in shipfitting, change the manual importing mode of ship companies in the process of production management about man-hour and production quota, improve accuracy of the management about man-hour and production quota

in shipfitting and achieve a reasonable tasking. By using the data of ship structure and outfitting in TRIBON M3, meanwhile develop and set up the correlation between the assembly information of the parts that were defined by assembly planning and the data of man-hour and production quota which were defined in the external database, to achieve the goal that the formation of man-hour list and work card include the class of assembly planning tree、the matching attribute information between assemblage and the parts as well as quota information, to avoid the extensive management of the manual importing mode about man-hour and production quota, at the same time increase efficiency and precision of production management in shipyard.

Key words: Block Assembly; Hull Structure; Outfitting; Production Management; Data Correlation; TRIBON M3.

17. 3D PRODUCTION PLANNING SYSTEMS AND THE DATABASE

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During the past 5 years, 3D models which CAD systems create have been increasingly utilized for various production planning and management tasks in the author's several shipyards, needless to say for design activities. The concept that the 3D models of CAD systems could be and should be useful and effective for production as well as design has been recognized, since many Japanese shipyards started to develop their original shipbuilding CAD systems in 80's, but it has been just a dream for long time.

This paper roughly reads the history of the shipbuilding CAD systems that the company has as well as the data which the system create and shows the reason why it took long period until the application of 3D models has reached from design to production. And then, it introduces recent examples of computer aided production planning (CAPP) systems used in the author's shipyards, which are applied to assembly planning, paint planning, scaffolding planning and so on.

Through the actual usage of those systems, the author obtained some of important knowledge about the effectiveness of 3D models used for production planning and the relationships among the data of CAPP systems.

Finally, based on the knowledge, the paper tries to discuss the necessity of a database for CAPP systems that is inconsistent with that for CAD systems.

Key word: CIM, 3D model, database, production planning

18. DIGITAL MOCK-UPS AND WORKING SIMULATION ON MIXED REALITY.

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Mixed Reality (MR) technology is the one of the virtual reality technologies that seamlessly merges the real and virtual world in real time to produce a new environment where physical and digital objects can co-exist and interact.

Needless to say, it is very important for manufacturing industries that their manufacturing sections check and review the design information and then feed their requests back to their design sections to improve the productivity, usability and customer's satisfaction before construction starts. For this purpose, they have traditionally used 2D drawings, scale models, partial mock-ups. And recently new computer technologies such as digital mock-ups, 3D viewers and virtual reality can be utilized for 3D CAD systems with computer hardware advanced.

In shipbuilding industries, however, these brand-new 3D technologies, excepted 3D viewing at design review, have not been usually applied on practical use yet. One of the reasons is that because the technologies allow users only to see but not to manipulate 3D models interactively, the knowledge from them is as almost same as that from CAD systems. On the other hand, MR Systems let the users go into 360 degrees full-scale CG image worlds merged with real world that are responsive to their position and orientation. In addition, they can interactively react to 3D models by their hands.

We tried to apply an MR system as digital mock-ups and simulation of working procedure in our TSU Shipyard. This article shows some of knowledge and effectiveness of MR obtained through the trial.

Key word: Mixed Reality, digital mock-up, frontloading, interactive operation, simulation

19. A NEW INTEGRATION METHOD TO COMPOSE A SINGLE VIRTUAL SHIP DESIGN SYSTEM FROM INDEPENDENT COMPONENTS

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Jan van der Zee, CONOSHIP, The Netherlands
Theodoor de Jonge, NUPAS-CADMATIC, The Netherlands

Since long time software developers and the users of software have searched for a workable way to exchange data between different software systems. Many attempts have been made to create solutions based on dictionaries

which try to include all there can be existent. One example is STEP but there are several others as well. The idea of creating a neutral model itself seems great, but in practice it is hardly used.

Conoship, SARC and NUPAS-CADMATIC have been investigating solutions to overcome the hurdles that are included in the neutral model interfacing. This group developed a concept and prototype in which each software systems uses each other's capacities, but at the same time stay independent. Not only data sharing but also reply/request mechanisms were designed to facilitate asking questions from one application to the other.

A jointly developed paper by Conoship, SARC and NUPAS-CADMATIC on this topic can be presented at ICCAS 2015 by NUPAS-CADMATIC.

20. THE INTEGRATION OF HUMAN FACTORS INTO PRELIMINARY RISK-BASED SHIP DESIGN

A. Piperakis, R. Pawling, D. Andrews, UCL Design Research Centre, UK

FAROS is a three year EC funded multinational research project investigating the relationship between ship design and human performance. The motivation behind the project is the fact that the majority of maritime incidents occur due to human error. The projects main objectives are to develop an approach incorporating human factors into Risk-Based Design of ships and propose design improvements to both cargo and passenger ships to mitigate risk. Human performance can be effected by a range of global design factors, such as ship motions, noise, whole body vibration, deck layout and equipment arrangement and a series of experiments has been carried out to evaluate their influence.

The project consortium consists of 12 members, including industry, academia and research institutes, one of which is the Design Research Centre (DRC), a part of the Marine Research Group of the Department of Mechanical Engineering of UCL. The main tasks of the DRC within FAROS involve the development of parametric cargo ship models, the integration of the design and evaluation tools, and the exploration and optimisation of the cargo ship designs using those tools.

This paper will illustrate the development of the parametric ship models and their integration with various design evaluation tools. These tools include those developed specifically for FAROS to represent the human element and attempt to bring human factors into the early ship design stages. Finally, preliminary results collected during the exploration and optimisation phase of FAROS, using the suite of analysis tools, will be presented.

21. INTEGRATED SYSTEM SIMULATION AND DEPENDABILITY ANALYSIS IN MARITIME INDUSTRY

Erich Rüde, DNV GL, Germany

The design of ship systems faces an increasing number of challenges such as tightening environmental regulations and rising fuel costs. There is strong motivation to search for efficient methods of energy conversion and - at the same time - keep operational and total costs as low as possible.

Conventional systems are well known and proven in terms of safety and dependability. To achieve at least the same safety standards using alternative, more efficient system layouts and to anticipate costs due to breakdown, safety and reliability analyses are essential. This paper shows an efficient method of executing such analyses on the basis of physical system simulation models using a single platform. All stakeholders participating in the system design benefit from the integration of energy and dependability analysis. Efficient implementation of design changes or updates, better communication between system designer and safety/dependability analyst as well as the reusability of component libraries and models are only a few of the benefits.

The dependability and cost analysis is carried out with HiP-HOPS, a semi-automatic fault tree analysis tool integrated in the simulation platform of SimulationX. The example used is of a waste heat recovery system (WHRS) that was analysed through simulations in the same platform and is described in the paper [citation here]. The resulting estimates of system availability and costs of different design modifications and potential system breakdown, together with the energy efficiency, build a set of decision criteria for choosing the best system design.

22. PARAMETRIC CALCULATIONS IN PRODUCTION DESIGN OF THE PROPULSION MACHINERY

Yuriy Batrak, Roman Batrak, Dmytro Berin, Intellectual Maritime Technologies, Ukraine

Computer applications for engineering usually aim to solve certain classes of problems. As a rule it is implicitly assumed that the initial data for such calculations are well defined and unambiguous. However, in those cases where there is a set of equally acceptable input data combinations or the specific data ranges are only known, the problem arises how to set the initial data and evaluate their influence on the design parameters. In such cases, designers are forced to use an approach, which is realized as a sequence of calculations based on the variation of input data, i.e., implement so-called parametric calculations. This approach is officially recommended by Classification societies in those cases

where the designer needs to assess the impact of uncertain factors. Taking this into account the developers of ShaftDesigner software have implemented special feature to enable parametric calculations for automatic assessing of the impact of various parameters. Currently three modules based on parametric calculations are used at the ship production stage to select the suitable propulsion shafting alignment plan. These include a module for defining of the acceptable bearing offsets space, a module for defining of the permissible ranges of propeller hydrodynamic loads variation, as well as a module for defining of the loads ranges that can be applied to the gearbox flange without violation of gear box shaft alignment criteria. The subject of this article is how these modules based on the parametric calculations are helping the software users to ensure reliable and trouble-free machinery operation.

23. HIGH QUALITY HULL FORM REPRESENTATION BASED ON SUBDIVISION SURFACES

Sebastian H. Greshake, Robert Bronsart, University of Rostock, Germany

Usually, a hull form is represented by tensor-product spline surfaces. Due to the topological limitation of tensor-product splines to quadrilateral surfaces, hull forms are composed of several patches. This results in discontinuities of different order between neighboring patches. Indeed, this is known to be error-prone in practice. Additionally, the quality of a hull surface measured in terms of fairness is limited due to discontinuities. Hence, the goal of this work is to represent a hull form as single spline surface, which is the natural solution to avoid discontinuities.

First, subdivision surfaces are introduced. Initially, subdivision is just another mathematical approach to define tensor-product splines, but in contrast it allows for a generalization of spline surfaces to arbitrary topology. Furthermore, surface features, such as knuckles, are easily defined based on subdivision.

Second, the application of subdivision surfaces is shown. The hull form of a typical container vessel is represented by a single, generalized cubic spline surface. The surface is basically G^2 everywhere, which enables a high-quality representation of the hull form. The application of surface features is demonstrated to define common hull components, for example the flat transom or the flat side and bottom, along with its appropriate transitions within a single surface.

24. AUTOMATIC DESIGN METHOD AND APPLICATION FOR COMPLEX SHIP BLOCK LIFTING

Rui Li, PhD, Lecturer, School of Naval Architechture, Dalian University of Technology, China

Numerous problems are existing in traditional block lifting scheme, such as complex process, low degree of automatic, lack of theoretical guidance and so on. To improve the deficiencies, this paper develops an automatic design system for complicated block lifting. The data extraction method of Tribon was used to distinguish the characteristic area of blocks, and the lugs were laid out rapidly at right places. Besides, using Matlab and 3ds Max, it could effectively forecast the potential problems by analyzing the lifting wires stress and simulating the lifting process. The system improves the efficiency greatly and is convenient for designers to modify the lifting scheme and make the design more safe and reliable.

25. INTEGRATED SOFTWARE APPLICATION FOR E-APPROVAL OF SHIP & OFFSHORE CLASSIFICATION

Triyan Indrawan and Topan Firmandha, Researcher at Biro Klasifikasi Indonesia

BIRO KLASIFIKASI INDONESIA (BKI) is a state-owned classification society that develops and maintains technical rules and regulations for the construction and operation of ships as well as the offshore structures. One of the main business activities is the plan approval for both new-building design and existing. The plan approval was conducted by using conventional and manual method which focused on the hardcopies storage and exchange system. Consequently, it is found out that the system is time consuming and needs a huge document's storage spaces in the office. DEWARUCI was developed by BKI-R&D and introduced as an electronic-based plan approval in order to overcome those challenges. The electronic plan approval processes through Dewaruci would be shortened up to 50 per cent compared with the conventional means, thus make it more effective and efficient. To support the system, Dewaruci is equipped with a set of technical calculation application system and proved to be able to integrate data amongst clients (i.e between field surveyor and technical surveyor) as well as between client and DCC server (Dewaruci Control Centre). Moreover, Dewaruci provides verification and validation of the data from the client's computer. Further these data will be collected and used as a data bank in the DCC server.

Keyword : Dewaruci, e-approval, software, technical requirement, BKI

26. RESEARCH OF CHARACTERISTIC OF WRINKLING IN COLD FORMING PROCESS FOR SHIP FRAME PART BASED ON NUMERICAL SIMULATION

LIPei-yong, SongJun-jie, WANGCheng-fang, MAOYun-sheng, Zhouyongqing, Xiangzuquan, Wuhan University of Technology, China

Abstract: Frame parts of civilian ships, such as transverse and longitudinal, generally are formed with cool forming method. In the forming process, winkling is one kind of defectness that occur commonly. Wrinkling will lead to waste of material and even damage of forming equipment mould and the production will be affected. So prediction and control of wrinkling in cool froming process are key technique for profile forming work. Nonlinear finite element method has been used to the numerical simulation of profil cool forming process and the calculation results are used to analyse the characteristic of wrinkling in the of forming process in this paper.

According to the characteristic of profile cool forming process, this paper presents the key technology in the numerical simulation briefly, including: material constitutive relation, contact and friction boundary condition between profile and forming mould, load and boundary condition. Then this paper introduces the modeling method for finite element model of mould and profile according to the structure characteristic of the bender and working principle of cold forming process. The numerical simulation results have been compared with the experiments results and they show that the calculation results are correct and this method can be used to study the cool forming process of profile.

Based on the calculation results the effect of some parameters, such as forming technical parameters and specification of the profile, have been studied and some useful results have been obtained. Analyses show that the main factors affecting on wrinkling includes the distance between two side moulds, the height and thickness of profile web. So rules for the factors affect on wrinkling are studied and some significant results have been got. The rules of wrinkling occurred in cool forming process can be used to guide the forming work.

Key words: profile parts; cool forming; wrinkling; numerical simulation

27. ACCURACY CONTROL OF HATCH COVER USING PRECISE MEASUREMENT TECHNIQUE

Ryogo Abe, Kokusai Kogyo Co., Ltd., Japan
Kunihiro Hamada, Noritaka Hirata, Hiroshima University, Japan
Ryotaro Tamura and Nobuaki Nishi, Tsuneishi Shipbuilding Co., Ltd. Japan

Generally, understanding shape deformation and the precise amount of three dimensional deformation at manufacturing processes is a critical issue in accuracy control. Since ships are very large products, three dimensional deformation measurements are very difficult to conduct during ship manufacturing process, and for that reason only few cases have been reported.

In this research, a hatch cover is selected as a target structure and the three dimensional welding deformations observed in each manufacturing process were measured by “total station”. As a result, welding deformations of each process are made cleared with their distributions. Moreover, the actual accuracy of the three dimensional measurements in the shipbuilding process is examined.

In the paper, overview of the three dimensional measurements is introduced and the measurement results and the welding deformation in each process are examined. Moreover, actual accuracy of the three dimensional measurements in shipbuilding are discussed in consideration of the important points to secure the accuracy.

28. DEVELOPMENT OF PRODUCT MODEL DATA EXCHANGE BETWEEN DIFFERENT 3D CAD SYSTEMS IN JAPANESE SHIPYARDS

Tokimasa Hiraki ,Mitsubishi Heavy Industries, Ltd.
Yoichi Nakao, Oshima Shipbuilding Co.,Ltd.
Yasuaki Ohtsuki, Tuneishi Shipbuilding Co.,Ltd.
Kohki Maeda , SEA Soken
Mitsuhiko Kidogawa, Class NK
Ken Itoh, CIM Creation

The maximum use of integrated 3D-CAD system, which covers from basic design to production design, is crucial for the shipyard to design competitive ships and to improve design/production efficiency. Especially in Japanese shipyards, the number of production design experts is decreasing, therefore dependence on the 3D-CAD system, which can generate precise parts data automatically, is increasing.

Commercial 3D-CAD system is a good tool which covers wide area of design stage, but the requirements of 3D-CAD system differ at each design stage. At the upstream design stage, the function to support the design spiral is required. At the downstream one, the function to generate precise parts data and detailed production information is essential. It will be possible that one 3D-CAD system has a strong point at upstream design stage, while another one has advantage at downstream design stage.

There is a possibility of applying different 3D-CAD systems optimum at each design stage for further improvement in design quality and efficiency. This challenge is being made in some shipyards in Japan.

Thus there is a strong demand for data exchange between different 3D-CAD Systems.

In general, data exchange at the level of product model is a challenging task because each 3D-CAD system has each design philosophy and implementation of data model. To solve this problem, cooperative R&D is being carried out with ClassNK and Japanese shipyards.

In this paper, authors present the fruit of R&D and introduce examples of practical application to the actual design process with successful results.

29. DIGITAL MANUFACTURING BASED ON 3D DESIGN INFORMATION

Tokimasa Hiraki, Mitsubishi Heavy Industries, Ltd.
Yuji Mimori, Mitsubishi Heavy Industries, Ltd.

In recent years Digital Manufacturing, the extensive use of digital information from initial design through detailed design and production to maintenance, has been accelerating in many industries, and the continuous renovation of manufacturing process by effective use of ICT is crucial for manufacturers to keep competitiveness in the global market.

In the shipbuilding divison of Mitsubishi, we have been developing in-house 3D-CAD system MATES since 1980's and continuous improvement has been carried out to realize CIM for shipbuilding. The 3D design and manufacturing information created by MATES is transferred to manufacturing department via factory LAN and is used in every production stage.

MATES covers wide area of design process from basic design stage to production design stage. MATES is a practical and proven 3D-CAD system and has a strong point at downstream production design stage with the function of generating precise parts data and detailed production information.

The 3D design information created in the designing department is widely used in the manufacturing department.

We also have been developing in-hose 3D-Viewer since 2000's. It has useful functions equipped exclusively to support designing and manufacturing process of shipbuilding. Over 500 sheets are deployed in the yard and used as a portal of 3D design information.

In this paper, authors focus on the renovation of manufacturing process by use of ICT, and present the examples applied to the actual manufacturing process as follows: (1) 3D-Viewer, (2) Steel plate printer, (3) Other NC equipment and devices, welding robots and so forth.

30. INTERNATIONAL SIMULATION OF REPLENISHMENT AT SEA USING VIRTUAL SHIP STANDARDS

Dr **Gary Henry**, Other co-authors will be from Canada, Germany, Italy and the UK, SEA, UK

This paper describes the design, development and testing of a real-time Replenishment-At-Sea (RAS) simulation. The project was undertaken by five contributing nations, Canada, France, Germany, Italy and the United Kingdom, collaborating under an international Project Arrangement (PA). The simulation itself is a High Level Architecture (HLA) distributed federation, demonstrating a simulation standard known as the Virtual Ship. This standard supports the rapid development and re-use of federates for simulating interacting ships at sea with their on-board equipment, while demanding only a small subset of the HLA functionality. To keep costs down, the federation implementation maximised the use of existing simulation software, while successfully avoiding the need to use commercial of-the-shelf software. The paper describes the Virtual Ship Federation Object Model (FOM), which is a small extension to the Real-time Platform Reference (RPR) FOM, and a novel method for implementing time management. The internationally contributing ship motion and hydrodynamic interaction federates and their data preparation activities are presented, together with the methods used for validating the federation, using tank test data and data gathered from at-sea trials. The presentation includes movies of the running simulation that illustrate various aspects of the simulation implementation.

31. A BILL OF MATERIAL OF INTEGRITY: ALIGNING CAD AND PDM

Stephen Cattanach, BAE Systems Naval Ships, UK

BAE Systems Naval Ships has experienced significant challenges on both the Type 45 and Queen Elizabeth Carrier Programmes in aligning Engineering Bill of Material (BOM) related data across its Product Data Management (PDM) and Computer Aided Design (CAD) Platforms. This can be attributed to a lack of a master data philosophy which has created significant data integrity / alignment issues and a lack of confidence in the BOM. Substantial manual effort (and cost) has been expended on each project to remedy this issue.

BAE Systems is currently in the assessment phase of the Type 26 Global Ship Combatant programme. This programme has tight schedule and cost constraints. A repeat of the alignment issues experienced on previous programmes will impact the ability to deliver the programme. An exercise of integrating the FORAN CAD and Windchill PDM Applications has been undertaken to provide a preventive solution. This integration will rely on the use of both COTS and new functionality.

Therefore a 15 month, 2 phase development programme in partnership with the application vendors has been agreed and initiated. This programme will deliver:

- A coherent Master Data policy is implemented
- Elimination of data integrity issues across the two applications, ensuring previous nugatory effort is eradicated
- Reduction of amount change and rework by up to 40%

In terms of approach a close partnership with each vendor has been established with agreed milestone activities in place with delivery of required capability aligned to programme need.

This paper will explain the approach, challenges and success experienced during this programme.

32. DATA GOVERNANCE AND DESIGNING WARSHIPS

Tony Wallis, BAE Systems Naval Ships, UK

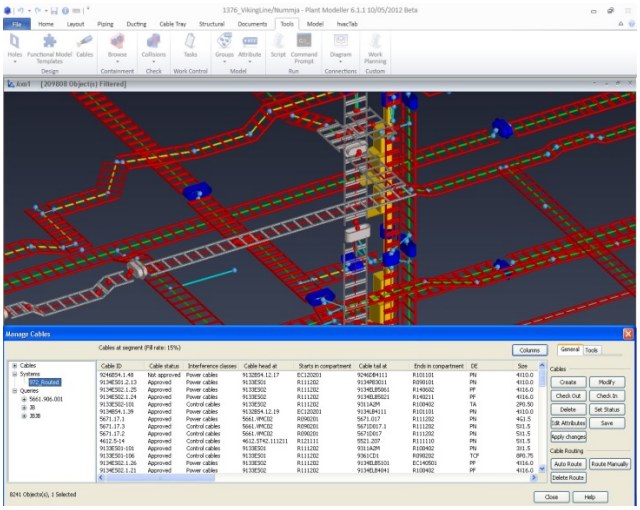
In 2012 BAE Systems Maritime - Naval Ships were challenged to improve their data management in order to drive out as much unnecessary cost as possible from their ship building programme, anticipating savings of tens of millions of pounds. The basis for this was more rigorous identification and control of engineering data. The challenge was that the true value of data wasn't appreciated across the workforce which could lead to costly rework downstream. Governance was required to bring in the controls required to manage data as an asset. This laid the foundations for subsequent Master Data Management activity, which would catalogue all of the data used, and Data Quality activity which would deliver tools and techniques to automatically characterise the data. The net result was that engineers spend less time finding and validating the data they needed to do their jobs. This enab led them to focus on using that data immediately, as well as rapidly identifying any of their own bad data for correction.
Naval Ships have developed and delivered a programme in around eighteen months, by adapting tools and techniques originally designed for the commercial banking, retail, and service sectors. This paper describe how the techniques were discovered, adapted and implemented, and the lessons learned along the way. In particular:

- How to successfully scope out a realistic plan for implementing Data Quality and Data Governance
- What the unique challenges for managing engineering data are
- How engineers learned to value their data
- What can be achieved within a limited budget.

33. CABLE ROUTING IN CRUISE SHIP DESIGN

Matti Juntunen, NUPAS-CADMATIC, Finland

NUPAS-CADMATIC has since 2009 been developing a user friendly and very powerful tool to manage electrical cable routing together with a shipyard building cruise ships. First ship, which were designed with the new cable routing tool was M/S Viking Grace with about 10 000 individual cables. Currently the cable routing tool is used e.g. in Main Schiff 4 project to TUI-Cruises, which have more than 20 000 individual cables routed with the cable routing tool. Idea in the presentation is explain lessons learned and next development steps like real time feedback from the production (e.g. barcode…). Also main principles of cable control will be explained.
See picture below about the new cable routing tool:



Some features which are included in the cable routing tool:

- Gives automatically e.g. penetration fill rate level
- Cable tray network and device placement in 3D model
- Cables have 45 attribute to define cables status in control chain
- Roxtec fill rate tool (www.roxtec.com)
- Etc…

34. BUSINESS AND INFORMATION MANAGEMENT ARCHITECTURES FOR DELIVERING PRODUCT LIFECYCLE MANAGEMENT (PLM)

Daniel McKendry, BAE Systems Naval Ships, UK
Ian Whitfield and **Alex Duffy**, University of Strathclyde, UK

In order to achieve effective through-life product management, the relevant information has to be identified at key points throughout the products life-cycle. It then has to be presented in a way which is

useful, configured, controlled and reusable. It is recognised that the Information Management environments must provide the means to capture, integrate and evolve information throughout the entire life cycle of a product based on the organisational objectives. Product Life Cycle Management (PLM) is the de facto means for a complex design programmes to ensure the robustness of its information. Critical to the success of PLM are the relationships between the Business Architecture (vision, strategy, process, etc.) and the Information Management Technology Architecture. The gap between these environments must be understood and bridged to ensure the success of first of class Naval Shi ps. This paper will describe specific challenges of first of class Naval Ships relating to product management and why specific mechanisms must be used when implementing PLM. This paper will propose a framework for implementing PLM as part of a joint PhD sponsored research programme between BAE Systems Maritime Naval Ships and the University of Strathclyde.

36. COST REDUCTION IN BASIC SHIP DESIGN SUPPORTED BY A SINGLE STRUCTURAL MODEL – A PRACTICAL APPROACH

Augusto Gómez, Francisco José Regueira, SENER INGENIERÍA Y SISTEMAS, Spain
George Korbetis, BETA CAE Systems SA, Greece

The use of 3D models in the basic design stage is today a reasonably extended practice. Some examples may be the idealized models for FEM calculations, today mandatory for meeting the new regulations by the class societies (HCR), the surface models used for stability calculations, CFDs or GA drawings, or the photorealistic models created for marketing and promotion.

In general, 3D models created in these early stages, maybe with the only exception of the main surfaces model, are created for one particular purpose with the specific modeling tools of each software application, highly customized for such use, and with limited possibilities for reusing in other disciplines or steps of the project.

Other aspects of the basic design, like traditional class steel drawings, are still created in 2D.

Some years ago, as part of a collaborative R&D action, a consortium of European companies comprising shipyards, designers and software developers carried out a research for the use of ship manufacturing detailed CAD models for FEM analysis, via automatic idealization, aimed to remove the time and resources required for FEM modeling from the overall design budget.

This paper presents an evolution of such approach, in terms of practical use-cases. In particular, it is described the use of the modeling tools of one marine CAD vendor, specifically configured for early structural modeling, combined with one FEM preprocessing application, one of the market standards in the automotive and aircraft industries.

37. AUTOMATED INTEROPERABILITY FROM CONCEPT DESIGN TO MULTIDISCIPLINARY FE ANALYSIS

George Korbetis, Serafim Chatzimoisiadis, Dimitrios Drougkas, BETA CAE Systems S.A., Thessaloniki/Greece

As the need for more competitive performance, design and safety arises in marine and offshore products development, the use of Computer Aided Design and Computer Aided Engineering becomes a standard process.

Results from CAE simulations provide feedback to the CAD department which has to update the design in order to achieve the required product's performance characteristics. The updated models have to be re-analyzed to validate their behavior. In most cases, this iteration requires to redefine the intermediate steps, such as the FE model set-up, which leads to considerable time consumption.

This paper, presents a method through the ANSA pre-processor to define multiple FE models which can serve different simulation analyses. The process exploits the ability of the ship design software to output CAD models of varying detail level to create a model database which contains the whole history of design. The Task Manager tool of ANSA defines automatically, different representations of the ship model according to the FE analysis that will be performed. Additionally, this method allows the automatic update of the FE model when a new version of a geometrical part or assembly arises.

38. RESEARCH OF THE PLASTIC DEFORMATION ZONE FOR SHIP FRAME COLD FORMING

ZhouYong-qing, LIPei-yong, SongJun-jie, WANGCheng-fang, MAOYun-sheng, XiangZuquan, Wuhan University of Technology, China

This article studies the problem of plastic deformation zone in the ship profile cold forming process. The theoretical method is applied to discuss the changes of the neutral axis during the forming process, and the formulas of ultimate bending moment for elastic and plastic deformation are deduced. The range of plastic deformation zone is discussed for three pivot bending method. The finite element model of cold forming process of ship profile is established using the software ANSYS LS-DYNA, and the following contents are

studied that including the material constitutive relation, the contact and friction problem between material and mould, the definition of the loading and boundary conditions, the selection of element type and the method of mesh. Both the results of theoretical method and numerical simulation show that the prediction of plastic deformation zone in the state of plastic instability is relatively close. The characteristics of plastic deformation zone in the process of bending can be obtained with the results of finite element numerical simulation. The results of this article are of certain guidance for ship profile cold forming work.

Key words: ship frame part; cold forming; plastic deformation zone; numerical simulation; finite element method.

39. PROJECT INNOVATION FOR HULL DESIGN AT SAMSUNG HEAVY INDUSTRIES

Mr. **Byeong-Seog Kang**, Samsung Heavy Industries,
Mr **Mutsuhito Kidogawa**, ClassNK
Christian Cabos, DNV-GL,
Bernd Tietgen, DNV-GL
Tapio Hulkkonen, NAPA Ltd

In 2011 Samsung Heavy Industries (SHI) established an R&D project for improving the hull design process for plan approval of ship structures. The primary intention was to look for benefits in improving the process and communication between different state of the art software tools used in practical ship design work.

At the outset of this customer confidential project, SHI invited two major class societies and one software company to participate. ClassNK, DNV-GL and NAPA joined the project late 2011 and continue to work together successfully.

The project work was initiated by the customer's practical development needs and a major improvement was required for the most critical design phases and the interfaces between those. The agreed core elements of the R&D project were 3D modelling in early structural design phases, Interfaces to class society rule check software, automatic FEM meshing and also feeding the results back to the 3D structural model.

The project was able to show clearly measurable savings in man-hours throughout the different phases of plan approval in comparison to the traditional way of working. The results are a remarkable improvement to SHI's structural design process. The saved man-hours also provide increased flexibility in project scheduling, allowing shorter throughput time and more possibilities for structural optimisation.

40. DEVELOPMENT OF AUTOMATIC CONTROL SYSTEM FOR WELDING DEFORMATION IN DESIGN PHASE OF SHIP AND OCEAN PLANT PRODUCTION

Hojung Kim, Heeyoung Heo, Junggoo Park and Seokhee Won, IT Based Production Research Part, Central Research Institute, SAMSUNG Heavy Industries, Co. Ltd.
Youngdeok Park, Accuracy & Engineering Part, Hull Fabrication Team, SAMSUNG Heavy Industries, Co. Ltd.

Shrinkage and angular distortion are mostly caused by welding in ship construction. When these two phenomena occurred in every stage, the dimensional accuracy is gradually degraded. To control both of these two phenomena, compensation concept is normally being applied in the design phase. This research aims to develop and apply an exclusive solver based on CAE (Computer Aided Engineering) technology for welding distortion to the commercial CAD (Computer Aided Design) program with re-designing method and Shrinkage compensation method. Automatic margin calculating system is operated with CAD information such as geometries, properties and welding locations. Upgraded automatic re-designing system covers a property of offshore plant and that of construction method. The proposed method was successfully developed and applied to the design phase and was found to enhance the dimensional quality as well as the productivity of shipbuilding.

41. RESEARCH ON SHIPBUILDING INDUSTRY VENDOR EVALUATION METHOD BASED ON DATA MINING

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Abstract: There exist many uncertain factors, shipbuilding enterprises must have strong ability to resist risk, which indicates that choosing reliable vendors is a key problem to enhance the overall supply chain operation efficiency. It is meaningful to form a supplier selection mechanism, for the enterprises, to make better use of and optimize resources, adapt to the change of market environment, and achieve the objectives that include reducing product development time, improving product quality, minimizing production cost, shortening delivery time, and rapid response to clients.This paper proposed a method of shipbuilding industry vendor evaluation based on data mining, built the shipbuilding industry vendor evaluation model using C5.0 algorithm, and proceeded the case study. This work provided a new thought to shipbuilding industry vendor management.

Keywords: data mining; shipbuilding supply chain; vendor evaluation; decision tree; C5.0

42. HOW MOBILE DEVICE TECHNOLOGY CAN INCREASE PRODUCTIVITY IN SHIPBUILDING

Stéphane Neuvéglise, Head of Solution Business Strategy, AVEVA Solutions Ltd,

Affordable, high-performance tablet computers, combined with ubiquitous WiFi internet access, have created new capabilities by providing key project decision makers with direct access to live 3D design models, anywhere, any time. This newly emerged technology is being rapidly adopted in the plant industries, where it can de-bottleneck critical decision points in a project schedule.

Shipbuilding, while also being a project-oriented process, has many unique characteristics and involves different stakeholders, creating different requirements if this technology is to provide it with comparable benefits.

This paper begins by describing how mobile technology is being used to visualise, inspect, comment on and approve design. Analysing real customers' feedback and experience, it then goes on to explore some typical usage scenarios by the various participants in a shipbuilding project, and the developments required to make such usage best practice in the marine and offshore industries.

43. REGENERATING HULL SURFACE DEFINITION FROM LASER POINT CLOUDS

Marcus Bole, Naval Architect, AVEVA Solutions Ltd,
Guiseppe Tringali (TBC), General Manager, Knud E. Hansen A/S

Laser scanning and other optical survey techniques offer an efficient method of electronically capturing the geometry of physical objects for use within CAD. For ship hulls, laser scanning offer an excellent method of capturing shape where plans are unavailable or deformation has occurred due to, for example, collision where a rapid repair must be designed and fabricated.
However, point cloud datasets are usually very large and can contain areas where the hull is obscured or not captured. This creates a challenge when creating geometry using automatic surface fitting methods, as gaps or features not part of the surface will cause the representation to diverge from the expected position. Furthermore, the definition produced will have many coordinates making it time consuming to correct or change.

This paper presents an alternative approach which augments an existing surface definition process by introducing fitting methods to generate definition where the hull is cleanly visible in the survey. In other areas, the user provides definition based on experience and any additional resources that may be available. As fitting is used selectively, there is no need to significantly clean the point cloud. Case studies of use of the technology in a shipbuilding environment are presented highlighting methods of validating the accuracy of the surface with respect to the point cloud.

44. DESIGN IN CONTEXT- AUGMENTED DESIGN

David Thomson, Solution Strategy Manager, AVEVA Solutions Ltd

Instant access to information is no longer the stuff of science fiction. With the arrival of ubiquitous high-speed WiFi and a proliferation of mobile devices it is a daily reality. But it comes at a price; constantly switching between the virtual realities created by multiple digital sources of information and 'real reality' has been proved to erode our ability to concentrate on the task in hand.

Today's ship designers are faced with just this problem. They have access to more information than ever before but must continually switch between their main 3D design application and numerous different sources of information. Individual contexts (for example, the designer's role, the system they currently have active, or the area of the vessel or equipment items on which they are working) require only small subsets of all the available project information. How can we bring relevant information directly into a designer's world in such a way as to reduce information overload and maintain their productivity?

This paper describes AVEVA's latest Design in Context capability, which brings reference documentation and information into a designer's main design application according to the context in which they are working. It examines some key prerequisites, including the related life cycle information management practices, and introduces the concept of the living Digital Asset before previewing this new capability and outlining its possible extensions into a vessel's construction and operational phases.

45. DESIGN INTEGRATION – WHY A GOOD LONG-TERM STRATEGY IS ALSO A GOOD SHORT-TERM GROWTH TACTIC

Steve Insley, Solution Business Manager, AVEVA Solutions Ltd

Today's marine marketplace is a challenging and uncertain environment; in such times, strategic aims like design integration may seem like a luxury compared to pressing tactical priorities to win and execute sufficient profitable business.

But in this paper we explore how current opportunities to integrate engineering with hull, outfitting and structural steel design not only provide long-term gains in

capability and productivity, but also increase a shipyard's agility to diversify into adjacent markets. It becomes easier to apply existing skills and facilities to new types of project while retaining the productivity and specialised skills essential for efficient shipbuilding.

Particular reference will be made to recent technology developments that integrate state-of-the-art structural steel solutions with outfitting design to enable users to respond more effectively to opportunities in markets such as offshore wind energy or oil & gas production. By adopting such technologies, not only can shipyards apply their skills and resources confidently across a wider variety of projects, they become better able to compete for high value-added shipbuilding projects when markets recover. To support this we will share our experience of some proof of concept sessions we have had with some of our clients and how we were able to demonstrate how shipyards using different design systems can successfully and profitably executed similar diversification projects.

46. INTUITIVE WELD MANAGEMENT: LEVERAGING 3D MODELS AND VISUALIZATION

D Morais, M Waldie, and **D Larkins**, SSI, Canada

Tracking and managing welds via rudimentary spreadsheets is the typical method used in the shipbuilding industry. It is notoriously inefficient and error-prone. It is laborious, unintuitive, and disconnected from other processes. This is significant because welding can account for 20-30% of production hours and approximately 10% of total cost. With shipbuilders expanding into the offshore market where weld standards are tougher, addressing this deficiency is critical.

The weakness is rooted in the non-pictorial aspect of the process. Therefore, SSI has completely rethought weld management by tightly integrating it with an associative 3D product data model generated from its AutoCAD based ShipConstructor application in conjunction with Autodesk Navisworks. This provides data-rich intuitive visualizations that can be easily generated and utilized by anyone in an organization using familiar tools, thereby improving communication and enhancing understanding.

47. PHYSICS-BASED SIMULATION FOR PRODUCTION AND INSTALLATION OF SHIPS AND OFFSHORE PLANTS

Myung-Il Roh, Sol Ha, Namkug Ku, Seung-Ho Ham, Seoul National University

As the weight and size of the erected block and module of the offshore project are increased, new lifting plans by using floating cranes have been tried to enhance the production efficiency in the shipbuilding area. . In this situation, a physics-based simulation is required to manage potential risk of lifting plan in advance. Similar requirements have been arisen in the installation of the offshore plants such as float-over and launching. Therefore a physics-based simulation system for production and installation of ships and offshore plants was developed in this study. The developed simulation system is based on six kernels: multibody system dynamics kernel, force calculation kernel, numerical analysis kernel, hybrid simulation kernel, scenario management kernel, and collision detection kernel. Based on these kernels, we develop a simulator including following graphic user inter faces (GUIs): modeling, visualization, and report GUI. In addition, the geometry properties of the block and facilities in shipyards are necessary to configure the simulation for production and installation of ships and offshore plants, so these are managed in the database and connected to specific commercial CAD system in shipyards. The developed simulation system was applied to various examples for production and installation of ships and offshore plants. The results show that the simulator is useful for various simulations of the operations in shipyards and offshore industries.

48. A SINGLE 3D PRODUCT DATA MODEL: A CONSISTENT SOURCE OF TRUTH THROUGHOUT THE SHIP DESIGN PROCESS

Darren Larkins, M Waldie, and **D Morais**, SSI, Canada

A key to promoting efficiency and quality in ship building, design and engineering is to have a single "source of truth" for data throughout the entire process. Contrary to common belief, drawings are not a source of truth. Indeed, they are not even truly a source since they are disconnected and frequently outdated representations of aspects of the actual design.
In reality, a comprehensive 3D product data model (PDM) is the most accurate reference point but to be a single source of truth, there can only be one, not many competing PDMs.

By utilizing a single 3D product data model that can be utilized starting in basic design and then through all other ship design phases, organizations can reduce errors and lower cost by maintaining information at various handoff stages. The information preserved is not only the obvious geometric and attribute data, but also the critical design intent that is incrementally built into the product data model.

This paper will show the advantages gained by companies such as BMT Nigel Gee, Vripack, and Gibbs & Cox who have utilized this approach by leveraging the Marine Information Model (MIM) as found in SSI's Autodesk based ShipConstructor software.

49. SHIP WORK BREAKDOWN STRUCTURES THROUGH DIFFERENT SHIP LIFE CYCLE STAGES

Malay Pal, Director – Shipbuilding, Siemens Industry Software

Definition of complete and accurate work breakdown structures of a ship is an important and critical activity in every shipbuilding project. This is required in every stage of a ship project, right from the inquiry and concept design stage, to basic, detail and production design, and continues through definition of as-built structure, maintenance work breakdown structure, etc., right up to defining work breakdown structures for decommissioning (for ship and offshore structures).

While the need is well understood, many shipyards and ship design organizations find it challenging to define these work breakdown structures across all stages of a project, and to understand the linkages between these work breakdown structures through the various phases of a design and build project. Things become more difficult when the ship or offshore structure enters its service life, when the maintenance (and later the decommissioning) organizations are different.

One key challenge in the definition of ship work breakdown structures is how to represent the same entity in different structures as it moves through its lifecycle, e.g., from concept design to basic design to detail design to production design. A new component based approach based on 4th generation of design (4GD) technology built into a PLM system to manage ship data allows for the definition of different but linked work breakdown structures of a ship through its different lifecycle stages.

This paper explains in detail the different work breakdown structures in shipbuilding and how 4GD technology can be used to define and manage the same.

50. AUTO-GENERATION OF HULL STRUCTURE DRAWINGS FOR CLASS APPROVAL

Alfonso Cebollero, Sener Ingeniería y Sistemas S.A., Spain
Min-Bong Park, Sener Korea Engineering and Systems Co., Ltd., Korea

Without a doubt, the use of 3D CAD/CAM software was a revolution in the ship design and construction processes in multiple aspects, but most applications still address production design only. In the near future, however, vendors should provide solutions to support all design phases in a single 3D environment, according to strong users' requirements.

On the basis of said requirements, this paper presents our procedures to use single 3D models from basic to production design, including in particular the generation of 3D-model-driven hull drawings for class approval.

Several actual cases are presented in detail, which serve well to illustrate the advantages of an all-phases, integrated approach.

51. APPLICATION OF 3D TOOLS TO BALLAST WATER MANAGEMENT SYSTEM RETROFIT

Shigeru Kasai, Sener Japan Engineering and Systems K.K., Japan
Koji Kawamura, Sener Japan Engineering and Systems K.K., Japan

The Ballast Water Management Convention applies to all vessels greater than 400 gross tons. According to IMO's Marine Environment Protection Committee, about 40,000 vessels will need to be retrofitted with an approved Ballast Water Management System (BWMS) within several years once the Convention comes into effect.

BWMS Retrofit is not a standard ship repair work, but a major scale construction work. The most important factor to make it successful is advanced preparation, by which we understand recognition of as-build existing engine room and 3D representation of its structures.

This paper describes first why laser scanner, point-cloud processing and 3D CAD are essential tools for that advanced preparation, as drawings of ships subject to BWMS Retrofit usually do not exist. We will then show how the quick creation of a complete 3D model optimizes the design, production and assembly stages, reducing the rework and costs.

52. RESEARCH ON 3-DIMENSIONAL STABILITY CALCULATION BASED ON CATIA

Zhang Mingxia, Chen Ming, Cui Yang, Lin Yan, Ship CAD Engineering Center, Dalian University of Technology, China

3-dimensional design is becoming indispensable for ship design, especially in initial design which is vivid to evaluate its hull form qualitatively and then assess its performance such as stability including both intact and damage stability quantitatively quickly. Traditional ship design is still based on 2-Dimension lines and performance calculation based on offset table using numerical integration which is time-consuming and often tough work. The paper mainly includes:

(1) The method of 3-Dimensonal hull form based on CATIA is researched and 3-D geometrical model will be

generated quickly according to the traditional body lines in 2-Dimension and then subdivision could be carried out.

(2) Intersection algorithm for 3-D hull model with arbitrary waterline surface is developed, in which, geometrical performance under certain waterline surface such as displacement, center of buoyancy, capacity of tanks and center of tanks can be obtained afterwards.

(3) Stability calculation algorithm based on the above 3-D geometrical model is studied which will simplify the procedures of traditional performance calculation and improve the calculation precision consequently during the initial design.

The initial design 3-D software based on CATIA will be developed and facilitate integration of design and performance calculation.

Key Words: Ship initial design; CATIA; 3-Dimensional geometrical model; Hull form; Subdivision; Damage stability

53. STEREO 3D PRESENTATION OF SHIP STRUCTURES USING LOW COST HARDWARE

Gordan Sikic, Head of development, USCS doo, Croatia

During last couple of years, as low cost hardware devices become more and more powerful, new approach in presenting ship structures become feasible. This allowed usage of technologies, previously reserved for high end simulation systems, to be incorporated into applications running on mid range hardware found in shipyards. In this paper alternative approach in data manipulation will be presented, using stereo 3D extensions to our ShipExplorer system. Experience in developing those extensions will be presented, as well as problems that had to be solved, including discussion to solutions used to solve them.

54. LIFECYCLE DESIGN SYSTEM FOR A FLOATING PRODUCTION STORAGE AND OFFLOADING VESSEL (FPSO) BY PLANNING OF UPGRADING WITH CONSIDERATION OF LIFECYCLE SCENARIO

Duseok Jeong, Yasushi Ueda, Kazuya Oizumi and **Kazuhiro Aoyama**, University of Tokyo, Japan

This paper aims to support early stage product design that then maximizes the lifecycle value of the product. Product systems with long lifecycles such as FPSO undergo many changes in their operational environment across their entire lifecycle as such in some cases, the systems will need to be upgraded. Because of these changes the resulting systems may become inefficient or even inoperative. Because of long lifecycles, these changes have high uncertainties, because they will occur in the remote future. This makes counteracting undesirable effects in design stage more difficult. One feasible approach to address the uncertainties is the marginal design of each component. However, such an approach can be inadequate if conducted without adequate consideration of the lifecycle of the product system, because of the additional resources required for setting the margin. Further, design impact grows with each passing design phase, so that it is necessary to fix design policy at an as early stage as possible. Furthermore, environmental change in the future leads to challenges that have to be met within the design of product system in early design stage.

This paper proposes a component upgrade plan based on the lifecycle scenario for counteracting the uncertainties. The plan consists of initial design and upgrade timing of each component. To deduce the plan, this paper also proposes a model that describes how the changes of operation environment effect on the lifecycle value of product system. The lifecycle value of the plan is evaluated from perspectives of cost and utility. The method was based on the case study of a FPSO and validated by using a prototype system.

55. MONITORING SYSTEM FOR ADVANCED SHIPBUILDING CONSTRUCTION MANAGEMENT: EXTRACTING AND UTILIZING MONITORING DATA BY CONSIDERING THE RELIABILITY OF MONITORED DATA

Yusei Hiro, Jie Liu, Kohei Arai and **Kazuhiro Aoyama**, University of Tokyo, Japan

In order to enhance productivity in shipyards, it's very important to obtain work records. Extracted work result information will help managers to better perceive and understand the current work situation on construction shop floors. We have been developing a monitoring system for sub-assembly job shop construction management by the image processing of video data and we reported this system at ICCAS 2013. However, some problems remained including:

- Noise data is generated in the work records due to the highly complex environment
- Specific worker names cannot be identified by only utilizing video data

This paper describes attempts to solve these problems and refine our monitoring system, by the introduction of two additional monitoring technologies: RFID and accelerometers. By the use of these technologies, we can obtain data of the specific worker's name, which enables us to match image-processed data to worker's name. Furthermore, we propose an extraction method for operation information by considering the reliability of each type of monitoring data. By comparing monitoring

data adequately, we can evaluate the reliability of each data set.

By this method, we were able to exclude 75% of a whole noise data, and judge worker's name 65% of the time correctly. These results indicate that this method considering the reliability of data is useful for obtaining detailed work records. As about 20% of the recorded data is excluded due to in adequate reliability, the paper discusses possible improvements for the future. Further, the utilization of the acquired work records for process improvement is explored.

56. INITIAL DESIGN AND SHAPE OPTIMISATION OF A FPSO HULL IN VIEW OF HYDRODYNAMIC CHARACTERISTICS

Bo-Young Chung, Hyundai Heavy Industries, Korea

This paper presents a process to optimise the main dimensions and the shape of a FPSO hull with process integration and design optimisation tools. Hydrodynamic characteristics in a specific ocean environment are crucial drivers to design a FPSO hull. In the process, a hull shape and a mass distribution were parametrically modelled and its hydrodynamic characteristics such as natural period of roll motion and relative wave elevation were analysed by the well proven commercial software tools. To determine the initial design, we first automated their execution and integrated them in a framework, and explored the design space with Latin hypercube sampling and optimisation algorithms. We evaluated the design alternatives with uncertainty in the mass, since it is reasonable to assume that the topside weight and its distribution of offshore structures are given but somewhat changeable during detailed engineering and construction.

Key words: process integration and design optimisation, hydrodynamic characteristics, initial design of offshore structures, FPSO, Latin hypercube sampling

57. THE DIGITALIZATION OF SHIPBUILDING, LAUNCHING A NEW ERA IN PRODUCTIVITY AND SHIP PERFORMANCE

Tim Nichols, Siemens PLM Software [LCDR, USN], USA
Glenn Ashe, President, American Society of Naval Engineers [CAPT, USN (ret.)]., USA

The digitalization of shipbuilding is transforming the way advanced, complex ships and offshore platforms are being designed, constructed and sustained. Driven by the demand for more adaptable, affordable, efficient, and reliability ships, all critical functions and operations in a shipyard, i.e., designers, engineers, parts suppliers, back shops, and waterfront personnel have been integrated into a seamless enterprise. Additionally competition in the shipbuilding industry has further accelerated this trend as leaders seek to protect their position while challengers seek to overcome them through innovation and efficiency breakthroughs.

The value of digitalization is evident in all phases of shipbuilding, e.g., systems designers and engineers work concurrently on 3D simulations of every system and compartment layout while construction planners can use the same 3D models to optimize material flow through the shipyard as well as final assembly and testing of all systems before the very first pieces of steel are ever welded. From concept and detailed design and then on through construction, system by system alignment with ship specifications, budget and schedules is rigorously management while the continuous flow of configuration changes are processed. For the most advanced shipyard, this digital synchronization extends to the key sub-system and parts suppliers to optimize the total enterprise.

The digitalization of shipbuilding is well underway in Korea and leading shipyards in Europe and is growing in importance in the US where new ship classes with modular systems and standardized platforms is a top priority to lower the total ownership cost of future fleets.

58. AR APPLICATION DEVELOPMENT FOR PIPE INSTALLING ASSISTANCE

Kohei Matsuo, National Maritime Research Institute, Japan

The paper introduces our recent research activities on a development of the AR application for pipe installation in a shop floor in shipyards. The application in the paper assists a worker by indicating various information on pipe installation through AR technologies. Once the worker points a camera with a tablet PC to a marker which is attached on a pipe, the AR system guides the worker which the pipe corresponds to one in the drawing paper, or where the pipe should be installed in the ship by visualizing its 3D image through AR technologies. As the worker retrieves information on the pipe from the ship floor in real-time, the application also realizes real-time work monitoring and management of outfitting works in shipyards.

The paper explains general information on AR technologies and its introduction to shipbuilding at first. The paper summarizes benefits and technical components for the practical introduction on AR technologies in shipbuilding by considering various characteristic properties of shipbuilding. Then, a concrete system development on the AR system mentioned above is particularly explained with indicating the system diagram of the system. Some demonstration of the system is also be shown in the paper, and the paper

finally concludes with a brief review of future perspective on our AR applications development for shipbuilding.

59. SHIP LIFE CYCLE VALUE MAXIMIZATION WITH FLEXIBLE DESIGN FOR RETROFIT AND MODIFICATION

Kazuo Hiekata , Taiga Mitsuyuki, Hiroyuki Yamato, Kyohei Koyama, Tomoki Saito and **Sinnosuke Wanaka,** The University of Tokyo, Japan

In ship building, the design objective is based on the performance in terms of technological aspects such as fuel oil consumption rate, maximum speed and etc at given operational profile. This research proposes an evaluation method for ship design to maximize life cycle value in the operation by means of design extensions for retrofit and hull modification in response to market fluctuation.

The method is consisted of following two major parts.

The first deterministic part is the detailed performance model of a vessel. This newly developed model represents the technological part and simulates the performance based on traditional ship theory.

The second part of the method is the life cycle value evaluation model in terms of NPV(net present value). This model includes the uncertain market model. The market model is based on the oil price or market fluctuation in every step. The market projection is conducted by binomial distribution based on the historical data. This method can consider repairs of the ship in a dockyard to obtain the optimized performance for long term depending on the oil price fluctuation.
The proposed method finally evaluates a ship design in terms of NPV with Monte Carlo simulation. This method is applied to selection of design options for a VLCC for Arabian Gulf and Asia, and shows that the design for optimizing the technological performance is different from the design for maximizing the NPV.

60. DEVELOPMENT OF SHIP PERFORMANCE DATA MANAGEMENT SYSTEM COMBINING EXPERIMENT DATA AND MEASURED DATA IN ACTUAL SEA

Taiga Mitsuyuki, Hiroyuki Yamato, Kazuo Hiekata, Shinnosuke Wanaka and **Masakazu Enomoto**
The University of Tokyo, Japan

According to the introduction of Energy Efficiency Design Index (EEDI), accurate tank testing is desirable. Moreover, the estimation of ship performance in actual sea, as well as that in ordinary water, has the important role for designing a ship.

This paper proposes the concept of new ship performance data management system with database of towing tank test data, measured data in actual sea and CFD data. On proposed system, researchers can refer to those three kinds of data, compare with each other, and generate new knowledge for more accurate tank testing or design plan considering the performance of ship in actual sea.

In addition, this paper deals with a part of proposed concept. Concretely, developed system makes towing tank test data measurement efficiently and enables to associate towing tank test data with measured data in actual sea by utilizing RDF (Resource Description Framework). An experiment data in towing tank test is analyzed automatically and sent to database via wireless LAN in real time. The developed system enables users simultaneous playback of data through web browser. Towing tank test data can be compared to the performance data of similar ship in towing tank and actual sea by utilizing semantic search engine in developed system.

Case studies indicate that this system facilitates towing tank test from the viewpoint of analysis of tank test data by using measured data in actual sea. In addition, this system helps to obtain knowledge derived from various ship performance data.

62. PROCESS AND KNOWLEDGE INTEGRATION VIA PORTALS IN SHIP BUILDING

Bhavik Thakker, Jeroen Kaarsemaker, Andi Asmara,
Royal IHC, The Netherlands
Jenny Coenen, TU Delft, The Netherlands

Ship building projects are realized by co-operation of several processes such as sales, engineering, production, purchase, logistics, project management, operations management and other support processes etc. carried out by different units within or outside one company. In many such instances the processes and data used to build the same ship are not in sync at different ship building unit because of the isolation created due to the geographical locations, partnerships, acquisitions, mergers, sub-contracting etc. Engineering processes for instance relies heavily on PDM and CAD applications, but an engineering sub-contractor does not necessarily use the same CAD applications and will have different process. In addition, engineers need information from the ERP system as well, but are not very familiar with terminology and interface of that logistic application. Communication and information retrieval becomes complicated in such scenarios where data is spread over different places resulting in loss of working hours. In order to address this issue, a concept of information

retrieval & communication via One Portal was envisaged which could facilitate all the searching and communication of information related to product and processes from different sources. The intention of such a portal is thus twofold: It should facilitate an employee entering or working in an organization to exactly zoom in to or search for the processes which are relevant to him/her and go through the work instructions and training material relevant to their process tasks; It should allow for searching the physical details, logistical details, planning details etc. of products and orders required for work on a day-to-day basis. Such information, which is spread across different applications, will become available within few steps (or clicks). This paper is focused on providing the conceptual arrangement of structuring such portals as a single source for all information and the insights into challenges faced till the final implementation.

63. SHIP SCALE CFD FREE SINK&TRIM SELF-PROPULSION SIMULATION AND IT'S DIRECT COMPARISON TO SEA TRIALS

Constantinos Zegos, Dr. Dmitriy Ponkratov, Technical Investigation Department (TID), Lloyd's Register, UK

Lloyd's Register (LR) is the eldest classification society and one of the leaders in hydrodynamic research. In testament to this unique legacy, LR has conducted and validated Computational Fluid Dynamic (CFD) predictions of self-propulsion both at model and ship scale. Model scale data was recorded at a reputable facility and sea trials data was obtained by the author of this paper who conducted the measurements of ship speed, engine power, shaft speed, propeller thrust and torque.

Propeller thrust and torque was measured using high precision sensors also used in Formula 1 car testing for measurements including wheel axis moment.

Prior to departure for the sea trials the hull was cleaned by removing the fouling and the propeller surface polished. The performance quantities were measured for all runs, however this paper will focus on one set of runs during which the weather was exceptionally good. As a result, the ship showed almost identical shaft speed, power, thrust and torque for the forth and back runs. Therefore it was assumed that the environmental impact due to waves and wind was negligible for this particular test.

Commercial CFD software was used to carry out simulations of the ship at the same conditions as the sea trails. In this paper all presented CFD results are calculated both for fixed and free sink and trim condition.

Since the model scale test data was available for this vessel, a comparison of open water, resistance and propulsion tests against the model scale CFD investigation was performed. This showed a satisfactory agreement in all characteristics so the work progressed to the second stage which consisted of full scale simulations of sea trials.

In ship scale all appendages were included, i.e. the bilge keels, propeller and rudder. Furthermore the superstructure was included to accurately model the air resistance. The thrust and torque coefficients predicted by CFD agreed well with coefficients measured during the sea trials by two independent gauges.

64. DATA MINING TO PREDICT HYBRID LASER ARC WELDING IMPROVEMENTS IN SHIP ASSEMBLY

Damir Kolich, University of Rijeka, Croatia

Most shipyards use submerged arc welding (SAW) or gas metal arc welding (GMAW) technologies in their steel panel line assembly processes. Since the welding work on panel lines make up to 50 percent of total ship welds, improving the process by decreasing the duration time as well as energy use and filler materials will decrease production costs. The advent of lasers in production yields advantages in faster speed and smaller distortions and the shortcomings of using just lasers in welding is the lack of filler material which is necessary to weld steel plates for shipbuilding. Hybrid laser arc welding (HLAW) takes advantage of the positive sides of both laser and gas metal arc welding to produce panels with shorter duration times. Much data exists about assembling panels with conventional welding means. Therefore a data mining methodology using an interpretable regression method for accurately predicting the duration time outcomes of panels assembled with HLAW technology will allow shipyard management to make better decisions to transform their assembly lines by integrating laser technology in order to become more competitive through reduction of production costs.

Keywords: Hybrid laser arc welding, gas metal arc welding, data mining, multivariate adaptive regression splines, ship assembly

65. ASSESSMENT OF INTERMEDIATE BENDING MOMENTS FOR DAMAGED HULL GIRDERS USING A PROGRESSIVE FLOODING ALGORITHM

José Miguel Rodrigues, Carlos Guedes Soares, Centre for Marine Technology and Engineering, Portugal

Knowledge, or an estimate, of the global loads a ship will be subjected to is a key issue in the design spiral and its calculation, regarding damaged vessels, should be an important factor on ship subdivision scheme design. The

traditional, deterministic, damage stability requirements are seeing a change in paradigm where the focus is now on the demonstration of a given design to achieve a prescribed level of reliability. This paradigm relies on the assumption of probabilistically defined scenarios distribution. In what damage occurrence relates, the Marine Environment Protection Committee of the International Maritime Organization (MEPC-IMO) damage configuration probability distributions, accounting for damage location, extension and penetration, is one such assumption and the resulting loads obtained from these serves as a base for hull-girder reliability studies. In this work, a subset of the MEPC-IMO distribution is applied to the case of a shuttle tanker in full cargo condition, damaged in way of its waterline, which is then subjected to flooding. Previous studies have been focusing on the final value for the vertical bending moment, yet, significant loads may arise during the intermediate stages. A generalized adaptive mesh pressure integration technique algorithm is used, implementing a quad-tree mesh scheme with exact pressure integration capabilities, in order to compute the coupled flooding progression and ship motion under a quasi-static approach and loads recording on each instant. Comparisons between intact, intermediate and final obtained maximum still water vertical bending moments, the location these occur and their value amidships are carried out and analyzed.

66. INFLUENCE OF BLOCK BUILDING METHOD ON OUTFITTING EFFICIENCY AT AN ASSEMBLY SHIPYARD

Lauri Kujala, Matti Nallikari, Arctech Helsinki Shipyard Oy, Finland
Henri Tokola, Heikki Remes, Aalto University, School of Engineering, Finland

In shipbuilding industry, the shipyards are constantly striving to develop their production strategies for increasing the production efficiency. One possibility to increase the production efficiency is to execute the outfitting work of a ship as early as possible for example in the block outfitting stage.

This paper investigates five different block delivery models and their influence on outfitting efficiency in an assembly shipyard. For all the five models, the individual building method is generated. In addition, a method to measure the efficiency of block outfitting and outfitting process has been developed.

The developed calculation model for outfitting process is based on the time relation between different outfitting stages i.e. modular outfitting, flat block outfitting, block outfitting and onboard outfitting. The time relations between different outfitting stages are defined based on literature and experience of experts from Arctech Helsinki shipyard. According to the literature this kind of analytical modelling has never been done before in assembly shipyard concept. The created calculation model gives good overview of the reduction of direct outfitting working hours when applying different block delivery models. The model can be applied in all kind of shipyards providing that the shipyard has outfitting statistics from the previous projects.

67. HULL FORM DESIGN OPTIMISATION FOR IMPROVED EFFICIENCY AND HYDRODYNAMIC PERFORMANCE OF 'SHIP-SHAPED' OFFSHORE VESSELS

Joo Hock ANG, Sembawang Shipyard Pte Ltd (A subsidiary of Sembcorp Marine), Singapore and University of Glasgow, School of Engineering, UK
Cindy GOH, Yun LI, University of Glasgow, School of Engineering, UK

It is well known that the shape of the hull plays an important role in the overall performance, efficiency and stability of ships. It is therefore crucial to obtain optimal design of the ship hull right from the conceptual design stage. 'Eco-friendly shipping' and fuel efficiency are important issues and challenges faced by marine and offshore industry today, in view of fuel prices volatility and more stringent environmental regulations. To add to this, the demand and technical requirements of offshore vessels have increased significantly as oil exploration ventures into deeper waters and hasher environments. Spurred by these factors, there is now an ever-increasing interest in hull form design optimisation to improve overall efficiency and hydrodynamic performance of 'ship-shaped' offshore vessels. Recent developments in advance optimisation techniques and high performance computing are key enablers for simulation based design (SBD) in ship and offshore applications where overall efficiency of design process as well as hydrodynamic performance can be improved greatly. This paper will integrate a hull shape modification technique with advance optimisation and evaluation algorithms, with the aim to improve the overall efficiency and hydrodynamic performance of 'ship-shaped' offshore vessels. By incorporating concepts from free form deformation and computational intelligence, we demonstrate through a case study the optimisation process of the hull form design of offshore vessel for reduced resistance and improved sea-keeping. Our results demonstrate an improvement in the performance as well as efficiency of the design process.

68. OPTIMIZATION OF SHIP DESIGN AND PRODUCTION IN A US SHIPYARD BY USING AN ADVANCED CAD/CAM SYSTEM

Fernando Malabet, EASTERN SHIPBUILDING GROUP, Florida/USA
Zanesar Islam, EASTERN SHIPBUILDING GROUP, Florida/USA
Veronica Alonso, SENER, Madrid/Spain

Rodrigo Perez, SENER, Madrid/Spain
Samuel Martinez, EASTERN SHIPBUILDING GROUP, Florida/USA

Shipbuilding in the USA is characterized by some singularities in comparison with other countries, regarding the design, production and the technologies applied: early design stage is based in drawings in 2D environments, detail design incorporates the use of general 3D CAD systems but with very little integration between disciplines, while the production process is organized around simple block drawings without assembly drawings or any symbolic representation for manufacturing.

Not having a seamless transition between basic and detail design stages, in addition with the lack of integration between the hull structure, outfitting and electrical disciplines, lead to very costly errors and inconsistencies in production, with the consequent waste of material and man-hours. In commercial shipyards the delivery time is a critical issue, so sometimes production workers have to take decisions on the fly when such errors arise.

The only way to change this situation is by using an advanced and integrated CAD/CAM System from early design through detail and production stages. The single true of information with innovative and automated-oriented capabilities for modelling and generation of outputs allow for the optimization of the overall process. This paper describes how the use of FORAN, developed by SENER, has improved the design and production in a US shipyard with features such as a seamless transition between basic and detail design, the integration of all disciplines, the fast generation of a complete ship 3D model, and the automatic generation of customized drawings.

69. RAPID MESH GENERATION FOR HYDRODYNAMIC ASSESSMENTS

Michael Johnson, Nigel White, Neil Southall, Lloyd's Register, Southampton UK
Tom Macadam, Yibo Li, Frank Lin, Lloyd's Register Martec, Halifax, Canada

A typical difficulty for users of panel-based hydrodynamic assessment methods is to establish a suitable hydrodynamic mesh. Modern hull design trends such as twin propellers and hooked bulbs are highly curved or 're-entrant' features which may be impossible for existing mesh generation tools to handle. Furthermore, designers may generate a body plan of 2D sections, rather than the 3D mesh required for hydrodynamic analysis, or only Finite Element models may be available; the shell of such a model might provide a basis for the hydrodynamic mesh but it is usually unsuitable for direct use in hydrodynamic analysis. Even when 3D mesh files are directly available, they are often unsuitable for use directly for hydrodynamic assessment due to being triangle-dominant, with high aspect ratio panels, and/or with large local variations in panel size.

This paper describes a new application 'HydroModeller' developed by Lloyd's Register which overcomes these problems and allows the rapid creation of good hydrodynamic mesh meshes suitable for use in hydrodynamic analysis. Panels generated are close to unity aspect ratio and the user may define the fineness. The waterplane 'lid' is also meshed. The algorithm for 2D to 3D conversion is described and examples of the meshing of a wide range of hulls and structures are shown. At the same time, some design capability is included, such as the creation of geosim hulls and the insertion of mid-bodies; the methods are described. The paper also discusses the effect of mesh accuracy and fineness on hydrostatics, use of mesh sections for slamming assessment, and the need for finer mesh when modelling higher speed ships.

70. INTEGRATED SYSTEM COMPLETION: A MOBILE PERSPECTIVE

Mike Montgomery, Intergraph, United States**,**
Marcel Veldhuizen, Intergraph, Netherlands

Before a vessel is handed over to the owner to start its operational life, a process of checking needs to be completed and documented to ensure that no blocking issues are left and that the vessel conforms to owner expectations. Particularly in very complex projects like an FPSO, this process can easily result in millions of man-hours. Increasing efficiency through the use of engineering information and a standardized workflow approach, it is possible for shipyards to significantly reduce the number of man-hours significantly while increasing the quality of the survey.

In this paper, the authors address the utilization of a data centric Design Solutions CAD system, from the design phase through final construction, to manage the collaboration with materials availability, bill of materials management, managing as-built drawings and scheduling of the block assembly construction process. The authors will discuss how an integrated system concept can drive an efficient system completion process using an integrated and mobile approach. Additionally, the authors will examine how a design-to-production CAD model can provide better ways to optimize the system completion and handover process.

71. HOW INTERGRAPH SMART™ YARD LEVERAGES THE ENGINEERING DESIGN BASIS TO IMPROVE WORK PROCESSES ACROSS THE PROJECT LIFE CYCLE

Jeff Bashir Intergraph, Singapore
Charlotte Hughes, Intergraph, United States

Intergraph Smart™ Yard leverages the engineering design basis to provide an extensive portfolio of integrated, preconfigured solutions addressing yards' key work processes. The purpose of this paper is to examine the methods and benefits of consolidating project's engineering design basis information and processes to reduce total cost and improve productivity and quality across the fabrication yard project life cycle. Yards can bring together engineering, procurement, project planning, fabrication, and construction within a single, collaborative knowledge management environment that leverages a portfolio of integrated, preconfigured solutions. Working in unison with yards' advanced automation production lines to meet industry challenges and timely deliveries, Smart™ Yard capabilities help yards develop new and more productive ways of working, minimizing risks, and delivering projects in a timely fashion for maximum construction readiness.

In this paper and presentation, the authors will provide a detailed walk-through of Smart™ Yard solutions within the context of the following workflows:

- Yard Engineering
- Data and Document Management for Handover
- Material Supply Chain Management
- Construction Planning
- Shop Floor Management
- Commissioning and Testing

73. HOW TO INTEGRATE DESIGN AND MANUFACTURING EFFICIENTLY WITH COMPLETE INSIGHT AND TRACEABILITY OF ALL INFORMATION REQUIRED: CASE STUDY OF THE INTEGRATION OF SMART PRODUCTION INTO SMART™ YARD IMPLEMENTATION FOR PIPING FABRICATION

Rachel Yee, Intergraph, Singapore
Hannu Kakela, Nestix, Finland

Shop fabrication, an early stage in industrial construction projects, has a significant influence on successful construction project delivery, since it brings higher productivity in a more controlled environment compared to the field. Effective planning and scheduling of industrial fabrication activities become essential to reduce time and cost of construction projects during this stage. However, the fabrication process is always complex and associated with a high degree of uncertainty. Such complexity makes it difficult for most fabricators to produce a reliable project estimation. This is especially true for fabricators using traditional management methods that lack advanced capabilities such as probabilistic branching, resource interaction, and production cycling.

In this paper, the authors will present a framework for optimizing shop planning and scheduling for a pipe spools workshop in Malaysia. The case study shows how through a tight integration of multi-discipline design, construction, material management, process machines, and heuristic approaches into an integrated system, it is possible to automate shop fabrication and promote the efficient handling of dynamic and complex pipe spools fabrication processes. Additionally, the authors will address how a design-to-production CAD model is used to explore different scenarios to determine possible improvements in the shop based on a complete insight of fabrication sequencing, material optimization and load balancing. Management of change is significantly improved by design information sharing, together with transparent production, real-time status and full traceability on the shop floor.

74. WIYHDRAWN

75. PRODUCTION PLANNING WITH MULTIPLE SOURCES OF DESIGN DATA

Hoonsik Jeong, Intergraph, South Korea
YunSung Chang/Ph.D., Samsung Heavy Industry, South Korea

The large Korean shipyards have focused on getting contracts for large offshore platforms to overcome the shipbuilding slump. However, they face many problems while building those structures due to extensive revisions, inexperience, and the need to improve production scheduling. In this paper, the authors investigate an effective solution for production planning based on integrating the 3D model with multiple sources of design data.

The engineering model from the design team contains much data and information required to generate the accurate drawings and BOM data. So, the engineering model is relatively heavy to be handled by production planners. The authors will discuss the importance of creating a single lightweight 3D model from two or more engineering models. The authors will show how integrating a lightweight 3D model into production planning enables shipyards to achieve accurate estimations of production schedules.

76. MODEL REUSE: THE LINK BETWEEN 3D MODELS FOR BASIC DESIGN AND 3D MODELS FOR DETAILED AND PRODUCTION DESIGN

Michael A. Polini, Intergraph, United States
Tapio Hulkkonen, Napa, Ltd., Finland

Due to an increased focus on safety and survivability, major projects utilize higher and higher fidelity 3D models developed in the early design stages as the basis for first principles-based analyses and simulations. Many of these solutions offer 3D modeling capabilities

that support the rapid development of models with the necessary geometric and properties needed for the analyses. Because of the increased sophistication of these models and analysis tools, the up-front engineering costs and lead-times have increased. While the 3D modeling features of these solutions are getting more and more powerful, they are limited and not on par with state-of-the-art, integrated, lifecycle 3D modeling tools on the market today. Project costs and schedules can benefit from a capability to re-use this 3D model data as the design moves from the early stages where the focus is on the engineering design to the downstream stages where the focus is on construction and production.

The authors have cooperated in the development of an interface between two market-leading solutions with strengths at the different ends of the engineering spectrum--Napa concentrating on the early design phases like stability, ship performance, plan approval, structural FEM analysis and Class Rule Checks and Intergraph Smart™ 3D that provides an integrated, concurrent enterprise solution strong in detail and production design for hull, structure, and outfitting. The authors will present the case that, used together, these tools enable a customer to work with "best of breed" solutions in every design phase that offer a strong integration with modern IT-technology and will provide an effective means of leveraging their investment in 3D modeling and yielding productivity and cost savings for the project. This development project has successfully integrated these two systems and guarantees the continuous design flow of information for the customer without duplicated work. In addition to highlighting key features and functions, they will discuss the benefits of this approach as it relates to several targeted projects in the marine industry.

77. PARAMETRIC HULL FORM GENERATION OF MERCHANT SHIPS

Manuel Ventura, Centre for Marine Technology and Ocean Engineering (CENTEC), Instituto Superior Técnico, Universidade de Lisboa, Portugal

In this paper it is presented a procedure for the generation of a parametrically defined hull form of merchant ships. The process is carried in three steps. First, a set of main control curves is generated parametrically. Next these curves are adjusted to obtain the desired hull properties and some additional auxiliary curves are created by querying the existing ones. Finally, from this resulting wireframe model, a number of parametric surfaces are generated. The main curves represent either local shapes, or boundary conditions for the hull surface or the variation of some geometrical property. The defining parameters are geometrical magnitudes associated to hull design variables. All the curves and surfaces created are formulated as Non-Uniform Rational B-Splines (NURBS). In this paper, some examples of application are presented. This procedure is intended to be a component of a multidisciplinary optimization framework for ship design.

Keywords: ship design, hull form, parametric generation

78. DESIGN FOR SUPPORT IN THE INITIAL DESIGN OF NAVAL COMBATANTS

S Esbati, D J Andrews and R J Pawling, Design Research Centre, Department of Mechanical Engineering, University College London, UK

Naval ships have traditionally been designed and built with the requirement to achieve a set of performance criteria. These include payload, speed and endurance, stability, structural strength and seakeeping but no or little emphasis on the through-life support aspect in the early, formative stages of the design process. Failing to include Design for Support features at early design phase can result in certain disadvantages, most notably long and expensive overhauls, reduced through-life adaptability and upgradability, and diminished operability.

A genuine implementation of Design for Support features in the early stages of the ship design could be made feasible by the early consideration of the vessel internal arrangement through the UCL originated Design Building Block approach. This paper will describe work on developing an analysis tool which provides the ship designers with a framework for an early stage assessment of various internal arrangements over a range of support-specific metrics. The research project considers both tool and method development.

The paper will describe UCL studies to investigate the impact of addressing support aspects like maintenance, through-life adaptability and the location preference of various features of the vessel on the design and internal arrangement of conventional combatants. The baseline design for this research project draws on the requirements for a representative 21st century general purpose combatant.

79. JOINT OPERATION FOR ULTRA LOW EMISSION SHIPPING

Dipl.-Ing-MBA **Rolf Nagel,** Project Manager JOULES-Project, Flensburger Schiffbau-Gesellschaft, Germany

The JOULES-project focuses on the integration of energy saving technologies in the early design stage, using advanced simulation models to be developed for the energy grid of the ship. Combinations of all energy consumers aboard a ship will be optimized to achieve the most energy efficient solution. Technology providers, modelling experts and yard partners will work closely together to produce in total 11 application cases in 5 application areas (Ferry, Cruise Ships, Work Boats, Offshore Vessels and Cargo Vessels). The aim is to achieve not only an emission reduction for CO_2-emissions as stipulated in a short term 2025 scenario

(appr. 23% in average for all application cases) and future 2050 scenario (appr. 50% in average for all application cases) but to reduce other air emissions like SOx, NOx and PM as far as practicable at the same time.

The results of the simulation of the ship concepts as developed in the application cases will be used for an assessment of main KPIs like Net Present Value, Cumulated Energy Demand, Global Warming Potential, Acidification Potential, Eutrophication Potential and particulate matter for the life cycle performance, using the LCPA (Life Cycle Performance Assessment)-Tool as developed in the previous EU BESST-project. This tool allows for the comparison of different technical solutions taking into account various financial input parameters like fuel costs, investment costs, discount rate etc. Furthermore, the "well to propeller" concept will be applied in the LCP-Assessment especially when using alternative fuels. A suitable way of representing the external costs of air emissions will be integrated in order to be able to fully compare new technical solutions with existing state of the art technologies.

Finally, using the results from the LCP-Assessment of the eleven different application cases, the most promising technologies will be further studied in up to 4 demonstrator cases. The results of the JOULES project are expected to allow political recommendations for further uptake of energy efficient technology in the maritime industry.

This paper will explain the approach taken by the JOULES consortium to achieve the ambitious goals in emission reduction.

80. CHALLENGES OF EQUIPMENT SUPPLIER MODELLING FOR THE JOULES PROJECT

Stefan Hughes, Lead Engineer – JOULES, Rolls-Royce PLC, UK

The JOULES project comprises tens of marine suppliers from many different European countries, working with different software packages and operating to many different procedures and practices. To create a virtual ship, it is necessary to both concentrate on the intricacies of detailed technical component modelling of each and every energy-producing or energy-consuming device on a future vessel, whilst enabling these models to be exchanged freely between the project partners, all the time keeping intellectual property rights of these suppliers intact.

A wide array of components and systems have been chosen to be included in the holistic ship model, the paper discusses the chosen components such as renewable technologies, prime movers, waste heat recovery and exhaust gas after-treatment, electrical distribution and energy storage, heating, ventilation and air conditioning, and propulsion systems in order to build a portfolio for ship designers to simulate and assess future vessel designs.

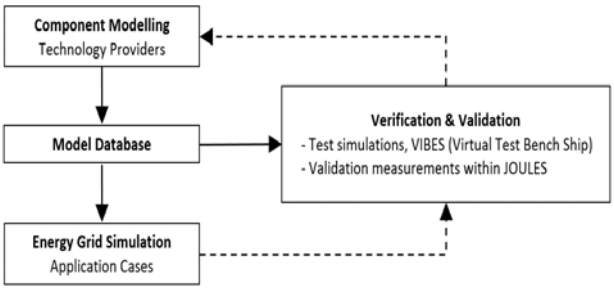
The paper discusses the challenges of gathering model requirements from the vast array of stakeholders within the programme, the choice of the Functional Mock-up Interface (FMI) standard for model exchange between the partners in the consortium, and the challenges of getting multiple companies and competitors collaborating to produce a holistic ship model which ultimately can be used to investigate the effects of combining multiple future technologies and efficiency improvements, and how it affects future vessel designs across their entire lifecycle.

81. MEASURES TO ENABLE THE PERFORMING OF SYSTEM SIMULATIONS IN A JOINT RESEARCH PROJECT

Dipl.-Ing. **Christoph Thiem,** TUHH, Germany

The energy system of today's ships can be very complex. By integration of advanced technologies (e.g. fuel cells, solar cells, flywheels, batteries, exhaust gas after-treatment) complexity will raise significantly during the next years. Thus, leading to an increasing potential for system optimization but also resulting in challenges regarding the number of component models and the complexity of system simulation in general.

Within the JOULES (Joint Operation for Ultra Low Emission Shipping) project the expertise of various equipment manufacturers and research institutes is used for providing component models. These partners make use of different development environments, in particular MATLAB/Simulink and Dymola. The component models are stored in a project internal database from which they can be downloaded for the modelling of ship machinery and systems by ship yards and other model users. For modelling of the application cases to be investigated different software is also used in the project (e.g. MATLAB/Simulink, SimulationX and Dymola). Between model providers and model users model evaluators are installed in the project as a third party.



Since different simulation tools can be found in the project an exchange format is needed. Within JOULES

the Functional Mock-up Interface (FMI) is used as a standard for model exchange. The standard was developed in the EU project MODELISAR [1]. A model which corresponds to the FMI standard is called Functional Mock-up Unit (FMU). Each FMU contains several files:

1. An xml-file which contains the definition of all variables and other model information.

2. The model equations can be provided in source and/or binary form (DLL = Dynamic Link Library).

3. Further data can be included, e.g. a model icon, documentation files or tables needed by the model.

For JOULES and for the maritime industry in general the FMI standard has the following advantages:

- According to [2] the import of FMUs for model exchange is supported by 27 simulation tools, the export by 20. These tools cover a wide range of CAE applications.
- The details of the computational model can be hidden in a DLL. Resulting from this the know-how of the technology provider is protected.
- According to simulations of component models in JOULES, FMUs work fast and do not need much memory.

To evaluate the quality of component models a quality assurance (QA) process was introduced to the project and implemented in the component database. Within the QA process robustness, exchangeability, ease of use, plausibility and accuracy are evaluated. The process is divided into different phases in order to use capacity and know-how of evaluators in the best possible way and has proven to be useful for the entire project.

References:
[1] MODELISAR consortium: Functional Mock-up Interface for Model Exchange, 2010-01-26
[2] www.fmi-standard.org (date: 2015-01-13)

82. URBAN FERRIES: COMBINING TECHNOLOGIES AND OPERATIONAL PROFILES

Arthur Vrijdag, Sandor Ivancsics, Deniz de Koningh, Damen Shipyards Gorinchem, Netherlands

Today, numerous transport related sectors are engaged in the development of propulsion system components that contribute to a sustainable future. The rapid development of energy storage technologies like batteries, flywheels or supercapacitors is clearly noticeable. These developments are generally made without a clear and direct link to specific industries. In the end, it is the platform builder (car or airplane manufacturer, shipbuilder) that is responsible for the integration of all these sub-solutions in a full operating sustainable propulsion platform.

For conventional propulsion systems, numerous design methods exist to help with an efficient concept design process. However, once energy storage devices are considered in the system configurations, the existing methods have their shortcomings. It is the experience of Damen that good understanding of the link between energy storage device (ESD) characteristics, the ESD charge/ discharge strategy and the operational profile (route plus timetable) is crucial. To the knowledge of Damen, no proven method exists that helps to reach a sensible system solution including ESDs, in an early stage of the design process, nor one to optimize such a system for maximum efficiency.

Within the EU JOULES project, Damen is looking into possible options for future design of urban ferries. This paper describes the effort to find a holistic approach to the integration and optimization challenge Damen faces as a shipbuilder. As will be shown, it is a complex puzzle involving domain (ship) knowledge, component knowledge (subcontractors), an detailed operational profile, LC(P)A analysis and integration knowledge. The paper describes how simulation is used as a powerful tool to help with the integration of components and how it supports the optimization of such a system. It mainly focuses on the process of selecting and integrating the appropriate energy storage device given a specific operational profile.

83. LIFE CYCLE PERFORMANCE ASSESSMENT - METHOD AND TOOL FOR DECISION MAKERS

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Christian Norden, BALance Technology Consulting GmbH; Germany
Dr. **Stephan Wurst**, BALance Technology Consulting GmbH; Germany
Rolf Nagel, Flensburger Schiffbau-Gesellschaft mbH & Co. KG, Germany

An increasing public awareness and fiercer environmental legislation, like emission taxes, have led to the fact that low emission shipping has become a key competitive factor for shipping companies and European shipbuilders and marine equipment suppliers.

The specific optimal solutions for emission reduction and energy efficiency highly depend on the transport or service task of ships, as well as on their operational profile. While a wide overview and holistic assessment of all available energy and emission saving technologies is necessary, industrial breakthrough can only be achieved if the available solutions are selected, adopted, integrated, assessed and finally demonstrated in realistic

application cases. The binding element between technologies and applications are modelling and assessment methods and tools. Those are needed to predict the behaviour of complex energy grids, to manage the energy demand in operation and to assess the performance of optimized energy grids both in view of cost efficiency and environmental impact.

In a comprehensive economic analysis, every cash flow associated with the vessel or one of its components has to be considered. Therefore, investment costs are only the starting point of the analysis. Operating costs and their future development affect the profitability significantly throughout the vessels lifecycle. The impact of emissions from shipping on society, especially SOx, NOX and PM emissions, are considered in terms of external costs. Consequently, a credible life cycle approach is needed to assess the lifecycle costs of green marine technology as well as its environmental footprint and its market potential.

Information about future fuel trends, different cost models, environmental issues and politics are integrated into inter-related time dependent variables spanning up a complex system that allows the simulation of future scenarios. Furthermore, these models allows sensitivity checks to identify the drivers of the complex system to investigate the best suited technology, most promising business strategies and environmental impact at the same time.

As one of the JOULES results an assessment method and tool have been developed allowing the different stakeholders to assess the environmental and economic system performance.

The paper describes the methods and provides a model and calculation example for one of the JOULES ship designs.

84. ADVANCED WHOLE SHIP ANALYSIS - A NEW GENERATION OF FE BASED STRENGTH ANALYSIS FOR CONTAINER VESSELS

O. Doerk, J. Rörup, Christian Cabos, DNV GL, Germany

Traditionally, cargo hold and global strength analysis in ship design were dealt with two separate Finite Element (FE) models and analysis approaches. Requirements for model generation, in particular regarding mesh size, were significantly different. A new Advanced Whole Ship Analysis procedure was developed which is based on analyzing a global FE model with a mesh based on stiffener spacing. This model can be generated with little effort based on an existing NAPA Steel design model. The new approach reduces time spent for FE modelling and analysis while at the same time increasing the quality of the results. Key success factors for this approach are a common design model and an adapted tool set automating the analysis tasks. Results from testing of this approach in a new building project for a large container vessel are reported.

85. EASY APPLICATION OF SIMULATION AT SMALL AND MEDIUM SIZED SHIPYARDS' PLANNING PROCESS

Deepak Narayanan, Center of Maritime Technologies e.V , Germany

Simulation has proven to be a powerful tool in aiding planning activities at large shipyards but have seldom been used at SME shipyards due to the complexity, cost and need for simulation expert to integrate the simulation solution in a SME shipyard. Easy application of simulation for the planning of SME Shipyard activities can be achieved by the two stage simulation concept, wherein manual interaction with the simulation environment will be minimal. In the first stage, all the shipyard activities will be simulated only within the planning tool anteSIM developed by CMT. In this stage the shipyard planner needs only to interact with anteSIM to export all the relevant information to Simulation database. Therefore there is no requirement of a simulation model or simulation expert. In the second stage, Simulation model will be modeled in the Plant Simulation environment along with the Simulation Toolset Shipbuilding, wherein detailed simulation studies which were not possible under the constraints of anteSIM will be performed. Even in the second stage, simulation expert is not required as the simulation model could be modeled under a one-time simulation consultant. The anteSIM tool will be utilized in both stages as an interface for data collection, data handling and statistical analysis center for the simulation studies. By integration of Simulation in planning activities, SME shipyards will be able to perform simulation studies for Contract negotiation, short and long term investment planning, shipyard critical path analysis, shipyard utilization analysis and other studies which will aid them with precise and reliable planning in comparison to planning without simulation.

87. THE USE OF PRODUCT LIFECYCLE MANAGEMENT IN THE DESIGN AND MAINTENANCE OF COMPLEX NAVAL ASSETS

Gavin Hamilton, CHIEF TECHNOLOGY OFFICER**,** ASC Pty Ltd, Australia

In 2006 ASC embarked on a strategic business initiative based around the use of Product Lifecycle Management (PLM) technologies and approaches in order to ensure that design and maintenance activities of the Collins Class submarines for the Royal Australian Navy could be performed effectively and efficiently given their 30+ year operational lifespan. This paper will provide an insight

into this PLM initiative by detailing the evaluation and selection phase of the technology that underpins the initiative, highlighting the challenges that have been faced, and the solutions that have been implemented. In particular the benefits that the initiative has had on transforming business processes at an enterprise level, improving the accuracy and dissemination of information across the enterprise, supporting the achievement of regulatory requirements, and the repository of information that is being formed as a result of the initiative thereby contributing to ASC's knowledge management objectives. Finally some real life examples and the cost and schedule benefits that have been achieved through this initiative will be provided to demonstrate the value of taking a strategic business approach to solving issues associated with the design and maintenance of complex naval assets.

88. WELDING MANAGEMENT IN SHIPBUILDING & OFFSHORE

José Sánchez-Arévalo, Sener Ingeniería y Sistemas, S.A. - Spain
Guangwu Liu, Sener Ingeniería y Sistemas, S.A. – China
Antonio Valderrama, Sener Ingeniería y Sistemas, S.A. - Spain

In a day-by-day increasing demand for complete control and monitoring of all the building aspects of critical structures, those from ship construction and offshore units have a special consideration due to the consequences from their collapse. Since raw materials have their own traceability, it is the erection phase -when a major transformation happens- the right time to resume the traceability of the manufactured entities, understanding them as composites from raw material and a new item to stick them together: the welding.

Welding are operations that involve the metal parts, the electrodes, the flux around, the skills from the welder (if manual) and even the atmospheric conditions, among others. And all these parameters have to be addressed properly so that any weld in the ship or the oil rig could be traced afterwards to know exactly its details. Therefore, it is of the utmost importance to keep all those aspects in a fully controlled environment, and it all starts at the time that the welding is required.

3D CAD/CAM tools for structure and piping design should incorporate the features to manage all the welding information as part of the final 3D model, from where to obtain any written report, any attributes as part of the manufacturing drawings and even any interface with the latest technology in automatic welding machines, either for structure parts and for pipes and pipe fittings.

FORAN System has already finished a complete welding management, including the automatic calculation and identification of any weld for structure and outfitting.

89. EFFICIENT MANAGEMENT OF SIMULATIONS IN VIRTUAL REALITY ENVIRONMENTS

Luis Sánchez, Sener Ingeniería y Sistemas S.A., Spain

Simulation in Virtual Reality environments is a powerful tool that can be used in planning, manufacturing, operation and training activities. The immersive experience achieved by the use of Virtual Reality solutions helps the staffs in the interaction with the 3D prototype.

Planning of assembly units must be carefully developed and analysed in all building phases, in order to optimize and improve processes avoiding extra costs. All tasks related to Operations and Planning have an important impact in production activities.

Complex projects in offshore and Naval ships markets makes necessary develop advanced training programs to prepare the operation staffs. In consequence, knowledge of systems, services and their components is essential to perform a high quality maintenance and operation tasks during life service of ships.

In consequence is necessary to manage all simulation tasks developed by different working teams and well organized according to requirements. A ship is a complex product where thousands of components must be assembled and disassembled during the entire life cycle of product: from building process to stage in service and maintenance. Then, a versatile toolkit for definition, management, organization and customization of simulations is useful in virtual reality software. This paper describes the solution based on Foran System, FVIEWER-VR developed by SENER, shows its advantages and explains how it could be applied efficiently in management of simulation tasks in combination with Virtual Reality Technology.

90. SCHEDULING FOR ASSEMBLY SITES IN SHIPYARDS USING LINEAR OPTIMIZATION

Jan Niklas Sikorra, Institute of Production Management and Technology (Hamburg University of Technology), Germany

In the early stage of production planning in shipbuilding, the ship is divided into building units called blocks. In order to schedule the production, these blocks are allocated to resources. The allocation of these blocks is done by estimating the operation time of the block on an assembly site and the delivery date of the block to the dock for final assembly. Using the operation time, the delivery date and constraints, a planner manually creates a schedule. The generation of the first plan is time consuming and prone to inconsistencies. The first plan

often also lacks optimization with regard to the target variables.

The generation of schedules is a common problem in the area of linear optimization in mathematics. There are existing models which can be adapted to the given problem. Adapting a model, focus is set on the ideal level of detail, as a high level of detail is an extensive cast which might lead to a pseudo exact result and could suffer from a lack of acceptance by the planners.

This paper describes an approach to assist the planner with generating production schedules for constructions on assembly sites in shipyards, using linear optimization. The model considers the operation time as well as delivery time as target variables, and capacity restrictions or properties of a specific assembly site as constraints. The focus is set on developing a tool with the ideal level of detail, to assist the planner in creating a better schedule for blocks on assembly sites.

91. VIRTUAL SHIP: AN INTEGRATED DESIGN ENVIRONMENT FOR OPTIMAL SHIP ARCHITECTURE

Benoit Rafine, Head of Complex System Modelling Department, DCNS Research, France

Shipbuilders currently have to cope with very high competition and the development of innovative maritime products is a great challenge. The design of new vessels is subject to global trade-offs mainly among the customer needs, a competitive price and a low environmental impact. The need of efficient tools to manage and optimize ship architecture, in relation with all these design requirements, is more and more current. This paper proposes an innovative design framework to help ship designers in the design of optimal ship architecture. This environment, called Virtual Ship, is used in the preliminary ship design steps. It ensures the link between the tools traditionally used to manage design requirements and to estimate global ship performances. Virtual Ship is a software platform which makes easier the estimation of impacts of ship architecture modifications (global ship shape, g eneral arrangement, components...) on both ship technical performances (hydrodynamics, structure, energy consumption...) and design requirements (customer needs, normative rules...). Consistency between design parameters and modelling tools, used to assess ship performances, is a key feature of Virtual Ship that ensures the coherent evolution of the ship. Virtual Ship also integrates multi-objective optimization strategies and decision making tools to help designers in the search for innovative and optimal ship solutions. This new ship design platform is tested on a real world application to measure the contribution of this innovative ship design method in relation to a traditional ship design process.

92. ACCESSIBLE IMMERSIVE VISUALISATION FOR SHIPBUILDING.

Andrew Connell, Director of Technology, Virtalis Ltd. (UK)
John Martin, Director, SAMOSC Ltd. (UK)

The objectives and requirements for implementing a visualisation system for design and manufacture in a shipbuilding environment are defined. Considerations when installing and integrating the system for use as a day-to-day tool by engineers and production teams are identified and explained. Visualisation techniques and methodologies are explained, together with their advantages and shortfalls and when they should be used. In particular, use of immersive visualisation for design verification, design review and customer acceptance at all stages of the design lifecycle, including collaborative review from remote multi-site locations.

Practical examples and experience of successful and effective use of visualisation techniques and methods for ship and submarine design and manufacture are presented.

The functionality of Interactive 3D visualisation systems is explained, and how they interface with disparate data sources.

Virtalis has worked with numerous massive shipbuilding data sets for almost 20 years, and has development agreements in place with all the industry leaders. The shipbuilding specific visualisation applications they have developed are described, with an overview of how they are being applied successfully in shipyard installations globally.

93. RESEARCH ON MPF PROCESS USING PUNCHES WITH HEMISPHERIC HINGE HEAD

JIA Bin-bin, WANG Wei-wei, ZHAO Chen, School of Material Science and Engineering, Harbin Institute of Technology, China

In traditional multi-point forming, surface concave is prone to occur due to the point contact between sheet metal and spherical surface of punch’s head. In this paper, a new structure of punch’s head with hemispheric hinge is designed to improve the surface contact condition between the head and the sheet metal. To swing follow the deformation of sheet metal and keep the working surface parallel with the sheet metal, the new head avoids the concave and solves the problem that happens when using the traditional punch’s head.

The numerical model is established for ABAQUS finite element software to simulate the forming effects of saddle surface when the punch is equipped with the traditional and hemispheric hinge head respectively. The

results show that the forming result of the hemisphere hinge head is much better than that of the traditional head in the same forming conditions. Due to the point contact between the traditional head and the sheet metal, excessive local deformation and surface concave are tend to appear when forming force is larger. On the contrary, the small forming force is incline to cause insufficient deformation and large amount of springback, in addition, the wrinkling is prone to appear on account of its smaller sheet constraints area in initial forming period. The hemispheric hinge head, which improves sheet stress state through increasing contact area, always maintains planar contact with the sheet metal, so that the surface concave is basically eliminated. Furthermore, the possibility of wrinkling is greatly reduced due to the increase of constraint area.

The numerical simulation method is applied to study the springback of saddle surface multi-point forming. The saddle surfaces where parameter “a” includes 480mm, 720mm and 960mm, and parameter “R” is 300mm are chosen to research the springback value variation law with the parameter “a” changing. The saddle surfaces where parameter “a” is 480mm, and parameter “R” includes 240mm, 260mm, 280mm, 300mm, and 320mm are chosen to research the springback value variation law with the parameter “R” changing. The results are characterized by two center section lines of saddle surface, where the curvature of the section line A-A is parameter “R”, and that of the section line B-B is parameter “a”. The simulation results show that the springback values of section line A-A and B-B decrease with the “a” value increasing, and increase with the “R” value increasing. Due to bidirectional reverse curvature features, the springback values of section line A-A and B-B are influenced not only by the parameter “a” and “R”, also influence each other.

The numerical simulation method is applied to study the thinning of saddle surface in multi-point forming. The parameter settings here are identical with that of springback study. The simulation results show that the variation of thinning rate with the changing of parameter “a” in section line A-A is identical with that in section line B-B. The smaller the “a” value, the more serious the sheet metal thinning in marginal area, the more serious the sheet metal thickening in central area. The thinning rate in section line A-A and B-B decreases with the increase of parameter “R”. The thinning rate is less influenced by the “R” when the “R” is small, however, the effect of parameter “R” on thinning rate increases significantly when the “R” is greater than 280 mm.

Keyword : multi-point forming, hemispheric hinge punch’s head, springback, thinning

94. PRODUCT LIFECYCLE MANAGEMENT IN THE SHIPBUILDING AND SHIPPING INDUSTRIES – AN UPDATE

Matthias Grau, Lars Wagner, PROSTEP, Germany
Christian Cabos, DNVGL , Germany

Shipbuilding and shipping industries are characterized by extremely short, highly collaborative and concurrent development processes and the long, maintenance-intensive life of the vessels. Proven in other areas of discrete product manufacturing and operation – namely automotive and aerospace, Product Lifecycle Management (PLM) offers a huge potential for process improvements and cost savings also to the maritime industries.

In our publications at ICCAS in 2011 [1] and 2013 [2] we reported on the approaches of PLM in the shipbuilding and shipping industries, their recognition and status of implementation. This paper updates those findings through evaluation of a new survey carried out in 2015.

As in other industries, information is increasingly becoming an asset also in the maritime field. Valuable knowledge is contained in and could be derived through analysing the large data sets built up over the product lifecycle. Therefore information sharing has the potential to bring benefits to all stakeholders involved in the process. Examples are performance management in shipping or class rulemaking in shipbuilding. Parts of the information created and held by the stakeholders will always be business critical; therefore there are natural limits in what can be disclosed. This paper looks at mechanisms how information sharing can be increased to the benefit of all stakeholders while intellectual property rights are maintained.

[1] Chr. Cabos and W. Grafe, Germanischer Lloyd SE, Germany, M. Grau, PROSTEP, Germany; Product Lifecycle Management in the Shipbuilding and Shipping Industries; ICCAS 2011, 20-22 September 2011, Trieste, Italy
[2] C. Cabos, DNVGL, Germany, M. Grau, Lars Wagner, PROSTEP, Germany; Product Lifecycle Management in the Shipbuilding and Shipping Industries; ICCAS 2013, 24-26 September 2013, Busan, Korea

Keywords:
Product Innovation, Product Lifecycle Management (PLM), Ship Lifecycle Management (SLM), Intellectual Property Protection (IPP), Supply Chain Communication (SCC), Digital Rights Management (DRM), Enterprise Rights Management (ERM)

95. MODEL BASED STRATEGIES FOR SHIPBUILDING

LCDR **Randy Langmead** USN (Ret.) and Director - Siemens Industry Software
Donald Gillikin, Business Consultant - Shipbuilding/Offshore Siemens Industry Software

Today, commercial and naval vessel owners are demanding higher and higher levels of interconnected shipboard automation and sensor systems to increase efficiency and performance of their vessels. Planning, designing, installing and testing these systems requires a much higher level of sophistication and design effort for naval architects and engineers. The "Model Based Enterprise" (MBE) is more than just Model Based Definitions (MBD). It's an Enterprise strategy that leverages MBD defined data to drive Model Based Engineering (MBe), Model Based Manufacturing (MBm) and Model Based Sustainment (MBs). And one that leverages a Model Based Systems Engineering (MBSE) methodology to utilize (and reutilize) interconnected and interdisciplinary computer data models across the ship life cycle. This methodology has been effectively used in the aerospace and automotive industries and the same can be true for shipbuilding. This methodology can enable enhanced schedule (and hence financial) benefits to ship designers, shipyards, and ship owner/operators.

In this discussion, this paper will expound upon the "MBE Maturity Model". It will relate greater levels of maturity to delivering "fit for purpose" data to Interdisciplinary teams through the ship life cycle, and discuss how a shipyard can chart their course to increased productivity and best practices.

96. DEVELOPMENT OF SEA TRIAL ANALYSIS SOFTWARE ACCORDING TO THE NEW ISO 15016 AMENDMENTS

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ISO is currently revising ISO 15016, which specifies guidelines for the assessment of speed and power by analysis of speed trial data. This guideline is widely used in analyzing speed trial data in order to estimate the performance of newly built ship. The new version of ISO 15016 recently passed DIS (Draft International Standard) stage and is expected to replace old version soon.

The new version includes many major changes and some of the included methods, especially theoretical method used in wave resistance calculation cannot be done by hand or using simple spreadsheet.

This paper discusses development of sea trial analysis software, named i-STAP that can fully support calculations required to apply the new amended ISO 15016. First, brief introduction on ISO 15016 standards and its amendments are given. Then analysis methods included in the amended version are discussed. Main functions and features of i-STAP are also discussed together with its application on actual sea trial data. Using i-STAP, the user can use any method included in the new ISO 15016 in analyzing sea trial data. i-STAP requires speed trial data and model test results as input and output corrected power and speed together with all intermediate calculation results so that the user can validate the results or investigate further.

97. HOW TO REALIZE ON-TIME DELIVERY AND COST SAVINGS IN MARINE AND OFFSHORE PROJECTS?

Tom KALKMAN, KEONYS, France

From initial proposal to commissioning, Marine and Offshore projects involve **staggering amounts of data** and documentation, large quantities of materials and resources, which must be **shared among all project participants**. This requires a **coherent and secure information environment** governing all aspects of the development process throughout the entire lifecycle of the ship.

Meeting market expectations
The shipbuilding market expectations could be summarized as follows:

o Accessing up-to-date information from day 1
o Integrated contract management
o Managing requirement changes
o Seamless collaboration while protecting IP
o Multidisciplinary design, engineering and manufacturing planning to reduce expensive rework on the shop-floor
o Downstream manufacturing technology to ensure speed and quality in prefab assembly phase
o Supply Chain Management with all suppliers

The ***Designed For Sea*** and the ***On Time To Sea Solutions*** from **Dassault Systèmes** have been designed to effectively meet these market expectations.

How to translate this technology into tangible business results?
Keonys, the preferred 3DPLM Partner from Dassault Systèmes, has built a unique expertise in successfully executing Shipbuilding PLM projects. In close collaboration with our customers, we identify challenges and translate PLM technology into tangible business results. Through our years of experience we are able to help our customers to create and market better products and offer services at a more innovative level.
Keonys delivers business value technology and services packages that simplify implementation, reduce customer risk and ensure on-time, on-budget deployment.

98. INTEGRATION OF MARKET UNCERTAINTY IN SHIP'S DESIGN SPECIFICATION

Romanas Puisa, Brookes Bell, UK

Ships are designed to very specific design requirements that reflect the shipowner's business model (profit strategy), existing regulations, technology, construction constraints, etc. Although design and construction requirements are fixed, it is assumed that the owner (operator) will have sufficient flexibility to adjust to future market circumstances through operational measures and additional capital expenditure. Thus, the asset value comprises two value components: the static one, which is conventionally valuated by the variations of the discounted cash flow method such as NPV, PB period, RFR, etc. and the dynamic one, which is highly uncertain, perceived as unquantifiable, and consequently marginalised.

However, the design specification could significantly be improved, if the design-pertinent managerial flexibility was quantified and incorporated into the valuation process. This way, the owner, and other stakeholders, would be better informed to select the right design specification amongst existing alternatives.

To this end, the paper focuses on integration of uncertainty in exogenous factors such as fuel price, supply-demand curve, regulatory regime, into the valuation process of design specifications. To systematically deal with the uncertainty, we apply the Real Options Valuation (ROV) that represents an extension to the classic NPV analysis and, more importantly, allows quantifying the value of future managerial decisions as the market uncertainty resolves. We demonstrate the application of ROV to a small Ro-ro passenger ship, within the context of its conceptual design stage where the best design specification amongst several alternatives is sought.

99. TURNING ABILITY OF A TANKER IN SHALLOW WATERS UNDER PRONOUNCED ENVIRONMENTAL EFFECTS

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Ship maneuvering is complex, yet an important aspect to be understood at the design stage. IMO has set certain criteria a ship has to comply with so as to ensure a satisfactory maneuverability of the vessel. However, maneuvering in shallow waters becomes even more complex to deal with and literally sea trials for these cases are non-existent. Issues like oil spillages from tankers, a product of poor maneuverability, have been lingering over the years. This remains a serious concern with the outcome having a striking effect on the ecological balance of the marine lives.

The issue arises from the fact that a vessel is not designed primarily for shallow waters and very often the ship operators have to deal with data based on experiences rather than a precise one. To make it worse, a vessel's controllability complicates in shallow waters with the ship movement becoming very sluggish. Also phenomenon like "squat" makes it more complex to deal with. Present work focuses on determining maneuverability of a tanker in shallow water subjected to environmental loads such as wind, wave etc. Hull characteristics for maneuvering are determined for different chosen shallow water conditions using a RANSE based CFD solver. A suitable mathematical model was selected which encompasses rudder, propeller and terms defining wind, wave and current effects in the form of empirical relations. The equations of motion have then been numerically integrated to obtain the maneuvering characteristics in standard maneuvers. Obtained trajectories serves as an input for operating tankers in shallow waters where environmental effects are quite pronounced.

100. DESIGNING SHIPS FOR SERVICE WITH THE HELP OF SHIP PERFORMANCE MONITORING

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Automatic monitoring of operating ships collects performance related data from the fleets of ships in service. For the first time, naval architects can have accurate information on the actual performance of their design in real operating conditions including information the weather conditions, speed profile and loading cases in real service.

This feedback to design is a new valuable opportunity supporting ship design for real service conditions. The success of future ship design is measured in reality in how well the ships perform in actual service conditions. Combining the measured performance data with the numerical simulation tools helps designer in improving their designs further.

This paper discusses usage of the service data for reaching better new design. A methodology is presented how to utilize the service data for optimizing design parameters to better suit the real operational conditions and reaching more environment friendly ships. Real service data is viewed and an example of improving an

existing ship design is presented in a form of practical example.

101. NUMERICAL ANALYSIS OF THE HYDRODYNAMIC BEHAVIOUR OF PLANING HULLS IN SHALLOW WATER USING A 2D+T METHOD

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The flow around a planing boat is strongly influenced by nonlinearities. These have to be taken into account for accurate calculations of the hydrodynamic forces acting on the boat. The nonlinearities include breaking waves, flow separation from the chines and the transom stern and in general strong deformations of the free surface. Furthermore the wetted surface area of the boat can change significantly when the boat travels in a seaway or when trim or sinkage changes. Therefore, the dynamic behavior of the boat is also strongly nonlinear.

In the paper a 2D+t method is further developed to simulate the flow around planing boats in shallow water. The method is able to account for the above mentioned nonlinearities. In a 2D+t method the 3D flow problem is replaced by several 2D flow problems in earth-fixed cross planes and the time-dependent flow resulting from the movement of the boat through these cross planes is computed. The combination of the obtained results in the cross planes delivers a good approximation of the original 3D flow.

In the 2D+t method employed, the flow in the cross planes is treated under the consideration of the nonlinear free surface boundary condition, so that the important nonlinear features of the flow are captured. A boundary element method is used to solve the associated boundary value problem. Due to the strong deformations of the free surface special treatments of the employed numerical grid are necessary to ensure the stability of the computations and a separation model has to be employed, in order to simulate the separation of the flow from the chines.

In the cases investigated in the paper, the behavior of prismatic planing boats operating in shallow water is studied. Calm water and also regular head waves are considered. The obtained results are compared with RANS simulations and with available experimental data.

Keywords: 2D+t theory, planing boat, boundary element method, shallow water

102. 3D MARITIM – SUPPORTING TECHNOLOGY TRANSFER FOR 3D GRAPHICS

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3D computer graphics is an enabling technology that has an enormous influence on all industry sectors form automotive over aerospace to consumer electronics. After significant improvements of engineering process triggered by Computer Aided Design, Simulation and Digital Mock-Up we now observe an increasing level of research and applications in production-oriented scenarios under the initiatives of cyber physical systems and industry 4.0. Furthermore, the later phases in the product lifecycle such as training, maintenance and retrofitting also open up a big variety of sophisticated applications of 3D graphics – just to name virtual training environments or mobile support for maintenance technicians with Augmented Reality. Besides realtime visualization of 3D models, now capturing reality by means of laser scanners or (stereo) cameras becomes more and more important in the processes.

All of those IT innovations do not originate from the maritime sector. It is mainly the gaming sector the drives the 3D technology and induces radical improvements in performance for a fraction of the previous costs. 3D graphics cards, the Kinect sensor or game engines are obvious examples for this trend. The automotive sector is quite fast in bringing this new 3D power to industrial processes, especially. With a traditionally high level of IT related research and development (R&D) and large scale production this sector has a position as an early adopter of various 3D innovations.

But also the maritime industry offers a plentitude of opportunities to improve their processes by advanced information technology. However, a simple copy and paste approach does not work here. Maritime 3D solutions must always take into account the specific requirements of unique copies or very small batch series as well as the industry structure characterized by small and medium sized enterprises (SME). Technology-oriented networks are a proven success factor to increase innovation power and enable SME for joint R&D.

Such a network that deals with 3D computer graphics technology for the maritime sector has been established some five years ago in Germany. Under the label “3D maritim” it combines end users (especially shipyards), maritime service providers, IT companies and research institutes. Our submission will present the activities and results of the 3D maritime network ranging from jointly formulating a vision for a complete digital copy of a ship

that accompanies the physical product in all phases of the lifecycle over workshop formats to share experiences in a given field of 3D technology to setting up a roadmap of maritime graphics and launching applied R&D projects.

103. APPLICATION OF MULTI-USER PART AND ASSEMBLY SYNCHRONOUS MODELING AND DESIGN COLLABORATION TO SHIPBUILDING

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Traditional computer-aided design methods represent the antithesis of true concurrent collaborative multi-user synchronous design, engineering and manufacture. Today's mega design and development projects are decomposed into modules and major assemblies which are farther reduced in complexity to sub-, or sub sub-assemblies with even some single part models being decomposed into sub-part models. The design of each model follows a serial workflow where one technical person: designer, engineer, analyst, process planner, etc. works their assigned design task before sending the file to the next person in the workflow. Each individual functions independently within the CAD file to create, refine, and mature the design, analysis, or manufacturing geometry, topology, and constraints along the PLM stream. As design errors are discovered in the model files they are diverted upstream in a convoluted workflow and feedback system that lengthens and disrupts the standard design cycle.

What is the root problem? Simply stated - our modern computer operating systems and engineering applications are based on 40 year old architectures designed to empower the single users. They are file based design and engineering applications that allow only one active cursor. Contrast today's single-user CAx tools with the highly collaborative virtual gaming worlds of Halo, World of Warcraft, StarCraft, Second Life, etc. or the collaborative tools of Google Docs, Spreadsheet, Presentation, etc.

This paper will discuss developments of multi-user part and assembly CAD environments and their application to Shipbuilding. We present a new collaborative workflow that allows engineering personnel, from different disciplines, to synchronously enter intranet "cloud-based" shared models, with each person maintaining full access to their own viewing frustum, mouse, keyboard, and CAD interface. This paper concludes with results and discussion of results that report accelerated and improved designs from the use of synchronous multi-user multi-discipline CAD environments.

104. HULL STRUCTURAL WEIGHT OPTIMIZATION WITH POT (PARAMETRIC OPTIMIZATION TOOL) ABSTRACT

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Hull construction forms an important part of the total cost of a ship. Adopting an initial design approach that accounts for the structural weight optimization is essential in terms of minimising overall cost of a new building.

For such purposes a POT is developed, which enables the user input of a wide range of design parameters (i.e. main particulars, midship geometry, frame spacings, weight components etc.) associated with user set tolerance (i.e. acceptable range).

Once provided with sufficient design data, POT performs initial naval architectural calculations (i.e. intact stability, motions & accelerations, freeboard, propulsion power required). With all relevant criteria met, POT constructs a midship section model in Bureau Veritas (BV) Mars rule check software automatically, and iterates the local and global scantlings until all BV rule criteria are met with the utilisation of minimum scantlings. POT then reads the geometric properties of the acceptable midship section created in BV Mars environment, and calculates the approximate lightship weight.

Above process is repeated as many times as required to form a pool of acceptable initial design solutions. The designer is enabled to observe the influence of various parameters on the structural weight, and ultimately provided with more information and confidence to make a decision on the most optimum initial design parameters to progress with, into the detailed design stage.