ICCAS 2017 – ACCEPTED & RESERVE ABSTRACTS

1. Development of Ship structural design and assessment system based on Harmonized CSR

Hogyun Park, Korean Register, Korea

IACS CSR-H (Harmonized Common Structural Rule) for Tankers and Bulk Carriers has been effective on July 1 2015. CSR-H requires much more engineering efforts and time especially than their predecessors, making the user-friendly software be needed for shipbuilders and classification societies. Using CSR-H software, ship designers are able to design ship structure efficiently and accurately. Especially, the fine mesh verification is to be performed fine mesh analysis for the various structural details. It is included in SeaTrust-HullScan, which is the structural design assessment software of KR (Korean Register) that has been adopted and being used in all shipyards in Korea

---

2. Improving shipyard steel material handling using computer simulations

Ujjawal Chauhan, IIT Kharagpur, India

"With today's technology, it has become easier to create and implement shipyard processes driven by algorithms. Leading players in shipbuilding and shipping industry such as Maersk and Hyundai are using analytics to their advantage. However, despite all these technological advancements, one of the key complexities that remain to be tackled is that of material handling, especially in steel stockyards. One of the problems that a country like India currently faces, due to its absence of large scale shipbuilding culture, is the lack of large scale expertise in complexities of material handling and lack of adequate research into digital infrastructure to tackle the problem. However, the entry of private firms in Indian shipbuilding industry in last several years is slowly changing this outlook.

The present work formulates a framework for material management in steel stockyards by considering the scheduling of crane and also proposes a simulator for operational efficiency to reduce handling times. The said simulator shall help not only in monitoring of stock but also support decisions on layout designs based on parameters such as size of stock and production requirements. "

---

3. Integrated Quantitative Risk Assessment for Marine LNG Systems

Byongug Jeong, Byung Suk Lee, Peilin Zhou, Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, UK

This paper sets out an integrated quantitative risk assessment method and introduces a software tool which is able to facilitate the assessment of fire/explosion risks for marine LNG process systems. The software (named IQRA) calculates the impact of jet fire, pool fire, flash fire and explosion for varying leak cases under process conditions. This function, coupled with a frequency calculator, allows the risks to be estimated in one environment. The program also provides a facility to carry out a range of parametric analysis so that designers and rule makers can identify the influence of parametric changes, which, we believe, is a feature very helpful for providing comprehensive guidance for safe design and rule-developing. Flexible frequency data input and selectable consequence models help the users to identify the sensitivity of data/model selection and assist the process designers to compare process alternatives, check design quality, and evaluate appropriate design options at design stage. Moreover, the built-in hierarchical modelling of systems enables the overall risk of highly complex process systems to be assessed with confidence based on historical failure data on component level. Finally, this paper demonstrates the effectiveness of this tool by discussing several case studies investigating the potential risk of LNG systems.

Keywords: IQRA, LNG safety, quantitative risk assessment software, hierarchical modelling method, parametric analysis

---

4. Improvements in Learning Process and Productivity. An Analysis of the Return of the Investment

Rodrigo Perez, SENER, Spain

CAD Systems help engineers and designers in various industries, designing and building 3D models of airplanes, bridges... and of course, ships, submarines and floating structures. Nowadays all the industry, an especially shipyards and design offices, uses CAD in order to design better and cheaper boats and floating artefacts. The use of a CAD System provides not only a cost reduction in design, but also a cost reduction in production, including two major aspects: savings in materials due to a more accurate definition of components and material management, as well as savings in materials due to a significant reduction of design

changes, and consequently reduction of rework in production; and savings of production man-hours due to the reduction of changes and rework.

This paper shows an analysis performed with information compiled as a consequence of the author experience in CAD implementation in numerous shipyards around the world during the last years, to provide a clear idea of the Return on Investment of using CAD Systems (in particular, the FORAN system) in a generic shipyard. Another key aspect of this paper, is the analysis of the learning curve of a new CAD System implemented in a generic shipyard. The data, hours expended designing blocks and units of different weights, collected for this paper during a couple of years from a generic shipyard, have been a fantastic tool for analysing the factors that affect a learning curve process.

---

5. Ensuring Software Reliability, Safety, and Security

David Card, DNV GL, USA

This article describes the motivation, approach, and results of an effort to introduce modern software quality assurance practices into the construction of mobile offshore drilling units (MODUs). This approach is applicable to the construction of other complex vessels such as cruise ships and LNG carriers where reliability, safety, and security are principal concerns.

DNV GL published the optional class notation OS D-203, Integrated Software Dependent Systems (ISDS), in 2010. ISDS defines a set of best practices for software engineering and system integration, based on generic international standards. DNV GL's software verification approach focuses on ensuring that software arrives at the shipyard thoroughly tested and ready to be integrated. Conformance to this standard is monitored via audits by the classification society. ISDS has been applied to eight Mobile Offshore Drilling Units built in Korean shipyards. Five of these vessels have been delivered and begun operations. Owners of the vessels in operation, Songa Offshore and Diamond Offshore Drilling Limited, have provided positive feedback on the performance of these rigs.

ISDS and similar approaches are needed to address increasing software complexity as well as the accompanying safety and security risks posed by modern control and IT systems.

---

6. Single Source Data – Help or Hindrance

J L Martin, SAMOSC Ltd., UK

There is a continuing drive towards single large volume database systems to integrate all data created and used in a shipyard. “Single Source of Data”, “Shared Data environment”, “Enterprise Architecture”, “Product Lifecycle Management”, are all marketing expressions used to describe a shared data capture and management system for use across all departments involved in ship design, manufacture, build and in-service support.

The single source data concept removes the need for numerous interfaces and the complexities of duplicated data quality and integrity management. A comprehensive shared data environment is presented as the ultimate in efficient data capture, storage and management, with claims of considerable benefits and advantages from use of inclusive database systems technology in a shipyard.

However, it is often assumed that ALL data captured during the lifecycle of a ship must be included in the single source database irrespective of its use, with superficial regard for logical categorisation or data modelling. This results in a database unnecessarily very large, convoluted, difficult to control, clogged up with superfluous data, and difficult to interpret.

For an effective and efficient single source database, careful consideration must be given to the format content, quality, categorisation, and lifecycle use of all data items.

This paper describes the data and information considerations necessary when implementing a shared data environment single source database, how shipbuilding data is logically categorised by its function and purpose, and identifies short-life data that can be deleted after use, to achieve a high quality concise database suitable for long term use.

---

7. The Virtual Ship: from design to training

Massimo Peverero, Davide Tozzi, Aldo Zini (CETENA S.p.A.), Italy

Simulation has always been used during ship design activities in order to verify and demonstrate the feasibility of the taken choices. During the years virtual reality gave a boost to the implementation of what we can call virtual prototype which means the set of models, algorithms, methodologies and best practices for implementing in the computer a realistic model of the ship both from the visual and from the behavioural perspective. The virtual prototype usually is the only prototype of the ship herself and represents an interactive realtime simulation of the ship under design: the Virtual Ship.

In the perspective of reusing models and simulations in the whole ship life cycle, a first success story is the implementation of training simulators which use, at the best, all the models, algorithms and simulations implemented and utilized during the ship design phase. CETENA has always been active in simulation based design and virtual prototyping and now has implemented a simulation system which reuse all the achieved experience and which can be used either for training and for design assessment purposes. The fact that a shipbuilding company is entering directly the ship training arena provides a new perspective in training simulation.

---

8. Numerical and experimental study of resistance, trim and sinkage of an inland ship in extremely shallow water

Qingsong Zeng, Robert Hekkenberg, Cornel Thill, Erik Rotteveel, Department of Maritime and Transport Technology, Delft University of Technology, the Netherlands

This research presents investigations of ship resistance, trim and sinkage in extremely shallow water using numerical and experimental techniques, and differences of fluid behavior around ship hull from that in deep water is analysed. Inland ships will generally experience a large resistance increment when the water depth is extremely shallow (e.g. depth-to-draft ratio is about or even below 1.2). In this research, CFD is used to simulate a model-scale ship travelling in shallow water with a depth-to-draft ratio ranging from 2.5 to 1.1. Navigating velocity varies from
0.4 m/s to 1.1 m/s, corresponding to roughly 8 km/h to 21 km/h for the full-scale ship. An additional case in deep water is implemented as a comparison. In the simulation, a hybrid mesh is used, i.e. a tetrahedral mesh with prismatic mesh in the boundary layer is built around the ship and a hexahedral mesh is built in the far field. A dynamic mesh technique is applied to realize trim and sinkage. All the CFD calculations are operated in ANSYS Fluent. Validations are completed with model tests in the flume tank and the towing tank of TU Delft. A 1/30 scale model that is only free to pitch and heave is applied. By this means, the validations can cover the aspects of resistance, trim and sinkage. A comparison of numerical and experimental results is made at the end of this paper with an explanation of why the differences occur.

9. Ship Motion Prediction using Simulation – Technology Developments and results from a dedicated Royal Navy Sea Trial.

Bernard FERRIER, Hoffman Engineering, USA

An essential condition for the safe recovery 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, greatly enhances the overall system operational capability.

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 modelling. 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 favourable to bring the vehicle into the dangerous recovery zone.

---

10. Research on the combinatorial optimization problem and PSO based solution in ship block lifting design

Dr Rui Li, Dalian University of Technology, China

Ship block lifting design is an essential design work in shipbuilding process as the safety and efficiency of the lifting work relies on it. Considering various limits of geometry, mechanics and techniques, the complex design process can be regarded as a typical NP-hard combinatorial optimization problem with behavioral constraints. Now in most shipyards, experience-based design method is a main approach to ship block lifting design, and there remains a large gap to a higher automated and effective stage in this field. To facilitate the development of automated design method, a solution to the combinatorial optimization problem in ship block lifting design is proposed by this research.

First, by constructing the hierarchy model of lifting constraints and the functions describing the LP(Lifting Point) fitness distribution in a certain lifting-plane, the model of the combinatorial optimization problem in ship block lifting design is established. Moreover, an improved PSO(Particle Swarm Optimization) algorithm with adaptive ability is proposed and applied to solve the normal lifting problem. As to two complex problems of block rolling and compound design, the model of algorithm is rebuilt by analysis the appended constraints. As a result, the optimization of LP arrangement in block rolling process which considering the 3D interference factors is realized, and the comprehensive design in multi-continuous lifting process of large scale blocks is optimized.

11. Adopting European CAD/CAM Software for use in the US Market: A Retrospective

Samantha Griswold, Josh Horst, Andrew Girdler, Nathan Larsen, Glosten, USA

Adopting new detail design software at the fabrication stage of a project is no easy task. Demanding project schedules, and a desire to start fabrication quickly deter many production design groups from taking leap. But, what if an initial delay in deliverables at the start of the project could be re-cooped by reduced modeling and drawing time, and an expedited deliverable schedule? This “what-if” is what motivated a Seattle based design firm and an Alaskan shipyard to take a risk and make the switch to utilizing a European style CAD/CAM software adapting it for use in an Alaskan shipyard.

This paper provides an examination of the challenges and successes of making the switch. As a case study, the authors utilize a 280' vehicle passenger ferry, currently under construction in Ketchikan, AK. This study describes the efficiency gains and losses in both modelling and creating engineering deliverables, and the corresponding evolutionary process of tailoring deliverables to match the client’s dynamic preferences and expectations over the course of the project. A description of the software selection process provides insight into the motivation for adopting the software.

The authors conclude with a discussion of the future of design deliverables in US shipyards with insights and aspirations from the production designer, software developer, and shipyard. The authors make predictions about how the documentation of production deliverables are changing in the US and how a designer’s choice of software can put them ahead or behind this change.

12. Virtual Reality Empowered Design

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

In much the same way as other advanced technologies in the past, Virtual Reality has been used until recently only in few professional environments due to its relatively high cost. Remarkably, in engineering projects whose final product is available as a digital mock-up allowing immersive interaction, VR has already shown its great potential for design review, ergonomics and usability studies and simulation of assembly operations, among other practical applications.

At present, the increasing availability of affordable VR gear and amazing portable devices is favouring the development of new solutions in much more fields of application, including home entertainment, which will let us interact with the virtual world like never before. Definitely, VR has burst into our lives.

How these new ways of man-computer interaction are being translated into the shipbuilding business? In particular, how computer aided design and manufacturing systems are incorporating VR technology? How will the new generation of naval architects and marine engineers design?

Starting with an overview of the state of the art of this technology, our paper addresses the above questions and describes the benefits arisen from the immersive experience of true VR in the ship design and production process. Particular attention is paid to the latest VR-related features in Sener’s FORAN software.

13. Innovative Progress Monitoring Tool for Electrical Detail Design

Anish S, Cochin Shipyard Ltd., India

Ship building is an art rather than science. With the globalization in picture, ship builders must integrate and deliver ships in shorter lead times with competitive margins no matter how complex the ship is. This paper focus on methodology which could be adopted for integrating detail design progress monitoring functionality within 3D software platform making use of production information using data analytics.
Initially an information model is developed with spatial, compartmental, ship system, component and other project specific data.

Following data shall serve as inputs

- Master equipment list and drawing list
- Equipments, foundations, cable ways, cable scheduling and nesting info.
- Fabrication, arrangement ,installation drawings

- BOMs and fitting list which are generated from 3D production data.

A data exchange mechanism with 3D software presentation layer is developed to automatically capture all type of data modification associated with individual entities and drawings at user end with time stamp. Drawing revision control is also managed automatically. Finally with real time integration of the data exchange mechanism with 3D software caters end users requirements for departmental schedules. A dashboard capability with customized reporting of various key progress indicators for higher management is also provided.

The above methodology allows a ubiquitous arrangement wherein the requisite data for data analysis is obtained from end user automatically. Further the availability of real time status of revision drawings improve the productivity reducing project timelines and prove to be a handy tool for design and planning departments.

14. Development for evaluation SW regarding to container securing strength

Jin-Young Park, Korean Register, Republic of Korea

Recently, As container vessel become larger, the number of loading tiers, lashing bridge tiers and loading patterns have been diversified. And Most of classification society has revised guidelines for securing devices to protect and customer's safety and property.

However, as the various securing device and methods for container cargos are applied, it is very difficult to calculate finding efficient arrangement plan within permissible load. So the Korean Register of Shipping developed SeaTrust-LS(Container securing strength evaluation SW) to evaluate the container stowage and securing in compliance with the KR's guideline, and have continuously revised and upgrade SW.

15. Hull form Generation from Curve Network Based on Open Source Software for 3D Ship CAD

Wangseok Jang, Seoul national university, Republic of Korea

This research aims to develop hullform generation function from curve network based on open source software for 3D ship CAD. Due to the activation of Harmonized Common Structure Rules (CSR-H) recently, structure analysis for whole ship components is required. Currently, 3D ship CAD development is actively underway for generating finite element model of whole ship components. At that design stage, hullform generation is required to express precise ship boundary to acquire accurate analysis of ship However, generating hullform not only smooth one but also satisfying C^0 continuity condition is difficult in small shipyards. Therefore, additional functions to generate hullform from curve network is required in 3D ship CAD under development.

In this study, the hullform generation function is developed to interpolate surfaces precisely from curve network using open source software. The main idea of the hullform generation is C^0 Coons patches created by cubic B-spline curves. If engineer need to use offset table, this function generates cubic B-spline curves like curve network (lines). And, searching intersections between curve network at knots extracts segmented B-spline curves which are boundaries of Coons patch from original curves. Because of ship hullform and using segment curves from cubic B-spline curves, the result of this function can be used in the 3D ship CAD with a certain level of smoothness even though hullform is mathematically satisfying the C^0 continuous condition.

16. Intelligent PME Software for productivity in Design offices

Prabjot Singh Chopra, Manager, Technical & Business Development, SeaTech Solutions International (s) Pte. Ltd. Singapore

Umamaheshwar Reddy Gadekari, Asst. Manager, SeaTech Solutions International (s) Pte. Ltd. Singapore

The 4^{th} industrial revolution will alter the way we work. Higher productivity growth has become a basic necessity in all spheres of life and commercial enterprise. In a design office, there are multiple design projects running concurrently. These projects are monitored and evaluated on a continuous basis to improve productivity. Ship design is a sequential process with numerous iterations to refine and optimize the design. Each document may undergo multiple revisions. The Project Monitoring System must address specific needs of the ship design process and it requires intelligent Project Monitoring & Evaluation (PME) software that automates the manual process and also provides a live dashboard for the management information system.

As each project progresses, the amount of project data can become very huge. The PME software needs to combine features for project execution, monitoring and evaluation, communication and a project database with ability to handle multiple projects concurrently. This paper presents PME software specially customized for use in a design office and estimates the expected improvement in productivity compared to the current systems.

18. Using virtual reality paradigm to present ship structures in CAD environment

Gordan Sikic, USCS d.o.o., Croatia

After implementing Stereo 3D viewing mode in ShipExplorer application, as a one of next steps, it was decided to explore virtual reality paradigm, that will allow complete immersion into the ship. Starting point was Stereo 3D module, and for head mounted display, it was decided to use OCULS RIFT hardware. Initially it seemed like well defined task; everything was already solved, the only new functionality would be additional viewing transformation in connection to head attitude. It turned out that implementation posed completely new set of requirements, much closer to real time visual simulations, compared to classical CAD visualization system like ShipExplorer. Some of demands were expected, but some were completely new, and were connected to virtual reality environment only.

In this article, decomposition of the task of adding virtual reality capabilities to existing software will be presented, starting with theoretical analysis, problems and additional requirements that appeared during implementation will be discussed, along solutions that were used to solve them. At the end, experiences gained during addition of virtual reality extensions into CAD environment will be summarized, inlcuding present and future usages of VR in ShipExplorer.

---

19. Real-time ship air-wake and free stream measurements using Doppler LiDAR

Jacqueline Christmas, University of Exeter, UK

Understanding the air-wake around a ship, and the location and form of the free stream outside the wake, is of vital importance for safe air operations, particularly in the launch and recovery of fixed and rotary wing aircraft. While CFD modelling may be used during the design phase of a ship, the computational complexity of CFD means that only a limited number of conditions can be simulated, and any subsequent changes to the ship's superstructure will, in any case, result in changes to the pattern of air wake. The traditional technology for measuring the free stream of air outside a ship's air-wake is anemometers, with one or more reference anemometers being permanently installed, usually above the bridge. However, it is well known that the reference anemometers are often installed within the air-wake, giving erroneous information for air operations. During sea trials, additional anemometers are temporarily installed at various positions on a ship's decks in order to measure the characteristics of the air-wakes themselves. Physical limitations mean that these can only measure a certain range of distances directly above the deck.

We describe the outcome of recent trials of Doppler LiDAR as a means of measuring both the envelope of a ship's air wake, and its structure, above the deck and up to 500m laterally away from it, and results from research into improving the resolution of the devices from 40m down to 5m.
Targetting multiple LiDARs at a single point in space, to obtain 3D vectorised flow, is particularly challenging.

---

20. Driving Transformation in the Age of Experience

Stéphanie FOURNIER, Dassault Systemes, France

In today's highly competitive, dispersed, and interconnected Marine and Offshore industry, shipyards around the world are forced to rethink the way they design and manufacture. There is a clear need to be smarter and more connected at all levels of the value creation chain. The ability to transform processes and the way to collaborate in order to achieve greater design, manufacturing, and operational efficiencies by leveraging technology (Internet of Things, Information and Communication Technologies, Robotization and Automation, Big Data) is critical.

A business experience platform that provides continuity throughout the entire project lifecycle from initial design to manufacturing and ship in service is instrumental in carrying out this digital transformation. This platform must integrate design, engineering, simulation, and business processes in a single collaborative environment based on powerful software applications for 3D modeling, real-time realistic simulation, information intelligence, and connectivity.

This paper will explore how the 3DEXPERIENCE platform, a unique holistic business-oriented platform, serves as the foundation for end-to-end and integrated scientific, engineering, marketing, manufacturing and business capabilities. It will present how it supports strong interaction and efficient collaboration between all stakeholders, strict process and resource planning, project management and performance monitoring via real-time dashboarding, as well as secured requirements traceability, conformity to standards, and supply chain relationship.

---

21. Improving launch and recovery operations through quiescent period prediction from radar

Jacqueline Christmas, University of Exeter, UK

Of major international maritime interest is how to improve the safety of a wide range of launch and recovery operations, or to increase the sea state under which they can be safely undertaken. Typical such operations include the launch and recovery of fixed and

rotary wing aircraft, or small boats, from ships. These operations share two common elements. Firstly, while the overall execution of such tasks may take a significant amount of time, the key waveheight-critical sub-tasks that actually limit the sea state under which they can be carried out is short, typically less than one minute.

Secondly, a fundamental property of most sea conditions that are of relevance to launch and recovery is that sets of large waves alternate with sets of smaller waves, with the smaller waves being of lower height than the standard sea statistics for the prevailing conditions. Consequently the intervals during which these lower amplitude waves occur are referred to as quiescent periods. If these quiescent periods can be predicted, then a maritime operation could be safely undertaken under conditions whose overall sea state statistics would normally prohibit its execution. Note that this involves the prediction of the actual shape of the sea surface and its temporal evolution, not the traditional discipline of wave forecasting through predicting the statistical properties of the sea.

We describe a method for short-term deterministic sea wave prediction based on radar observations of sea surface profiles, and present results obtained from sea trials undertaken off the western coast of Scotland.

---

22. Parametric design and multi-objective optimisation of containerships

Alexandros Priftis, University of Strathclyde, UK

The fluctuation of fuel price levels, along with the continuous endeavour of the shipping industry for economic growth and profits has led the shipbuilding industry to explore new and cost-efficient designs for various types of merchant ships. In addition, the introduction of new regulations by the International Maritime Organisation has added further constraints to the ship design process. In this respect, proper use of modern computer-aided design/computer-aided engineering systems extend the design space, while generating competitive designs in short lead time. The present paper deals with the parametric design and multi-objective optimisation of containerships. The developed methodology, which is based on the NAPA and CAESES software systems, is demonstrated by the conceptual design and optimisation of a mid-sized, 6,500 TEU containership. The methodology includes a complete parametri c model of the ship's external and internal geometry designed within NAPA, as well as the development and coding of all tools required for the determination of both the design constraints and the efficiency indicators, which are used for evaluating the parametrically generated designs. Such indicators defining the objective functions of a multi-objective optimisation problem are herein the energy efficiency design index, the required freight rate, the ship's port efficiency and the ship's zero ballast container box capacity. The set-up multi-objective optimisation problem is solved by use of the genetic algorithms.

---

23. Performance Verification of a Submarine Air Conditioning System.

Jan D. Wilgenhof (MSc), MecDes, the Netherlands.
Jesús Molina Toledo (MSc), Navantia, Spain.

One of the large energy consumers in a conventional submarine is the air-conditioning system. The system removes a large part of equipment waste heat as well as metabolic heat and water vapor produced by the crew. It also reduces the humidity of intake air during and after snorting in tropical waters. Air temperatures and humidity in the compartments are important in view of crew endurance and equipment limits (e.g. humid air in electronics).

In the first design stage the air conditioning cooling power is estimated. In the detail design stage it is desired to verify the performance capability with the then available data on structure details, insulation, deck covering, accommodation separation walls, etc., as well as ventilation duct arrangement and air flow rates. Besides cooling power verification it is also desired to know resulting temperatures in the compartments in different sailing conditions. A conventional heat balance cannot provide this because it assumes fixed (maximum allowable) space temperatures and it is performed only for steady state.

Therefore a dynamic air energy balance has been developed, which simulates the heat transfer with the environment and the heat transfer between the spaces in the submarine as well as the thermal contribution of the ventilation flow, based on variable space temperature. Equipment and crew are included as heat sources. This software tool contains also a ventilation network model for the air flow rates, a water vapor concentration model for the humidity and an air cooling model.

Several types of air cooling equipment were developed: a dry air cooler model and a cooling coil model in an air conditioning unit which provides the temperature and humidity ratio difference as well as sensible and latent cooling power. A large number of tests of air conditioning units were used to develop the model. Also attention was paid to efficiency. In this way the tool enables calculation of the resulting temperature and humidity in each space in the submarine as well as power consumption.

The model has been applied on the S80 submarine now under construction. Besides space temperatures it was also requested to determine the cooling power margin, power consumption and future growth margin. The installed cooling power will result in lower compartment

temperatures than the maximum allowable in a certain sailing condition. By adjusting the cooling power downward the available cooling power margin can be found. Then the average power consumption for this sailing condition can be found.

The new software tool enables faster and more efficient analysis, in particular if a lot of submarine operation conditions have to be analyzed; demonstration of compliance with building specification requirements; optimization of the cooling power distribution over the spaces; finally it provides more accurate energy consumption data for the submarine endurance and range calculations.

---

24. Experience Capture in Shipbuilding through Computer Applications and Neural Networks

Sangeet S U and Dr. K Sivaprasad (Mentor), Department of Ship Technology, Cochin University of Science and Technology, Kochi, India.

It has always been a severe loss for any establishment when an experienced hand retires or moves to another firm. The specific details of what his job/position entails will always make the work more efficient. To curtail such losses, it is possible to implement a system that takes input from a new employee regarding the challenges he/she is facing and match it to a previous occurrence where someone else held his/her chair. This system could be made possible with input through the ages from the array of individuals who managed that particular job and processing this data through a neural network that recognizes the pattern. The paper is based on data collected from traditional wooden dhow builders and some of the modern day unconventional shipyards. The process entails the traditional value passed down through generations regarding a particular profession and analysis has been done regarding how this knowledge/experience can be captured and preserved for future generations to work upon. A series of tools including SharePoint, Mat lab, and some similar software working in tandem have been used for the design of the same. The design is inspired based on some of the practices followed in certain Canadian shipyards. This research will provide valuable insight as to how information sharing can be applied through generations for effective application of production capabilities.

---

25. An evolutionary model for understanding the effects of limited information on ship design decisions and lock-in

Dorian C. Brefort, Colin P. F. Shields, David J. Singer, University of Michigan, USA

Within modern ship design, designers rarely have complete knowledge of the design space *a- priori*. Instead, the generation of knowledge is a temporal process that involves synthesizing new information based on past and present knowledge. For this reason, aggregate models that presume complete information can fail to accurately represent the design space. Traditional methods like the design spiral have been developed to decompose a design into sub-problems that can be solved sequentially by individual domain-based teams. In this environment, management of sub-problem interdependencies is attempted through requisite single-solution design iteration. However, these interdependencies produce externalities between earlier design decisions and the utility of future design alternatives. When information on these externalities is limited, it can be difficult to predict the effects of decisions on the utility of future alternatives, and thus understand how decisions may alter the design space.

This paper explores the effects of limited information on the ship design process. A method is presented to understand these effects on the selection of alternatives and thus the utilities of future decisions. By better informing the designer, this process attempts to reduce the likelihood of premature, overly-constraining, and potentially erroneous lock in. An evolutionary algorithm is used to simulate the process of creating new information and making design decisions, whose externalities produces dynamic payoffs of future selections. The method is illustrated on the design of a ship's distributed system, where externalities between sub-systems cause the design space to shift as a consequence of previous decisions. This case study shows how designs can become locked-in, and how designers can start understanding the effect of their decisions on the overall design outcomes.

---

26. Mitigation of Ineffective Collaborative Working

Paul Moscrop, Daniel Stokes, BAE Systems, UK

Collaboration between shipyards can have considerable difficulties, particularly if one yard is providing the design and manufacturing information of part of the vessel, such as a major block, to be integrated into the design and manufacture of a ship at the second yard.

This is further complicated if shipbuilders from two countries are involved, and the requirement to design and build the block is for integration into a ship design with both organisations having different evolving business systems, processes, and program needs across the design and build product lifecycle.

For the build yard to manufacture the block, it needs a design maturity and disclosure from the block design yard which may not be well defined. Furthermore, if manufacturing digital data is integrated into the design disclosure (to support the design yard practice), it is

likely to be different from the intelligent manufacturing data required to support the build yard process.

If the lead yard design disclosure conversion plan and process, required to support the build yard construction of the block, is not fully defined the intended integration of the block into the ship design will be complex and inefficient. In such a case it will have significant impact on the timely build of the block, integration into the ship, and the ship budget and build programme.

This paper will outline potential problems of collaborative working, particularly with design shared across two companies/countries, having diverse computing systems, methodologies and working practices and discuss the issues and considerations to resolve such problems.

---

28. Improving shipyard safety and realizing cost savings in shipbuilding through advancements in digitalization

Ujjawal Chauhan, IIT Kharagpur, India

With current technology of easier availability of cloud computing platforms and digitalised 3D ship models on tablets and other mobile devices, the information from a naval architect to a production supervisor is now able to flow seamlessly. This has changed how modern shipyards now look forward to approach the building of ships. These current technologies have also enabled digitalisation in context of safety and related procedural domains, areas that have conventionally been reliant on paper based approaches and enforcements have been carried out by human safety officers which are prone to miscalculations and errors in judgement.

The current work develops a safety system in context of a shipyard that can be used globally in close integration with shipyard capabilities to create a flexible Permit-to-Work system that can be used to replace conventional methods of manual filing of permits and applications using paper. The proposed Permit-to-Work system will not only fulfil the requisite statutory regulations as mandatory at every shipyard, but also lead to substantial cost-savings, improving the transparency, ease of use and proactive engagement of shipyard labor workforce. The Permit-to-Work is reliant on cloud computing and 3D models of ships, and can be integrated with augmented reality solutions, thus bringing the latest technologies in computing down to every shipyard through easy and cost-effective solutions.

---

29. A Function Learning Method for assessing the effects of Design Bias in Early-Stage Ship Design.

Michael J. Sypniewski and David J. Singer, Department of Naval Architecture and Marine Engineering, The University of Michigan, USA

Modern engineering design teams are required to support growing product complexity while experiencing shortened development cycles. In response to this environment, complementary computer- aided engineering systems are developed to facilitate smooth design processes and create optimal end products. However, the designer is ultimately responsible for applying these tools and interpreting their results, and incorrect applications of tools may produce designs that are ill-representative of reality. Since many analyses and optimizations are history-dependent, initial designer bias can exhibit substantial impacts on design outcomes and necessitates being investigated accordingly.

Traditional methods do not provide an appropriate platform for assessing this bias. Social experiments often suffer from being costly, timely, qualitative, case-specific, non-replicable, or study- dependent. In addition, although an individual assessment of bias may benefit its associated organization, it does little to aid the holistic understanding of bias-dependent relationships that affect the design process and solution space. Addressing these issues, this paper proposes a method for modeling designer bias to begin to understand and quantify its effects. Drawing from machine learning techniques, the method defines a function learning approach for constructing design space representations which are utilized to simulate designer bias. To demonstrate this method, an early-stage ship design case study is presented which simulates bias and investigates its effects. An analysis of the case study illustrates the influence of designer bias on the design process and the bias-dependence of outcomes.

---

30. CAD/CAM Integration with ERP/PLM in Naval Shipbuilding

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

This paper highlights case studies of integrating a CAD/CAM system with ERP and PLM in a naval shipbuilding context. Naval shipbuilding requires powerful tools to manage large and complex projects. Regulations are stringent, extensive documentation is necessary, and frequent change is a constant component of the process. To manage this complexity, multiple programs must constantly leverage up-to-date and accurate Engineering data from a CAD/CAM product model. To support a workflow of concurrent processes throughout a shipyard, SSI has developed a product called the SSI EnterprisePlatform that harvests

Engineering data from its Autodesk based ShipConstructor CAD/CAM application. This solution utilizes a strategy of "platformization". The SSI EnterprisePlatform generates information in the correct format and representation needed for varying use cases and brings a product-focused approach to enterprise-wide availability of engineering data that is cost-effective, scalable, configurable, consistent, and transparent.

31. Analysis of Sloshing in Tanks Using Image Processing

RAHUL KAMILLA, ITT Kharagpur, INDIA

Sloshing is referred to as the violent movement of liquid in a partially filled tank that undergoes dynamic motion. There are several examples of such types of motions. In ships sloshing motion occur in cargo tanks of oil tankers and LNG carriers and in large fuel oil tanks. The sloshing motion is mainly due to large dimensions of tanks with smooth plane surfaces in contact with the liquid. The tank layout fails to damp the sloshing motion of the liquid. The sloshing motion becomes more violent when the parent vehicle's motion contains energy in the vicinity of the natural frequencies for liquid motion inside the tank. Determination of these frequencies is critical to determine the nature of fluid motion inside the tank and thereby predict impact load on the structure holding the liquid. The determination of hydrodynamic pressure on the tank walls due to liquid sloshing motion finds application in the design and construction of liquid tanks in ships. In some cases, sloshing is also critical as it can get coupled with the parent vehicle's motion dynamics. This paper deals with extraction of data from video recording of liquid sloshing motion inside a rectangular tank. Image processing techniques are used for this purpose. The important fluid dynamic properties which can be determined by image processing are discussed in the paper. The analysis presented is mainly for 2D motions. We also discuss how to improve the technique further so as to capture 3D liquid motion characteristics inside the tank.

32. An adapted ant colony optimization method for exploring survivable distributed system configurations within a notional naval combatant

Colin P. F. Shields, Michael J. Sypniewski, and David J. Singer, Department of Naval Architecture and Marine Engineering, The University of Michigan, USA

Current state-of-the-art naval vessels and future naval concepts employ large and interdependent distributed systems. Within these distributed systems, components exist throughout the vessel that create and consume a variety of resources to generate desired system functionality. To facilitate the transfer of these resources, distribution systems are routed between components within the vessel. The absolute and relative configurations of these distribution systems have implications on the cost, production, survivability, and reliability of both the individual systems and the vessel as a whole. However, the complexity of evaluating configuration outcomes makes them difficult to consider in early-stage design. Furthermore, for a given configuration of components, numerous system configurations may be feasible. This non-linear growth of the potential solution space is compounded by the distribution of multiple types of resources and the interdependence between their respective system's functionality.

In order to properly address this problem, new distributed system representations are needed in early-stage ship design. These representations must enable leading indicators to predict late-stage design outcomes without excessive modeling and analysis detail. This paper addresses these requirements through the provision of a network-based distributed system representation. Using the network representation, an adapted ant colony optimization method is used to enable bi-objective exploration of the distributed system configuration design space. To this end, the ant colony optimization algorithm is described and implemented on an early-stage design warship concept. Employing network-based system analysis, the optimization guides the design space exploration towards establishing a Pareto front for vulnerability and cost metrics.

33. Spatial Augmented Reality for Manufacturing Information of Curved Shell Plates

Kazuo Hiekata, Taiga Mitsuyuki, Masakazu Enomoto, Kota Okada, Yoshiyuki Furukawa, the University of Tokyo, Japan

The process for ship curved shell plates is not standardized because it is heavily depending on implicit knowledge. As a solution of that problem, an accuracy evaluation and creating process plans by using laser scanner was proposed. The system calculates displacement errors and suggested process plans visualized as computer graphics on a digital display. However, it is often difficult for workers to recognize the intended spots correctly because the plates have unique and big surface.

In this paper, we developed a spatial augmented reality system to project the manufacturing information onto the intended spots of curved shell plates. A projector calibration is conducted by using RGB camera, three-dimensional scanner, and projected markers. After the calibration is conducted at once, the manufacturing information can be projected onto the intended spots when workers move and set the projector, because each

device is combined with each other as an integrated system.

At the end of this paper, we conducted a case study using a curved shell plate model. In the case study, Kinect sensor was adopted as RGB camera and three-dimensional scanner. The shape of the model was obtained as a point cloud data by using Kinect, and its displacement errors, compared to designed data, were calculated and visualized as a color map by existing system. Finally, we could verify that the color map was projected onto the intended spots, even though the model was moved and deformed.

Categories: Information technology, VR & Visualization, Augmented Reality, Systems Integration

---

34. On a Concept of a 3D CAD/CAM system based on geometric theory for CFRP plates molding process in shipbuilding

Kohei Matsuo, National Maritime Research Institute, Japan

The paper describes a concept on a 3D CAD/CAM system for CFRP plates molding process especially for shipbuilding. CFRP should be a new material even for a ship, and we can already see a practical example to use a CFRP as material of a part of a ship. If we consider a manufacturing method of a CFRP molding process for curved plate surfaces, we meet various patterns of arrangements of carbon fiber along the objective free surface. The paper proposes the theoretical method based on geometric theory especially for free surface, and we propose new arrangement patterns of carbon fiber along with lines of curvatures on an objective surface. The paper explains our new method theoretically at first, and we show some examples which is made in our laboratory how our method is effective and reasonable. Finally, we summarize our future concept of a 3D CAD/CAM system especially for using CFRP as material of ships.

---

35. Big Data Platform for PLM (Product Lifecycle Management) Systems in Shipbuilding and Offshore Industry

Seong-Hoon Kim, Myung-Il Roh, Min-Jae Oh, Seoul National University, Republic of Korea, Namkug Ku, Dong-eui University, Republic of Korea, Sehyun Myung, Youngsan University, Republic of Korea

In shipyards PLM (Product Lifecycle Management) systems are being used to create, store, and manage all the information for design and production of ships and offshore structures. As the ships and offshore structures are getting complicated, the PLM systems are required to handle very large amount of data called big data. However, it is difficult to handle efficiently such big data with the existing method for data processing. Therefore, the need to apply big data technologies to the PLM systems has emerged these days. In this study, the big data platform for the PLM systems was proposed and implemented. Furthermore, we analyzed KPIs (Key Performance Indicators) from the PLM database and evaluated them by using the big data platform. The big data platform is based on Hadoop that is the most representative framework for big data, and it includes ETL (Extraction, Transforming, and Loading), data mining, and OLAP (On-Line Analytical Processing) engines that can be operated on Hadoop. The platform uses the ETL engine to retrieve data from the PLM database. Also, it uses the data mining engine to extract data for KPI evaluation and uses the OLAP engine to evaluate KPIs. To evaluate the applicability of the big data platform, it was applied to calculate KPIs in the actual shipyard. The result shows that the platform can be effectively used to be linked with the PLM systems in shipbuilding and offshore industry.

Keywords: Big data, PLM (Product Lifecycle Management), Hadoop, KPI (Key Performance Indicator)

---

36. An Enterprise Modelling Approach for the Early Ship Design

Robert Bronsart, University of Rostock, Germany, Wisam Jabary, Tischrin University, Syria

The early ship design has a predominant influence on the entire design and is of utmost importance for the tendering and subsequent downstream processes. In order to achieve the objective of efficiently supporting the early ship design phase, the *Enterprise Modelling Approach* is adopted. The main motivation is its principle concept of data integration and interconnected process management being supported by functions like configuration, collaboration and change management, which in turn rely on version and rights management functions. The state of a design can be monitored continuously in detail which is regarded highly important.

Predefined Activities are introduced as a core concept to apply knowledge of the design process itself and at the same time guarantees the highest flexibility and design freedom towards innovative ship designs. By this, the fundamental design tasks of the traditional ship design spiral are implemented through input, output, control and tool connectors. However, the underlying simultaneous nature of the design process, particularly in the early stage with frequent changes of any design aspects, is supported by an integrated platform which enables a multi-objective and multi-disciplinary optimisation towards a holistic ship design.

The highly modular software system is built up in such a

way that no restrictions to specific tools are imposed: all partners in a potentially globally distributed design team will continue to apply any CAE-tool which best meet their requirements to efficiently perform the specific design tasks.
The design of a Ro-Ro vessel shows the benefits of the implement CAE-work-bench.

37. Optimal Arrangement Method for Naval Surface Ship Considering the Stability, Operability, and Survivability

Sun-Kyung Jung, Myung-Il Roh, Seung-Min Lee, Ki-Su Kim, Seoul National University, Republic of Korea

When designing the naval surface ship at the preliminary design stage, several ship performances, such as stability, operability, and survivability have to be considered at the same time. It is a complex problem that many design alternatives can occur because many compartments have to be placed in the limited space. However, the arrangement design has been relied on the experienced designer and mother ships in actual design. And there is no way to evaluate the arrangement quantitatively. Due to these reasons, the probability of design change increases as design progresses. Therefore, in this study, the optimal arrangement method of a naval surface ship considering stability, operability, and survivability is proposed, and the optimal arrangement program is developed. At first, 'ship template model' which is a data structure for representing naval ship arrangement information was configured. Second, a method that can quantitatively evaluate ship stability, operability, and survivability in preliminary design stage was proposed. Third, the optimum arrangement of naval ship can be obtained using optimization module developed based on the design variables, objective functions, and constraints of the problem. Finally, user interface which visualize of the optimum arrangement in 3-D is developed. The designers can visually check the result of the arrangement, and check the values easily through this. The method was applied to the example of a 7000-ton class destroyer, and as a result, it is confirmed that the method and program can be an efficient tool for evaluation or verification of arrangement in the preliminary design stage.

Keywords: Naval surface ship, Arrangement design, Optimization, Stability, Operability, Survivability

38. Naval Ship Design Rules Embodiment in a CAD Tool

Jesús A. Muñoz, SENER Ingeniería y Sistemas, S.A. Madrid, Spain
Virginia Marcos, SENER Ingeniería y Sistemas, S.A. Madrid, Spain

The design of a naval ship must be subject to very restricted design rules that have to be applied during the design stage. The number of these design rules is very high although most of them can be reduced to some reduce measurements with different parameters for the different location of where the design rules have to be applied. For any customer designing these type of vessels, to have the ability to impart design rules by aiding user the application of these rules when carrying out their daily design tasks within a CAD tool is a very high priority because the large amount of time necessary to do the validation. The validation of the design rules may take various forms including, where possible, capability that could be applied preventing the user from imparting an aspect of design that did not adhere to an associated design rule. Where prevention of the user imparting a non-conforming aspect of design was not feasible the issuing of an associated warning/notification may be adequate informing the user of the associated rule and if they proceed they will be imparting an aspect of design that breaks a required rule. It is noted that there is a lot of inferred associativity between components and that components of certain types would need to be readily identifiable to allow an associated rule to be applied.

This paper discusses the different situations that can appear and describes the adopted solution to be integrated in a CAD system.

39. A study on the supporting system of ship basic planning by using marine logistic big data

Mohammad Danil Arifin ST.MT, Kunihiro Hamada, Noritaka Hirata, Yuki Koide, Hiroshima University, Japan

In last decade, a large amount of data is growing exponentially which forms as Big Data. There are many potential and highly useful values hidden in the huge volume of Big Data, which is widely used in various fields. Thus, the trend of Big Data is true for the maritime industries, too. In marine industries, Big Data i.e. port data, ships data, routes data, international trade data, and data provided by AIS (*Automatic Identification System*) recently more and more rapidly increased. If these data are effectively utilized, great innovation may be achieved in the maritime industry.

The objective of this study is to develop a support system for ship basic planning which can examine the demand of bulk carrier, the effective principal particulars for cargo transportation in each route. In order to realize these, the authors develop a model consist of three distinct models i.e. shipper model, ship-owner model, and operator model which is defined based on the Marine Logistic Big Data by using statistical, hierarchical, and deep learning analysis methods. In this paper, the bulk carrier which operating from Australia to Japan is taken as an example to be simulated and the effectiveness of the proposed model is shown and discussed.

---

40. A Framework Study on Plate Forming Caused by Flame Heating with Elastic FE Computation

Jiangchao Wang - University of Science and Technology, Wuhan, China
Hong Zhou - Jiangsu University of Science and Technology, Zhenjiang, China

Plate forming or plate bending is an important technique during the fabrication of ship structures, in which flame heating is usually employed due to its cheap and practical features. With the advanced computation approach, the deformed shape, even out-of-plane distortion of examined plate after flame heating can be accurately predicted. However, for a certain curved plate of ship, it's still an engineering problem to effectively design the parameters, travelling path of flame heating with computational analysis. In this study, inherent deformation was presented to consider the flame heating process during an elastic FE computation, and mesh of plate model will be recreated due to the different heating pattern at each bending step. Later, an elementary rule to design the travelling path was proposed, in which the magnitude of flame heating was also considered and confirmed automatically. With above mentioned framework, three typical shapes of curved plates generated by flame heating as application were demonstrated.

---

41. Intent-driven CAD vs. Mechanical CAD in Shipbuilding - a Review and Solution Outline

Matthias Grau, PROSTEP, Germany

Ships are complex, often unique one-of-a-kind products. Even sister ships can significantly differ from their prototype. They are made of hundreds of thousands to millions of single parts and components which have to be created and placed as part of the design process, managed in bills of materials for part manufacturing or purchasing and assigned to assembly stages for production planning and logistics. Being able to carry out highly integrated and concurrent cross-discipline design is essential for shipyards to be competitive.

The toolsets used to design and manage these complex products are either based on dedicated "intent-driven" ship building design software or more general mechanical CAD systems. The differences between these two approaches are significant. We will show the ways parts are created and stored, organized in structures and BOMs as well as look into topological relationships, space based navigation and how they are realized in those systems.

Semantics is important if it eventually comes to exchanging ship design information or feeding downstream processes. Intent-driven systems carry semantically rich primary information that can be used to generate 3D geometry, 2D drawings and topological relationships as required and when needed. This can even be used to feed mechanical CAD - based environments. The reverse direction however is the supreme discipline and is harder to achieve due to weaker semantics on the source side.

The authors of this paper have successfully realized exchanges in both directions. We will report about this challenging endeavor and show the preconditions and limits of CAD conversion in shipbuilding. The sheer amount and complexity of ship design information makes it difficult to verify the results of such a conversion process. Virtual reality methods turn out to be capable to address this challenge. We will present examples of state-of-the-art virtual reality sessions for design validation.

---

42. Optimization of layout and size of stiffener in shell structure for shipbuilding

Zhijun Liu, Shingo Cho, Akihiro Takezawa, Mitsuru Kitamura - Graduate School of Engineering, Hiroshima University, Japan

Topology and size optimization for the concept design of vessel component within given loads has been receiving increasing interest in the application of shipbuilding design. In this study, two-stage optimization method is employed for stiffener design in plate and curved shell structure of ship prow. In the first stage, we perform the stiffener topological layout optimization for minimizing global compliance and maximizing first-order modal frequency. Potential stiffener distribution are identified based on the optimal result. Two types of pre-defined stiffeners (I-shaped and T-shaped) are employed. The optimized shell structure with stiffener is again optimized until no more potential stiffener location can be identified. In the second stage, size optimization based on parametric modeling for minimizing the total structural mass is conducted. Based on the optimized parametric information of shell thickness and stiffener size, the final optimal design of the ship prow which satisfies the performance requirement can be obtained. It proves that two-stage optimization method is helpful for stiffener conceptual design even in other hull parts.

---

43. Automatic Piping Arrangement Design Considering Piping Supports and Curved Surfaces of Building Blocks

Hajime Kimura, Kyushu University, JAPAN

During the ship design, designers have to deal with all pipe-routes in order to generate high-performance piping layouts. However, the routing task requires huge work hours because there are many regulations and functional design rules in the field. Especially in piping design, consideration must be given to the position and direction in which pipes are passed, in order to properly support pipes from pipe racks and structural members with support. In this paper, a new piping path planning system is proposed in order to automate piping design corresponding to pipe supports and curved hulls. In the proposed system, candidates for positions and directions to which pipes should be passed are given in advance as 'candidate points' from the circumstances of pipe racks and support. Then, the system selects the appropriate candidate points automatically to generate piping paths keeping constraint of many factors, e.g., gravitational flow, or geometrical limitation of the pipe-bending machine, etc. Therefore, it is quite practical. The proposed system is implemented to a computer program, and the performance of the system is demonstrated through several simulations.

44. As-Build Documentation base on Scan data

Christian Barlach, R&D Manager, ISC A/S, Denmark

The majority of the work done today in the Offshore Oil and gas industry are brownfield work. Work involves modification and upgrade on existing facilities, which in many cases are 20 to 30 years old. The strategy of as-build documentation has changed over the past 30 years from very high quality to almost no investment, which has resulted in a very uneven documentation. The miss-match between the documentation (2D drawings and text document) and the actual facility have required large investment in human offshore survey to re-create reliable documentation needed to support the maintenance work and upgrade to the process. During the last 10 years the usages of 3D scanning have become a common task of maintenance work. Equipment needed to perform the 3D scanning have benefitted from the IT technology general evolution and resulted in an explosion of the amount of data accumulated by 3D scan data, i.e. cloud-of-point. The 3D scanning is in many cases linked to individual jobs, rather than a general way of establish an up- to-date as-build documentation. This can lead to conflict and double scanning when 2 jobs overlap in the location and as a result the usages available space 2 times. The current paper presents an approach how to consolidate all individual data collections in form of cloud-of-point and establish a 3D representation of an asset that can support the ongoing work and also deliver traditional documentation like the 2D general arrangement drawings that have been neglected for many years, but which is still highly respected and missed asset.

45. Integrated development environment of autonomic software for USV (Unmanned Surface Vehicle) based on ROS (Robot Operating System)

Hye-Won Lee, Myung-Il Roh, Luman Zhao, Seung-Ho Ham, Nakwan Kim - Seoul National University, Republic of Korea
Chan-Woo Yu - Agency for Defense Development, Republic of Korea

As the warfare changes recently, the utilization of UWS (Unmanned War System) is increasing. Among them, the USV (Unmanned Surface Vehicle) mainly performs mine detection and marine surveillance and reconnaissance. In order to carry out various strategies unmanned, the autonomic software mounted on USV takes charge of detection, decision, and command procedure itself. To operate various hardware such as sensors and devices on USV, the autonomic software should include complicated control algorithms, and the communication between the control algorithms and the hardware is required. Therefore, before the actual operation is performed, it is important to verify the control algorithms through various tests at the early design stage of the autonomic software. However, it is difficult to carry out such tests until the actual USV hardware is developed, and even if there is, it is difficult to create actual environment to perform various strategies. Therefore, an integrated simulation environment was proposed in this study, in order to verify and improve the control algorithms of the autonomic software, based on a virtual prototype of USV and ROS (Robot Operating System). ROS is a robot software platform that integrates the hardware and software interfaces through network communication. To check the applicability of the proposed environment, the HILS (Hardware-In-the-Loop Simulation) was performed for an example of a small USV. As a result, it can be seen that the environment can be effectively used to develop the autonomic software for USV with less time and cost.

Keywords: Simulation, Virtual prototype, ROS (Robot Operating System), USV (Unmanned Surface Vehicle), HILS (Hardware-In-the-Loop Simulation)

46. A Study on Decision Support Methodology for Evaluating IoT Technologies using Systems Approach.

Kazuo Hiekata, Taiga Mitsuyuki, Bryan Moser, Ryuji Ueno and Ryota Wada, University of Tokyo.

Recently, a wide variety of IoT technologies have been developed in the shipbuilding industry, such as

performance monitoring, structural health monitoring, and IoT integration for design. However, it is difficult to compare and evaluate the impact of the introduction of IoT technology because the function and the application area of IoT technologies are diversified. In order to utilize the IoT technologies for enhancing competitiveness of shipbuilding industry, evaluation of them should be conducted based on the maritime industry's needs.

In this paper, a decision support methodology for developing and introducing IoT technologies in the shipbuilding industry is proposed. The proposed method consists of three parts: selection of evaluation criteria, selection of function to be evaluated, and quantitative evaluation. To select reasonable criteria for evaluating various kinds of IoT technologies, technic of systems approach is applied and the potential maritime industry's needs is identified. Then, the functions, which maritime industry should perform as a system to realize the needs, are deployed using system modeling language, Object Process Methodology. As for evaluation method, parametric ship operation simulation is conducted to evaluate multiple IoT technologies with various functions.

As a case study, the proposed method was applied to decision support on introducing 25 IoT technologies. Considering each technology's maturity level, the methodology revealed the quantitative effect of each technology introduction on the selected evaluation criteria. This study provides the basis of decision support for complex maritime industry and can be further extended to take various technology evolution into consideration.

Categories: "IT in Design (Early)" or "Other use of IT (Industry/Academia)"

---

47. Development of the Unified Direct Strength Analysis (Unified-DSA) system in conformity with the multi-purpose analysis of ship hull structure, utilizing the comprehensive CAE Modeling Application; TechnoStar Ship Modeler TSM

Yasunori KAMIMARU, Daisuke FUJITA, Junichi FUNATSU - TechnoStar Co., Ltd, Japan

As presented in ICCAS2013, TechnoStar (TS) developed TCAD-DSA/CSR; the Direct Strength Analysis system conforming to Common Structural Rules (CSR), by using TS Shipmodeler (TCAD), which has been practically contributing for the best suited design for the complex requirement.

Meanwhile, CSR was revised to the CSR-BC&OT by harmonizing BC and OT Rules and following IMO new safety concept GBS (Goal Based Standard), which was taken effect on 1 July, 2015.

In order to adapt to CSR-BC&OT, the advanced TS Ship Modeler (TSM) has been newly developed, through a collaborative research with Japan Marine United, Imabari Shipbuilding, and Oshima Shipbuilding, under the Joint R&D Program Scheme of ClassNK, in 2015. Furthermore, TS continues evolving TSM by DFX data application, which gives the strong modeling tool with the world's highest performance and availability for ship structural analysis.

By using this TSM, TS developed the most up-to-date DSA; Unified Direct Strength Analysis (Unified-DSA), which can be comprehensively applied to the structural analysis by Rules in subject, as follows;

(1) Partial model (3-holds) analysis by CSR-BC&OT, and Container Carrier Rules (NK)
(2) Full ship hull model analysis for evaluation of the longitudinal, torsional, ultimate strength
(3) Entire ship model analysis for the evaluation of ship vibration characteristics
(4) Local fine mesh model analysis for fatigue strength evaluation

We describe here about details of functional development and application results of the Unified- DSA, and we mention about the successive research of DSA application to the dynamic structural response to the wave load in time domain.

---

48. Efficient Model Data Reuse through Advanced Copy Techniques

Joseph Baumer, Intergraph PP&M, USA

Advances in 3D modeling for shipbuilding design, such as associative topological relationships and rule based design, have led to significant improvements in modeling efficiency, data consistency, and change management. These same advances have caused difficulties in the effective reuse of design data, both within a shipbuilding project and between similar shipbuilding projects.

This paper will describe how advanced copy techniques are being applied to overcome these difficulties. Topological relationships can be either maintained or broken and reconnected as appropriate to effectively reuse large sets of multi-discipline, structure plus outfitting, design data. Rule based design automation can be re-triggered to modify the design during the copy operation such as when a similar shipbuilding project is constructed at a different yard utilizing different construction details or delivered to an owner requiring different piping specifications. This paper will also explore how referenced design data can be combined with live design data to reduce model size and improve performance when reusing design data.

Finally, this paper will describe real world examples of how these advanced copy techniques can be used in different design scenarios such as:

- Repetitive areas or zones within a single shipbuilding project.
- Repeated ships where a new project utilizes an existing design with modifications.
- Derived ships where new shipbuilding projects use ship specifications and design data from multiple, existing designs.
- Jumboization projects where an existing ship design is lengthened to increase the ship's capabilities and capacities.

---

49. Leveraging Engineering 3D Design Models for Production Planning Through the Shipbuilding Project Lifecycle

Stalin Ybiernas, Keppel Singmarine, Singapore
Najaf Bashir, Intergraph PP&M, Singapore

Two of the top key factors in efficient shipbuilding are the efficient use of an integrated engineering 3D design solution and efficient production processes. Keppel Singmarine has been exploring new ways to improve the optimization of the data exchange between these two factors through an efficient and early information exchange process. This is done by introducing production planning departments to the same integrated engineering 3D model used in design, which has allowed production planning to start in earlier stages of the project. The early preparation of production processes has given Keppel Singmarine the benefit of identifying potential bottlenecks as early in the design cycle as possible.

An important aspect of shipbuilding is knowing exactly when certain activities need to be executed in order to support the pre-outfitting of blocks, movement of components, installation of equipment items, etc. Knowing in advance when these activities are to be executed has allowed Keppel Singmarine to further optimize the complete supply chain and provide just-in-time support for the complete production process.

This paper will describe how the production planning department at Keppel Singmarine uses an integrated engineering 3D model to provide early feedback for block and assembly boundaries, generate detailed assembly planning drawings, create advanced outfitting block assembly plans, plan equipment loading, and more. This will eventually lead to the realization of Industry 4.0, where direct connection with- and feedback from the shop floor will be further leveraged in order to optimize production processes and therefore improve overall schedule.

---

50. A Case Study in Optimizing 3D Early Design for Shipbuilding

Jinsup Cheong, Samsung Heavy Industries, South Korea
Kristin Cochran, Intergraph PP&M, United States
HeeWon Lee, Intergraph Marine Center, South Korea

The use of 3D models provides proven benefit throughout the ship design lifecycle, and particular focus is put on extraction of high-quality production output. But due to the unique challenges of the early design stage of the shipbuilding process, a multi-purpose 3D model can also be leveraged to significantly reduce design hours and improve accuracy of analysis. The key to optimizing the process is the ability to re-use the same model data from basic design through production design, for both outfitting and structure. This requires an ability to import (and modify) data from outside sources, a drawings extraction process that transitions from classification to production using the same model data, flexible analysis interfacing capability, and an ability to seamlessly carry the model forward to detail design and production.

This paper presents a case study of the re-engineering of the early design CAD modelling process at Samsung Heavy Industries. Improvements focused on optimization of the 2D to 3D modelling workflow, unification of outfitting and structure models, and interfacing 3D model data to analysis software, resulting in significant productivity and quality improvements. Lessons learned from this project suggest further optimization based on emerging technologies.

---

51. Smarter Production, Panel line Optimization

Kimmo Salmi, Intergraph PP&M, Singapore

The panel line is usually the heart of a fabrication workshop at any shipyard or offshore oil rig manufacturer. Cruise ships, oil tankers, and offshore drilling rigs consist of thousands of panels that needs to be manufactured in a timely fashion. Efficiency and quality of the panel line is crucial.

A panel consists of several plate parts, stiffeners, and sub-assemblies such as T-girders. At the panel line, these parts and sub-assemblies are welded together in order to form the panel itself. Depending on the type of panel line, there are several steps to be taken, such as cutting, marking, tag-welding, final welding etc. Therefore, a panel line represents a process with multiple steps. Due to often limited buffer space between the different work steps, some work stations cannot effectively carry out their task, thus creating inefficiency at the panel line
The ideal situation is an optimized panel line where all of the work stations are working and buffer spaces are empty. To realize this, it is important to know how much time each work step requires with direct links to the overall material supply chain. Having this information

allows for optimizing the manufacturing sequence for each panel.

This paper will discuss how panel line optimization can be attained by taking the complete process into account. This paper will also explain different optimization targets, such as maximizing throughput time, minimizing lateness, and reducing scattering.

---

52. Smarter Production, Industry 4.0: Dream or Reality?

Marcel Veldhuizen, Intergraph PP&M, Netherlands

It is amazing to see what engineering departments often deliver to fabrication teams (a fancy 3D picture or flattened "dumb" 2D DXF drawings) as an input. The data exchanged is often of very poor quality and hence a lot of time is spend fixing the information before starting the task at hand (cutting, welding, etc.).

Design tools often do not force an engineer to think through the complete production process, causing assumptions that the fabrication data is entered manually or semi-automatically. This translates into a manual corrections during the fabrication process.

An important aspect to smarter production is a full insight into material processes in order to ensure that the right material is available at the right time. Bear in mind that material management goes beyond the warehouse and is absolutely critical to an efficient production process!

All of this is applicable regardless of if engineering and fabrication are done by the same company or if fabrication is subcontracted; in all cases there is a lot of room for improvement in this area. If the fabrication processes work well, then the next stage, construction, will become easier to manage since the same logic applies.

In this paper, a detailed description will be provided on how production processes (internally as well as externally) can indeed become much smarter if the different processes are aligned. Also some of the key performance indicators that are often used to create schedule information will be discussed, since indicators need to be chosen carefully in order to truly reflect the actual situation.

---

53. Extending the 'Life' of a Design 3D Model to Deliver Detailed and Reliable Information to the Shop Floor and Improve Production Planning

Davide Guzzi, Intergraph PP&M, USA

3D CAD technologies have been used in the naval industry for many years and have brought tangible benefits to the entire shipbuilding project lifecycle. Design time shrinkage, accurate BOMs and more reliable design drawings have had a positive impact on the entire procurement, fabrication, and construction processes.

A lot of information coming from the 3D design model is also used at the shipyard to prepare the most effective building strategy and to plan, in advance, production activities at the shop floor (e.g., welding, scaffolding, blocks lifting and transportation, and more). However, despite the fact that design 3D models are extremely rich in terms of data, the information made available to production planning teams is non-intelligent 2D drawings. Because of this, a big amount of very important information like weights, CoGs, and quantities are not directly accessible to people working in production planning.

This paper shows and explains the principles of a new 'CAD agnostic' technology that streamlines the process of making design 3D models lighter and available to non-design personnel at the yard, without losing the information relevant to plan production activities at the shop floor. This paper also illustrates how the resulting lightweight model can be used to estimate quantities for welding and painting activities and to automatically create drawings and BOMs to be used at the shop floor for scaffolding and lifting activities.

---

54. Investigating the impact of distributed system routing densities on vessel operability

Conner J. Goodrum, Colin P. F. Shields, and David J. Singer - The University of Michigan, USA

Modern multi-mission naval vessels are becoming increasingly complex from a design perspective due to a rise in the number of distributed systems onboard. The number of components in each system is also increasing, and these components are becoming more interconnected. This has led to more distribution system routings throughout vessels, which presents new difficulties in systems integration and analysis. This paper presents a set of analyses focused on identifying the vulnerabilities created by these interdependent and connected routings and components. Specifically, the methods address how system routings introduce the potential for cascading failures, where a small amount of damage causes wide-spread failures. Using centrality-based network metrics, distributed systems are evaluated to better understand the

effect of distributed system routing densities on the vessel's overall operability in the presence of damage. The analyses use a distributed system representation method that is compatible with the limited information present in early stage design. This provides a framework to conduct vulnerability analyses without the need for detailed CAD models or simulations that are typically only available later in the design processes.

The analysis presented considers a few representative distributed systems which are converted to logical topology networks. These are analyzed both independently and interdependently. These systems are routed through a physical architecture network, which is analyzed to quantify the routing densities through the physical spaces. The effect of damage on the overall system operability is investigated by simulating damage in the physical solution space, and measuring the overall system operability using a developed scoring metric. The routing density of the damaged nodes is compared to the overall system operability in an attempt to correlate the two, and to highlight distributed system vulnerabilities within the vessel's physical architecture.

55. Auto-Fine Mesh Generation for Local Analysis based on the Consistent Finite Element Model

Myeong-Jo Son, Jeong-jae Woo, Ho Gyun Park, Jeong-Youl Lee, KR; Korean Register, Republic of Korea

Under the circumstances of Common Structure Rules for Bulk Carrier and Oil Tanker (CSR-H; Harmonized Common Structure Rules) which is on effective from July 2015, the modeling area for finite element (FE) has been extended to forward and afterward cargo hold regions of a ship, more design manhours are required in the FE modeling than that of previous rules. In addition, it is mandatorily required to generate the fine-mesh model for hot spot zones, but the target area has been extended so extensively, more design manhours are required for fine-mesh modeling than that of coarse mesh modeling. Moreover, the local area for fatigue analyisis should be modeled with very-fine mesh. However, these kinds of FE modeling for different level of detail and different purpose of analysis are time comsuming and repetive works. In this research, we would like to introduce the auto fine mesh modeling fuctionality that can generate fine-mesh and very-fine mesh model from the coarse mesh model, and retrieve and restore them to coarse mesh for certain purpose by re-mesh fuctionality. Through this process, FE model can be managed and reused with a consitent FE model from the initial design stage to detailed design stage of a ship.

56. Cyber Physical System in Shipbuilding toward realize Smart Shipyard: Integration of Monitoring System and Shipyard Simulation System

Kazuhiro Aoyama, Mayuna Hoshi, Yusei Hiro, Ryo Kitamura and Kazuya Oizumi
The University of Tokyo, JAPAN

Even in shipbuilding, Realizing Smart Shipyard is desired to improve the productivity using concept of CPS (Cyber Physical System) based on IoT (Internet of Things), as many industries desired. The key point of CPS is the tightly linking Physical World and Cyber World by information technology to enable close coordination of various kinds of construction tasks in the Physical World. At the last conference ICCAS 2015, we reported a developed monitoring system for a shipyard using video cameras at a work site and wearable devices with a worker, which are a smart glass and a smart watch. This monitoring system can provide useful information of an accurate current status in a construction process to generate Cyber World in a shipbuilding. In order to realize CPS in a shipbuilding, we have to make a strong linkage of Cyber World to Physical World.

In this paper, we propose the integration of monitoring system and shipyard simulation system. We developed a shipyard simulator to find the specific improvement points for ship construction. This simulator has a model of products flow and workers flow in shipyard, and functions of simulating construction with optimizing construction sequences and resource assignments.

We integrated this simulation system with the developed monitoring system, in order to use the monitored data as input data for simulation. This integration enabled to compare the real production process, which is obtained by monitoring system, with the ideal process that is calculated by simulation system, to get the performance of actual construction and discuss the improve point of the current process.

Furthermore, in order to use this integration effectively, we defined "the construction system model" to manage the information of construction holistically and to strengthen the cooperation between the monitoring system and the shipyard simulation system. We realized the CPS concept with some important functions that can grasp the construction progress in real time, detect the delay of construction in real time, and cope with the delay at an appropriate timing in real time using the construction system model.

57. High Performance Virtual Reality for Massively Complex 3D Models

Ken Goh, Knud E Hansen Australia, Australia

Interactive virtual reality (VR) is clearly revolutionising the way we design, build and operate vessels and train crew. Recent VR headsets enable a new level of immersion and flexibility compared to using VR caves and projectors.

To prevent nausea when using VR headsets requires a very high image refresh rate. Modern vessels are generally massive and complex 3D models that cannot be rendered fast enough for VR headsets. VR models are therefore carefully hand-crafted by collapsing the complex detail of a vessel into simpler visual models. This process is both inefficient and labour intensive, especially as the scope of the vessel increases.

ShipSpace technology has been designed specifically for the massively complex 3D CAD/PLM models of modern vessels, allowing them to be displayed interactively in VR as they are designed. This allows designers, engineers, executives and owners to walk and meet virtually inside their vessels as the design evolves. ShipSpace does not require labour intensive optimisation of these models to repurpose them for VR. Design details can be examined and discussed while they are still on the drawing board, when changes are cheap and easy.

This paper will present ShipSpace and examples of how the groundbreaking capabilities of this technology is currently revolutionising the sales and design processes.

58. The Next Generation of Asset Integrity Management System

Jose Esteve, Bureau Veritas Marine & Offshore, France

Ship owners, ship managers, and offshore units operators are faced with challenges to manage the lifecycle of their assets as information is often spread across various information systems or software. They need to easily access and consolidate all the data intuitively to quickly figure out the overall situation and thus identify faster the dangers related to the integrity of their assets.

Bureau Veritas and Dassault Systèmes have engaged in a two-year development partnership to address these challenges with a new generation of Asset Integrity Management System powered by the 3DEXPERIENCE platform. At the heart of this solution, a 3DEXPERIENCE twin of the assets enables to connect data coming from the real world to the asset integrity analysis in the digital world through 3D visualization and data analytics at any level (from unitary structural members up to the entire asset) made available to all stakeholders.

This paper will present how this new Bureau Veritas solution can optimize the lifecycle of assets through the following main capabilities: 3D model creation and lifecycle management, asset integrity monitoring, interoperability with information systems (ERP, CMMS, DMS ...), interventions planning, and integration of interventions results and findings in the 3D model. Beyond the software functionalities, both partners are convinced that it will serve as a business digital transformation catalyst.

This solution will enable comprehensive RBI of the hull structure as each individual element is tracked with its current or foreseeable degradation, thus enabling better and faster maintenance and repair decisions, therefore saving time and money.

59. Experience Capture in Shipbuilding using Microsoft Share Point

Yashwant R. Kamath, K. Sivaprasad, Department of Ship Technology, Cochin University of Science and Technology, Kerala, India

Shipbuilding being heavy, one off kind, and made-to-order industry has many characteristics that add to the complexity of the production process. Ships are generally multifunctional and should have multiuser capabilities while in operation. Requirements to fulfil contradicting rules and regulations are a headache for the shipbuilders. Capture of shipbuilding experience and preservation of it would definitely help to improve problem-solving capacity in a shipyard production centre. Systematic collection, storage, compilation and categorisation of shipbuilding information broadly explain the term 'Experience Capture'. Recording of experiences in a traditional shipyard context is highly optional and therefore the function has limited scope for integration within the shipyard and with other life cycle activities of ships. Microsoft Share Point, an online content management system, which is an efficient data handler for problem solving provides ample scope to be implemented in shipbuilding context. The features of Microsoft Share Point would make the Experience Capture implementation more productive in a shipyard. Systematic implementation of Microsoft Share Point as a Data handler tool for Experience Capture in shipbuilding is proposed in this paper. Microsoft Share Point being a powerful and robust software with limitless capabilities which includes document management, team collaboration, intranet and extranet can be implemented very effectively in the shipbuilding industry.

With recent advancements in cloud integration, authorised personnel can access the database globally. Moreover the Share Point has highly secure database with exceptional indexing and searching capabilities, by which data can be retrieved easily.

60. The Concept of SPEEDS (Smart Platform of Enhanced Engineering Data for Shipping and Shipbuilding) and innovative use of ship 3D data

Kunihiro Hamada, Hiroshima University, Japan

The Concept of SPEEDS (Smart Platform of Enhanced Engineering Data for Shipping and Shipbuilding) and innovative use of ship 3D data If you would like to offer a paper for the conference, please paste your 250 word abstract here: Although 3D-CAD has been used in the shipbuilding industry for a long time, effective use of 3D data in the production and new initial design based on the 3D model is not advanced compared with the expectation. Moreover, it is difficult for a ship owner and a classification society to use the 3D model effectively because CAD and the security policy are different according to the shipyard.

Considering the above discussions, Japan society of naval architects and ocean engineers established the project research committee and has examined the information platform named SPEEDS (Smart Platform of Enhanced Engineering Data for Shipping and Shipbuilding). SPEEDS aims to realize the sharing and exchange of various information on ships among the all maritime industries including shipyards, classification society, ship owner, operator and the supplier. A simplified 3D geometry information and a variety of attribute information are described in the SPEEDS and the player in maritime industries can utilize these information promptly and effectively based on the various use cases of ship lifecycle.

In this paper, aims and overview of SPEEDS are discussed with some examples intended for the use cases in shipyards.

61. EMD-based Natural Excitation Technique for modal parameters identification for ship structure

Hongyu Cui, Dalian University of Technology, China

Modal parameters, such as natural frequency, damping ratio and modal shape, are important for structure modification, optimization and health monitoring for ship, offshore platform. Ambient vibration system identification technique can extract modal parameters using only response signals, which is more comfortable actually. In this paper, an approach is based on the empirical mode decomposition method, the natural excitation technique, and the Hilbert transform. The experiment of a ship model is completed to demonstrate the accuracy of this method in identifying natural frequencies damping ratios. First, the original signal is decomposed into a series of modal responses by empirical mode decomposition (EMD). Then the natural excitation technique (NexT) is applied to obtain the impulse response function. Finally, the modal parameters identified by Hilbert transform (HT). The resu lts demonstrate that the method of this paper is effective, robust and promising to modal parameters identification for ship structure.

Keywords: ship, operational modal analysis, parameters identification, empirical mode decomposition, ambient excitation

62. Event Driven Shipyard Practice: A platform for Department and Sub-Department Level Communication

Dr. S.K Jha, Gandhi Institute of Science & Technology, India
Khandoba Rao Miriskar, Vidyut Bhaskar, Intergraph, India

Ship production is a joint effort across many departments and teams under them. The collaboration between these departments and teams play pivotal role in scheduling construction and delivery, particularly, when it comes to repairing, refitting and maintenance activities. In addition, careful distribution of responsibilities is a necessity for an orderly functioning shipyard.

Work estimation and scheduling of projects is done based on the yard capacity with margin time. Also, Shipyards face situations where there are disparities and confusion between departments on their jurisdictions. When it comes to coordination and contribution of all the branches of any organization, their quantitative representation is crucial for evaluating its efficiency.

During lifecycle of any project, the milestones are achieved in phases. Accomplishment of milestones are events and these events trigger successive events. Further, occurring events can be one or many depending upon the type of event. Event can be an epicenter for other events or it can be just another bead in the chain of manufacturing process. Platform developed on this concept will provide room for inclusive and transparent manufacturing. It will also address the problems of present Project Management software (in Manufacturing Industry) that perform in a close proximity of finance, procurement and purchase mostly.

Therefore, a platform encompassing the activities of a shipyard; particularly production and design activities which can raise events across the departments and facilitate the workforce response is required. This paper will elaborate how this concept can assist ship production uniquely and connect emerging technologies.

63. Research on large-scale marine propulsion shafting load test and adjustment technology

Wang Ji, Liu Zhongchi, Xue Dongxin, Zhang Shengjun, Wang Feixiang, Dalian University of Technology, China

Power shaft is an important component which transmits power from the engine to the propeller in ship power system. Currently, because the sizes of cargo ships become bigger and bigger, the sizes of the power shafts increase. During the installment of shafting, a very important step is making the bearing loads meet the requirements of shafting alignment manual. The Traditional method is just measuring the bearing loads repeatedly and gradually adjusting the bearing displacement by worker's experience. The repeating measurements and adjustments takes a lot of time and the results are not accurate enough, especially for large power shaft. It can lead to high temperature of bearing, tile kilning and ship outage during navigating, which will bring huge economic losses. So a more reliable and accurate adjusting method is very necessary. This paper firstly investigates marine propulsion shafting load test method, improves the jack-up method and strain-gage method respectively, and increases the precision of bearing load measurement. On this basis, this paper studies bearing displacement adjustment calculation method, calculates bearing load influence factors which take bearing stiffness into account, establishes special nonlinear optimization model with absolute values symbol, and establishes bearing displacement adjustment algorithms. Finally, by applying data of several ships, the bearing load measurement method and adjustment techniques promoted by this paper are verified. The result shows that they are able to meet the requirements of actual construction technology.

Key words: Bearing load; Shafting alignment; Jack-up method; Strain-gage method; Displacement adjustment

64. 3D Digital Classification

Christophe CHAUVIERE, Olivier DEGRAND, Bureau Veritas, France
Thierry LE GAL, Lionel LE GUENNIC, Cédric CHEYLAN, DCNS, France
Alexandre TEW KAI, Glenn DUTRIEUX, Dassault Systèmes, France

The shipbuilding industry is moving towards a new era where 2D drawings will disappear and be replaced by 3D digital mockup.

The classification process includes a design approval which, today, is based on drawings review. Typically, shipyards submit their drawings which are approved by the classification society in accordance with applicable class rules and standards. The final design approved by the classification society is then marked by a set of approved "stamped" drawings.

Shipyards and class societies will have to modify this process and enable direct 3D digital classification in order to improve the exchange of information between the different stakeholders and ultimately accelerate the classification process. Compared to traditional drawings approval, the advantages include: reducing shipyard workload with fewer drawings to create, improving quality and a common understanding of design and class comments by using the digital mockup directly, optimizing the calculation process by directly interfacing the 3D model with all calculation software such as structural and stability software.

A proof of concept has been initiated by DCNS, Bureau Veritas and Dassault Systèmes to validate that a new 3D-based digital classification process powered by the 3DEXPERIENCE platform will benefit all the parties involved. In particular the following challenges have been identified: 3D model definition and exchange process, shipyard intellectual property protection, management of model revisions, creation and follow-up of comments in the 3D model, update of class process and access for field surveyors, exchanges with ship owner. All these elements are part of the proof of concept and the first conclusions are detailed in this paper.

65. Synchronised monitoring of sustainability and life cycle costs with a modular maritime IT - platform

Dr. Reinhard Ahlers, Christian Norden, BALance Technology Consulting GmbH, Germany
Alessandro Fontana, Donatella Corti, SUPSI, Italy
Maurizio Petrucciani, Dassault Systèmes Italia Srl, Italy
Jacopo Cassina, Holonix S.r.L, Italy

Cruise ship passengers and operators are becoming increasingly more aware of the caused environmental impact. Consequently, sustainable product-service systems are getting more important in the maritime industry. At the same time, profitability goals and customer requirements must be matched to remain competitive on the global market. Impact assessment of design changes in terms of environmental impact and life cycle costs is becoming crucial and therefore needs to be supported by intelligent assessment tools that in real time could provide decision maker with effective information.

The European project MANUTELLIGENCE (Manufacturing Intelligence Engineering Platform) has developed a modular IT platform to enable, during the design phase, the balancing between life cycle costs and environmental friendly production, operation, and maintenance. The challenges are very similar for different industries. Therefore, end users from the shipbuilding industry but also from construction, car

manufacturing and rapid prototyping are involved to develop a common approach. Dassault (3DEXPERIENCE - platform), SUPSI (MaGa - LCA tool), BALance (BAL.LCPA – Life cycle cost assessment) and HOLONIX (iLiKe - sensor platform) have developed the supporting IT platform.

The platform allows to assess the consequences of design changes on sustainability and life cycle costs based on different operational scenarios. It supports data collection from supplier as well as from the product operational phase (sensors implemented in the product), to adapt and improve the next product generation. A platform implementation has shown the reliability and utility of the approach.
The paper presents the IT platform architecture, the modelling approach, and the implemented processes.

Related Topics: IT in Design (Analysis/Calculations; Modelling methodologies), Information Technology (Modelling Methodologies; Systems Integration; Data Exchange; Co-operative Working; Document Management) and Other use of IT (Information Sharing)

---

66. Methodology for efficient application of 3D ship modelling software

Damir J. Kolich, Armin Becirevic, Niksa Fafanjel , University of Rijeka, Croatia
Richard Lee Storch, PhD, University of Washington, USA

Today's Naval Architecture and Ocean Engineering University Departments prepare students with much theoretical knowledge. However, students will need to develop more practical skills in 3D modelling than what is presently the case. Since many shipyards are subcontracting the design documentation out of yard to exclusively design companies, more and more students upon graduation are finding jobs in small and medium enterprise companies (SMEs) that prepare detailed production documentation using advanced 3D modelling software. Thus, it has become normal for many design engineers to work locally since the internet has enabled efficient communication between shipyards and design houses. However, the need for engineers with practical 3D modelling skills is growing, and Universities need to meet this ever growing demand. Therefore, the development of a methodology whereupon students can receive the practical skills in 3D modelling during University studies through cooperation with the SMEs would be useful. In this paper, an innovative approach to bridging the 3D modelling gap is explained. A case study at an actual University Naval Architecture and Ocean Engineering Department in cooperation with an SME describes how students are receiving hands on experience. Likewise, a practical demonstration in designing a section of a real ship is described in a succinct and clear manner. The theoretical knowledge of understanding how to read classification drawings is explained as is the practical 3D modelling application. The Nupas- Cadmatic program is the 3D modelling software used in the case study.

Key words: 3D modelling, SMEs, shipyards, Nupas-Cadmatic

---

67. Numerical simulation of hydrodynamic impact on an offshore wind turbine structure

E. Smith, S. Olgun - PLM Technology, Denmark
C. Barlach, E. Tsakadze - ISC A/S, Denmark

One of the main challenges in optimisation of an offshore wind turbine structure is investigation of its interaction with extreme sea-waves, which are rather frequent phenomenon in the shallow depth (0-30m). Shallow water offshore wind turbines can consist of three sections: the foundation with the monopole, the substructure with the transition piece, and the tower with the wind turbine. The transition piece, which is the focus of this study, represents the structural element connecting the windmill turbine’s tower and foundation structures, and through it the environmental and system loads are transferred to the foundation. The investigation was carried out by deploying the Abaqus finite element software, where variety of different methods such as the Coupled Eulerian-Lagrangian, Smoothed Particle Hydrodynamics and Computational Fluid Dynamics were used to study the hydrodynamic impact on different combinations of the offshore windmill transition piece structure. Combining the 3D modelling capabilities with the above-mentioned methods made possible to develop a technique for the prediction of the forces on the transition piece. Likewise, a special script was developed to optimize the transition piece geometrical structure. To find a balanced solution for the design, this paper evaluates the interaction between forces imposed by the waves and the geometrical shape of the structure. Obtained results provide a fairly initial understanding of the optimization of the working platform structure.

---

68. Ship Concept Design based on a 3D-CAD-System including a Requirement Verification

Hannes Lindner, Robert Bronsart, University of Rostock, Germany

Ship design is almost completely performed with help of 3D-CAD-systems. However, the early ship design, especially at the pre-contractual stage, is often still developed and documented based on 2D drawing tools. The reason for this can be seen in the presumption that modelling and modification of a 3D model is too complex and time consuming. Therefore, the need for an efficient-to-use 3D-CAD-system combined with a PDM-system in the concept design phase is apparent.

In order to apply a 3D-modelling-tool linked with a product data management system within the ship early design, a novel system infrastructure consisting of interfaced specialized components has been realized in close cooperation with two shipyards. The system infrastructure is designed to suit best the following key requirements:

- 3D-modelling: fast and flexible creation of geometry
- Information-handling: capability of handling all required information
- Data-sharing: assuring that all parties involved in highly parallel design tasks work on the same data.
- Requirement-tracking: store and associate design requirements with information objects

A system infrastructure is presented, in which a general purpose 3D-modelling tool is linked with an external PDM-system. The PDM-system is the core-component of the infrastructure and acts as information hub for all related tasks. The geometry resides in the CAD-system and is linked to the PDM-system via a bidirectional interface for an automatic synchronisation of the data. To associate ship design objects with requirements a formal description is implemented, which allows for an efficient verification of the created ship design against these formulated requirements.
Based on an example ship it is shown that the implemented system architecture can be applied in the early ship design phase to develop a 3D ship model from the very beginning.

This paper is referring to the category “IT in Design” as well as the system integration and data exchange in the “Information Technology” category.

---

69. A study on the improvement and application of system dynamics model for demand forecasting of ships

Yujiro Wada, Hiroshima University, Japan

Shipbuilding is an industry in which the change in demand has been extremely drastic. Therefore, it is important to develop a method of demand forecasting for new ships in order to realize sustainable development of the shipbuilding industry. Recently, sufficient actual data on the shipbuilding market has become available, and it is expected to define an accurate demand forecasting model by using these data. In this study, the system dynamics model of previous study is improved by using latest market data, and optimal measures planning system for shipbuilding industry is developed based on the proposed model. Followings are the characteristics of this study:

- In order to predict ship price, causal relations between order books in shipyards, construction capacity, and ship price are examined, ship price prediction model is newly defined. Additionally, the ship price prediction model is integrated in previous demand forecasting model.
- By using the latest data for each size of ship, it is possible to define the order prediction model, construction model, and scrap model according to the size of ships. The basic concept and detailed model used in forecasting the orders, construction, and scrap for each size of ship are shown.
- In order to realize sustainable development of shipbuilding industry, optimal measures planning system is developed by using an optimization method and the proposed demand forecasting model.

Thereby, some simulations using the proposed demand forecasting model and system are conducted, and the effectiveness of the proposed model and system are shown.

---

70. Title: Application of numerical simulation of corrosion in ship and marine structures

Zhu Shengqing, Yang Rui,Xiao Gang, GLB, China

The corrosion of the ship/boat body and offshore structure by sea water and marine atmospheric is a long term challenge to marine and ship/boat industry. The modernized design on corrosion-resistance of ship/boat body and offshore structure is boomingly technology for both shipbuilder and the ship owner/operator. The technique of computer simulation on corrosion is currently rising and it becomes to play more and more roles as being applied in corrosion-resistance design and corrosion assessment.

This study focus on the issue of corrosion by sea water and marine atmosphere. The report aims to present the application of numerical simulation technique on both corrosion assessment and the design of Cathodic Protection for ship body. A start of art assessment on the effect of the corrosion-resistance design. Environment, material and structure to the ship body are also detailed.

---

71. Effective Utilization of Digital Design Assets during the post-design phases in modern shipbuilding

Mikko Yllikäinen, CADMATIC, Finland

The shipbuilding industry has a long history of producing and consuming paper-based documentation for the manufacturing, assembly and verification phases of shipbuilding projects. Currently, much time and effort is invested in creating the required documentation and information. The resultant construction documentation is

static by nature and prone to interpretation errors at construction sites. For these reasons, shipyards are seeking alternative ways of working.

In addition to documentation, modern ship design tools produce intelligent three dimensional product data models. The wide adoption of modern technologies and advancements in mobility have allowed the use of product models in novel ways. Traditional documentation cannot fully be omitted in the near future. The adoption of easily accessible interactive documentation as a part of the afore-mentioned processes, however, streamlines construction workflows, increases speed and reduces errors. Interactive construction documentation also reduces work in the design phase by cutting the need to create excessive amounts of static materials.

This paper discusses effective ways of utilizing intelligent product models during the post-design phases. It surveys technologies that can be successfully used to help people make the right decisions at the right time, thereby creating competitive advantages for shipyards and delivering concrete savings.

---

72. Protecting Intellectual Property Rights in Distributed CAD environments

Ludmila Seppälä, CADMATIC, Finland

The megatrends of globalization and digitalization are shaping the future of the marine industry and shipbuilding. They have impacted greatly on the way design processes are handled. As projects become more complex and the demands for digital 3D models and production data rise, organizations' most valuable intellectual know-how will increasingly be stored in digital project environments.

Distributed design in marine CAD projects is a mature technology offered by most software providers. It reflects the business need to split design and engineering workloads between several participants and subcontractors to ensure that the best and most efficient available design resources are utilized.

The protection of intellectual property is commonly ensured by ICT policies, protocols and access controls. In distributed design environments, however, the replication of projects necessitates additional filtering. This ensures that external subcontractors have access only to the parts of the 3D product model required for their tasks. The stored know-how and intellectual property contained in the models is thereby protected from uncontrolled distribution via 3D models, digital handouts and 3D viewers.

The paper discusses business processes related to IPR in distributed marine projects, future IP issues in design tooling, and the role modern CAD can play.

---

73. Integration of ship hull form modeling based on subdivision surfaces with other ship design tools

Sebastian H. Greshake, Robert Bronsart
University of Rostock, Chair of Ship Design, Germany

The industry standard for the representation of hull forms are tensor-product B-spline surfaces. All major modeling packages and data exchange formats are based on this surface representation. How- ever, tensor-product B-splines are limited to four-sided surfaces. Aside of the necessity to compose hull forms of several patches, it makes hull form modeling and fairing inefficient.

An extension of classical B-splines are generalized B-spline surfaces. They originate from the field of subdivision surfaces, whereas the term subdivision refers to a method that enables B-spline surfaces of arbitrary complexity. Thus it is possible to represent entire hull forms with a single surface and hull form modeling and fairing is considerably simplified.

Hull form representation based on generalized B-splines improves hull form modeling. To be useful for ship design, it is essential to provide an integration with other design tools. Naturally, this is a matter of data exchange.

The integration of generalized B-splines in the ship design process is based on a method that generates a set of conventional B-spline patches from the hull form representation. The patches inherit their continuity properties from the original surface what effectively means that they join G^2 almost everywhere. Near a few irregular points the patches join at least G^1. The patches are finally exported to the commonly used file format IGES which can be read by almost all design tools.

Note: This paper contributes to the category Information Technology with a special focus on CAD and Date Exchange as given in the call for papers.

---

74. Enhancement of the ship noise prediction program

Shinichi TANAKA, Japan Marine United Corporation, Japan

For the protection of the seafarer from the risk of noise-induced hearing loss, THE CODE ON NOISE LEVELS ON BOARD SHIP of International Maritime Organization was entered into force as mandatory. The requirement of the new code is more conservative than the conventional guideline.

So far, estimation of noise level by using results of measurement of existing ships without numerical analysis was common. But, for the new code, conventional method is not appropriate because its accuracy is not enough. Due to above mentioned circumstances, recently, some projects of research and development of code of numerical noise analysis have been proceeded.

Conventional analysis program are not suitable for analysis at earlier design stage, because the analysis period tends to get longer.

Therefore, Japan Marine United Corporation (JMU) enhanced the conventional analysis program by adding new functions which is called "Advanced noise analysis (ANA)". By new functions, designers enable to use shipyard's holding data such as hull model, furthermore the correction of model becomes easier.

Reduction of the analysis period was confirmed by comparison with the conventional program.
Moreover JMU confirmed that the accuracy of the analysis results is satisfactory by the comparison of calculation results of noise analysis by ANA and measurement results of existing ships. As a result, JMU make sure that the ANA is effective as the noise analysis program of evaluation of noise level at the initial design stage.

This paper presents the details of analysis functions including the result of verification with regard to prediction accuracy.

---

75. Bow Shape Optimization of a Cruise Ship for Minimum Added Resistance Based on Actual Operational Profile

FENG Pei-yuan, HE Jia-yi, FAN She-ming, WANG Jin-bao
Marine Design & Research Institute of China (MARIC), China

Nowadays, the prediction of added resistance in waves plays a more and more important role in ship design, which is of high economical and practical interest. Therefore, this study focuses on the design optimization of a cruise ship for minimum wave added resistance based on her actual operational profile. Since the size of modern cruise ships has been growing significantly during the last decade, the likely sea states they may encounter are in the region of short waves, where added resistance is mainly caused due to wave diffraction/reflection. In this paper, a state of the art numerical code for the estimation of wave added resistance is developed. The code is based on a fast and reliable semi-empirical formula developed by the Ship Design Laboratory of NTUA, and is further extended by us to incorporate the estimation of ship's mean wave added resistance along her route based on long-term wave statistics. The parametric geometry model of the cruise ship is established and the optimization process is formulated within the CAESES software. Extensive computations are performed to investigate the influence of hull geometrical parameters on the ship's wave added resistance. The key question to be addressed is how the obtained optimal hull form will be influenced by considering wave added resistance as additional objective. Finally, it is demonstrated that the long-term mean wave added resistance of the cruise ship can be well reduced through the proposed optimization process.

Key words: cruise ship; added resistance in waves; parametric model; design optimization; operational profile; wave statistics

---

76. Implementation of wearable computing in shipbuilding

Rogero Fernando, Patel Micro Data, India

Our work describes the design and prototyping steps involved in implementation of augmented reality and area learning technologies in ship building industry through wearable computing. Augmented reality is a new technology in which computer rendered graphics can be visualised in blend with real environment. Area learning is a computing technique which gives wearable computers the ability calculate its position with respect to real world. Combination of this both provides a new form of visualisation technique which allows real-time comparison of design and fabrication flows through superimposing computer rendered ship models in real environment. In addition to visualization user interaction like dimension and design alteration could be facilitated. Successful Integration of our product with existing CAD systems can act as a Computer Aided Quality (CAQ) tool facilitating in ergonomic study of manufacturing and operation easiness which In turn will enable achieving quality product at reduce cost by improve manufacturing work flow resulting in minimizing design to product tolerance.

---

77. Efficient Hull Form Design Optimization using hybrid evolutionary algorithm-morhing approach

Joo Hock ANG, Cindy GOH, Vijay P. JIRAFE, Yun LI
Sembcorp Marine Ltd, Singapore, University of Glasgow, UK

Hull form design and optimisation is an important topic in the shipbuilding industry. This is especially so in the face of more stringent environmental regulations and reduction of ship operational cost due to fuel consumption. An efficient hull form design can improve the overall efficiency of the vessel by reducing drag and

therefore lowering carbon dioxide emission and fuel consumption. Traditional methods of hull form design and optimisation process, using trial-and-error approach require many designers' man-hours to produce more efficient hull form designs, which may be only sub-optimal and not efficient. While latest simulation based design methods and tools may help to automate some of these processes, they still require considerable human input and the end result often depends heavily on the designer's experience and knowledge. This paper introduces an innovative concept which aims to address the above issues. By automating the entire process of hull form design optimisation with minimum user intervention, it is able to produce optimal hull form designs more efficiently. This is achieved by coupling an intelligent global search method- Evolutionary Algorithms (EA) with an efficient shape manipulation approach known as morphing and evaluate the performance using computational fluid dynamics (CFD) analysis. A case study comparing the hull forms created from existing simulation based design approach to that from the proposed hybrid approach will be presented. It is envisioned this proposed hybrid EA-morphing approach will help to improve the overall design efficiency and ability to produce more optimal hull forms for future ships.

---

78. The examination report, the effective information collaboration between different several design stages.

Taisuke Kunisada, Sanoyas Shipbuilding Corporation, Japan

The design of the shipbuilding was greatly divided into 4 stages of the "Basic design", "Functional design", "Detail design" and "production design", and efficiency by various methods have been pushed forward on each stage. 3D-CAD, that began in the 1980s, evolved to an indispensable tool at the stage of each design stage.

The concept that "Shared one model from first to final design stage" has been suggested, in the beginning of application 3D-CAD. However, the development of 3D-CAD, which covered all design procedure, has not been achieved. Nevertheless shipbuilding design method, based on 3D model, was established, but plural 3D-CAD tools are applied for each design stages, therefore the information between each design stage cannot be related. Today's 3D-CAD application may be said that the part optimization on each stage, but it is not said the efficiency of the design yet.

Why the development of 3D-CAD which can cover all design stages has not pushed forward? Because required design information for each design stage is different. This fact appears conspicuously between the hull design stages.

Sanoyas Shipbuilding Corporation begins the examination of the method to reduce the design cost and time, with the plural numbers of 3D model. This method is to pick up required information from 3D-CAD, applied in Functional design, and to transfer to 3D-CAD, applied in Product design.
This report mentions about a background and problems for the 3D model cooperation between different design stages, and a necessary development to establish their cooperation.

---

79. Modelling and Simulation of Organic Rankie Cycle for Waste Heat Recovery of an Offshore Supply Vessel

ChunWee Ng, I C K Tam and D Wu, Newcastle University, UK

Organic Rankine cycle (ORC) involves using an organic fluid like hydrocarbon or refrigerant as the working fluid to generate electrical power from waste heat energy from diesel engines. Compared to water, the organic fluid has lower boiling point with lower specific heat of vaporisation, meaning that it is able to exploit waste heat of lower temperatures like HT cooling water and lubrication oil thereby improving the overall energy efficiency by utilising waste heat from low to medium temperature sources.

As there is room for optimisation due to the possibility of using different organic fluids for different waste heat temperatures, a commercial multi-disciplinary 1D software called LMS Imagine.Lab Amesim which is based on model-based systems engineering is used to derive the optimised system design for the waste heat recovery system.
As a case study, operating data like exhaust and cooling water temperatures from a seagoing offshore service vessel is used as input to the models of the ORC in this software and a study is made to check the feasibility of its installation using the system engineering approach.

---

80. An Integrated Optimization System for Reduction of Calm Water Resistance and Added Resistance in Waves of a Cruise Ship

Jiayi He, Marine Design and Research Institute of China, China

Optimization of hull forms for the calm water resistance has become a routine in ship design. In operation, however, ships will encounter sea states where the added resistance can be significant. Therefore, it is important to also consider the added resistance in waves in the optimization process. An integrated optimization system has been built to optimize the hull form of a cruise ship for calm water resistance and added resistance in waves. The cruise ship is modeled by a fully parametric

technique using CAESES, such that the waterline entrance angle, the waterplane area coefficient, the bow's flare angle distribution can be controlled independently by three parameters. Additionally, partially parametric modeling technique is used to control the longitudinal distribution of the volume of the forebody. The hull parameterized by combined fully and partially parametric modeling techniques can produce small to intermediate modifications that capture the hull features that are closely correlated to the calm water resistance or the added resistance very efficiently. The calm water resistance is computed as the sum of the frictional resistance and the wave resistance. The frictional drag is estimated using the classical ITTC formula and the wave drag is predicted using SHIPFLOW's nonlinear potential flow solver. The added resistance is estimated using semi-empirical formulas developed by Liu and Papanikolaou (2016) and implemented & integrated into the system by us. Multi-objective optimization will be conducted using CAESES, considering the calm water resistance and added resistance in three running conditions: the design, cruise, and economical speed

---

81. The implications of Uninhabited Vehicle Technology on Fleet Structures and Ship Design

N. Kouriampalis, R. J. Pawling and D. J. Andrews, Design Research Centre, Department of Mechanical Engineering, University College, London, UK

Uninhabited and Autonomous Vehicle (UxV and AxV) technologies are developing, and they are finding increased application to both civil and military applications at sea. These include; hydrographic survey; offshore structures inspection; harbour and coastal security; mine counter-measures; and anti-submarine warfare. With increased capabilities of the vehicles, the possibility arises of a capability – be it civil, governmental or military – being provided by a co-operative fleet consisting of a mix of uninhabited vehicles. The motherships in such an operational concept may themselves be relatively limited in their "built-in" capabilities, compared to current vessels used to deliver the same capability. This raises the question of how to design the complete "fleet", including the selection of the uninhabited vehicles and the sizing of the mothership, including different options for launch and recovery. This paper describes an application of numerical methods previously applied in other industries – specifically Queuing Theory. This mathematical approach has the advantage of being well developed, and having a number of numerical solutions capable of very rapid computer solution. This allows the preliminary ship design problem to be expanded to include multiple units. This paper will describe the QT based representation of the UxV network, its example application, and integration with early stage concept ship design tools, the latter being vital to ensure that this approach expands the scope of preliminary ship design, rather than displacing engineering design with operational analysis.

---

82. Variation of Asymmetric Side Hull Staggered and Separation of Pentamaran Hull Resistance by Computational Fluid Dynamics (CFD)

Yanuar, Firman A. Nugroho, Zulfah Zikrina, Universitas Indonesia, Indonesia

Fast vessel technology is rapidly developing with the increasing of the demands in maritime field such as military, shipping and tourism. The substantial of designing fast vessel is to create a vessel with highest speed by the lowest fuel consumption. Ship hull optimization is one of methods to reduce fuel consumption in designing the high speed vessel. The advantages of multihull vessel are huge payload, wide deck area, good stability and seakeeping, also decrease the total resistance due to wave making resistance caused by wave interference of the hulls. Multi-hulll vessel are divided by number of hulls which are catamaran, trimaran, quadramaran and pentamaran. In a research by Tuck (1998) shows that the wave resistance of catamaran, trimaran and quadramaran based on Michell's theory (classical thin ship theory) is decreasing with the increasing of number of the hulls and Froude Number at the high speed. Pentamaran hull is a hull form development of catamaran, trimaran and quadramaran which has inner and outer side hulls. This research is aim to show the effective configuration of pentamaran ship hull with 0.33, 0.38 dan 0. 44 separation ratio of inboard and outboard Asymmetric hull at outer and inner position by investigating the characteristic of total resistance at Froude Number 0.1-1 compared to symmetric pentamaran hull. Computational Fluid Dynamics (CFD) method have been performed to predict the resistance of hull-form besides its advantages is economical in time and cost. In this research, the calculation of pentamaran hull resistance is simulated by ANSYS – FLUENT (CFD Software Package). The multiphase region is separated by defining boundary air inlet as the flow of air and water inlet as the flow water in the pentamaran hull ship region. The free surface model is performed in calm water condition by Volume of Fluid (VOF) model and k-epsilon is used as turbulent viscous model. The validation data obtained from the Computational Fluid Dynamics (CFD) method were found almost similar with latest pentamaran experimental data. The result shows the coefficient resistance characteristic of Asymmetric pentamaran hull ship compare to symmetric pentamaran hull ship.

Keywords: fast vessel; multi-hull; pentamaran; ansys – fluent; volume of fluid

---

83. Development of an efficient installation method for vertical pressure vessels in offshore plants with 3D scanning technologies

Mingyu KIM, SAMSUNG Heavy industries, Republic of Korea

In offshore plants, most of the equipment is manufactured by professional companies in order to guarantee the product functionality. However, misalignment issues can arise in installation of the equipment due to unavoidable discrepancy between drawing and real object. It requires many additional works such as adjustment or even re-installation. This problem has resulted in a serious impact on productivity as the size of offshore plans have been increased in relation of their complicatedness. The aim of this study is to dramatically reduce reworks by predicting problems in advance with application of 3D scanning technologies. Since the 3D scanning technologies enable us to easily obtain the real shape of objects, the installation procedure can be virtually simulated and certain problems possibly detected in an early stage. Among the various types of the equipment, an efficient installation method focused on vertical pressure vessels is proposed. Because its shape is extremely vertically high, it is difficult to identify and fulfill design tolerances with traditional measurement methods. This study consist of three chapters in which pre-processing of 3D points cloud, the procedure of virtual installation simulation and the way of identifying problems are described. Consequently, we have obtained good experiments realists since two vertical pressure vessels were installed without any reworks and additional facilities usage. The results obtained from our study indicate that the reduction of working time by 70% can be achieved by the proposed method.

---

84. Pre-processing module for the welding distortion analysis according to the different assembly sequences

Minseok Kang, Hyun Chung, KAIST, Republic of Korea

The determination of assembly sequence is crucial for the productivity and quality. Each block of ships and offshore plant structures are usually composed of dozens or hundreds of parts. Most parts are connected to each other by welding. The amount of welding distortion is varied according to the different assembly sequences. So effects of welding distortion should be considered when determining the assembly sequence.
Thermo-elasto-plastic simulation is usually performed to evaluate the effects of welding distortion in advance. For the simulation, the basic information such as nodes, elements and properties is required. In addition, detailed analysis conditions should be set for each stage in the whole scenario of the simulation. The cost of this series of pre-processing is significant. Even though the input file for the simulation of an assembly sequence is completed, the detailed analysis conditions should be newly set when the assembly sequence is changed.
In order to reduce the pre-processing cost for simulating multiple assembly sequences, an input file generation module is proposed for the welding distortion simulation by ABAQUS. This module is based on the input file information of an assembly sequence and considers connection relation between parts in the assembly. The proposed module is applied to an assembly structure and the results show that it is useful to reduce the pre-processing cost for the welding distortion simulation with regard to the different assembly sequences.

---

85. Technological Advancements made in Nakilat's Fleet

Fairuz Aledroos, Nakilat, Qatar

Nakilat is a Qatari shipping company with the world's largest LNG shipping fleet, comprising of 63 LNG carriers, and it owns and operates 4 very large LPG carriers. With this comes the responsibility to ensure no disruption to its 24/7 global operations across its fleet, thus enabling safe and timely cargo deliveries worldwide.

A 'Unified Ship Management Project' was undertaken to upgrade all vessels' existing communication systems, utilize new hardware and applications as well as enhance the communications process with reliable back-up systems, not only for operational benefits but also for better crew welfare. All outdated Fleet Applications on vessels and Fleet office interfaces were replaced to create a futuristic software landscape comprising of a globally-supported maintenance system with source codes belonging to Nakilat, including standard online /offline ship management systems and reporting capabilities. To achieve this, Nakilat utilized the robust SAP platform and maritime-oriented IT solution, AMOS, to create an integrated ERP system.

Communication systems were upgraded incorporating high-speed internet and a cloud-based firewall compatible with KA band for future use. Using Fujitsu vShape, a centralized data center for all vessels was created to enhance responsiveness, reliability and efficiency. All modules of the Fleet Management system were fully interfaced with the SAP system at headquarters and a cloud-based reporting platform for users was implemented.

These implementations not only led to substantial cost savings for the company and leaner manpower requirements, but also eliminated single point failures and allowed for remote backup of systems, 24/7 connectivity and a centralized database for Nakilat's entire fleet.

---

86. Power with simplicity to visualize your Digital Asset – a revolution for decision making

Gauthier Stonestreet, AVEVA Solutions Ltd, UK (co-written and co-presented with Lundin Norway)

Today, shipbuilders use digital models to perform the design and engineering, planning, procurement and manufacturing of ships. But in most cases, this digital model is used only by specialists with dedicated software solutions. What if the digital 3D model were as easy to use as a smartphone? What if everyone could use it intuitively?

It is common practice to have isolated and redundant models for each discipline and each purpose. Which means there is no way to share all information with all stakeholders. It also makes it hard to be sure all information is up to date with the latest status. What if all the information related to the design, construction and operation of a ship were available in one place? What if everyone had access to the information? The main challenges then are:

- How to consolidate complex and massive information from all type of disconnected sources?
- How to publish this in a simple way to all, without provoking any information overloads?

Now, ship-owners and ship-operators are also relying more and more on digital information and 3d models in their activity. Consequently, the need to have one single centralized and up-to-date information hub is becoming crucial to all the actors involved in a ship's life cycle, from design to decommissioning.

This paper describes how you can bring power and simplicity into your Digital Asset, offering a very intuitive access to all digital information, based on a revolutionary graphical approach. It also describes a real use case, from Lundin Norway, using this technology daily as a Decision Support platform. Finally, it will also present the latest evolutions of this technology, offering a view "from the Lab", as an opening to new ideas and opportunities for shipbuilders.

---

87. Advanced reporting as a tool in complex multidisciplinary analysis – case generic survivability assessment

Roope Kotiranta, Surma Ltd, Finland

Modern ship design process includes several multidisciplinary analysis which produce significant amount of data. A good example of this kind of problem is a generic survivability assessment, whether used to analyze the safety of a passenger ship, an offshore platform or a naval vessel. The actual result is a complicated network of information, from which it may be difficult to find the key factors affecting the capabilities of the analyzed vessel, or the reasons leading to these. Traditionally, the analysis results have been static documents which do not capture the interaction between the disciplines. The designer may be provided, for example, with the final survivability level but not with the factors which actually lead to that level and how the design could be improved. This means that reporting of the results should also seamlessly support the design process.

This paper describes a novel HTML-based dynamic reporting concept used in SURMA survivability assessment. An introduction to a modern survivability assessment is provided highlighting the goals and key challenges in the process. Then the solution, informative, interactive and user-driven reporting is explained with sufficient use-case examples to show how the challenges mentioned are overcome. Finally some ideas regarding the different possibilities of future enhancements and means to extend the scope of application are discussed.

---

88. Design of cargo hold ventilation system for energy-saving PCTC using CFD

Woorim Lee, Hyundai Heavy Industries, Korea

Ventilation system for cargo holds in PCTC (Pure car and truck carrier) consumes considerable amount of energy due to its large hold area, which contains 6,000-7,000 cars. A lot of fans installed in a PCTC supply air into the cargo hold with an air change rate of 10. Recently, IMO allowed reduction of required air change rate to 6 for Ro-Ro space when an air quality control system is installed complying with IMO guidelines. With the decreased of air change in a cargo hold 40% of energy would be saved while a ship is in navigation. However, the performance of ventilation system could be poor, and it is necessary to rearrange ventilation system to maximize the ventilation performance.

In this research the design of cargo hold ventilation system for PCTC with air quality control system using CFD is presented. Air quality in cargo holds with a decreased-air-change ventilation system is analyzed with CFD programs. After computations, an effective design of ventilation system is obtained with less effort and time.

---

89. Studies of Development of Risk Management System Based on Computer to Shipbuilding

Ilham Salo Arta, Sepuluh Nopember Institute of Technology, Indonesia

In a Shipyard, Risk Management has not been executed systematicaly. The results of Shipbuilding risk

inspections are still being kept in the cupboard and computer folders separately.

Management of risk are not supported by system which can help Shipyard, Owner Surveyor, Class and State Regulator to control, to search, to review, to evaluate and to do the inspections. This Final Project has a main goal to design a Computer-based Application that makes Quality Management process in Shipbuilding better. Firstly, the Existing Quality management in shipyard was observed which is taken as the sample is PT. PAL Indonesia Shipyard. Secondly, Determining parameters are required in Risk Management Application.

Thirdly, Designing Computer-based Applications based on application parameters.

Application parameters are identified during shipbuilding stages, processes, outfittings, and ship documents, risks that occur in every state of Shipbuilding, as well as standards and check lists. Software used to design the application is combination of PHP as programming language, Sublime Text 2 as text editor and MySQL as database. This computer-based applications can help risk management implementation in controlling, searching, reviewing, evaluating, and doing the inspection. Once the application has been designed, it was tested by verification and comparison systems. It is concluded that the application system is better than the existing system which is personally conducted in the Shipyard.

---

90. RhinoPiping, Innovative piping software

Arnold Matthieu, Navinn, France

RhinoPiping is a plugin based on Rhino3D, and developed by Navinn since eight years. It brings parametric 3D piping design to Rhinoceros' powerful surfaces modeling engine. It opposes heavy and complicated tools offered by traditional solutions by providing a lightweight, low priced solution. With a very short learning curve, it aims at company looking for efficiency and simplicity. Half a day is usually more than enough training for rhino3D users.

Our fully customizable 3D catalog, allows us to create any kind of piping element, thus capitalize a company's knowledge inside an integrated piping design system.

Furthermore, RhinoPiping comes with a sophisticated attributes system, which can improve your piping design workflow. For example, you can create and assign a status for each piping element, and visualize directly from the 3D Design which parts are awaiting design validation, which ones were already ordered, or installed onboard. The free edition will also give you the opportunity to share these informations easily with your customers/partners.

M. Bornac, from the naval engineering company Ship-ST: «Using RhinoPiping since three years, I'm really satisfied with its flexibility and its ease-of-use. The attribute system is even compatible with non piping elements, for example we use it in our hull design process» We aim to make piping design smarter, especially for small companies, which don't need or can't afford heavy solutions.

---

91. Influence of computer applications in resistance prediction of vessels

Sri Harish Kalidass, Blue Bear Systems and research Limited, UK

The efficient and convenient way of predicting resistance and other performance parameters of marine vessels are necessary for preliminary design phase for a better design and hassle free deadline approach. It’s therefore been the motivation of this project for standardising and amending the existing method of predicting the resistance of planing vessels and displacement hull type vessels.

This report predominantly focuses on predicting the resistance by using savitsky’s method of planing hulls using different methodological approach of which is influenced by the computer applications and softwares like Maxsurf and MATLAB.

This research paper includes a standard Simulink model created using MATLAB software for predicting the resistance of the planning vessels. This base model can be used to predict the resistance of similar types of vessels by just changing the inputs. This report is focused on the experiment objective, methods and results and also includes an appraisal and conclusion to establish the test efficacy and outcomes of the study.

The project was carried to A) enhance the understanding of design and working of planing hulls, B) determine the optimum trim angle, moment, power and drag force(resistance) theoretically by using empirical equations at different speeds with constant LCG and to perform the resistance analysis for the same hull using Maxsurf software and compare the results. C) Understand the effects of relative hydrodynamic parameters on the performance of planing hulls with respect to speed, by way of evaluating a practical example.

---

92. Escape & Evacuation (E&E) assessment - An alternative use of E&E software during ship construction

Mark Way, Babcock International Group, UK

This paper will present the approach taken by Naval Architects in Babcock International Group's Rosyth team, acting as Alliance members of the Aircraft Carrier Alliance, to assess the safe escape and evacuation (E&E) of the construction workforce during the build of the Queen Elizabeth Aircraft Carriers. With between 800 to 1300 personnel on-board at any given time a key question was asked:-

- How many access points and where to allow safe and efficient evacuation? A review of regulations related to E&E revealed surprisingly little guidance for a ship in build. Further, a ship built in the UK is covered by the Building Regulations but the provisions under escape can be incompatible with a ship type configuration, so:
- What is an acceptable approach to assess E&E for a ship in build?

This paper will present a summary of the review conducted of relevant National and International Regulations & Codes. It introduces the bespoke rationale developed to assess the vessel during the various stages of her build. It will provide an overview of EVI, the E&E software used by Babcock under licence from Brookes Bell Group (originally Safety at Sea). It will cover the software's adaptation to a build scenario, including taking into account significant changes to the vessel's configuration, number & distribution of personnel on-board and conduct of physical trials. The paper will present an example assessment demonstrating areas requiring specific attention to ensure valid results are produced to aid decision making on the location and number of access points.

---

93. Android - Based Application Design for Welding Inspection of the New Shipbuilding

Sufian Imam Wahidi, Sepuluh Nopember Institute of Technology, Indonesia

Welding inspection on the new shipbuilding construction activities is still peformed manually where a welding inspector does inspecting by reference to a form of inspection. Welding inspection activity is less effective when done on the construction of new vessels, this is because not every welding inspector had the similar knowledge and experience. The purpose of this final project is to observe existing system, to design an application based on android to guide the welding inspection of the construction of new vessels, and to test the validity of the application in enhancing the effectiveness of welding inspection of the construction of new vessels. Design of application is executed by making a mock- up designs interface, designs of database, and coding the sources. This application features a list of the regulatory process, review the results of monitoring the progress of ship construction, and a menu to adding welding inspector. The trial was carried out applications to several respondents who have experience of welding inspection on the new ship construction and the parties who have an educational background in the field of shipping. From the test results a questionnaire, it is obtained using that this application can be applied in support of the new ship construction welding inspection process.

---

95. Automated generation of detailed cabling documentation for cruise ships', passenger and commercial vessels' accommodation

Antonios-Vassilios Lalechos, Electrical, Electronic & Control Systems R&D, LePlan, Greece

The increasing size and complexity of the accommodation of Cruise ships, passenger and commercial vessels, requires a novel and enhanced way to address all sort of challenges concerning the electrical and electronic aspects of each project from conceptual design phase up to and including commissioning phase. Today tasks such as the conceptual - final drawings design and management, generation of BOMs and instructions to field installers, are commonly handled from different persons or teams, making it challenging to accurately monitor the process and deliverables. Numerous major and minor changes are often hard to communicate to all involved parties timely. Optimising the process is a must in order to reduce design time, cut cost, minimize errors, enhance budget accuracy and compliance, and more importantly generate a complete and easy to follow set of electrical drawings.

Inspired as a 21st century, Particle Accelerators facilities planning tool, LePlan electrical design and documentation tool is an innovative software that converts verbal specifications/concepts using a wording easily understood by naval architects and shipping interior designers into actual electrical plans in an autonomous and automated way. The tool generates course cable lengths estimates required for budgeting as well as final accurate estimates for procurement purposes. Additional deliverables include unified electrical drawings for all systems, cable installation instructions, complete vessel’s data-center wiring plan, unique cable identification and optimal cable path based on cable interference restrictions.

---

96. Development of a Code for Power Prediction of a Ship at Preliminary Design Stage

Dr. Mashiur Rahman, Bangladesh University of Engineering and Technology (BUET), Bangladesh
Md. Mesbah Uddin, Chittagong Dry Dock Limited (Bangladesh NAVY), Bangladesh,
Ahammad Abdullah, Chittagong Dry Dock Limited (Bangladesh NAVY), Bangladesh,
Md. Maksudul Alam, Bangladesh University of Engineering and Technology (BUET), Bangladesh

This paper develops a code (C++) for an estimation method of ship effective power at preliminary design stage. Container ships, passenger vessels, Oil tankers, LNG carriers and bulk carriers were taken into consideration on the base of similar ship list. Hull resistance, appendage resistance, wave resistance and added resistance are taken into account. In total eleven hull resistance prediction methods were examined, eight of which were computerized. Model test data of four vessels were used to evaluate these eight programs and best method was selected. For added resistance due to sea-state was divided into wind and wave resistance. The head sea and wind conditions were only considered. Various methods for estimating wind resistance were examined and a program developed capable of providing resistance estimates regardless of wind direction. The problem of added resistance due to waves was examined and two programs written around the methods examined. To facilitate prediction estimates, the sea state was chosen as the prime function. Wave height is estimated for the appropriate sea state and wind speed in turn from the wave height. Factors such as appendage resistance, fouling, and hull roughness were examined and appropriate methods selected for inclusion into the integrated program. Methods for determining propulsion coefficients were also examined. After calculation of power, we compared it with the model ships. The method providing the best overall results was incorporated into the Power Prediction program.

---

97. Android-Based Application Design for Project Management of Shipbuilding in Indonesia

M. Sholikhan Arif, Triwilaswandio W.P, Loudrian Yudharana, Ridho Pahlevi Wachid, Dept. Naval Architecture & Shipbuilding Engineering / Marine Technology Institut
Teknologi Sepuluh Nopember Surabaya, Indonesia

The project management activities in shipbuilding in Indonesia, nowadays not have the system that intergrated shipbuilding project with stakeholders yet. A *project manager* as the leader should be responsible for the project, still do reporting of shipbuilding project management manually, it takes a long time to deliver the information and decision making on the project when there are things that need to be resolved quickly. Information like progress of the project, minutes of meeting, memorandum, result of the meeting are still reporting manually. So, it needs a long time to receiving the information. In this research, the researchers trying to design an android-based applications for shipbuilding project management to help a *project manager,* in carrying out his duties as the person in charge of the project. Methods that has been used by this reseach is collecting data of project management in shipbuilding, identified shipbuilding's problem of project management, making the concept, intergrated the project management, and built program of android-based application. This application has the following advantages, integrating scope project manager as follow: project's time management, project's cost management, project's quality management, project's risk management, human resource management, project's communication management, project's purchasing and procurement management, and management of project's interest, and it applied to the shipbuilding project. The result of testing against a respondent who is experiences as a project manager and educational background in shipbuilding by using a detailed questionnaire, it can be inferred that the application required in support the project manager to manage a shipbuilding projects.

Keywords: Android application, project management, shipbuilding, project manager.

---

98. Minimizing the Designer / End User Gap Using Virtual Reality

Winston Pynn, Marine Institute of Memorial University, Canada

Naval architects do not manage the daily operations of ships, nor does the ship's officer or captain design them. However, the vessel's design process requires the naval architect to capture the ideal, often with little to no input from the final users of the space. It is of no surprise that a crew member might not see a vessel until sea trials or later, and perhaps be less than enamored at the layout of its bridge or engine room for example. This demonstrates the gap between the final user and designer.

I will argue in this paper that we now have the tools available to inexpensively use completely immersive virtual reality to review and modify a wide range of ship compartments in real time, anywhere in the world, months in advance of construction. For illustration purposes of this document, the compartment in focus will be the bridge and its internal arrangement. The focus will be on the modelling of several bridge layouts from large project ships designed by senior students in the Naval Architecture Technology program at the Marine Institute of Memorial University using "Rhinoceros 3D" modelling software. It will then report on the subsequent testing and modification in nearly real time of these

designs using the HTC Vive Virtual Reality system by several ship captains currently teaching at the Marine Institute. Video will be taken of the designer / user interaction and be available as a supplement to the paper.

---

99. A Bayesian-Network-Based Risk Model for Oil Spill from Tanker Collision Accidents

Dr Xiang Tan, Research Fellow, Nanyang Technological University, Singapore
Mr Jidong Tao, Research Associate, Nanyang Technological University, Singapore
Dr Dimitrios Konovessis, Associate Professor, Singapore Institute of Technology

Marine transportation of oil involves high risk due to the devastating consequences of oil spill. Since maritime transportation is a complex system consists of the vessel as hardware, human, the environment and their interfaces, various factors can influence its safety performance regarding oil outflow. In the light of these considerations, Bayesian networks are chosen to quantify the risk of oil outflow following a collision accident by taking into account the relevant factors as well as their causal relationships. Risk is defined in the present study as the product of the collision probability and the consequence of oil spill which is described by probabilistic oil outflow volume. In the Bayesian network model, human factors, ship design factors and environmental factors are included to describe the collision probability and the probabilistic oil outflow volume is described by models from past studies.

The model is implemented in a parametric way, which enables conducting sensitivity studies to evaluate the relative influence from different factors. In particular, variables related to the conceptual design of the ship are varied systematically and the trade-off among several selected criteria including safety are discussed to get a preliminary insight into the cost-benefit aspect which is crucial for modern ship design.

---

100. Enabling a Paradigm Shift in Ship Structural Design with a 3D Approach

Mr. Tapio Hulkkonen, Senior Product Manager, NAPA, Finland
Dr. Shin Hyung Cheol, Basic Hull Design Dep't, Shipbuilding Division, HHI Mr. Nak Hoon Yi, Basic Hull Design Dep't, Shipbuilding Division, HHI, Korea
Mr. Deok-Hoon Jang, Business Development Manager, NAPA Abstract, Finland

In 2016, Hyundai Heavy Industries (HHI) implemented NAPA Steel's 3D model-based ship structural design tool across its business. NAPA's new interactive 3D structural modelling interface allows users to create a single flexible product model for the whole vessel effectively. HHI was able to use these models throughout the design process, including class society rule checks, creating plan approval drawings, Finite Element model generation, weight calculation and other tasks.

Following the introduction of NAPA Steel, HHI expects the design time and man-hours to be reduced by 30% in ship initial and basic structural design. By linking the structural design databases and drawings to the NAPA 3D model, design quality is improved and the probability of human errors is reduced as common information is shared and the update process becomes simpler.

NAPA's software has created now a paradigm shift in how HHI designs vessel and has helped the business become more competitive for the future of shipping. The presentation gives an overview on the process of this paradigm shift at HHI. It highlights the technology used with practical examples, changes to the traditional design process, and the benefits achieved so far.

---

101. Holistic ship design – how to utilize a digital twin in concept design through basic design and detailed design

Torben-H. Stachowski, Digitread, Norway

Ship design has been characterized as a complex and sometimes disconnected process going between many stages and supported by many different systems. Sharing of information and knowledge and driving change has been challenging. Information carrier typically were drawings and documents hindering introduction of state of the art processes.

NX for product definition and simulation with Teamcenter as backbone is an enabler for a more holistic approach to ship design. Addressing all phases of ship design and construction allows ship designers to work in a unified and global way. Users across disciplines share the same information regardless of geography. Information can be utilised by all kinds of users in covering their particular needs.

This paper covers the ship design process starting with Concept Design and shows how a master model supports the necessary steps in Concept Design with 2D/3D GA, rendered presentations, simulation and decision making. While the Digital Twin will be matured into Basic Design and further to Detail Design and Production preparation, each stage remains as managed objects which can get accessed at any time and maturity of the ship lifecycle.
All stages are supported with functionality and tools driving productivity and optimal decisions. Knowledge based engineering is utilized in all stages adding effectivity and predictively. All stages Concept, Basic, Detail Design as well as Production preparation are traceable and "alive" as maintained models for future

use. Both specialized CAD and CAE users have access to "living" model data. All users with HTML5 compatible devices have access to models, documents and drawings providing the correct information at the right time. Disciplines such as piping, outfitting, accommodation are all addressed in a holistic fashion in a single managed environment avoiding unnecessary import and export. ECOs are taken care of and driven in a controlled way giving all decision makers timely and extensive information for better innovation and decision making.

---

102. CAD/CAE on Integrated System of Ship Structure Custom Developed Based on NX Platform

LR Wang, China Classification Society, China

With the advent of the era of intelligent manufacturing, using 3D CAD model for ship design, design verification and ship survey, ship construction and ship operation will be the principal work mode. It is a hot issue for ship design engineers to build the 3D geometric model of ship structure, to realize the automatic update of the 3D model, and to convert the geometric model into finite element (FE) model quickly and conveniently.

A CAD/CAE integrated system of ship structure is introduced which has been developed by China Classification Society (CCS) based on Siemens NX platform. The system develops a parameterized and rapid 3D modeling system which meets the thinking habit of ship engineers. The finite element mesh of ship structure is automatically generated according to geometric model, and meets special requirements of FE model in rules for classification. Ship structural physical attributes are automatically applied to the FE model. FE model can be updated automatically when the geometric model is modified. It will save labor cost and greatly shorten the ship design cycle.

Key words : ship structure, finite element meshing, integration of CAD/CAE

---

103. Acoustic Simulation for Cabin on Ship by Finite Element Method

Yasuaki Ohtsuki, Tsuneishi Shipbuiding Co., Ltd.
Yohei Wakisaka, Altair Engineering, Inc., Japan

New approach by Finite Element Method (FEM) to estimate sound pressure level (SPL) in cabin has been introduced in this paper. Statistical Energy Analysis (SEA) is known well as a method to achieve same purpose. But, SEA requires so many input data from many experiments with complete ship. This means that SEA cannot be applied for ship in design phase. On the other hand, FEM requires only information from design phase as input data. Then, this approach is expected as a method to estimate SPL for ship in design phase.

Firstly, in this approach, a ship is divided into structural domain and fluid domain. Both domains are consisted of properties only from design phase. Structural domain is structure of whole ship and structural vibration is propagated through this domain. In addition, in structural domain, main engine and diesel generators are also modeled to apply excitation forces. In this paper, the excitation forces are estimated from the relation between rotational speed and magnitude of force on catalog of the engines. This excitation forces are known as guide force moments. On the other hand, fluid domain is air in cabin and structural vibration is propagated as sound pressure through this domain.

Secondary, the ship model is used to calculate structural vibration and sound pressure. SPL results are compared between this calculation and experiment in this paper. In addition, this paper mentions to effect of ballast water for SPL in cabin.

---

104. Predictive Engineering Analytics for the Marine Industry

Wim Cardoen, Siemens Industry Software, Belgium

Modern ships operate increasingly autonomous through strongly interacting subsystems. These systems may be dedicated to a specific, primary objective of the vessel (such as special purpose, naval and more) or may be part of the general essential ship operations. Between them, they exchange sensor data and make coordinated operational decisions, ideally without any user interaction.

Designing such ships is complex, and requires an efficient development approach that can consider the mutual interaction between subsystems and the inherent multidisciplinarity from the very beginning. Scalable simulation technologies have to take the lead in this process. Whereas in the shipbuilding industry, virtual modeling was for a long time limited to point solutions for specific problems such as hydrodynamics and mechanics, it now has to be applied on a much broader scale and drive development.

On top of that, the design of such ships doesn't stop after delivery. Through software updates or because of maintenance, subsystems can change. But the overall behavior of the entire vessel still needs to be optimal. To make sure of that, product design and product use need to be coupled. That requires traceability over the entire product lifecycle. To deal with these challenges, Siemens PLM Software presents predictive engineering analytics (PEA). PEA combines engineering simulation and testing with intelligent reporting and data analytics, to develop digital twins that can predict real product behavior throughout the entire lifecycle. This will help shipbuilders develop and maintain complex vessels faster and with greater confidence.

---

105. Conceptual Design of Trimaran Unmanned Surface Vehicle (USV) for Maneuverability and High Speed Testing

Zulfah Zikrina, Aqil.A Reksoprodjo, Fereizqo A. Sulaiman, Ida B. Krishna, Aldwin A. Hermanudin, Universitas Indonesia. Indonesia

Indonesia is a developing country who has many potential in maritime field. The nature resources of Indonesia sea is possible to support our economical issues. Nowdays, our marine wealth has been exploited by foreigners through illegal fishing issues, so that the security of Indonesia's sea is priority problem to be solved. Therefore, President Jokowi proclaimed "Nawacita" which contain the priory of the security of the country and are also determined to restore the glory of maritime Indonesia. Based on that issues, the Unmanned Surface Vehicle (USV) is one of project which has ability to increase the security of Indonesia's Sea. The developed country such us United State of America already uses Unmanned Surface Vehicle (USV) to help the Navy to maintain the sea borders. In this research, the Unmanned Surface Vehicle (USV) will be designed to deal with characteristic of Indonesia's sea. The trimaran concept is currently being adopted worldwide for the perfection and development of patrol boats and navy vessel. Compared to the mono hull concept, the trimaran concept has many advantages. Less energy used at high speed, greater stability which caused by the side hulls that support the main hull, larger deck area due to the larger beam of the ship, those are the advantages of the trimaran concept compared to the mono hull concept. The prototype of this Unmanned Surface Vehicle (USV) has 21 kg Displacement, 1.1 meters Length, 0.6 Beam and 0.27 Height. The prototype will be examined the maneuver and speed testing in steady free surface area. By discovering the performance, the concept of trimaran Unmanned Surface Vehicle (USV) is able to do more advance mission in other cases.

Keywords: illegal fishing, trimaran, Unmanned Surface Vehicle (USV)

---

106. Tools for predicting parametric rolling and its application for second generation intact stability criteria

Jesús A. Muñoz, SENER Ingeniería y Sistemas, S.A. Madrid, Spain

This paper explains how to develop a computer application implementing the numerical algorithms necessary for evaluating the appearance of parametric rolling in a vessel. In the analysis of this problem it is considered of interest the geometrical representation of the hull of the ship and other elements which have decisive influence in this phenomena, such as the sea situation and the loading condition. Ideally, the application would determine the roll angle that occurs when a ship is on waves of different characteristics.

In this work it is offered a software methodology for addressing the problem of predicting the parametric rolling as this concept is one of the elements involved in the evaluation of the intact stability criteria of second generation. The foreseen come into force of the second generation of intact stability makes necessary getting tools to make easier the evaluation of the behavior of the vessel subject to hydrodynamics phenomena as the appearance of the parametric rolling.

---

107. A model based approval process for basic hull design

Dr Ole Christian Astrup, DNV GL, NORWAY

Traditionally, drawings are used for communication in industry because they are the clearest way to tell someone what to make and how to make it. Technical drawings provide a means to communicate product complexity in a comprehensible and effective manner thanks to visual abstraction. It is still an explicit requirement that the designer/yard shall provide the Classification society with Class drawings documenting the design to be approved to the Society's Rules.

At the same time Computer Aided Design (CAD) models have now displaced paper-based technical drawings and documentation as the main carriers of definitive product data in several major industries. Within the last ten years or so, the engineering industry in automotive, aerospace and construction has gradually converted to using CAD models directly for communicating designs to manufacturers, builders, maintenance crews and regulators.

This paper explores both the barriers to overcome and the requirements needed to establish a fully digital workflow providing a seamless and transparent digital model exchange between stakeholders during the ship newbuilding basic design stage. A 3D digital model established early in the design stage and shared among stakeholders will eliminate the need for producing 2D drawings for the verification of the design by Class. The digital 3D model is the basis for verifying the design against Class Rules and functional goals. A design centric work process involving the various stakeholders is the result of linking the Class rules directly to the Computer Aided Design (CAD) early design tools used by the designer.

---

108. Marine Propulsion Shafting Simulation Interfaces

Mohamed Zeid, Caterpillar Propulsion, Sweden

The marine propulsion shafting lines are subjected to different types of simulations. The most common is the shafting simulation in torsional, lateral and axial direction. Such type of simulations are basically carried out by propulsion maker, this in order to ensure well performance in relative direction. However, it is not always the case that all relative input are available for propulsion maker. On the other side, the tools used to perform these shafting simulations are developed significantly along the years. Also, the hydrodynamic simulation tools as well as the structural analysis tools developed significantly. With such high level of sophistication in the analysis tools, simulation process and level of input, it shall be expected a more close to zero failure/vibration observation within the torque transmission equipment. However, there is still existing significant number of cases on the market. One of the most common reasons for major failures is the missed interfaces among different types of simulations. In order to have a better control, the energy flow to/from propeller is represented within different types of propulsion shafting modal simulations (Torsional / Lateral and Axial). Also, the simulations interfaces domains highlighted and relative practical cases presented as well.

---

109. Big Data Analytics to predict system's behavior: the RaaS (Radar as a Service) concept

Alessandro Garibbo, Leonardo S.p.A., Italy

Predictive Maintenance (PM) is a type of preventive maintenance carried out on the basis of mathematical models processing Big Data produced from measures taken through (embedded) sensors from mechanical, electromechanical, electric and electronic (sub)systems to predict the remaining time before the failure (or a critical state) of a given (sub)system. This is of paramount importance at sea, where opportunities for repairing are intrinsically limited and frequently hampered by bad weather conditions. This is also essential to plan actions at the right time (i.e. just in time) avoiding the necessity of costly corrective maintenance on failure and guaranteeing longer lifecycles, increased safety and business continuity, also helping improving ship energy efficiency. The project 'Radar as a Service' (RaaS) consists of a Proof of Concept (PoC) for application of PM on a terrestrial radar produced by Leonardo by exploiting measures and maintenance messages routinely issued by the radar itself. RaaS is built upon two enabling technologies: in-memory database and algorithms for the correlation of time series and for the prediction of phenomena (Machine Learning). Cross Industry Standard Process for Data Mining (CRISP-DM) methodology was extensively used for building the predictive model. The PoC demonstrates that PM offers real benefits both in the short term and in the medium-long term. Further implementations in the naval environment could extend RaaS capabilities and PM concepts to other complex systems, such as shipborne radars, equipment, plants and installations. These benefits can also be used to generate innovation in maintenance and service business models.

---

110. Offshore Sub-Stations

C. Barlach, R&D Manager ISC A/S, Denmark

Renewable energy with Wind farms has grown from a few local initiatives started 10 years ago to a major industry with country like Denmark, UK, and Germany leading the way with offshore windfarms. Beside the wind turbines, which are very visible in the farms, the task of establish the support infrastructure for transmission of the generated power require design and fabrication of offshore structure for electrical Substations. Substations mission is to transform the current to a higher level, than produces by the turbines, so power can be transported over longer distance. The Substations range from traditional 4 legs jacket to mono-pile and gravity based sub-structure with topside that has very different design requirements than the Oil and Gas production platforms. They have a much different ratio between systems, than Oil and Gas facilities and are fully packed with electrical equipment. Heavy cabling that require new approach compare to traditional cable tray layout used on oil and gas platforms. This is a young industry with many new companies contributing in the design and fabrication, which have resulted in the usages of different IT tools compare to the IT tools used in both the shipbuilding and oil and gas industry. ISC designed the very first substation in the world in 2002 (Nysted, Denmark) and have since undertaken more than 18 substations in the northern Europe. This paper presents the evolution of the substations from the early beginning as well as highlighting some of the characteristic of the Substations.