International Conference on Smart Ship Technology
26-27 January 2016, London, UK

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Autonomous Ship Technology - Smart for Sure, Unmanned Maybe

This paper gives an introduction to autonomous (possibly unmanned) commercial shipping. The aim of the paper is to give technology insight into the state of the art of autonomous technologies giving a rational foundation for speculations on the possibility and nature of future autonomous shipping. A review shows that there is a long road ahead for the creation of autonomous ships. A number of critical tasks for unmanned shipping are discussed along with potential solutions and their maturity. Nautical tasks, machinery and cargo supervision do not pose significant hurdles for unmanned shipping. Maintenance tasks have been traditional show-stoppers, but are expected to become rather straightforward as much more reliable engines based on LH2 and electric drives (batteries or fuel cells). Communication bandwidth is expected to continue with exponential growth. Non-technical hurdles are the real issue for unmanned ships: society and in particular the maritime community need to accept unmanned transport; most legal frameworks at WHO level are not ready to accept new quasi-clients that may challenge the international ADGM. However, there is no doubt that autonomous technology will progress, as manned ships with more autonomous technology will be safer and more user-friendly. With time smart ships with increasing degree of autonomous systems will pave the way technically, economically, and legally for unmanned ships.

Design Code for Unmanned Maritime Systems

Volker Bertram, DNV GL, Germany

This paper describes a ship performance monitoring approach based on assorted “smart” technologies. Simulations on a ‘virtual’ sea trial demonstrate the capability to approach what only a ‘real’ sea trial can provide. The approach is the result of an innovation by taking a goal based approach, enabling the designer to trace a requirement to a goal and demonstrate compliance through a combination of the application of national and international standards, elements of Classification Rules, and where standards do not exist risk based assessment methods. The most appropriate method for assessing compliance against the Design Code being determined by the design solution. This paper will look at drivers behind its development, and outline how the Design Code could fit into a future regulatory regime for unmanned ships. Key is to establish a framework where reasonable compliance can be achieved.

The Future of (Shipping) is Connected and Smart

Dirk Burger, Lloyd’s Register, Netherlands

The emerging nature of pervasive networks that allow data to be generated/stored/accessed allows the user to access increasingly large amounts of data. The maritime system is slowly adopting a similar framework in which the user can begin to think of a good human-agent team as achieving a degree of distributed cognition and that brings new opportunities for the efficient use of maritime data to support decision making.

Potential Benefits of Augmented Reality Technology in the Smart Ship

Scott Patterson, Babcock International Group, UK

Driverless ships are coming; the first steps are underway on much larger commercial vessels, led by companies such as Rolls Royce and the EU MUNIN project. The UK MAES Regulatory Working Group was formed in 2014 to formulate a regulatory framework and to develop a Code of Practice for the safe operation of MSs. An initial Information Paper was presented in W1-05 to IACS for feedback, from which the MAES project intends to develop requirements for regulation, equivalence, training, standards and accreditation for MS (Surface). A Code of Practice will be presented by the UK to MSC in June 2016. Various nations and organisations are liaising with the MAES project and considering the way forward. Several hi-tech issues need to be addressed for MSs to be safe, reliable, economic and efficient. This paper will look at some of the more advanced hi-tech issues that need to be addressed, with suggestions for their potential implementation.

Classification Considerations for Cyber Safety and Security in the Smart Ship

George Reilly, Managing Principal Engineer, ABS, USA

ABSTRACT: The ship intelligence era will also enable ship operators to make better decisions and can have a profound effect on the future of maritime safety. There is already significant research activity in establishing international standards for shipboard cyber security. This paper describes the key elements required to achieve shipboard cyber security, and outlines the theory of the “no more than one serious event” approach. This approach stresses the need to have a comprehensive approach to shipboard cyber security, one that integrates all domains (i.e., safety, security, and privacy). The paper also describes how the “no more than one serious event” approach is implemented with respect to shipboard cyber security, and how the approach is validated.

Human-Agent Collectives: Immer sing Autonomous Agents

Bryan L. Cohn, US Navy, Virginia Commonwealth University, USA

Human-Agent Collectives (HACs) are formed by the merging of human and artificial agents. HACs are intended to allow human operators to perform tasks that may be overestimated). However, there is no doubt that autonomous technology will progress, as manned ships with more autonomous technology will be safer and more user-friendly. With time smart ships with increasing degree of autonomous systems will pave the way technically, economically, and legally for unmanned ships.

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This represents a preliminary program
Protecting vital equipment and maximizing a vessels operational efficiency are key drivers for ship owners. As environmental regulation becomes more stringent and widespread, compliance becomes more challenging. New monitoring methods for fuel, oils and equipment required for compliance can lead to unforeseen consequences, including damage caused by poor fuel quality and cat fies. Amidst the drive for operational efficiency, effective condition monitoring tools become increasingly important in helping to reduce emissions and to uptime of machinery. Traditional monitoring technology has advanced at a rapid pace. The evolution of the practice of condition monitoring, from the days of engineers physically examining equipment and relying on their senses and intuition, to the sophisticated online sensors technology available today, has enabled operators to plan and manage maintenance more effectively and to avoid unforeseen downtime in order to achieve this, sensors are installed onboard three case studies, which correspond to three ship types, in order to test the performance of the sensor technology and to obtain data for further analysis. The full paper will discuss these tools in more detail, describe the novel features and describe the interactions between the tools being developed in order to achieve a real time, single package guaranteeing cleanliness and intergrated transport.

**WIRELESS CONDITION MONITORING FOR SHIP APPLICATIONS**

Anna Lito Michaila, Dr Irakis Lazakis, Dr Gerasimos Theotokatos, University of Strathclyde, Glasgow, UK, Prof Takis Varelas, DAMOS.

Wireless systems have proven to be robust and provide good quality of service for condition monitoring applications in a large list of industrial applications. From nuclear to electrical industry to water supply and other manufacturing processes, the standards for wireless communication in industrial applications have being established and are moving towards standardization to make them reliable enough to use in other industries. Such a system can be developed for ship applications as it is demonstrated in this paper. The methodology followed and the scope of recorded data for the purposes of condition monitoring of machinery and equipment onboard ships is presented. Offshore condition monitoring employs effective condition monitoring techniques centred around real time, accurate data, supplemented by onboard testing and sampling, operators have the tools they need to proactively schedule maintenance, avoid catastrophic engine damage and prevent unexpected downtime. To illustrate a real world application, this paper will include a case study with Watson explaining how it has benefited from employing a combination of monitoring tools.

**INTEGRATED SHIP OPERATIONS DATA MONITORING SYSTEM FOR DATA COLLECTION AND PERFORMANCE ANALYSIS**

Kwang-Phil Park, DAEWOO shipbuilding, Korea, Michael Stewart, BLOG, UK, R. Rosing, A.J. Bos, G. Schenk, P. v.d Ven, HMC, Almere, the Netherlands.

Over the past decades, most of navigation and propulsion systems installed on ships have been automated with various kinds of sensor. The automation and sensor systems not only made less crew be able to manage the ship, but also made ship operation and maintenance more effective. The sensor data is captured from engines, ship structure, environment etc in order to evaluate the performance of the ship. However, in order to make full use of the data, the data should be analyzed and processed. Data analytics can be used as an input for determining the required power generated and it is commonly used to calculate the annual fuel consumption [4]. In this work, instead of the traditional load factors method, a stochastic approach is analysed to characterise loads with the direct purpose of decreasing the amount of electrical power required, and fuel consumption, on board. When the ship is docked, stochastic electrical plan load analysis incorporates the uncertainty in a probability distribution function (pdf) and different stochastic models for loads. Three stochastic models describes loads that are always "on", loads that cycle on and off loads that are independent of the current load. The choice of the right model results in a fully deterministic and discrete ones depending on the different load behaviour. Once the model and a distribution are chosen, a variant of the Monte Carlo simulation [5] is implemented to evaluate the total load pdf for some independent and dependent loads. The stochastic load analysis results are evaluated and compared with the traditional load factor approach for two ships with model interesting outcomes. The methodology is planned and developed in order to better exploit the possible full scale data available after appropriate on board measurement campaign.

**HE EVOLUTION OF ONLINE CONDITION MONITORING**

R. Rosing, A.J. Bos, G. Schenk, P. v.d Ven, HMC, Almere, the Netherlands.

"In order to aid clean, safe and efficient transport, HMC has developed the following tools: Safeline is our suite of tools to calculate the capacity, efficiency and energy consumption of the vessel, and to identify potential savings. The tool contains fatigue algorithms performed on an on-board computer, the results of which are reported to the crew and stored. Our loading computer, CP2.0. The CPC 3.0 loading computer uses a meshed hullform to enable actual calulations, rather than tabular interpolation. This further enables calculating the tool with the user friendly graphical interface (GUI) developed in Java language. Data trends can be predict to time to failure and allow for better maintenance planning and spare part scheduling.

**11.15-11.50 SHAPE- AND STRESS-SENSING OF A CONTAINER SHIP BY USING INVERSE FINITE ELEMENT METHOD**

Adnan Kefal, Erkan Onderk, University of Strathclyde, UK

Dynamically tracking three-dimensional displacement and stress fields of a structure by using discrete on-line data is a major challenge in modern engineering. A new efficient inverse finite element method is developed in order to perform an accurate structural health monitoring process. Inverse Finite Element Method (IFEM) is a new state-of-the-art methodology that can precisely reconstruct full-field structural displacements, strains, and stresses from real-time discrete strain measurements. The main aim of this study is to perform shape- and stress-sensing of a container ship by using IFEM. Implementation of the IFEM algorithm is done by considering a four-sided quadrilateral shell (Q4) element. Firstly, hydrodynamic motions and pressures of the container ship are calculated by using an in-house frequency dependent hydrodynamic analysis. Secondly, these hydrodynamic loads as well as relevant boundary conditions are applied to a direct FEM model of the container ship’s mid-body and its structural response is calculated by using an in-house finite element code. The resulting total deflections and rotations from the FEM analysis are then used as an input for the IFEM algorithm. This study is aimed at improving the accuracy of IFEM results and to demonstrate the potential of IFEM analysis of the container ship’s mid-body by using the simulated strain data obtained from different number of strain sensors located at various locations of the container ship. Finally, the displacement and stress results found in both IFEM and direct FEM analysis are compared to validate the current approach for ship shape and stress monitoring.

**11.50-12.25 SHIP SENSORS DATA COLLECTION & ANALYSIS FOR CONDITION MONITORING OF SHIP STRUCTURAL SYSTEMS**

Mr Ramin Raptodimos, Dr Irakis Lazakis, Dr Gerasimos Theotokatos, Prof Takis Varelas, University of Strathclyde, UK.

The INCAS (Inspection Capabilities for Enhanced Ship Safety) project aims in integrating robotic plataform, structural and machinery condition monitoring systems to perform an accurate health monitoring process. In order to achieve this, sensors are installed onboard three case studies, which correspond to three ship types, in order to test the performance of the sensor technology and to obtain data for further analysis. The full paper will discuss these tools in more detail, describe the novel features and describe the interactions between the tools being developed in order to achieve a real time, single package guaranteeing cleanliness and intergrated transport.
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