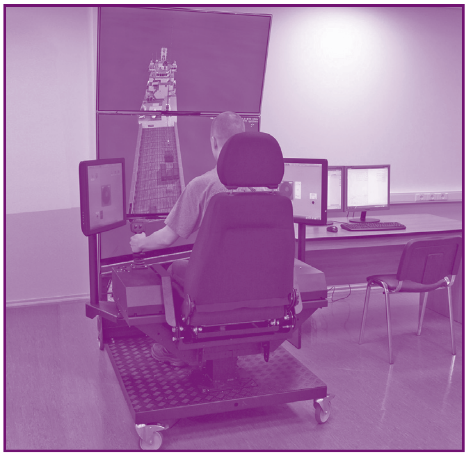
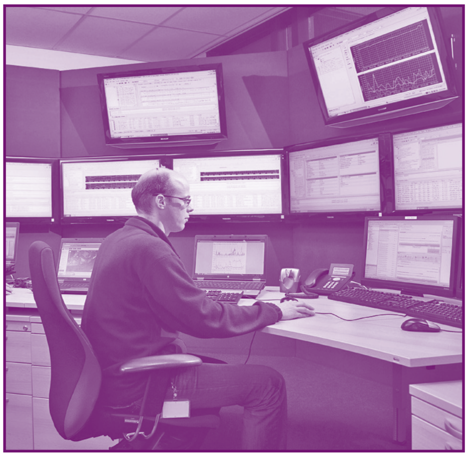
The Royal Institution of Naval Architects

Smart Ship Technology


International Conference on Smart Ship Technology

26-27 January 2016, London, UK

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08.30-09.00 **COFFEE & REGISTRATION**

09.00-09.35 **MARITIME AUTONOMOUS VESSELS - REGULATORY ISSUES**
Jmaes Fanshawe CBE, MASRWG, UK

With the exponential rise in the development and operational utility of Maritime Autonomous Systems (MAS) there is a concomitant requirement for a pragmatic Code of Practice for their use. MAS today are, in the main, relatively small vessels, operating on both the surface and underwater. Their operational capabilities can be divided into three main sectors: Marine Scientific Research; Oil and Gas and Defence. Meanwhile, research is well underway on much larger commercial vessels, led by companies such as Rolls Royce and the EU MUNIN project. The UK MAS Regulatory Working Group was formed in 2014 to formulate a regulatory framework and to develop a Code of Practice for the safe operation of MAS. An initial Information Paper was presented to IMO in June 2015 for other nations to become aware of the work the UK is undertaking on the combined requirements for regulation, equivalence, training, standards and accreditation for MAS (Surface). A Code of Practice will be presented by the UK to MSC 96 in June 2016. Several nations and organisations are liaising with the MASRWG; international consensus is a key component of this work. But an increasing number of MAS are being operated safely in different parts of the world. They work within the existing conventions and regulations as far as possible. Risk assessments and safety cases are a critical part of their safe operation. But there are gaps in the existing documentation and scope for confusion, particularly within the plethora of emergent definitions; 'Autonomy' itself is a good example. The Code of Practice will address this and many other issues. It is important that MAS do not spawn the need for new regulations but that they find their place within the existing structure wherever feasible; the principle of equivalence is a critical element of this. The aim is to allow mariners operating all vessels (manned or unmanned) to perform any task, for business or pleasure, both legally and safely. An Industry-led Code of Practice for MAS(S) will help to make this transitional process as smooth as possible.

09.35-10.10 **AUTONOMOUS SHIP TECHNOLOGY – SMART FOR SURE, UNMANNED MAYBE**
Volker Bertram, DNV GL, Germany

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 the vision of unmanned ships is nothing new, just more widely promoted and with better artist visions. Key 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 disappear as hurdles with much more reliable engines based on LNG and electrical 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 IMO and other regulatory bodies would require changes; economics (costs are often underestimated, savings 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.

10.10-10.45 **DESIGN CODE FOR UNMANNED MARITIME SYSTEMS**
Ben Cuckson, Lloyd's Regsiter, UK

Lloyd's Register has been working with the marine industry to assess the applicability of the existing regulatory regime for commercial ships to Unmanned Maritime Systems (UMS). One of the outcomes of this work is the drafting of a Design Code for UMS. This Design Code provides a structured approach to the assessment of the design of a UMS against safety and operation related goals. The Design Code has been written to support 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 UMS, equivalent to what is established for commercial ships. Detail will be provided on the goal based structure of the Design Code and examples provided of how demonstration of compliance against the Design Code can be achieved for different size vessels and design solutions.

11.15-11.50 **THE FUTURE (OF SHIPPING) IS CONNECTED AND SMART**
Volker Bertram, DNV GL, Germany

This paper describes a ship performance monitoring approach based on assorted "smart" technologies. Simulations ("virtual sea trials") contribute to the hydrodynamic knowledge base replacing conventional model tests. On-board sensor data and AIS data ("big data") are combined for complementary insight and cross-referencing. It is shown that the applied technology can be used for other applications as well, such as improving port operation, trim and routing optimization, cargo maintenance, etc. For all elements, the paper discusses expected developments in the foreseeable future. The ship performance monitoring approach is now in the prototype stage with first operators testing the system in daily operation. Selected insight is shared. Challenges such as data swamping, market skepticism and misconception are discussed, along with roadmaps for overcoming these challenges.

11.50-12.25 **SMART SHIPS -SOME REGULATORY ASPECTS**
Chris Balls, ADOMS, UK

Shipping is a highly regulated Industry with a vessels flag state having responsibility for ensuring compliance with numerous international regulations however it is still possible to progress introduction of new technology. The paper will take main conventions and describe relationship with some developments so far in terms of smart ships and also future possibilities. SOLAS Construction and loadline regulations may be able to further optimize design with data gathered during operations which can assist with development of class rules better condition monitoring leading to extended drydock intervals survey windows etc. Design data and hydrodynamics as well as cargo data can be presented in more user friendly form to assist in optimizing vessel performance and monitoring from ashore can reduce burden on ships staff. SOLAS V navigational equipment has already benefited from such things as ARPA and ECDIS more efficient passage planning will be possible by utilization of better performance and weather data. Technology can improve vessel security and crew comfort. MAR POL technology to monitor emissions. COLREGS need to keep lookout -but maybe could be done by an operator shore. STCW need to consider related syllabuses to ensure relevant and cover new technology without loss of common sense and back to basics knowledge. Unmanned ships takes many of these aspects to extremes -taking people off ships will present new challenges for example at least there is element of seafarer self-preservation at present which helps preserve assets as well.

13.25-14.00 **SHIP INTELLIGENCE – A NEW ERA IN SHIPPING**
Oskar Levander, VP Innovation, E&T, Rolls-Royce Marine, UK

Ship intelligence is one of the main technology trends in the marine business and it will be an enabler for some of the most fundamental changes we will experience in shipping. Ship intelligence will cover a variety of technical topics, such as increased automation, smart controls, robotics, optimization, decision support tools, health management, predictive maintenance schemes as well as remote and autonomous operation. The era of ship intelligence will also see some new trends in the shipping business. The ship operations will treat ships as integrated parts of larger production or logistic chains with focus on total asset utilization and profit optimization. Ship Management will move towards total awareness with remote monitoring, support and operation becoming a vital part of the operation. The increasing technical sophistication level will favor the large ship owners with sufficient size to take advantage of all the technical innovation. However, the ship intelligence era will also enable new business models based on on-line solutions and start-up alliances. The system integrator role will grow in importance in the design and construction of new ships, as all systems will be connected and act together for optimum total performance. Ship intelligence will also be the enabler for the development of remote control and autonomous solutions that will be introduced into shipping in the near future. Today there is a lot of R&D focus on unmanned airplanes and driverless land based vehicles and society is getting more mature to accept these game changing solutions. It is only a question of time when shipping will follow in the same path. The first unmanned commercial ships will likely be locally operated vessels, since single flag states can permit their operation before international regulations are in place. Studies show that most essential technology building blocks are already in place, but practical marine solutions will require some further development. The roadmaps indicate that the first remote controlled commercial ship demonstrator could hit the water within 3-5 years. We are at the dawn of the ship intelligence era.

14.00-14.35 **CLASSIFICATION CONSIDERATIONS FOR CYBER SAFETY AND SECURITY IN THE SMART SHIP ERA**
GEORGE REILLY, MANAGING PRINCIPAL ENGINEER, ABS, USA
JOHN M. JORGENSEN, DIRECTOR, IT SECURITY, ABS, USA

Safety is the responsibility of every individual and organization. For ABS it is the essence of our existence and it is the driver of all the activities of all our employees. As the marine industry develops and introduces new technologies it is the responsibility of Class societies to consider the potential impacts on safety and develop guidance and rules that reflect an assessment of risk while allowing the technology to develop and its benefits to be realized. As the industry has developed more highly instrumented, automated and interconnected "Smart" ships, we have also become aware of the unforeseen technical problems and risks that can develop in parallel. The potential for those dangers to be realized increases significantly with the ready ability to connect shipborne equipment and systems to shore. The subject is now familiar to the public with the term Cyber Security. Fortunately, other industries are further down the path of integrated and interconnected systems which means that as we enter the 'Smart Era' in the maritime industry, we can learn from their mistakes and take them into account, particularly during design of system architecture. Through IACS, Class societies have already started reviewing problems of the complexity in highly interconnected systems, and it is recognized that currently a limited number of cyber related problems are due to malicious actions. Poor access protocols, weak passwords, poorly executed updates or modifications and the poor cyber habits of personnel all need to be addressed. Developing appropriate requirements and tools to take account of the whole system 'attack surface' are needed. This paper sets out to put the various risks into perspective and outline the ways in which Class is maintaining its focus on safety throughout this "Smart Era".

14.35-15.10 **DON'T SHOOT THE PILOT! THE ROLE OF NAVIGATIONAL ASSISTANCE IN ENSURING SAFETY AT SEA THE DIGITAL AGE.** *Linda de Vries, Chalmers University, Sweden*

Navigation of seagoing vessels is one of the oldest, and most hazardous, professions on earth; the use of local expertise in safely navigating dangerous waters has been documented since ancient times. At present, navigational assistance is predominantly performed on board by maritime pilots and from shore by Vessel Traffic Services (VTS) operators. Technological advances over the past decades have supported on board navigation and communication, as well as introduced new possibilities for increased monitoring, assistance and control from shore, potentially changing the nature of navigation and navigational assistance. This paper discusses some empirical studies conducted within the context of a multinational project to develop a future e-navigation infrastructure. It proposes a model of successful navigational assistance based on observations and interviews conducted during simulations of a prototype sea traffic management system, in VTS centres and pilot stations, and on board vessels. Starting from the perspective that maritime safety is created through the interaction of humans, technology and the environment in which they operate, it investigates how both on board and shore-based assistance may aid the navigation of vessels, thus establishing the preconditions for promoting safety through future navigational assistance services.

15.40-16.15 **HUMAN-AGENT COLLECTIVES: IMMERSING AUTONOMOUS AGENTS WITHIN MARITIME DATA,** *Chris Greenbank, BMT, UK*

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 terms of this ability to not only store large amounts of data pertaining to the system, but offering means by which to optimise efficiency and safety. The more technology that is added to this maritime system will not only increase the level of available data, but presents the mariner with a significant problem: what to do with this data? Data, in these systems, exists not for its own sake, but rather to help the key stakeholders make decisions that affect efficiency. These individuals may be on- or off-board. Although people are good at identifying patterns in data, the quantity of data that is now produced makes that increasingly inefficient. This talk/paper will discus s the use of autonomous agents that may be used in such data-rich environments and focus on the nature of shared goals and objectives that exist between human and agent members of the team. Designing the interaction between the human and agent is critical in ensuring that the human can delegate tasks and objectives to the agent team, whilst also being provided with the right level of information that allows the human to trust and accept the information being provided to them. Once this is accomplished we 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.

16.15-16.50 **POTENTIAL BENEFITS OF AUGMENTED REALITY TECHNOLOGY IN THE SMART SHIP,** *Scott Patterson, Babcock International Group, UK*

External drivers have reduced crew size for each generation of vessel. The negative effects of this reduction have been mitigated by the increased levels of automation in modern systems but exacerbated by the growing requirements of regulation and compliance. Ship's companies are now required to keep a larger than ever territories on the physical ship safe and clean whilst managing a plethora of operational, logistical and engineering data on the digital one. An innovative approach is required to help cope with the growing challenge and bridge the gap between the physical and the digital ship. Solutions are needed which make personnel safer and more efficient. As the data available from the smart ship grows in volume it must empower the crew, providing the ability to call up information seamlessly and on demand. Augmented reality is a live direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. The technology functions by enhancing the current perception of reality. By contrast, virtual reality replaces the real world with a simulated one. The following paper and presentation will explore the potential benefits of augmented reality as part of the future vision for a smart ship and detail the rapid progress made to develop the technology for the support environment. It will also cover the obstacles which will have to be overcome in order to deliver that vision.

09.00-09.35 **THE EVOLUTION OF ONLINE CONDITION MONITORING**
Parker Kittiwake

Protecting vital equipment and maximising a vessels operational efficiency are key drivers for ship owners. As environmental regulation becomes more stringent and widespread, compliance becomes more challenging. New operating methods for fuel, oils and equipment required for compliance can lead to unintended consequences, including damage caused by poor fuel quality and cat fines. Amidst the drive for operational efficiency, effective condition monitoring tools techniques become increasingly important in helping operators manage, avoid or mitigate these costly issues. Over the last decade, online condition 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 sensor technology available today, has enabled operators to plan and manage maintenance requirements with the least possible impact on schedule and cost. Through having easy access to the information that gives an accurate picture of the state of the system in real time, and not just when an engineer can get to a machine for routine testing and sampling, operators are forewarned where issues arise and can take preventative action before catastrophic damage occurs. This paper will explain how through employing 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, the paper will include a case study with Matson explaining how it has benefited from employing a combination of condition monitoring tools.

09.35-10.10 **WIRELESS CONDITION MONITORING FOR SHIP APPLICATIONS**
Anna Lito Michala, Dr Iraklis Lazakis, Dr Gerasimos Theotokatos, University of Strathclyde, Glasgow, UK, Prof Takis Varelas, DANAOS, Greece

Wireless systems have proven to be robust and provide good quality of service for condition monitoring applications in a long 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 been used successfully. These systems have proven to provide significant reductions in maintenance costs 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 a vessel is presented. Off-line and real time on-line measurement approaches are combined allowing for incorporation of inspection data onto the system. Additionally, the recorded data are processed and presented through a decision support system developed for the INCASS (Inspection Capabilities for Enhanced Ship Safety) project in order to assist crew members in taking timely and effective maintenance actions. The result is a reliable user friendly graphical interface (GUI) developed in Java language. Data trends can be used to predict time to failure and allow for better maintenance planning and spare part scheduling.

10.10-10.45 **HOW DATA IS SHAPING THE FUTURE OF VESSEL DESIGN, NAVIGATION AND OPERATIONS,** *Esa Henttinen, NAPA, Finland*

At its most advanced, data is paving the way for the unmanned vessels of the future. But data analytics can also be applied today to address current challenges, delivering enhanced safety, efficiency and productivity. In the next 5-10 years, the mandatory adoption of ECDIS, incoming EU MRV legislation and the market drive for transparency and greater ship-shore connectivity will see the industry rely increasingly on the transmission and sharing of data. The smart solution is to implement systems that can automate much of this to increase productivity and reduce man-hours. Digital reporting and automated analytics should become the status quo, replacing noon reports with continuous digital monitoring, for example, to streamline reporting into one tool. A data-driven approach to operations will maximise safety along the most cost effective route, with bunkering stops at the most economic locations, travelling at the speed that will ensure the best possible fuel-efficiency, while arriving precisely on time. A future that is possible today with effective application of available technology. The paper will also outline how effective data analysis and predictive algorithms can help save lives if a navigational error has lead to a flooding emergency. This will include information on NAPA's in-house research and algorithms developed in the EU FLOODSTAND project. Finally, the paper will discuss NAPA's participation and contribution to The Advanced Autonomous Waterborne Applications Initiative. Led by Rolls-Royce, the collaborative project aims to produce the specification and preliminary designs for the autonomous, unmanned ships of the future.

11.15-11.50 **SHAPE- AND STRESS-SENSING OF A CONTAINER SHIP BY USING INVERSE FINITE ELEMENT METHOD,** *Adnan Kefal, Erkan Oterkus, University of Strathclyde, UK*

Dynamically tracking three-dimensional displacement and stress fields of a structure by using discrete on-board strain data is known as shape- and stress-sensing. Solving this inverse problem is fundamental 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 based on the iFEM methodology. The numerical implementation of the iFEM algorithm is done by considering a four-noded inverse quadrilateral shell (iQS4) element. Firstly, hydrodynamic motions and pressures of the container ship are calculated by using an in-house frequency-domain panel code for a certain frequency of waves. 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 found from the FEM analysis are used as a source to obtain the simulated sensor-strain data. Thirdly, iFEM analysis of the container ship's mid-body is performed by utilizing 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 and to examine the effects of sensor locations and number of sensors on the precision of the iFEM solution.

11.50-12.25 **SHIP SENSORS DATA COLLECTION & ANALYSIS FOR CONDITION MONITORING OF SHIP STRUCTURES & MACHINERY SYSTEMS**
Mr Yiannis Raptodimos, Dr Iraklis Lazakis, Dr Gerasimos Theotokatos, Prof Takis Varelas, University of Strathclyde, UK

The INCASS (Inspection Capabilities for Enhanced Ship Safety) project aims in integrating robotic platforms, structural and machinery reliability tools in order to enhance ship inspection, maintenance and safety. In order to achieve this, sensors are installed onboard three case studies, which correspond to three ship types, bulk carrier, container ship and oil tanker respectively. Sensors are installed for monitoring hull structural characteristics and machinery parameter measurements are also monitored and data are collected in order to inspect and examine main engine, pumps and turbocharger components and parameters behaviour through condition monitoring. Moreover, the INCASS project also addresses and identifies the methods for transforming the real time monitoring data (raw data), collected from the onboard measurement campaign using permanent sensors or portable equipment or a combination of both for the ship, into meaningful, useful data and information that will be utilized in developed structural and machinery reliability analysis and assessment tools. Furthermore, the developed tools using the information from the onboard data collection activity will be capable of calculating and assessing the performance and reliability of the ship which will provide input into a decision support system capable of addressing emergency decision making and assisting in the overall decision making process for repair, maintenance and optimised ship operations.

13.25-14.00 **TOOL DEVELOPMENT AND INTEGRATION TO ACHIEVE CLEAN, SAFE AND EFFICIENT TRANSPORT**
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: Safeplan is our suite of tools to calculate hull and cargo structural integrity information under fatigue conditions during transport and the effect of actions such as route changes and changes in speed. It contains: Fatigue Monitoring System (FAMON), which consists of strain and acceleration sensors in a fixed (Hullmos), or mobile configuration (the Marine Quality Kit, MQK). The last can also determine fatigue of the cargo. In addition, it contains fatigue algorithms performed in an on-board computer, the results of which are reported to the crew and stored. Our loading computer, CPC2.0. The CPC 3.0 loading computer uses a meshed hullform to enable actual calculations, rather than tabular interpolation. This furthermore enables coupling the tool with our other tools. EcoTrim determines the optimal trim of the vessel to reduce both the frictional – and the wave making resistance, thereby reducing the fuel consumption. Dockplan show the critical path in docking a ship, thereby giving a better insight in the time-scheduling. Stowplan has a main target the minimization of the number of re-handles during stacking of containers. This tool is applied to both stowage – and yard planning. 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 clean, safe and integrated transport."

14.00-14.35 **IMPLEMENTATION OF STATISTICAL METHODS IN SHIP DATA TO MEASURE THE PERFORMANCE AND EFFICIENCY**
Ibna Zaman, Kayvan Pazouki, Shirley Coleman, Rose Norman, Shervin Younessi, University of Newcastle, UK

The shipping industry faces challenges in terms of monitoring the fleet condition and performance. Energy efficiency and sustainable shipping provide competitive advantages to the industry by lowering the operational costs and improving ship utilisation. Smart sensors and satellite communication can facilitate an integrated network between on-board and on-shore systems and allow a large amount of condition data to be evaluated in real-time. There are different types of sensor data available in a ship such as position, speed over ground, wind speed, fuel flow, shaft toque, shaft RPM and emission data. The sensor data must be pre-processed and relevant features extracted to get meaningful information. An expanded use of sensor technology will necessitate equipment design changes, development of complex monitoring algorithms and forecasting systems to develop component interdependencies, interfaces and respond to changing operating condition. A more data-centric approach will expand the value chain whilst potentially minimising maintenance costs and will promote the safe and efficient operation of the vessel. This paper presents the implementation of different statistical analysis techniques in ship sensor data to monitor the performance.

14.35-15.10 **STOCHASTIC ELECTRICAL PLAN LOAD ANALYSIS FOR INCREASING FLEXIBILITY IN ELECTRICAL SHIP SYSTEMS,** *Alessandro Boveri, Federico Silvestro, Paola Gualeni, DITEN University of Genoa, Italy*

Due to the recent need of more flexibility in electrical ship systems, especially for "All Electric Ships"[1]-[2]-[3], and because of the uncertainty in evaluating the electrical load demand at design phase, a more rational approach is necessary in order to design for a satisfactory Electrical Plant Load Analysis (EPLA). The EPLA is used as an input for determining the required electrical 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 characterize loads with the direct purpose of decrease the amount of electrical power installed on board. Whereas traditional load factors account for uncertainty with margins, stochastic 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 independently of other loads and loads that depends on the configuration. The chosen pdfs are the uniform, triangular 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 working scenarios such as: cruising, manoeuvring, in port and function. Further, statistically important factors are evaluated and results are compared with the traditional load factor approach for two ships model with 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.

15.40-16.15 **INTEGRATED SHIP OPERATION DATA MONITORING SYSTEM FOR DATA COLLECTION AND PERFORMANCE ANALYSIS,** *Kwang-Phil Park, DAEWOO Shipbuilding & Marine Engineering, Korea*

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 a ship's operation in an efficient manner, but also opened opportunities for investigation of ship performance based on operation data. This paper deals with an integrated monitoring system which collects ship operation data during a voyage and two performance analysis functions utilizing the data. When sensor signals are transferred to navigation consoles or control systems, they are also recorded into a database of the monitoring system through interface modules between them. In this way, it is possible to realize a data collection architecture without major changes of existing systems. The monitoring screen is designed to show all the data regarding to ship operation in an integrated way. For navigation performance analysis, ship speed-power relations are obtained from the operation data and compared with those of model test at a similar draft condition. In order to indicate the performance of engine, the relevant processed sensor data are plotted on engine parameter curves which reported from an official test. In the first place, the concept and configuration of the developed system are described. And then the functions are demonstrated by using some operation sample data and simulation data. In conclusion, the necessity and usefulness of the integrated ship operation monitoring system are discussed from a long-term data collection and performance analysis point of view.

16.15-16.50 **REAL-TIME EVALUATION OF SECOND GENERATION INTACT STABILITY CRITERIA,** *Arman Ariffin, Jean-Marc Laurens, ENSTA Bretagne, France Shuhaimi Mansor, Faculty of Mechanical Engineering, UniversitiTeknologiMalaysia, Malaysia*

The performance of a vessel cannot solely be determined as a function of its size, speed and autonomy. The seakeeping behaviour of the vessel in extreme weather conditions is very difficult to predict and the IMO is in the process of introducing new intact stability regulations to deal with failure modes generally associated with extreme weather conditions such as parametric rolling, broaching or pure loss of stability in astern waves. Traditionally, the on-board crew only operates the vessel from a location to another whilst any other repairs, maintenance or decision will be performed by a support crew ashore. The rapid increase of computer power and communication technology allows the onboard crew to perform some advance computation based on the real-time behaviour of the sailing vessel. At the International Maritime Organisation (IMO), the development of second generation intact stability criteria is thoroughly discussed before being enforced in the maritime industry. The lower level (level 1) criteria are conservative but should be easily implemented in stability codes. In this particular study it is examined how an existing and extensively used commercial computer code, in the present case GHS©, could handle level 1 criteria. The possibility of interfacing and integrating with onboard systems for the evaluation of second generation intact stability criteria based on real-time data collected from onboard systems is explored. The proposal is to interface the stability code with the existing Integrated Platform Management System (IPMS) and Weather Meteorological System (WMS). The paper describes the procedure and finally an illustrative example is presented.

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RINA Certificates of Attendance will be issued at the event, which contributes towards the Institution's Continuing Professional Development Scheme. For further details regarding the scheme please contact Giuseppe Gigantesco, Director, Professional Affairs on Tel: +44 (0)20 7235 4622 or e-mail: membership@rina.org.uk

STUDENT SPONSORSHIP
A number of sponsored places at this conference are available for Student Members of RINA. For more information, please contact Paul Rosenthal, Professional Affairs, RINA on Tel: +44 (0)20 7235 4622 or e-mail:prosenthal@rina.org.uk.

PROMOTIONAL OPPORTUNITIES
Why not use this conference to promote your company's products and services? It provides an excellent opportunity to increase your profile and to network with a highly focused audience. We offer a number of cost effective options, including various conference sponsorship packages, exhibition space and literature distribution. If you are interested in any of these promotional opportunities please contact the Conference Organiser to discuss your individual requirements.

CANCELLATION CHARGES
Cancellations received in writing two weeks before the event takes place will be subject to administration charge of £200+VAT. Cancellations received after this time cannot be accepted and are subject to the full event fee. Delegates may be substituted; however, this must be sent in writing and confirmed with the conference Co-ordinator. It may be necessary for reasons beyond our control to alter the content and timing of the programme. In the unlikely event that RINA cancels the event for any reason, our liability is limited to the return of the registration fee.

DATA PROTECTION
Personal data is gathered in accordance with the Data Protection Act 1998. Your details may be passed to other companies who wish to communicate with you offers related to your business activities. Please tick the box below where appropriate:

☐ Please do not pass my information to any third party.

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If you have any questions regarding this or any other RINA event please contact, Catherine Staunton-Lambert, Conference Organiser, on:

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