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Design & Operation of
Wind Farm Support Vessels

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DAY 1 PAPERS:

08.30-09.00 **COFFEE & REGISTRATION**

09.05-09.40 **Keynote, TBC**

09.40-10.15 **DEVELOPMENT OF RULES FOR CLASSIFICATION OF WINDFARM SERVICE CRAFT,**

Mårten Schei-Nilsson, Section for Passenger, Ro-Ro, Light Craft and Naval, DNV Oslo, Norway, Thomas Grafton, Section for Container, Gas Carrier and Special Ships, DNV Pusan, Korea

In 2011 DNV released the first editions of its rules for Windfarm Service Craft. The rules were tailored for craft intended for transport of technical “service personnel” to offshore windfarms and developed as a response to a growing demand from the rapidly expanding offshore windfarm industry. Initially DNV released two sets of rules with the common object to raise the safety consciousness in the industry by setting an internationally recognized standard. One was intended for non-convention craft carrying up to 12 “service personnel” in addition to the ship’s “crew”, developed in the absence of an internationally recognized standard for this type of craft which are more prone to sail between different jurisdictional waters than similar craft built merely for national use. The second rule set was for vessels carrying up to 60 “service personnel”, recognizing the fact that “service personnel” can be considered “able bodied” and should therefore not be considered as normal “passengers” allowing for certain relaxations with regards to safety requirements. While the former has gained a widespread recognition and has been constantly updated as the industry has evolved the latter has, so far, turned out less successful due to lack of internationally accepted terms for and definition of “service personnel”. This paper will describe how DNV has worked with the industry and flag authorities to develop these rules as well as DNV’s continuous involvement in this market for both types of craft.

10.15-10.50 **FATIGUE AND SAFETY - MANNING LEVELS, COMPETENCE AND QUALIFACTIONS,** *David Cantello, TÜV SÜD PMSS, UK*

The demands placed on WFSVs, their crews and the people they carry in the current and future operational environment require that the issues involved are properly identified and appraised in order that operations are conducted safely. The majority of vessels currently operating would be at - or beyond - the limits of the vessel's design and crew's capability in the more distant installations. PMSS has considerable experience of offshore wind farm vessel operations and it has been noted that some significant issues can be attributed to, amongst other things, manning levels, competence and human factors such as fatigue induced by both working time issues and to the workload involved in systems and equipment monitoring. In future offshore developments some of these issues will be exacerbated by increased transit times, required time on station (loiter time) and the environmental conditions experienced further offshore. It is a fact that many of the MCA Cat 1 craft or others currently under development specify similar crew size to present vessels. However, vessel design needs to recognise the inter-related issues of workload, competence and qualifications, operating environment, fatigue and the impact of such issues as the Maritime Labour Convention (MLC).

10.50-11.20 **COFFEE**

11.20-11.55 **HUMAN SYSTEMS INTEGRATION REQUIREMENTS FOR WIND FARM SUPPORT VESSEL DESIGN AND OPERATION,**

Dr Trevor Dobbins; STResearch & FRC International, UK, Jon Hill; Trident Marine & FRC International, UK, Tyler Brand; StrongWake, Canada

The increasing development of the offshore wind farm sector has highlighted issues with both current support vessels, and future requirements as operations move further offshore. Human Factors issues are included in the Systems Engineering approach to vessel design. Unfortunately this often does not always address the wider issues included within Human Systems Integration (HSI). It is essential that the maintenance engineers are delivered to the turbines in the best condition possible to ensure that maintenance is carried out effectively, safely and within the operational window provided. Therefore the vessel must be designed to support the optimal delivery of the passengers, as well as the vessels crew. As the wind farm locations move further offshore the need to operate at higher speeds and in poorer sea states becomes a necessity. This increasing demand on the crew and passengers requires that the Human Element is effectively addressed, and therefore all aspects of HSI become a priority. With the increasing manning requirements of the expanding industry sector, the effective and appropriate training of personnel is a critical requirement. The competencies required for high-speed offshore operations, in poor sea conditions, safe interaction with both ships and fixed-platforms, demands a higher level of competence than is often delivered by traditional training schemes. Also, the growing demand for international interoperability between organisations means that training and qualifications need international recognition. This paper will describe how the recognised HSI process can enhance wind farm support vessel design and operation to improve both safety and operational performance/effectiveness.

11.55-12.30 **DEVELOPMENTS IN SEAT DESIGN AND REGULATION,**

Jules Morgan, KPM-Marine, UK

Developments in commercial vessel speeds, capabilities operating conditions and regulations have been increasing at an exponential rate and in some instances exceeding those experienced in the Military environment. The Paper details a best practice guide on all aspects of seat design/selection and development in terms of WBV, comfort levels, Crash testing, limitation of fit and physiological effects. This paper augments with all WBV and Human factors subjects and is backed by 5 years of research and Doctoral research at Imperial College London. This paper is a valuable guide to Naval Architects, Owners, Operator, Crew, doctors and Injury

12.30-13.30 **LUNCH**

13.30-14.05 **OWTIS™ SHIP DEVELOPMENT - REDUCING OFFSHORE INSTALLATION COSTS AND IMPROVING SAFETY,**

Marzena Dziedzicka, W3G Marine Ltd, UK

In 2010 W3G Marine Ltd (W3GM) was formed to address the offshore construction challenges for the upcoming offshore wind industry. The result has been the development of a number of technologies that will be possible to apply as the industry develops and strives to become more efficient and cost effective over the coming decade. The key asset development has been around the OWTIS™ - Offshore Wind Turbine Installation Ship. This is a floating ship with a 1500t crane and particular deck facilities for sea-fastening structures on the deck. The development of the design was initiated by the knowledge that the way to reduce overall costs is to maximise the construction time on site. Further work has been done for the loading, transportation and installation of fully assembled turbines which will be possible in the future. The OWTIS™ has been further developed in association with IHC Merwede in Holland.

14.05-14.40 **COST-BENEFIT ANALYSIS ON CREW TRANSFER VESSELS TO MINIMIZE DOWNTIME OF FUTURE WIND PARKS,**

Siemon Smid, Olga Mala, Marek Rannala, Tallinn University of Technology, Estonia

The objective of this study was to perform a cost-benefit analysis to compare high stability 25m Crew Transfer Vessels (CTV) for Offshore Wind Park (OWP) servicing in relation with possible operation in high sea state, compared to monohull/catamaran crew transfer vessels and helicopter services. The study concluded that usage of a 25m SWATH (Small Waterplane Area Twin Hull) Crew transfer vessel for servicing OWP-s is economically beneficial for any OWP further away than 50 km from coast and consisting of more than 70 wind turbines (WT), in comparison with any other vessel or manned helicopter. The undiscounted cash flow of deploying a SWATH CTV in comparison to a monohull/catamaran CTV is a total amount of 13 million €, in case of the maintenance of five OWPs located approximately 85 km from the shore and consisting of total 359 wind turbines. A manned helicopter is only suitable for crew transfer to wind parks less than 50 km from the coast and with less than 70 WT-s. The cost-benefit analysis shows that a VTOL (Vertical Take-Off and Landing) UAS from a SWATH vessel can create additional benefits in reducing downtime of wind parks, thanks to its ability to carry out preventive maintenance more efficiently, to reduce the size of the maintenance team required, to prevent corrective maintenance and to further reduce downtime of wind parks. The cumulative benefit of the combination of UAS and SWATH can bring up to almost 48 M€ of benefit in reducing cost of downtime.

14.40-15.15 **PERFORMANCE EVALUATION OF SERVICE VESSELS AND ACCESS SYSTEMS FOR OFFSHORE WIND,**

Breanne Gellatly, Carbon Trust, UK, Simon Mockler, DNV-Kema

Selecting an optimal O&M fleet of vessels for a wind farm is site- specific, depending on distance from port, number of turbines, turbine type and reliability, and maintenance contract. The prevailing environmental conditions and the potential power production of the site are key access design drivers; however, the parameter most often linked with performance of a vessel and the resulting access to the windfarm is operational wave height. The Offshore Wind Accelerator (OWA) has collaborated closely with DNV KEMA to develop a methodology for evaluating service vessel performance. The objective was to create procedures that can be adopted by industry to allow the performance of different access systems to be compared. This can then inform vessel selection and be used to improve O&M logistics models. As part of this methodology, a series of sea trial procedures to measure performance were developed and sea trial programs have been undertaken at two wind farm locations for service vessels fitted with personnel transfer systems. The initial findings from these will inform the conduct of a further sea trial campaign in the autumn of 2013.

15.15-15.45 **COFFEE**

15.45-16.20 **SUBMERSIBLE HULL CATAMARAN**

Dennis Knox, OSSeas Consulting, British Virgin Islands

A revolutionary new design for a catamaran style vessel with the capability to transform into a semi-submersible. The hulls and the superstructure can be physically separated by the superstructure jacking up on vertical supports and the hulls being ballasted down below the wave energy zone. This provides high speed (40 knots plus) transit capability when in hull-up mode, as well as vessel stability in high seas (4m plus) when in hull-down mode. The ability to transform from one vessel type (high speed catamaran) to another (semi-submersible) is unique in the maritime industry. For the offshore wind farm application this means a vessel that can get to and from site quickly, and once on site be capable of working and safely transferring personnel, in sea conditions that any other vessel would find unworkable.

16.20-16.55 **NEW DEVELOPMENTS IN SMALL CATAMARAN DESIGN**

Albert Nazarov, Albatross Marine Design Co., Ltd, Thailand

The paper presents the review of design experience and applied research of catamaran craft, up to 30m in length, of total over 30 catamaran designs, developed by ‘Albatross Marine Design’ and launched during recent years. Architecture of catamarans is discussed; typical catamaran hull shapes are reviewed and their suitability for different applications and desired speeds are studied. Recommendations are given for hull shape particulars selection. Performance issues are studied using available theoretical methods and sea-trials data of number catamarans. Components of resistance of catamarans and methods of their prediction are reviewed. Comparison of methods is presented and samples of their applications for hull shape selection are shown. Seakeeping performance is discussed in terms of vertical accelerations. Results of full-scale measurements of vertical accelerations on number of craft are presented. Controllability discussion is based on turning track measurements for power catamarans of different configurations at different speeds. Structural design issues are reviewed with special interest in composite craft and their improvements. Perspective applications of catamaran concept for different types of craft are indicated, including workboats and wind farming. Presented are samples of catamaran designs for special, small commercial and pleasure catamarans.

16.55- **GENERAL DISCUSSION & DRINKS RECEPTION**

DAY 2 PAPERS:

08.30-09.00 **COFFEE & REGISTRATION**

09.05-09.40 **DESIGN-DRIVEN INNOVATION: MOTHERSHIP CONCEPTS FOR ACCESSING THE FAR SHORE WIND FARMS,** *S McCartan and B Verheijden, EBDIG-IRC, Coventry University*

Recent research has indicated that current wind farm support vessels will not be appropriate for accessing far shore wind farms. In order to improve operability of WFSV accessing the far shore wind farms, mothership vessels will be required. Extrapolating the European Wind Energy Association's (EWEA) growth scenario for the period up till 2030 employment in the installation, operation and maintenance, of offshore wind farms is expected to produce skilled employment of 851,400. To meet this demand it will be necessary to recruit land based technicians. Therefore, next generation motherships will need to address the user needs and aspirations of a new generation of technicians, who may not have previous marine experience. This paper presents several mothership concept design proposals, that challenge perceptions of the working and living environment on commercial vessels by using Design-Driven Innovation to create next generation vessels.

09.40-10.15 **MODELLING OF SUPPORT SYSTEMS FOR OFFSHORE WIND FARMS,** *Ema Muc-Pavic, Anne Salha, Rachel Pawling, UCL, UK*

Conceptually varied support solutions including motherships, offshore accommodation, fast transfer vessels including novel hull forms have been proposed and must he compared against each other with a toolset and procedure capable or encompassing the complete system of systems. This includes overall maintenance strategies, fleet composition, and flexible ship design models. This paper describes recent research at UCL to develop a modelling approach for the maintenance strategy. The project developed a Matlab model incorporating a range of input parameters such as array location, configuration and equipment reliability and developed a maintenance strategy utilising a choice of vessels. The paper then illustrates the application of the UCL developed Design Building Block Approach to the design of a wind farm support vessel and concludes by describing how these tools could be combined to perform a holistic analysis using methods successfully used in a recent procurement project.

10.15-10.50 **MOTHER-SHIP CONCEPT: THE ANSWER TO THE CHALLENGE OF UK ROUND 3?,** *Adrien Benoist, STX France, France*

Offshore wind is following the same development with new environmental constraints that offshore Oil and gas faced few decades ago. UK round 3 developments will push the current operational boundaries with new constraints for operation and maintenances. Considering those assessments, STX France has been developing 3 concepts for offshore wind O&M (A Multipurpose vessel, a Mothership and an accommodation & maintenance Jack-up). Mothership configuration is quite challenging in term of available technology for daughter craft launch and recovery system. Safety for technicians during launch or recovery operations needs the top priority and despite the large range of recue davit systems on the market, there's no marine officer to bet on a davit 100% reliability on an everyday basis. Adding to this fact that 20m workboats are quite heavy compared to current available range and there's an obvious need to find another system solving this issue. Within this context, Divex boat LARS, supported by Carbon Trust, appears as a solution which needed to be investigated. This joint project has been going through promising tank trials showing movements between Divex recovery cradle, STX France mothership and Alnmaritec typical daughter craft.

10.50-11.20 **COFFEE**

11.20-11.55 **LINEAR AND ROTATIONAL STRUCTURAL STIFFNESS OF MOORING SYSTEMS,** *Guillermo Mazon, University of Cantabria, Spain*

The paper presents a study of linear and rotational structural stiffness provided by mooring systems used to fix offshore floating structures such as buoys or wind turbine vessels.First the study introduces most common settings in floating structures mooring and the purpose of the study is evinced. Next the "OC3-Hywind" floating wind turbine prototype is presented as the model in which the study is based. Specific features of this prototype are described as well as the environment in which the study has been tested. Linear stiffness, correspondence between the applied force and the resulting displacement, is analytically defined. Matlab® scripts have been developed to solve the equations established in the former problem and results are presented in a graphical form as a function of different variables such as the length or weight of the mooring lines or the direction and magnitude of the external forces. Finally the paper focuses in the rotational stiffness, ratio between the momentum resulted from the external forces and the resulting structure gyration. A comparison has been made between two different types of mooring lines attachment to the floating structure. These types are direct mooring and "crow foot" mooring configuration, in which each mooring line split into another two lines to reach the structure fairleads. Results are presented in a graphical form analogously to the linear stiffness case. The results obtained enable direct understanding of the stiffness issue that is very useful in the design of mooring systems for floating structures.

11.55-12.30 **ROLLS-ROYCE WATERJET ADVANTAGES,** *Jan Knutar, Rolls-Royce Oy Ab, Finland*

Combining high-performance pump unit, excellent manoeuvrability and strong design gives the operators full control of the vessel at any sea conditions, which in practice means maximized safety. High-efficiency steering nozzle and reversing bucket provide together excellent manoeuvrability at any speed in all directions, making quick dockings with perfect precision standard every time. A good protection against impacts and strong design together provide a minimized need of maintenance. This means well performing water jets at any conditions. These advantages for customers are achieved through a variety of developments using the latest computational fluid dynamics (CFD) techniques combined with extensive testing at the Rolls-Royce Hydrodynamics Research Centre.

12.30-13.30 **LUNCH**

13.30-14.05 **PERFORMANCE EVALUATION OF WIND FARM SUPPORT VESSELS,** *S.Phillips, IB.Shin, C.Armstrong and D.Kyle-Spearman, Seaspeed Marine Consulting Ltd, UK*

This paper summarises the experience gained by Seaspeed in the evaluation of performance of WFSV through extensive programmes of sea trials and model tests. This has been extended to the development of a techno-economic model to assist in the selection of the most appropriate size and type of vessel for particular wind farm applications. The model tests have covered a range of self-propelled free-running trials of different designs, investigating vessel performance in both the transit and transfer modes of operation, including the influence of different access systems. Full scale sea trials on a range of craft have been undertaken in order to investigate and confirm vessel performance in operational conditions.

14.05-14.40 **DEVELOPMENTS IN COMPUTER MODELING OF ATTITUDE AND RIDE CONTROL SYSTEMS FOR A SUSPENDED MULTI-HULLED WINDFARM VESSEL,** *Mike Longman, Nauti-Craft Pty Ltd Western Australia*

Testing of a 1:10 scale model catamaran windfarm vessel, simulating both transit and transfer operations in various wave conditions, has been undertaken. A specialized 8m catamaran prototype/demonstrator has been designed and constructed. MSC.ADAMS (Automatic Dynamic Analysis of Mechanical Systems) software, commonly used in the automotive industry, has been implemented to build a model for design, virtual prototyping and optimization of the 8m vessel (Adaptable to other vessels). The model includes chassis, hulls, location systems, propulsion, hydraulic support systems and a hull/water interface model. The buoyancy based water interface model allows simulations of vessel response to varying sea conditions at various speeds. Simulations of pylon docking, providing pylon contact relative motion, forces and friction forces, show that transfers can be undertaken with improved safety and be able to operate in larger seas than the equivalent sized standard vessel. Modeling of "Deck Attitude Control System" (DACS) enhancements show further improvements are possible with relatively low levels of energy input. Active damping with variable damping valves (common in advanced automotive shocks) have been used to reduce chassis accelerations, control natural frequency modes and provide active bump stops. Various damping algorithms are under development.

14.40-15.15 **PHYSICAL AND NUMERICAL ANALYSIS OF A CONCEPT OFFSHORE WIND FARM SERVICE VESSEL HULL DESIGN,** *Matthew Shanley, University College Cork, Ireland*

Offshore wind turbine maintenance and accessing a wind turbine during high sea states is a key issue for the successful operation of an offshore wind farm. The paper addresses this issue by examining a concept hull design for an offshore wind farm service vessel. The proposed design reduces the vessels heave and pitch motion by dampening its response to the wave motion. The design underwent both numerical and physical methods of testing. The numerical modelling was carried out in a 3-D wave basin built in ANSYS CFX and is based on symmetry across the hull which allows for three degrees of freedom. Physical modelling at 1:25 scale took place in the wave basin at Beaufort Research in University College Cork. A number of variations of the concept were tested and the results showed the aspects of the concept that could be beneficial to personnel transfer, through reduced response amplitude operators at zero forward speed.

15.15-15.45 **COFFEE**

15.45-16.20 **ANN APPROACH FOR HULL FORM OPTIMIZATION OF A FAST WIND MILL SUPPORT VESSEL,** *Assistant Prof. Bülent Devrim DANIŞMAN, Istanbul Technical University, TURKEY, Egemen ÇELİK, Senior Naval Architect / Artı Engineering, TURKEY*

Catamarans attract naval architects with their large deck area and high speed capabilities when to design a wind mill support vessel. Since a catamaran consists of two individual hulls which interfere with each other thus it deserves a special treatment to be investigated in terms of resistance. Optimization of symmetrical demi hulls often fails in reducing the interference wave resistance. In this study, an ANN based optimization procedure is presented which yields an asymmetric demi hull geometry that reduces the wave resistance of the catamaran. According to the procedure, the geometry of the catamaran is presented by a limited number of design parameters. A flow solver based on Dawson's algorithm is used to train an ANN to learn responses of the flow solver to the variations of the design parameters. Then ANN is used as an objective function in the optimization procedure with its computational speed advantage compared to the flow solver. In the scope of the present study, as both the structural design and hydrodynamic loads of an asymmetric demi hull would be unique, the hydrodynamic loads are calculated by using CFD. Then these loads are applied to the demi hull to investigate the responses of the structure using finite element method.

16.20-16.55 **MARINE DIESEL ENGINE SIMULATOR FOR SELF PROPULSION TESTS IN EVALUATING THE FUEL SAVING RATE FOR A SUPPLY VESSEL,** *Agoes Priyanto*, Nur Izzudin Bin Abu and Sunarsih, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Malaysia*

As the supply vessel operates in the rough open seas, a marine diesel engine simulator whose engine rotation is controlled to transmit through propeller shaft is a new methodology for the self-propulsion tests to track the fuel saving in a real time. Considering the circumstance, this paper presents the real time of marine diesel engine simulator system to track the real performance of a ship through computer-simulated model. A mathematical model of marine diesel engine and the propeller are used in the simulation to estimate fuel rate, engine rotating speed, thrust and torque of the propeller thus achieve the target vessel's speed. The input and output are real time control system of fuel saving rate and propeller rotating speed representing the marine diesel engine characteristics. The self-propulsion tests in calm water and waves were conducted using a supply vessel model to validate the marine diesel engine simulator. The simulator then was used to evaluate the fuel saving by employing a new mathematical model of turbochargers for the marine diesel engine simulator. The control system developed will be beneficial for users as to analyze different condition of vessel's speed to obtain better characteristics and hence optimize the fuel saving rate.

16.55- **GENERAL DISCUSSION**

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