MTPC 2014

Newcastle University

The 5th UK Marine Technology Postgraduate Conference

MTPC 2014

9th – 10th June 2014

marine science and TECHNOLOGY

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It is with great pleasure that I welcome postgraduate students from all of the premier Marine Technology institutions here in the UK to Newcastle. The marine industries are an essential element of the global economy, and it is the presenters at this, the 5th UK Marine Technology Postgraduate Conference, who will ensure the success of this sector for many decades into the future.

Rapid changes are taking place in the world today, with turbulence to be found in the natural environment, as well as in the financial, political and social spheres. These developments challenge our best and brightest to identify new ways of solving old problems and innovative ways of solving new problems. The papers to be presented at this conference demonstrate that in the world of Marine Technology we have much talent ready to respond to the challenges.

The high calibre of the papers and of the presenters combined with the many attractions that Newcastle University and City have to offer will, I am sure, make this a memorable event. So once again, welcome to MTPC 2014!

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The inaugural conference (UK MTPC 2010) aimed to bring marine technology researchers together was held in Newcastle and we are happy that this year the conference returns to Newcastle University's campus.

The conference is an opportunity for postgraduate researchers to present their work, learn about research projects at other institutions, network amongst like-minded people and build contacts for the future. The event is also an ideal opportunity for professionals from academia and industry to learn more about the cutting edge research currently taking place within UK marine technology institutions.

This conference is kindly sponsored by Lloyd's Register, with support from RINA and IMarEST.

Conference Programme

Monday 9th June 2014

10.00am Registration

10.30am Welcome Address and Keynote Speech

10.45am **Session 1:**

Hydrodynamics I

Chair: Dr Michael Woodward
michael.woodward@ncl.ac.uk

12:30pm Lunch

1:30pm **Session 2:**

Offshore and Renewable Energy

Chair: Dr Narakorn Srinil
narakorn.srinil@strath.ac.uk

3.15pm Refreshment Break

3:45pm **Session 3:**

Ship Design and Structures

Chair: Dr Adam Sobey
ajs502@soton.ac.uk

5.30pm Close

7.00pm Conference Dinner

Tuesday 10th June 2014

9.00am **Session 4:**

Hydrodynamics II

Chair: Ms Maryam Haroutunian
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10.20am Refreshment Break

10.50am **Session 5:**

Marine Engineering

Chair: Dr Kayvan Pazouki
kayvan.pazouki@ncl.ac.uk

12.30pm Lunch

1.30pm **Session 6:**

Marine Transport

Chair: Dr Stavros Karamperidis
stavros.karamperidis@ncl.ac.uk

2.20pm **Session 7:**

Ship Operation

Chair: Mr David Trodden
david.trodden@ncl.ac.uk

3.35pm Refreshment Break and Judges Discussion

3.45pm Presentation of Prizes

4.00pm Close

Sessions

An Improved SPH Method for Wave Generation in Free Surface Flow Simulations

Muhammad Zahir Ramli supervised by Professor Pandeli Temarel

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Seakeeping analysis involving violent flows is still quite challenging because the conventional Reynolds averaged Navier-Stokes (RANS) approaches for complex numerical methods are not effective in such flow simulations. This research aims to apply smoothed particle hydrodynamics (SPH), a fully Langrangian meshless method to investigate the behaviour of ships travelling in realistic waves. SPH has been used in a wide variety of hydrodynamic problems overcoming the limitation of finite volume/element type methods. It is capable of dealing with problems involving free surface flows, deformable boundary and moving interface. This makes it a suitable alternative for simulating range of hydrodynamic problems, especially those involving severe flow discontinuities, such as slamming, wave breaking and fluid fragmentation, around complex hull-shapes, where the meshes tend to distort and, even, collapse completely.

The main goal of this research is to perform the possibility to implement SPH in 3-dimensional problems for the seakeeping analysis of ships, treated as rigid and flexible body, operating in rough seas. The outcomes of the research will focus on predicting wave-induced motions, distortions and loads and the dynamic behaviour of a flexible ship with particular references to response in reasonably large amplitude waves.

Current work deals with improving standard SPH formulation in generating free surface waves propagating using paddle motion. SPH is based on the convolution of variables through a kernel gradient to estimate the velocity and pressure gradients. The kernel summation of standard SPH formulation is observed to be insufficiently accurate in obtaining the velocity and pressure field, thus perform badly in simulating free surface hydrodynamics. In order to exploit fully particles inside the kernel domain, the accuracy of gradient estimations in divergence-free incompressible SPH (ISPH) is improved up to second order with kernel renormalization technique. Then, the new improved method is modified in order to maintain the stability without increasing the computational cost by slightly shifting the particle away from the streamline while correcting their hydrodynamic characteristics. This will avoids the highly distorted particle spacing around free surface particles which cause instability. It has also been observed that the new improved method results in a very noisy free surface prediction where the calculated pressure oscillates violently. Standard SPH formulation of identifying free surface particles cannot locate free surface with absolute precision and lead to misjudgement of the free surface boundary. To overcome these problems, arc method is applied for fast and accurate boundary recognition.

This improved method is validated for 2-dimensional and 3-dimensional long non-breaking-regular wave case with paddle motion defined by linear theory. The wave propagates in regular waves without decaying with sponge layer absorbing the propagating wave effectively at the right end side of the tank. Analyses on the velocity field and pressure distribution aspects of this new method are then discussed. This initial works will be combined later with ship motion simulation to demonstrate the applicability of the new techniques.

An Intuitional Introduction of Solitary Wave Theories and Their Applications

Qicheng Meng supervised by Professor G. X. Wu

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The solitary wave is a special form of water waves. It is self-reinforcing and maintains its shape while it travels at constant speed. From the mathematical perspective, it is due to the cancellation of nonlinear and dispersive effects. Its characteristics indicate that it can retain the energy over a long distance. That is the reason why solitary waves occurring in a tsunami are destructive.

Not only does the solitary wave occur on the surface, but we also found it in the interior of the ocean. As we know, the water in the ocean is stratified. At the interface, so-called internal solitary waves can be generated and propagate. Owing to the reductive gravity effect, the amplitude of internal solitary waves can be as large as 150 metres or more. It is a grand but ubiquitous phenomenon in nature.

The presentation is aimed to share the knowledge of solitary wave theories and how they link to the engineering applications. The discovery of solitary waves has been a classic story to challenge the pre-existing theories. Novel wave theories had to be developed to cope with this natural phenomenon. Then the theoretical studies and laboratorial experimental studies uncovered more physical natures and can be extensively applied to the marine engineering. In the presentation, the author will try to explain the theories and their applications in an intuitional and interesting way.

In addition, latest progress in the analytical and numerical studies on solitary waves will be illustrated. The author has found that using higher-order analytical solutions as the initial conditions of numerical simulations can significantly improve the accuracy and extend the range of validity of the numerical simulations for solitary waves. This fundamental research is supposed to be essential for simulations of marine engineering problems with respect to solitary waves in the environment of complex geometry and topography.

Development of a Nonlinear Mathematical Model of High Speed Planing Craft Capable of Modelling Roll Motion

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High Speed Planing Crafts have been widely used in many fields of application such as military patrol vessels, rescue boats, sport and leisure craft etc. The motions of these craft in waves are potentially extremely large due to their non-linear hydrodynamic characteristics. This behaviour can have a significant impact on both the crew operability and the structure of the craft itself. A number of existing investigations have been conducted using both model experiments and numerical simulations of planing craft in waves but almost all of them are limited to longitudinal plane motions (surge, heave and pitch), which corresponds to head sea condition. In reality, these craft will encounter other sea conditions such as oblique or lateral seas that would cause motions in other degrees of freedom, i.e., roll, sway and yaw. Therefore, there is a need for a nonlinear mathematical model with these additional degrees of freedom especially roll motion which appears to be a significant influence of ship operability.

A nonlinear mathematical model capable of simulating the motions and accelerations of high speed planing craft in heave, pitch and surge has been developed based on the works of Zarnick (1978) and Keuning (1999). The hydrodynamic coefficients applied to the model are obtained from a combination of theoretical and empirical relationships. The total forces and moments acting on the hull are found from integration of sectional forces and moments determined through a strip theory approach. The sectional forces are determined by wedge water entry theory developed by Wagner (1932). The planing hulls used in the simulation are based on Fridsma's experiments (1969) and used further for validation. The numerical differentiation and integration has been verified through a systematic investigation of the number of hull sections on the instantaneous equations of motions evaluation and varying time step in time marching integration in order to get the most appropriate numerical methods for any arbitrary hull form.

This paper will present the results of the verification and validation process carried out using Fridsma's experimental results. The paper will then continue to show the approach used to model the additional roll degree of freedom (coupled with heave and pitch) and make initial comparisons with the limited experimental data available.

The Motion and Security of Moored Floating Bodies

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The RNLI is an independent charity funded by voluntary contributions, in 2013 their lifeboats launched on 8,304 occasions aiding 21,938 people, including 425 lives saved [1]. The institution is committed to reaching "at least 90% of casualties within 10 miles of their stations in all-weathers within 30 minutes." In order to achieve these targets 40 all-weather lifeboats are permanently moored afloat (Figure 1). The location and configuration of these single point moorings (SPM) has to date been determined by local knowledge of wind, tide, current, fetch and topography complied over generations. Clearly the loss of a lifeboat whilst secured on its mooring is preventable and is therefore unacceptable and so a method is needed to improve upon this imprecise science as a failed mooring would cost money and potentially lives.

Due to the expansion of offshore oil and gas extraction much research has been published over the last thirty years on the behaviour of large scale tankers stationed at SPM in deep water or at harbour jetties in shallow water. To date there is a lack of published data on the efficacy of the SPM of circa 17 m vessels located in shallow depths up to 10 m. The aims of the tests outlined below are to formulate a method to accurately predict the motions and forces of a lifeboat interacting with its SPM and subsequently explore the potential and feasibility for in-situ energy extraction from the moored vessel's motions.

Unlike a taunt mooring a SPM maintains its security by changes in suspended line weight in order to optimise the mooring to the varying forces [2] the quantification of which will be the focus of the initial stages of the project. At low frequencies the mooring behaves like a spring but as the frequency increases inertia and drag forces begin to take significant effect [3]. In shallow water the use of constant hydrodynamic coefficients cannot be justified [4] and the dynamic tension of the mooring depends strongly on the ratio of elastic stiffness to catenary stiffness and typical displacements are 4-10% of water depth [5]. Initial trials in a forced loop flume tank will use an Xsens motion recorder and load cells to measure the motions and resultant mooring line loads of a 1:20 model lifeboat. The tests will be performed under varying mooring configurations and chain lengths for depths of 2, 5 and 10 m and unidirectional current flow rates of 0.5, 2.5 and 5 m/s. These acquired data will be compared to; (1) the numerical simulations of a hydrodynamic model built upon a double pendulum dynamic and (2) in-situ recorded data at RNLI lifeboat stations at different coastal locations around the United Kingdom.

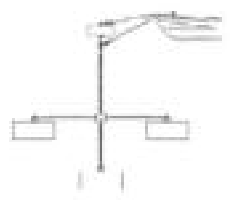

Figure 1: Single point swing mooring located at Humber (adapted from RNLI drawing MT- 00390).

The improved understanding of the mechanics of mooring line damping and the six degree motions of a lifeboat at its SPM will result in the reduction in risk of failure from improved selection of mooring location and design. The quantification of the rolling, pitching and heaving of the moored lifeboat in different sea states will facilitate the future work on the economic feasibility of extracting energy from its motions.

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A Comparison of Uncoupled and Coupled Analysis for Offshore Floating Wind Turbines

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This presentation will investigate and compare the platform nonlinear dynamic responses and mooring line tensions of offshore floating wind turbines based on coupled and uncoupled analyses. The OC3-Hywind Spar platform and a 5 MW baseline wind turbine developed by the National Renewable Energy Laboratory is considered as a preliminary study. The FAST software is used for the uncoupled analysis whereas the bundle OrcaFlex-FASTlink package is used for the coupled analysis. Simulation results for OC3-Hywind behaviors under various environmental loading conditions (winds, waves and currents) will be compared and discussed, aiming to highlight the importance of mooring lines dynamics and their contributions to overall 6-DOF responses of floating turbines. Some comparisons with available experimental testing results will also be made to validate the analysis models and outcomes.

Development of a Coupled Model of Dynamics for Floating Vertical Axis Wind Turbines

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The need to exploit larger wind energy resources has pushed offshore wind farms into deeper waters where floating foundations become economically feasible. So far the optimal onshore wind turbine design, that is, the 3-bladed horizontal axis wind turbine (HAWT), has been 'marinised' for use offshore, but it may not be the optimal design for floating wind applications. The vertical axis wind turbine (VAWT) is one promising alternative for large multi-megawatt floating wind farms as it may be more suitable for this application than HAWTs [1]. As floating VAWTs are a novel concept, their relatively complex dynamics in the offshore environment are not yet fully understood. This article presents the current development of FloVAWT, a coupled dynamics design tool for analysing floating VAWTs during preliminary design stages. It has been developed entirely in the MATLAB/Simulink environment that allows for accelerated model development, interchangeable modules and use as an educational tool.

The aerodynamic model implemented in FloVAWT is based upon the Double Multiple Streamtube (DMST) model with a number of modifications. Firstly the conventional velocity formulation used was substituted with a vector formulation first utilised in VAWT vortex models by Strickland. Further additions include the Gormont-Berg dynamic stall model, tip losses, 3D effects, turbulent incident wind, tower shadow effects and tower forces. A novel approach has been taken when calculating induction factors for a moving rotor, whereby the induction factor is not only a function of the ambient wind speed but also of the platform-induced wind speed.

The hydrodynamic model was built using the Marine Systems Simulator (MSS) Toolbox. The coupled 6 DOF equations of motion are based on the Cummins equation for floating structures. To improve the computational performance of the design tool, the convolution integral representing the radiation force is approximated through a state space model for each DOF coupling. First order wave excitation and wave drift forces are implemented through potential flow theory, and a linearised hydrostatic matrix is used. A number of catenary mooring line models have been developed, with the quasi-static model being the most elaborate and solved using an energy-based approach. Modelling of tensioned mooring lines is achieved through a linearised stiffness matrix. Some inertial characteristics specific to a rotating turbine are also modelled. Gyroscopic forces and the variation of the global inertia matrix have been included through analytical formulations. A case study of a floating VAWT is presented to showcase the potential application of this design tool.

References

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Numerical Investigation of Unsteady Aerodynamic Performance of an Offshore Wind Turbine

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For an offshore wind turbine, the good aerodynamic performance is the key factor which affects the power coefficient. In this presentation, unsteady flow features and the blade aerodynamic loading of the National Renewable Energy Laboratory phase VI wind turbine blade were numerically investigated by using computational fluid dynamics (CFD). The aim of this presentation is to assess the prediction capabilities of wind turbine aerodynamic performance and set up the experience of wind turbine aerodynamic design in order to provide fast and effective detection means of numerical simulation performance. CFD numerical simulation is able to describe complex geometric boundaries and flow structures. The CFD method developed is systematically validated for a range of problems starting from simple 2-D model problems to full scale wind turbime blade cases. The analysis also shows significant improvements in airloads prediction compared to a table lookup based Blade Element Momentum theory analysis. It is found that both the normal forces and pitching moments are dominated by three dimensional aerodynamic effects.

Turbulence and Wake Effects in Tidal Stream Turbine Arrays

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Societal concerns about the climate change and greenhouse gas emissions coming from burning fossil fuels for energy production have led to increased activity in the renewable sector. Many countries and political unions have set targets to increase the share of energy generated from renewable sources such as biomass, geothermal, solar, wind and oceans.

The ocean has been largely overlooked in terms of electricity generation up to now due to the high costs and harsh working environment. Ocean energy is mainly concerned with wave and tidal energy; however other methods of generating electricity from salinity or temperature gradients are being investigated as well. Since the tides result from the gravitation force of sun and moon acting on the earth, the time and extent of tidal flows can be predicted with a high degree of accuracy which makes it well suited for reliable long term electricity production. The marine energy resources of the oceans (wave and tidal energy) are estimated to be about 70 – 100 TWh/y for the United Kingdom alone, which would cover about 20% of the UK's electricity demand and contribute to CO2 savings of up to 100Mt.

Predicting the performance of tidal stream turbines is a challenging task as the performance depends strongly on the local geographical conditions (bathymetry) of the channel, river or coastal area. A key to success of tidal energy converter is the performance when deployed in arrays (or farms), which is necessary to generate sufficient energy to supply homes and in order to commercialise such technologies while reducing the costs.

However, there are several issues with the development of tidal turbine arrays at present such as the interactions of turbines in a highly turbulent flow field and their effects on the power production performance of single turbines and arrays as a whole. Further, due to the high costs of developing this technology, little full scale data exits and the unique features of each tidal location make it very difficult to assess the power performance of tidal stream turbines prior to deployment. This is why it is important to have reliable performance and flow field predictions based on scaled experimental tests and validated numerical simulations to reduce the cost of development.

This work aims to investigate the wake and turbulent flow field of tidal stream turbines in different operating conditions and examine the effects on the performance of single turbines and arrays through experiments and numerical simulations. The presentation will provide a brief summary of existing technologies and methods used to simulate tidal stream turbine characteristics as well as giving an overview of the research project and its aims.

The Floating Production, Storage and Offloading Vessel Design for Deep Sea Oil Field Development

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The oil and gas exploration and production activities in deep sea are now on a steady increase globally. Therefore, it is necessary to design a cost effective and safe system for these operations. The main objective of this research is to design a Floating Production, Storage and Offloading (FPSO) vessel suitable for operation even in extreme meteorological and oceanographic conditions. In order to achieve this, the impacts of extreme environmental loads on the vessel have been evaluated in terms of the maximum responses in surge, heave and pitch modes of motion. Furthermore, an interactive programme, the Principal Dimensions Programme (PDP) has been designed to accurately evaluate and optimise the principal particulars based on the obtained response amplitude operators (RAOs). Results show that the vessel length, which is directly proportional to the cube root of the cubic number (the overall volume), is a measure of the critical wavelength. Close to the critical wavelength in extreme metocean condition, the vessel could be subjected to several billions Newton meter of Wave Bending Moment if not suitably damped. This design technique, in addition to the numerous useful data obtained, helps to ensure good performance during operation and so reduces downtime, and increases uptime, safety and operability of the vessel even under the some harsh metocean conditions.

Keywords: FPSO, principal dimensions, response amplitude operators, extreme environmental loads.

Formulating Design Requirements of Sustainable Fishing Vessels for Indonesian Fisheries

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As one of the biggest Nation in capture fisheries in the world, Indonesia has huge number of fishing fleets. According to Indonesian Ministry of Marine Affairs and Fisheries, there were about 557,140 fishing vessels along the 81,000 km of Indonesian coastal line in 2011 [1]. The differences on the local resources have led to variety design of local fishing vessels and it became the identity of each fishing community in every region in Indonesia. Local fishing vessels have been improved for many decades based on local demand and support by local knowledge. However, the economic condition, education background and lack of access to the technology limited the improvement of the fishing fleets [2]. The designs of the vessels have been inherited and, with other traditional fishing vessels, tend to evolve and not to follow the conventional process for designing fishing vessels [3]. On the other side, changes on fish resources and environment have raised the question as to how the existing fishing vessels could survive in the future and could fulfil the future demand of the fisheries sector in Indonesia.

To develop sustainable fishing vessels for Indonesian fisheries, it is important to understand all design requirements that fit to local needs without ignoring global concerns in this sector. The changes on resources, environment, technology, regulations, and future demand are supposed to change the design requirement and parameter on designing fishing vessels [4]. Studies have been done in three fishing communities in Indonesia to identify local needs related to fishing vessels. The design requirements that should be considered when designing fishing vessels for Indonesia will be presented. Any obstacles that would affect the design of fishing vessels will be defined as well.

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Polymer Failures on Yacht Structures

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In the last few years, the demand for large vessel construction from royal owners has increased. With the increase in mega yacht construction and the increase in yacht length, a surge of coating system failures was observed. The main type of failure observed was cracking of their epoxy-based filler components. The rise in yacht length and therefore the complexity of construction made the filler cracking problem more apparent. Mega yacht design can be comparable to naval vessel design. The level of complexity of mega yacht construction is much closer to frigates and warships than commercial vessels. The primary purpose of this study is to perform a detailed investigation on epoxy-based filler failures, in an attempt to fully understand the fracture behaviour of the polymer material. Finite element methods will be used to investigate fatigue crack initiation and crack propagation of the filler material. Also, the numerical results obtained will be validated with experimental testing procedures.

Overall, filler cracking can be attributed to a combination of factors which lie among the design of the material; material manufacturing methods; application methods (voids presence); thermal cycling effects; vessel construction issues and high levels of cyclic stress transmitted to the filler. A design tool of prediction of mechanical loads transmitted to the polymer material will be developed. Also, the effect of the mismatch in material properties between the substrate and epoxy filler will be studied. The influence of parameters such as stiffness of the materials, thermal expansion coefficients and fracture toughness values will be examined. The initial numerical results that have been obtained show a better understanding on the epoxy filler behaviour. Again, the primary purpose of this research is the development of essential guidance for best practice in yacht design, development of application guidelines, filler manufacturing and maintenance guidelines.

Modelling Pipeline CO_2 Corrosion for CO_2 Partial Pressures of up to 150bar

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The effect of carbon dioxide corrosion on pipelines is very important to the Petroleum and CO_2 sequestration industries due to the severe impact on lost production and pipe integrity. Several models have been developed over the years for the accurate prediction of carbon dioxide corrosion rates in order to cut costs associated with corrosion mitigation and prevention.

For oil and gas production, the focus has predominantly been on the investigation of internal corrosion of pipelines for relatively low partial pressures of CO_2 – not exceeding 20 bar. Sequestration applications on the other hand are known to involve the transport of captured carbon dioxide in the super-critical state ($ScCO_2$) often via existing offshore pipelines to its designated geological reservoir where it is eventually injected. For these applications CO_2 partial pressures are in the range of 700-120 bar or greater.

The aim of this project is to develop a universal model which will accurately predict pipeline internal corrosion rates for a wide range of carbon dioxide partial pressures. Attempts will be made to investigate internal CO_2 corrosion of pipelines by the implementation of prediction tools such as multivariate analysis and neural networks. Predicted results from these models will be compared against each other and against data sourced in open literature, for validation purposes.

Preliminary Performance Estimates of Flapping Foils for Autonomous Surface Vessel (ASV) Propulsion and Power Extraction in Waves

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Keywords: flapping foil, ASV, wave energy, quasi-steady

The motivation of this study is to contribute to the attainment of self-sustainable wave energy scavenging for propulsion and power generation on board ASVs, such as AutoNaut shown in Figure 1. Comparing studies on flapping foils for power generation and that of wave devouring foils for augmenting marine propulsion, this paper proposes that there is a need to overlap these studies and analyse the power extracting capabilities of wave devouring flapping foils. A quasi-steady method is implemented to investigate the dominant mechanical and kinetic parameters that affect the performance of a flow-induced flapping foil with a forward speed in incoming waves. The kinematic 2D model is simplified to represent an ASV pitching and heaving in head waves with a single foil, which is constrained in pitch by a rotational spring and constrained in heave by a linear damper, mounted at a constant depth beneath the vessel. The aerodynamic properties of a NACA0012 foil, over an angle of attack range of 180 degrees and at a Reynolds number of 3.6x105, are interpolated from experimental data to evaluate the hydrodynamic forces in the quasi-steady model. Although the numerical method does not solve the problem formulations as a dynamic system, the model shows close correlation with the 2D quasi-steady and 3D potential-flow models implemented by Zhu et al [1]. The fundamental numerical method, in comparison to the methods applied by Zhu et al, is validated by modelling the same system of a flapping foil with prescribed pitch in a uniform flow and comparing the flow-induced heave amplitude. Results from numerical simulations show an inverse relationship between the thrust and power coefficients, also supporting conclusions made in previous studies. At low wave frequencies this model shows that the wave devouring foil system has the potential of extracting power from the system as well as generating thrust.

Figure 1: AutoNaut developed by MOST (Autonomous Vessels) Ltd [2]

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Cavitation Noise Prediction of Marine Propellers using a Systematic Series Approach

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The rising environmental awareness regarding the various emissions caused by the marine transportation has recently targeted the underwater radiated noise from marine shipping. The low frequency underwater radiated noise has been known to travel miles due to the low absorption rate of the medium, and therefore has been thought to shadow the survivability of the marine mammals that use such frequency bands for their fundamental living activities. Originating from the above concerns the international organizations such as IMO and MEPC has made calls to study the underwater-radiated noise from marine shipping with the potential guideline development or regulation to be enforced in the future.

Within the above framework this PhD is dedicated to the cavitation noise prediction by using a systematic approach. The systematic approach will utilize the readily available Meridian Series Propellers and will provide a better understanding of Propeller design in terms of the effect of various propeller parameters on underwater radiated noise. This information will provide a guideline for any regulation to be enforced and ensure the sustainable noise levels for marine environments.

During the course of the PhD, the research has also been planned alongside the UNEW's SONIC project commitments. As planned in the project proposal; activities such as Full Scale on-board pressure measurement campaign has been successfully completed and due to be repeated on a larger extent by UNEW this summer. Furthermore cavitation tunnel experiments with The Princess Royal dummy model have been successfully accomplished and the ECT Report is due to be submitted by the end of May 2014. Finally a round robin test of The Princess Royal propeller in inclined shaft conditions with Hydro Testing Forum members has been agreed. The systematic tests have been accomplished successfully with significant findings and the report for the experimental campaign is due to be shared with forum partners by the end of the month.

Overall the experience accumulated from the activities during the course of the second year of PhD has enabled better understanding of measurement capabilities, processing techniques and an understanding of best approach. The knowledge will now be utilized during the summer of 2014 for the planned cavitation tests of the selected subset of the meridian series propellers with the produced wake inflow. The data acquired using the available sensors such as hydrophones, pressure transducers and cavitation observations will then be utilized to create a noise prediction tool using statistical tools such as Regression formulas or Advanced Neural Networks.

Data-rich Experimental Fluid Structures Interaction of Composite Structures Under Wind Loading

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An experimental technique to accurately quantify the deformation and the bend-twist coupling of aero-elastic tailored composites foils under fluid loading is presented.

A three dimensional Digital Image Correlation (DIC) methodology suitable for use within a wind tunnel is developed. The technique allows for the measurement of full-field deflection during fluid-structure interaction (FSI) experiments. Combined with DIC the foil tip vortex strength and position is assessed using Particle Image Velocimetry (PIV) to correlate the variation of the vortex position and strength due to the deflection of the board. The results presented in the paper, using the non-contact, full-field, data-rich DIC and PIV techniques provide a complete response of the structure under investigation. The data-rich nature of the experimental measurement techniques allows for a wide range of analyses of structural response to fluid loading.

Experimental results are presented for a high performance curved foil from a NACRA F20 catamaran tested within the University of Southampton RJ Mitchell wind tunnel. The fluid regime is chosen to have a Reynolds number equivalent to light upwind sailing conditions (6 knots) with a fifth of the fluid loading experienced in the water. The design philosophy of a curved foil is to provide both a hydrodynamic side-force to counteract the aerodynamic forces of the sail but also to provide a vertical lift force to reduce wetted surface area and hence resistance.

The results present the aero-elastic response of the foil. The data is examined to evaluate the coupled deflection and blade twist over the tip region of the foil for a representative range of wind speeds and angles of attack. The range of wind speeds and angles of attack create flow conditions varying from fully attached flow to a separated flow. Analysing the data-rich deflection results from the full field technique it was possible to detect an interesting twist phenomenon near the tip of the board, which could be affecting the amount of vertical force generated by the deformed foil. This phenomenon highlights the benefits of the presented methodology over fixed-point measurements as the board tip deflected shape can be assessed in a three dimensional analysis. The comparison of the foil deflection with its tip vortex, evaluated at one chord downstream, provides an understanding of the composite structure response under loading.

Marine Engineering Energy Modelling to Evaluate the Efficiency and CO_2 Emissions from Larger Carriers

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The CO_2 emissions from large carriers transporting wet and dry cargos are dominated by those emitted by the two-stroke diesel-engines burning heavy fuel oil (HFO) that provide for power and propulsion. These engines are usually fitted with an exhaust gas waste heat recovery system used to produce steam for heating (cargo and accommodation) and also for generation of electricity using a turbo-generator for service, cargo and engine ancillary needs. Alternatively shaft generators are sometimes used for generating electricity.

This presentation examines the CO_2 emissions from large carriers and identifies where losses in the marine engineering plant occur using a marine engineering plant (MEP) energy model that has been developed by the author. A description of the plant is provided covering the various equipment including main engines, waste-heat recovery plant, boiler, steam-turbines, etc. The presentation then explains the modelling effort for each component and sub-component by way of explaining the algorithm development which embeds the mathematical relationships. The paper also explains the validation and verification processes used by the author to ensure authenticity of the various components and also the integrated model representing the marine engineering plant.

The presentation will explain how the model is used to show the efficiencies of the components and subcomponents in the plant and CO_2 emissions emitted. The results also address the changes that occur as the vessel is subjected to various operational scenarios such as speed, loaded and ballast passages, and in port operations.

The development of the model has identified key areas to target for efficiency improvements whilst also identifying the physical limitations of these improvements through examining the heat balances. The paper concludes by making recommendations into the improvements of the main and auxiliary systems from large carriers are necessary to reduce their CO_2 emissions at navigation and at port and the author's future work will be discussed.

Assessment of the Effectiveness of Fuel Cells as an Alternative Technology for Marine Propulsion Systems

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There is a significant interest in the development of energy efficiency of ship propulsion systems; due to the rise in fuel prices and the increasing pressure on the marine industry to reduce its environmental impact. A recent IMO study estimates that shipping in 2007 have emitted 1,046 million tonnes of CO2, which is about 3.3% of the global emissions during 2007 [1]. Moreover , shipping is also responsible for a greater percentage of NOX emissions which is about 20 % of global NOX emissions from all sources [2]. Also, compared to other transport modes, shipping has the highest SO2 emissions [3].

Hybrid electric power and propulsion concepts was one of the Energy Efficiency Design Index measures published by the IMO in 2009 to reduce the Greenhouse Gases emitted by ships through increasing its energy efficiency. This work aims to improve and enhance our understanding of hybrid propulsion system onboard ships using fuel cell as a main source of power and its effect on the energy efficiency of propulsion system to reduce harmful ship emissions. This work presents a time-domain simulation tool capable of predicting the required power for a ship developed by using MATLAB/SIMULINK which was used to model and simulate ship propulsion system containing ship, propeller, motor, and a fuel cell as a source of electric power to make use of its better fuel efficiency even in part load, quiet operation and lower emission operation [4,5]. This tool is used to examine how fuel cell can be used to provide long endurance missions for an autonomous ship model.

In parallel with the simulations, model scale experiments were done using a 1/60 scale free running tanker model developed by University of Southampton which is capable of navigating itself through test routines and recording the results using the Robot Operating System (ROS). Experimental results from towing tank self-propulsion tests and lake tests are used in the validation of the simulation tool and the results from SIMULINK have shown good match with the experimental results especially propeller revolutions readings but errors were higher with thrust and torque that's why more experimental work is needed to be done after some hardware modifications to have more accurate data.

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Environmental Policy Constraints for Acidic Exhaust Gas Scrubber Discharges from Ships

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The main products in the combustion of fossil fuels in air are carbon oxides and water. Due to fuel impurities and incomplete combustion a number of by-products may also be produced, the main ones being sulphur oxides, nitrogen oxides and carbon based matter (soot, smoke). The by-products exist in small quantities but have a disproportionate effect on the environment. Sulphur and nitrogen oxides in the atmosphere form either wet precipitates (acid rain, snow and fog) or dry precipitates (acidic gases and salts). These precipitates affect the acid-alkali balance of fresh water systems, in which pH recovery to original levels takes a long time because of reduced concentrations of dissolved alkaline substances.

Increasingly stringent environmental legislation on sulphur oxide emissions from the combustion of fossil fuels onboard ships (International Maritime Organization (IMO) Regulation 14) can be met by either refining the fuel to reduce sulphur content or by scrubbing the exhaust gases. Commonly used open loop marine scrubbers discharge warm acidic exhaust gas wash water into the sea depressing its pH. The focus of this paper is on the physics and chemistry behind the disposal of acidic discharges in seawater.

Seawater is a weak alkaline buffer solution which contains a large number of dissolved salts, some of which affect its pH. Calcium carbonate is a sparingly soluble alkaline salt common in seawater. Therefore, the seawater alkalinity is frequently estimated in calcium carbonate equivalent moles. The buffering capacity of seawater is also influenced by water temperature, depth, salinity and coastal runoffs. For example, glacial ice melting in the summer introduces fresh water into seawater reducing the acid buffering capacity. Typical values of seawater alkalinity around the globe range from 2200-2400μmol/kg. In parts of the Baltic Sea, however, alkalinity is far lower at 800μmol/kg.

The IMO Marine Environment Protection Committee (MEPC 59/24/Add.1 Annex 9) requires the wash water to reach a pH greater than 6.5 at a distance of 4m from the point of discharge. We examine the engineering constraints, specifically size and number of ports to identify the challenges of meeting regulatory compliance.

Implications of Ballast Tank Geometry and Cleaning Technology on Treatment Efficiency

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Regulation D-1 of the 2004 BWM Convention requires that pumping seawater into a ballast tank should achieve a volumetric flushing efficiency of 95%. The ship-board tests of Regulation D-2 require a total treatment efficiency of 90%. The ballast water treatment efficiency of a multi-compartment ballast tank depends on the geometry (hole resistance, compartment capacitance, outlet position and connection pipes position), exchange volumes (flushing time) and cleaning technology (cleaning efficiency). To examine the influence of tank geometry and cleaning technology on satisfying IMO protocols, we develop and validate a general network model to analyze the transport of contaminants through a ballast tank.

We apply the model to analyze flushing from typical ballast tanks. For the double hull tank considered, we identify configurations where the requirement for exchange volumes can be relaxed. The reduction of flushing from 3 to 1.7 exchange volumes may achieve a cost saving of about $22,314-31,045 for a ship per stop. When ballast water sampling is undertaken from the discharge port, the contaminant reduction of the sample is not necessary to be 95% at three exchange volumes.

We investigate the influence of cleaning technology on the total treatment efficiency of the closed-loop system. For the future closed-loop treatment system consisting of an exchange unit and a cleaning unit, at a cleaning efficiency of 70%, 1.9 exchange volumes is needed to achieve the 90% treatment efficiency; the cleaning technology for the double hull tank needs to achieve at least 58% efficient to attain a treatment efficiency of 90% at three exchange volumes.

Complex Adaptive Development Analysis of Marine Container Transport System

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Marine transport is a waterway based, extremely competitive means of transport providing transfer of high volume of cargo over long distances in the possible cheapest way. Marine transport system consists of ships, ports, waterways, intermodal connects, supportive systems (e.g. education, finance, customs, insurance etc.), and system users components. As nature of global trade developments, marine transport system components specialise on certain cargo types. Thusly, it is possible to differentiate and to categorise marine transport systems for each major cargo types of seaborne trade. Evidently, containers are one of the main cargo types of shipping business at present and around 17% of total seaborne trade volume as weight is carried in container boxes. If we look at the value of cargo carried, we can notice that much higher proportion of seaborne trade as value is carried in container boxes. The marine transport system specialised on container cargo type can be called as "marine container transport system". From a system science point of view, marine container transport system started systematically "being" to enable "door to door" delivery of various industrial products from shipper to consignee via utilisation of standardised transport units on integrated different means of transport. Characteristically, marine container transport system is a complex system obtaining many adaptive capabilities.

Since first container shipped in 1956, container transport has experienced various adaptive changing enforcements from the system environment and achieved significant complex adaptive developments in the dynamic system environment. One of the main objectives of this research is to determine development of system properties and functions of global marine container transport system to have clear comprehending on chronological system development direction stages and underlying self-organisation dynamics of marine container transport system. Furthermore, this research mainly focuses on analysis of actual state of present marine container transport system operations and raising business trends. By the guidance of raising business trends and known significant further system environment changes, this research mainly contribute to forecast adaptive development and self-organisation of marine container transport system for upcoming years. Ship size enlargement trend effect on container shipping, competition of new generation shipping alliances, utilisation of the LNG as a marine fuel for container ships, and effect of new canal extensions and constructions on container shipping are determined as four main adaptation directions for marine container transport system. Operational research network modelling approaches, Cournot oligopoly competition model, cooperative and non-cooperative game theories, system dynamic simulation, and decision making systems are main methodologies of these research. Findings of this research will provide huge benefits to well establishment of future planning strategies and critical decision makings of marine container transport stakeholders.

Agents' Behaviour: Buying and Selling of Ships

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The purpose of this research is to investigate what can be regarded as the average period of ownership in shipping and therefore determine the typical investment horizon for a vessel owner. This PhD research aims at providing further insight into strategies adopted by agents in terms of sale and purchase policies, which will facilitate marine service and equipment providers, such as sale and purchase brokers and retrofitted equipment and systems manufacturers at targeting customers. The analysis incorporates factors such as owner nationality and adopted business model and it is focused on the three main ship types – bulk carriers, tankers and container ships.

To date, the changes in ownership of all vessels of 30 000 dwt and above built between 1987 and 1997 have been recorded. The data will be extended in order to incorporate younger segments of the fleet and statistically extrapolated to reach conclusions with regard to the current and likely future behavior of owners. The results to date reveal that the patterns of behaviour corresponding to first and subsequent owners differ considerably with first owner retaining the vessel for much longer and that at least 20% of shipowners keep vessels for their full economic life.

Intelligent Navigation System for Unmanned Surface Vehicles

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Unmanned surface vehicles (USVs) are gaining attention due to their increasing uses by both military and scientific missions. Without the need to deploy a human operator onboard, benefits include no human risks/casualties, lower operating costs as well as the reduced energy consumption for most missions. Researches into the USV path planning and autopilot control are being studied so to improve USV's performance and to ensure appropriate levels of safety. It is necessary for a USV to have its own intelligent navigation system onboard to provide precise navigational information such as the position and orientation needed for the path planning.

Nowadays the most common navigation method employed for position identification is the Global Positioning System (GPS), which is able to provide absolute position information. However, it suffers problems of signal reliability and continuity in harsh environments. Recent trends to improve the accuracy of the navigational data are to use multiple-sensor data fusion technology. In my research, instead of using a stand-alone GPS receiver, an inertial navigation system (INS) has been employed as a complementary device. The INS measures accelerations and rotations by inertial sensors and is able to predict ongoing positions when the GPS signal is not available. In a complimentary arrangement the navigational data obtained by the GPS can be used to correct the drifting of inertial sensors thereby overcoming the INS's shortage with long-term accuracy.

My presentation introduces a hybrid navigation system in which a number of different signals are merged to provide precise navigational data. It has been developed using an embedded hosting platform consisting of navigational data acquisition and fusion processes. Kalman filter techniques have been applied to merging data obtained from a GPS receiver and an Inertial Measurement Unit (IMU) to provide the accurate position of the USV. Also, signals from an AIS receiver and a marine radar are processed to determine target ships' (TS) positions. To improve the fault-tolerant capability, a fuzzy multi-sensor data fusion system is designed to handle the situation when malfunctions occur. The output of navigation system is a synthetic navigation map representing the dynamic environment in which the USV operates such that it could be used to assist mission planning such as path planning.

Human Orientated Ship Design

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The human error is still the main contributing factor of accident, even though excessive amount of automation and technological developments are utilized to increase safety. Unless seafarers, designers and regulatory bodies give enough importance to human factors issues, immense task load will continue to trigger human errors on boards. Current human machine interface systems did not decrease the amount of task loads, just converted them to different kind of work (e.g., monitoring instead of manoeuvring). There is also incompetency on human machine interface design and HMI design does not meet the limitations and capabilities of the seafarers. The intention of this paper is identify human errors on board ships and try to decrease accidents rates by implementing decision support system which will improve collision avoidance on board ships. Navigation is one of the significant and difficult operations on board and it requires high concentration and situational awareness. Even a single human error inherent to navigation can be very hazardous for human health and ambient environment. Decision making demands extra effort and cause stress on navigators. This study aims to help navigator in decision making in diverse crossing situations and decrease the workload and errors of the navigator.

The School of Marine Science and Technology is the largest and broadest-based marine school in the UK, covering the fields of marine engineering, marine biology, naval architecture, offshore engineering, coastal management and small craft technology, and enjoys a substantial international reputation.

We have a vibrant research community with an excellent reputation worldwide, offering the widest range of postgraduate and a wealth of undergraduate options, including our Newcastle University Marine International (NUMI) venture to provide taught programmes to new students overseas.

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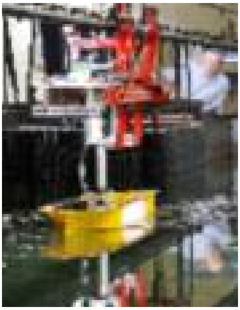
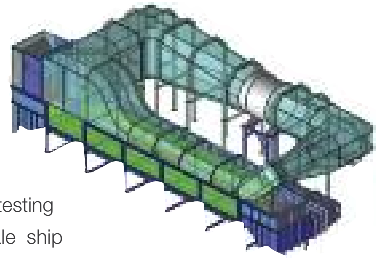
Towing Tank



The MAST towing tank is 3.7m long and 1.25m deep. It is used mainly for calm water, wave resistance and seakeeping experiments. Models are towed using a monorail carriage system that has a maximum speed of 3 m/s in its normal mode. The carriage can be remotely or manually controlled, while the 32 channel data retrieval system is on-line to a PC. A recent innovation is a modern telemetry system which will allow data to be sampled without any wired connections between the carriage and shore based equipment. The tank is equipped with wavemakers that can be used to generate regular waves of up to 0.12 m in height and wave periods in the range of 0.5 to 2 seconds. They are also capable of generating long crested random seas using a variety of wave spectra. The towing tank has played a central role in numerous research projects including the provision of extensive test data in the design of the School's research vessel.

Combined Wind, Wave and Current Tank (WWC Tank)

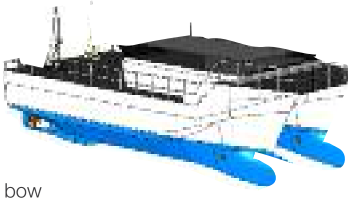


The combined Wind Wave Current Tank is one of only a handful of such facilities in the world, and was designed for use with any, or all, of the components with equal emphasis. The Wind Wave Current Tank was designed with small scale model testing for renewable energy devices in mind. However, it is also suitable for standard resistance, sea keeping and wind loading tests experiments. Since entering in operation in 2005 the WWC Tank has been involved in testing tidal energy devices, wave overtopping of sea walls, small scale ship resistance and determining the wind resistance of the School's research vessel which was designed in-house.

Emerson Cavitation Tunnel

The Emerson Cavitation Tunnel was originally installed in the School of Marine Science and Technology in 1949 and entered service in 1950. The tunnel was completely modernised in 1980, and was further equipped with modern flow measurement systems in 2000. An enhanced measuring section with higher speed capability and matching control systems was installed during 2007. The facility offers background research and development services related to cavitation, noise, propulsion, turbines, coatings and hydrodynamics related activities to both – academia and the marine sector.

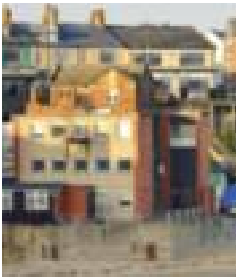
Research Vessel, The Princess Royal



Newcastle University's new research vessel, The Princess Royal, has been designed in-house by staff and students in the School of Marine Science and Technology. The catamaran has established itself as the ideal platform for small research vessel due to its stability, large deck area and manoeuvrability. The unique marriage of the catamaran and the Deep-V hull form with anti-slamming bulbous bow gives enhanced seakeeping, efficiency and speed potential whilst maintaining its other inherent virtues. The main duties of the vessel include conventional trawling, sampling, dredging, observation of marine wildlife, wind farm support, coating/fouling inspection, cavitation and noise research.

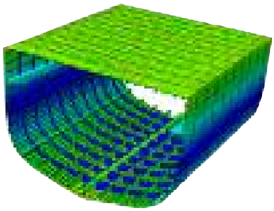
With an operational area encompassing the North-East coast of England, inspiration has been drawn from a local source so it is no coincidence that the boat features tunnel sterns and the deep fore-foot of the Northumbrian Coble.

Dove Marine Laboratory



The Dove Marine Laboratory is based on the North East coast at Cullercoats, about 10 miles from the main campus. Facilities include a large open plan aquarium with a flow-through water system, a closed re-circulating seawater system, experimental cabinets, research and teaching laboratories. As well as providing excellent facilities for marine science research, the Dove also plays an important role for technologists who work in the field of the marine environment. Some of the work that has been conducted in the Dove laboratory includes ballast water treatment and marine coatings research.

Computer Research Facilities



The School has its own computing cluster for teaching and private study, as well as a more informal space containing similar computing facilities adjacent to the cluster. The School also benefits from a dedicated network of computers, many equipped with specialist application software for marine structural design and marine science analysis. Powerful servers are utilised to run advanced numerical models including finite element analysis, computational fluid dynamics and in house developed software. Some of the specialist software available includes Aveva Marine, ABAQUS, Maxsurf, Shipflow, ANSYS, AutoCAD, Primer and many others.

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