UNIVERSITY COLLEGE LONDON

POST GRADUATE PROJECTS
2002

NAVAL ARCHITECTURE

Design Methodology for Sailing Yachts
Miss L. EADIE. MoD UK

The aim of the work undertaken was to produce a procedure for yacht design. It is envisaged that this procedure shall be offered to UCL undergraduate students for their ship design exercise. This implies that the yacht design procedure shall run alongside the existing containership and warship design procedures.

The yacht design process like the warship and containership designs shall take place in four main stages:

1. A design task or requirements document shall be set or agreed upon.
2. Initial Sizing to size the vessel to the desired payload or requirements.
3. The Parametric survey to investigate the choice of hull dimensions.
4. Design Development to further progress the design in terms of powering, structure, stability etc.

Designing a yacht from first principles implies determining the layout configuration or configurations desired, and confirming that the area criterion can be met for the chosen LOA. The resulting displacement is determined by a weights analysis, driven by the chosen layout. As such the level of detail examined to accurately initially size a yacht is greater than that for a large ship.

The fact that the development of the hull dimensions from a known displacement is not determined in the initial sizing section is to ensure that initial sizing produces a yacht sized directly by the requirements.

In order to provide a parametric survey for this procedure the option of a design driven by layout and therefore by Bmax, or a design driven by minimizing resistance have been presented. This should provide the procedure with the ability to cater for pure racing and pure cruising yachts as well as a hi-bred. It should be noted that the resistance formulae do not cater for an increase or decrease in SDR.

The design development section of this procedure represents the greatest proportion of the work. However, as mentioned it has been presented as relatively linear procedure i.e. one stage feeds to the next.

In conclusion it is felt that the procedure can be used to develop a yacht design. The methodology has taken account of the aim to align this procedure against the containership and warship procedures currently used at UCL. As such, similar design phases and milestones have been set.

The validity of this procedure is perhaps constrained to tighter limits than the ship design procedures. Hull statistics formula used to size the vessel, along with the resistance formula have been specified as valid for LOA of 5m to 15m. A means around the initial sizing limitation exists if a yacht is to be scaled from a previous design. However no alternative method for determining resistance apart from the use of specialist software has been found.

148

The Effect of Integrated Full Electric Propulsion on Frigate Configuration
M. GILBERTSON MoD UK

The development of Integrated Full Electric Propulsion (IFEP) will allow systems without the constraint of a large and heavy mechanical gearbox to be developed. The aim of this project will be to discover some of the possibilities that exist in the development of frigate configuration through the use of IFEP technology. There is a much greater flexibility in the placement of prime movers using IFEP than with earlier systems. This flexibility is not as great as is possibly thought however, as the nature of frigate design is such that it will, in all likelihood, remain an upperdeck layout driven configuration. In addition to this the problem of equipment size and weight remains. The dimensions of ICR Gas turbines such as WR21 are such that it would seem extremely optimistic to say that it will fit in a three deck frigate.

Side Hull Configuration Variation Study
E. GLYPTIS Private Student, Greece

Side hull configuration is one of the most important considerations during the trimaran design process. The relatively small displacement side hulls provide the necessary intact and damage stability characteristics of the vessel. Given their role and the design flexibility in size, shape, location and dimensions, the designer can optimize the performance of the vessel, whilst meeting the stability requirements for intact and damage.

This project focuses on the possibilities of side hull configurations and their effect on the vessels stability and hydrodynamic performance. The criteria the vessel has to meet and the most important damage cases are identified. A selection of side hull configuration is done, with the side hull dimensions and size varied. Three sets of configurations are obtained. The first two sets examine the effect of varying the dimensions with the displacement constant. In the final set the dimensions are kept constant with the displacement varying. The resistance characteristics of every configuration is obtained using the Holtrop & Mennen regression method and the vessel is checked for intact and damage stability Two extreme loading conditions of the ship are examined, one being when the ship is fully loaded and the other when the ship is empty but fully ballasted.

The objective is to compare different side hull configurations and examine the effect of their size and dimensions on stability and resistance of the vessel. The best side hull case for each configuration is obtained that gives an indication of the ideal size and dimensions for the side hull. Finally, the extent of the floodable length on each side hull configuration is examined. This will provide the naval architect with the information on the extent of subdivision on the side hull.

Investigation of the Effect of Side Hull Geometry on Parametric Roll Resonance in Trimarans
LIEUTENANT S. HABIB PN

Once a wave passes along a ship (moving into wave), the waterplane changes and hence the buoyancy. This change results in the variation of the metacentric height. These changes create dynamic instability and due to this instability the ship will develop excessive roll motions. This phenomenon is known as parametric resonance and is governed by a Mathieu equation.

The concept of parametric resonance has been studied in UCL for the last few years and this thesis is continuation of that study. In previous years a trimaran was examined with only one position of side hulls i.e. amidships to main hull. In this thesis various positions were examined along with different size and geometry of side hulls.

Initially analytical analysis of the problem was carried out using the Mathieu equation of roll motion. The Mathieu equation was modified in the process for trimaran configuration. Results obtained from analytical analysis were verified by carrying out model tests in the towing tank of UCL. In addition to that, an estimation of speed was carried out to give an idea of the speed range for a trimaran at which resonance will start.

At the end of the report a comparison was established between trimaran and pentamaran hull forms. It was done to check which hull form behaves better in a roll resonance situation.

Numerical Simulation of Sloshing Waves in a Tank using FLUENT 5.5
LIEUTENANT F. MUHAMMAD PN

A study has been carried out to investigate the use of commercially available CFD software FLUENT 5.5 to model fluid sloshing waves in partially filled, moving tanks. The aim of the project was to validate the results from FLUENT 5.5 against accepted results for the sloshing problem. Mr Neil POLLOCK took up the same project last year using FLUENT 4.32. The software failed to produce any meaningful results[4].

The results presented in this report indicate that although the results do not meet the criteria very accurately, they are a big improvement from the results obtained from FLUENT version 4.32. The main problems seem to be the inability of FLUENT to handle multiphase models accurately and viscosity effects.

FLUENT, as in previous years, have claimed that their newer version (version 6.0) has improved capabilities for handling multiphase models. After comparing my results with those produced by Mr Neil POLLOCK last year I have no doubt about their claim.

Light Weight Alternatives to Pentamaran/Trimaran Box Structures
N. NOEL-JOHNSON, MoD UK

This report investigates a number of alternatives to the box structure of a pentamaran or trimaran ship. The study aims to generate solutions that offer a weight saving over a benchmark steel structure. Two solution routes are considered: longitudinal isolation and the use of composite materials. The loading on the box structure is observed to be dominated by local loading on the wet deck due to slamming. Following design and analysis of the alternative structures, it is found that longitudinal isolation does not offer any potential weight saving over a fully integrated box. Similarly the use of most composite material arrangements does not result in a lighter structure. Finally the study examines the use of curved face composite sandwich panels. A weight saving is achieved but the result is subject to a number of caveats relating to the method of analysis and practical integration issues.

The Nature of Frigate Sizing
LIEUTENANT COMMANDER Y. PERRON CF

Frigate designs are influenced by a series of factors ranging from their roles (general or specific), their operational capabilities, the through life costs, to the technical requirements such as availability, reliability and maintainability.

Frigate sizing associated with a specific design is not a linear process and it appears that some 'plateaux' exist when balancing the design. These 'plateaux' are associated with the number of 'passing decks above machinery spaces'. When an increase in capability is added to a balance design, the necessary volume demand increase requires a much larger balance design. Due to the requirement of

structural strengths, length limitations are necessary and the balance solution must possess a second passing deck. Putting the conceptual design tool SURFCON© through its paces, this dissertation explores this frigate design curiosity by incrementally increasing the payload volume demand from a baseline ship. Five different payload scenarios and a total of 10 different models have been conceived for this exploration.

The dissertation discusses the use of the Building Block Design Methodology, the conceptual design tool SURFCON© and frigate design in general. Several discussion points on various areas of design are illustrated as well. These include the powering aspect of design, the stability implications and overall design limitations based on dimensions.

From the resulting balance ships, it can be seen that plateaux are present in two of the five main scenarios. When the design reaches its maximum design length (based on L/D=14), a second deck requires to be added and the vessel balances out at a much larger displacement, as expected and known for many years.

Part of this work was to use SURFCON©. With no previous knowledge, it took several weeks for the author to be comfortable with the PARAMARINE© and SURFCON© software packages, however, once the teething pains were passed, the tools were found to be very flexible. SURFCON© demonstrated a high potential for concept design.

Application of Lightweight Novel Structures in Ships
LIEUTENANT P. PIRES DA SILVA Portuguese Navy

This report details the research on possible application of novel lightweight structures used in aeronautical and civil engineering fields to ship design. From a wide range of structural solutions it was found suitable for technology transfer for the truss transverse framed deck and the hull diagonal grillage, both from the civil engineering field of knowledge. Both applications are illustrated later.

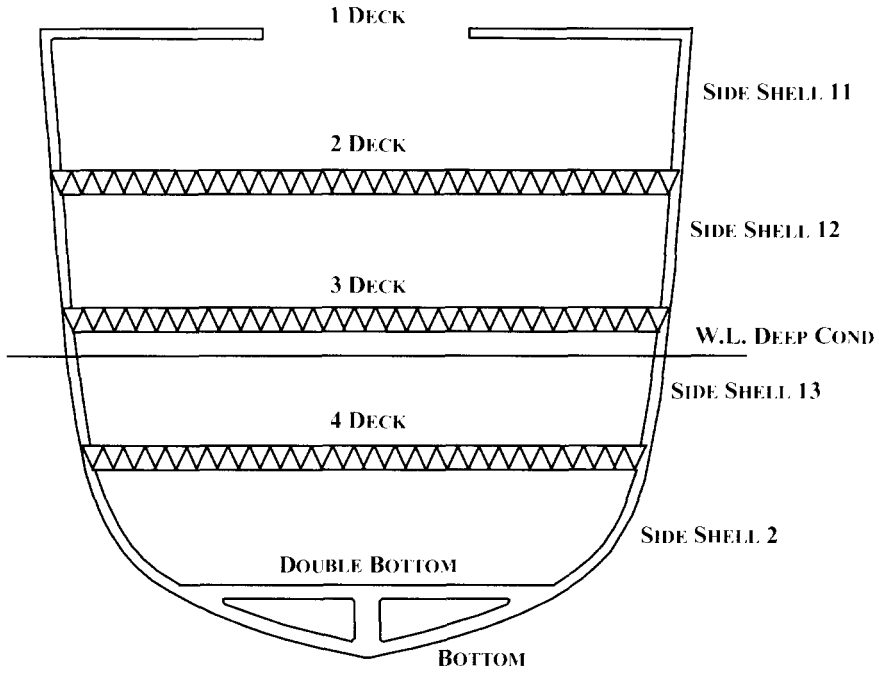
The truss framed deck system was applied in two 2002 ship designs, a slender Pentamaran main hull and a broader beam aircraft carrier monohull. For a weight optimized deck grillage, weight comparisons were made between beam transverse framed and truss transverse framed decks. Depth, cross members angle θ, span and load effects on weight were studied with the following main results:

- For the Pentamaran, the use of optimum truss deck system predicts weight savings of 20% per unit transverse structure, 6% (15 ton) per deck grillage, and 0.9% of ship displacement, resulting in a reduction of 1.6% in displacement when a new balanced design is generated.
- For the aircraft carrier, the use of optimum truss deck system predicts weight savings of 26% per unit transverse structure, 20% (858 ton) per deck grillage, and 8% of ship displacement, resulting in a reduction of 2.3% in displacement when a new balanced design is generated
- The direct weight savings offered by truss deck systems increase with the lateral load, span and truss depth,
- Indirect weight savings, resulting from the fact that ship systems do not have to contour the transverse supporting structure as in the case of beam framed decks were estimated in 2 and 12 tonne per deck, respectively for the Pentamaran and aircraft carrier.

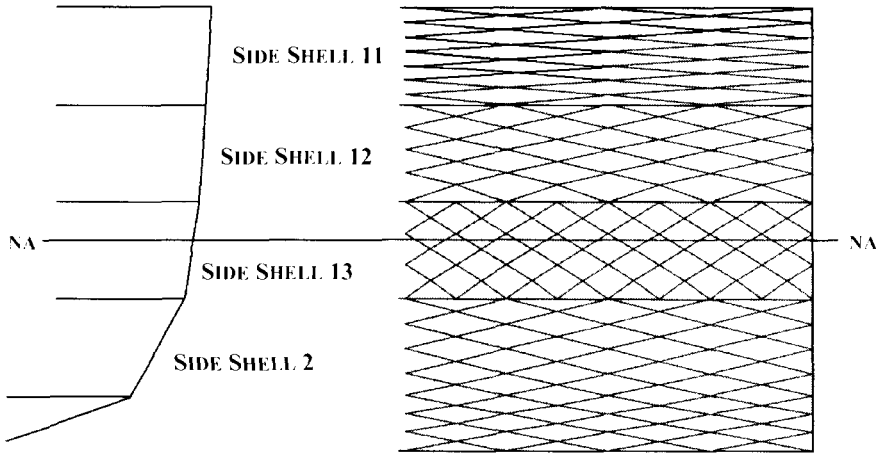
The diagonal grillage was applied in the 2002 ship design Pentamaran main hull. For weight optimised orthogonal and diagonal grillages it was shown that:

- The diagonal grillage is 7.9% lighter than the orthogonal grillage. However, if the transverse frames are not considered in the orthogonal grillage, its weight reduces and the diagonal grillage becomes 8.6% heavier than the orthogonal grillage.
- The weight savings found in the diagonal grillages result from both a reduction in the plating weight, that accounts in average for 63% of the grillage weight, and the use of lighter longitudinal support beams than the transverse beams of the orthogonal configuration.
- If the FLW Pentamaran is balanced considering the weight of the diagonal grillage applied in the main hull, the new balanced ship has less 2.8% displacement corresponding to a reduction of 147 tonne.

The combined effects of applying truss deck systems to three decks and diagonal grillage to the main hull of the FLW Pentamaran design were also considered. The weight savings would be of 123 ton (2.3%) and a new balanced design would have less 229 tonne (4.3%) in total displacement.



TRUSS DECK SYSTEM ON PENTAMARAN MAIN HULL



DIAGONAL GRILLAGE HULL

Role Damping of Appendages for Trimaran Ships
LIEUTENANT P. TRIUNFANTE MARTINS Portuguese Navy

In this report a theoretical method is used to model different trimaran appendage configurations. The method consists of a numerical lifting line application with corrections to take into account the vessel's boundary layer and free-surface effects in order to calculate the lift coefficient slope of the appendage, which is used to estimate the damping contribution.

The numerical method was validated against wind tunnel tests and the overall method was compared with free-decay tests covering several speeds and appendage dimensions, showing good correlation.

Furthermore, a comparison has been made against values from a linear analysis of each test and against available programs to model trimarans, having obtained results closer to the analysis than the existing program, in most cases with a difference below 12%.

Static Analysis and Assessment of Thermal Insulation of Steel Catenary Risers
H. UMARU-MOHAMMED. Private Student, Nigeria

The Steel Catenary Riser (SCR) is an attractive solution from an economical point of view for deepwater field development around the world. The SCR concept is a relatively new idea, the first being installed by Shell on its Auger Tension Leg Platform (TLP) in 1994 in the Gulf of Mexico. Their use has given a new dimension to oil exploration and transportation in water depths where Riser concepts could not tolerate the environmental loads or would have become too costly. The SCR is simply just a long steel pipe which forms a Catenary shape by application of a tension at its top. The Catenary shape of SCR imposes high stresses in the touchdown area: this in turn creates the need to understand their behaviour during installation and operation. The need also to achieve flow assurance within the Riser pipe has resulted in fitting Risers and flowlines with a high degree of thermal insulation.

This dissertation project covers two main parts of the design of SCRs. The first part involves Riser selection and then designs to help in understanding their behaviour. This is achieved by deriving analytic solutions for first the static

profile of the Riser under the influence of its self-weight and then for the bending moment distribution along the Riser. With derived expressions for the static model of the Riser a full static analysis could then be performed on the Riser. The second part involved performing a thermal insulation assessment on the selected Riser, and was done by deriving an expression for the overall heat transfer coefficient U-value for the arrangement. With a U-value design target of 2.0 W/m^2K, the design involved choosing the correct amount of insulation coating to help achieve the design purpose.

Through the results of the static analysis a good understanding of the Catenary Riser behaviour is obtained. It would show that the Catenary Riser behaves like a chain in that the amount of curvature induced in it is dependant on the top tension applied to it. The results would also show that the stresses at the touchdown point area of the riser are localized. Similarly, the results of the thermal insulation assessment would show that the flow assurance of the pipe is achieved easily by application of an insulation-coating layer. However, it would be found that the addition of the insulation coating would lead to problems associated with the stability of the Riser. The stability of the Riser was achieved by increasing the wall thickness of the pipe, which would turn out to be a costly means of achieving Riser stability.

Development of a Design Concept Tool and its Application to Fast Ferries
J. WOODHOUSE. Private Student, UK

A study of the suitability of three different hull configurations, the semi-displacement monohull, catamaran and pentamaran, has been conducted with reference to a range of fast ro-pax user requirements. The factors investigated include: payload weight, speed, material and engine type, with the performance of the options being assessed in terms of transport and fuel cost efficiencies together with the required freight rates as applied to the Edinburgh to Zeebrugge route. The payloads were assumed to consist of combinations of passengers and cars. To aid simplicity the inclusion of trucks has been omitted.

A concept design tool was developed to aid the study. Predictions for the geometry, weight, powering and costs were made, using a combination of algorithms. User requirements taken from existing vessels, were inputted into the computer models, and the results were found to compare favourably. The full details of each option have been included in a CD found at the end of this report. An annex of the more important results is also included.

The results showed that a range of deadweights, 300-400 tonnes, most suited the monohull form. The design drivers were found to be the for the most part the Froude displacement number and beam limitations. For deadweights above and below this range, it was found that the multihull configurations demonstrated superior performances for machinery type and resistance reasons. Due mainly to the initial build cost, the pentamaran displayed lower through life costs than for corresponding catamarans, despite the latter form's increased efficiencies. Further investigations showed that for higher speeds and deadweights CODAG fitted monohulls performed better than those fitted with medium speed CODAD systems. Because of the large number of catamarans currently in operation, it was felt that the costing predictions for this hull type could be excessive. A brief sensitivity study showed that small decreases in the structural costs resulted in significant through life cost savings. It has thus been suggested that the initial costs for all the hull types should be validated against existing ships.

MARINE ENGINEERING

Understanding Environmental Control within the Maritime Internal Battle
LIEUTENANT G. ANKAH RN

Throughout naval history, one of the most frightening scenarios has been that of a fire at sea. Unsurprisingly, fire related disasters in the maritime environment have accounted for a large number of casualties over the last 40 years. In general, relatively few casualties are attributed to the flames themselves. It has long been known that the biggest killer in most fire related disasters, on land or at sea, has been as a result of exposure to smoke and toxic gases. This thesis provides an overview of the formation and behaviour of these hazardous combustion products, attempting to understand the various phases of smoke production and the resultant dangers onboard a ship. It is important to identify the advantages and disadvantages of current and future detection equipment with a view to provide a précis of recognized ideas regarding smoke control and management. Ultimately, the detection and subsequent clearance of combustion products during a fire at sea can only be achieved with the timely provision of the requisite knowledge to aid the decision making process. In addition to the application of effective Maritime Fire Suppression Systems, the integration of smoke detection, containment and clearance systems must be considered as a key part of the Maritime Integrated Safety Management System. Consistently at the forefront of military thinking, management of the 'Internal Battle-space' remains a key issue in a warship's ability to achieve its aims. Increasingly, the civilian sector is striving to achieve compliance with current and future regulations for fire-safety onboard. However, this is generally only applicable to new ships. Ultimately, recognition of current research projects can provide a guideline for future research and development programmes that may, one day, improve the safety record of vessels worldwide.

An Investigation into the Applicability and Performance of Series Active Filters in Marine Propulsion Systems
LIEUTENANT J.J. BAILEY RN

The advent of power electronics in electrical propulsion for marine applications has led to a reduction in the quality of the power system voltage and current waveforms. Such distortion can affect the operation of other systems connected to the power system and some form of power conditioning has become necessary. The aim of this project was to investigate the application of the emerging technologies of Series Active Filters. Series Active Filters represent the latest power conditioners. They have been made possible by the recent developments of high power semi-conductors.

The connection of the Series Active Filter is shown at (FIG.1). In a voltage controlled mode, it represents a controlled voltage source which injects voltages onto the power system waveforms to correct for voltage distortion. The filter may also operate in a current controlled mode. Here it represents an active impedance which is zero for the fundamental current but high for all other currents. In this latter guise, the filter blocks the flow of harmonics from a load into a power system.

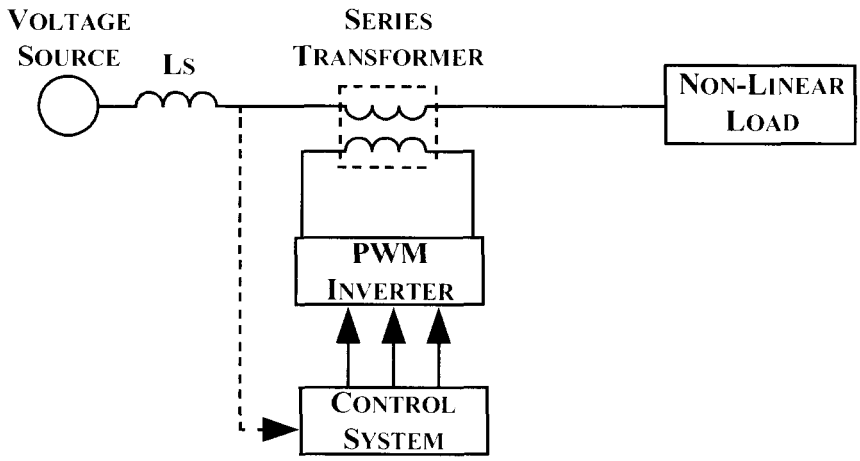


FIG.1 OPERATION OF THE SERIES ACTIVE FILTER

Investigations into the Series Active Filter were undertaken by:

- Development of a Simulink model of the filter including the application of a self-tuned vector filter control system.
- Validation of the completed model utilizing two separate sources of power system data.
- Development of expressions for power rating of the series active filter.
- Comparison of the performance of the Series Active Filter with other systems utilized for power conditioning.
- Research into the progress of issues involving the practical implementation of the Series Active Filter.

In conclusion, the series active filter represents a cost effective, feasible means of power conditioning for the marine power system, particularly when applied to condition the low voltage ship service section of a marine electrical system.

Progress in the Development of NO_X Reduction Technologies
LIEUTENANT J.P. ELLIS RN

Nitrogen Oxides (NO_X) emission is a global problem to which shipping contributes significantly. Worldwide NO_X emissions from ships have been estimated at around 10M tonnes annually, equivalent to 50% of all land-based NO_X from the USA or 14% of total NO_X emissions from fossil fuels. NO_X emissions result in severe ozone depletion in polar atmosphere and formation of photochemical smog and acid rain. The strong ozone depleting effect is 20 times more potent than CO_2 and this is why the International Maritime Organization has focused on reducing NO_X by acceptance of the MARPOL Annex VI Regulation 13.

Independent research has been carried out throughout this project to gain a full understanding of the chemistry of NO_X formation within combustion engines and the effect of the subsequent emissions on the atmosphere. An investigation and review of all current NO_X abatement technologies pertaining to Gas Turbines and Diesel engines has been conducted highlighting the mechanism by which they operate and the standards achieved. The examination also extends to emerging NO_X reduction techniques and their potential for future application.

Finally the introduction of NO_X reduction techniques to the Marine Industry has been reviewed with particular focus on the changing legislative requirements, the practical implications and problems associated with installation onboard vessels, and the cost v benefit to ship owners. Whereas the potential exists for introduction of this technology in the marine environment, considerable investment is required by ship owners. It is apparent that commercial gains will continue to dominate the decision process until legislation becomes more stringent.

Methodology for Assessing the Fatigue Life of the Offshore Power Cable
T.E. ETUK Private Student, Nigeria

Gas or rich gas offshore oil fields pose a particular problem to the Exploration and Production companies. In the established shallow to medium depth fields, such as those in the southern and central North Sea, fixed pipelines take the gas ashore to terminals for processing and ultimate consumption. However, with marginal fields, the story is different, as they are not amenable to gas – to – pipe field development especially more with stranded fields in deeper waters. It is unlikely that the laying of pipelines to transport the field gas ashore will be cost effective for anything other than the largest reserves of gas and where there is ready market for the gas.

Though natural gas fuel is environmentally more attractive than crude products it is often seen as an unwanted by-product in oil rich fields because of handling problem. It is therefore highly desirable to develop and utilize cost effective technologies for the utilization of natural gas. Currently, the proven options available to the offshore oil and gas companies for the disposal of the natural gas are to reinject it into the field or to flare it off. Reinjection has expense without any associated revenue, as it requires additional energy to drive gas compressors and flaring is environmentally unacceptable.

Potential options for solution are:

Gas – to – Liquid, Gas – to – solid and Gas – to – wire.

During the 2001/2002-Ship Design exercise, our group implemented the Gas to Wire Concept (GTW) using a Monohull vessel. This involves the conversion of gas energy to electrical power on the floating gas production vessel and the export of the generated electricity ashore via high voltage Subsea cables using High Voltage Direct Current (HVDC) transmission to the point of sale.

Though our group demonstrated the concept to be feasible, the behaviour of the power export cable was the area that needed careful attention. The main aim of this project has been to develop a methodology and models for the analysis of the behaviour of the power export cable by considering the operating and the environmental conditions using simplistic approaches. This analysis uses:

- Simplified Catenary models.
- Boundary layer approach.
- Linear approximations.
- Asymptotic formulae in developing the methodology.

In this project a single core HVDC submarine cable rated at 350kV, 500MW, 100km (1400mm^2 Copper conductor), is used in the analysis. The cable hangs down from a floating production and power plant and forms a Simple Catenary as it touches down at the seabed. West of Shetland area of North Sea is used in this analysis.

The objectives have been to derive and set up mathematical models to solve the elastic Catenary profile, study the area of operation to determine the

environmental conditions and loads, develop models for the static analysis and carry out a full static analysis, use simplistic models to study the dynamic response. These mathematical models were implemented using Matlab programming language. Different models for the mechanical behaviour of power cables and wire ropes were investigated. The issue of fatigue was considered critical and this was investigated with different models.

With the Catenary configuration it has been found the there are two regions of concern:

- The vicinity of the touch down point where the curvature of the cable is highest.
- The top where the interaction between the vessel and the cable at the flexible joint is severe.

These two points represent point of maximum alternating stress amplitude stresses, and expectedly points for fatigue analysis.

Mechanics of the submarine cable, the behaviour of its constituent members and their interaction with Catenary profile has been studied and used in the static and the dynamic response calculations to the environmental and service condition. These responses are used in the evaluation of the fatigue life of the cable at the critical points.

It has been identified in the studies that there are two main causes of fatigue:

- The first order motion, which comes as a direct result of wave loading transfer motion.
- The second order motion, which is a result of the slow drift motion of the floating unit.

Furthermore, the top pretension level applied and the stiffness of the flexible joint at the top and even the angle of the flexible joint at the top makes with the horizontal determine the fatigue life of the cable as these two parameters affect/modify the Catenary curvature which determines the stresses.

158

Magneto Hydrodynamic Propulsion.

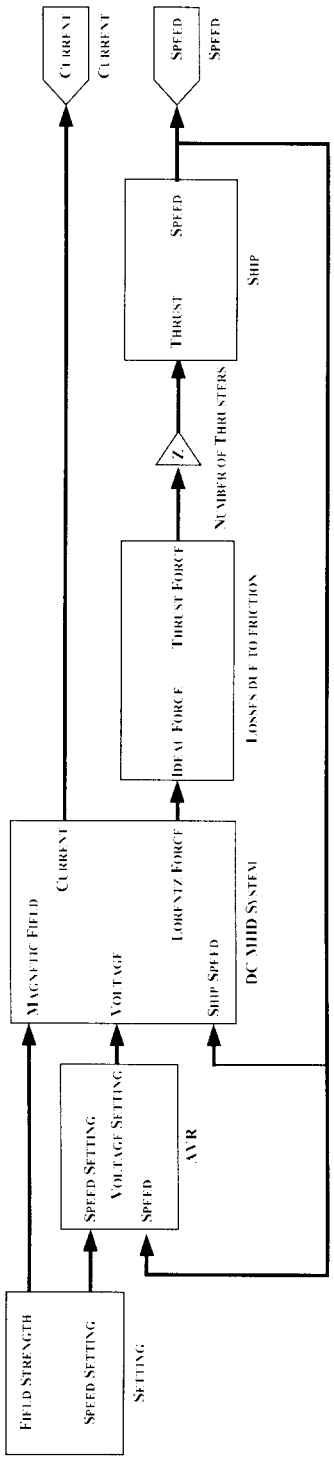
LIEUTENANT F.D. GEERTSMA RNN

In the fiction book *The Hunt for the Red October* by Tom CLANCY, the Russian submarine *Red October* is equipped with a Magneto Hydrodynamic propulsion system. Due to this propulsion system the *Red October* is the quietest submarine at that moment in time. This is however a fictional story. The question therefore is:

'Is there a possibility for a real ultra quiet propulsion system?'

Magneto Hydrodynamic propulsion is a propulsion system which does not make use of propellers and therefore does not have the noise created by the blade cavitation. The propulsion system is based on the interaction between a magnetic field and current, which results in a Lorentz Force propelling the ship. Due to this, a Magneto Hydrodynamic propulsion system is very quiet and in theory can obtain a very high efficiency. However the problem with a Magneto Hydrodynamic propulsion system is to create a magnetic field strong enough to propel the ship at an acceptable efficiency level. To achieve this a high field magnitude is necessary, which can not be achieved with normal magnets. However with the rise of Superconductivity and High Temperature Superconductivity creating a high magnitude field is possible.

The aim of this project is to assess the properties of Magneto Hydrodynamic propulsion and the possibility for its real-life implementation. Firstly Superconductivity and Magneto Hydrodynamics have been researched. The inner Direct Current MHD propulsion system for the *Yamato-1* has been modelled and validated. The *Yamato-1* is the first ship with a MHD propulsion system in existence and was built in 1990 in Japan. Furthermore an inner Alternating Current MHD propulsion system has been modelled for the *Yamato-1* and compared to the DC MHD propulsion system. Both propulsion systems have also been modelled as a propulsion system for a SSK submarine. With all these models the various parameters have been varied to examine the influence of these parameters. For the modelling Matlab Simulink has been used. The results show the efficiencies for different values of thrusters size, magnetic field strength and conductivity of seawater. From these results it can be concluded, however, that the technology level at the present is not advanced enough, although Magneto Hydrodynamic propulsion looks to be a viable possibility for the future.



MODEL INNER DC MHD PROPULSION

Modelling of Air Independent Propulsion Systems using Empirical Data
LIEUTENANT N.A. HARDIMAN RN

Air Independent Propulsion (AIP) is fundamental to covert submarine operations and has been the subject of intense research over the past century. Whilst nuclear propulsion represents the ultimate form of AIP, for most nations this is prohibited due to the high cost of development and the infrastructure. Smaller nations have concentrated on extending the submerged duration using closed cycle heat engines such as Stirling, Diesel and Steam Turbines, and electrochemical energy conversion devices such as fuel cells. All of these plants are capable of being retrofitted into ageing submarines by inserting into a new section of pressure hull known as a plug.

This thesis examines the current state of development of each of these AIP systems. The volumetric and gravimetric impact of each of the plants with increasing endurance is investigated graphically.

A program has been developed which utilizes a user defined mission profile to investigate the performance of a neutrally buoyant plug of 300 tonnes in a submarine of 1500 tonnes displacement. The size of the plug and displacement of the submarine were taken as typical values for a conventional submarine. These values are variables but were fixed to allow a comparison to be made with different systems. The submarine propulsion system is configured within a hybrid system with the AIP plant supporting the lead acid battery for submerged operations. The user defines the times at sprint and patrol speed to create a simple mission profile and the top speeds for each aspect of the profile. The program has been further developed to examine the performance of the AIP in terms of the surfaced period versus submerged period over a 90 day period. Simulations were completed with differing profiles to assess the sensitivity of the plants to differing profiles.

The primary limitation of the AIP plant is the submerged endurance, which is a function of the fuel and oxygen carried. The more limiting of these 2 factors is the amount of oxygen carried. The supply of oxygen via electrolysers and artificial gill technology is examined, and the recharging of the supply tank using a Liquid Oxygen (LOX) plant. A LOX plant has been added to the model and the new indiscretion ratio calculated to assess the utility of using a LOX plant compared to carrying extra reactants.

Both of the models have been developed in modular form to allow empirical data to be replaced with more sophisticated mathematical models of each set of equipment in any future studies.

Thermal Cycling of Ceramics
I. MAKRIS Private Student, Greece

Solid oxide fuel cells are considered to be the forward-looking technology in power generation. They are electrochemical energy converters, which transform the chemical energy of a fuel gas into electrical energy. The operating temperatures are very high, in the order of 700°C to 1000°C and as a result a variety of fuels can be processed. The fuel cell contains an anode and a cathode with a solid electrolyte sandwiched between them. This multilayer structure usually consists of ceramic and metallic materials.

It can be realized that the cyclic operation of the fuel cells, imposes various thermal loads, also in cyclic frequency, which may lead to failure of the materials. This project sets out to investigate the behaviour of ceramics under thermal loading and cycling using a unique method. Even though a number of techniques

have been developed in order to realize the extent of damage occurring in ceramics during the thermal shock, none can provide a complete understanding.

The method used for this project involves the thermal shock of the component using a focused infra-red heating source whereas cooling is being done by natural convection. The apparatus utilized, was developed for these experiments and involves radiant heating by way of two tungsten filament lamps in combination with two elliptical reflectors. This way the temperature gradients induced are very large, resulting in the maximum thermal shock being imposed. Another great advantage of this method is that it presents a three dimensional problem, unlike existing methods, and therefore manages better to simulate operating conditions.

The equipment had to be calibrated, mapped and tested before it could be used for thermal cycling. The ceramics used for the cycling are considered to be state of the art materials for the use of SOFC, particularly Yttria Stabilized Zirconia and Strontium doped Lanthanum Manganese. Different geometries have been considered to examine whether this has any effect in the normal operation of the material. However the main problem investigated regards the cracking of the components after a number of cycles due to the change in the thermal stress resistance, which results in the thermal stress exceeding the materials stress limit, and therefore the material cracking. There is an attempt to model this problem in order to ideally predict the most likely location of the cracks.

The Integration of Maritime Fire Suppression Management Systems
LIEUTENANT N.R. MCCALLUM RN

Fire at sea accounts for approximately 25% of maritime casualties and an average of 30 vessels are lost or considered constructive total losses every year. Fire is perhaps the most daunting incident that can confront the crew and passengers of a ship. It is the crew alone who must deal with any fire incident at sea by utilizing fixed systems and manual techniques. However, it is not just the fire that must be dealt with but the control or containment of smoke, pyrolised gases and toxic fumes. Additional to these problems is the safety of personnel, be they crew or passenger, and the prospect of their evacuation whilst possibly panicked, in shock or in an injured state.

Considering the extent of these incidents and losses for which there are currently systems and techniques available, this project was proposed in order to research all areas relating to fire and smoke within the maritime environment. Due to the size and scope of the research area the project was divided with another MSc student who was to analyse smoke and ventilation aspects. This particular project was to examine current systems and investigate areas of ongoing research and development in fire detection, suppression and incident management. The emphasis of the work was to identify potential weaknesses in the research areas and propose issues of possible future integration.

The aim of this project is to produce a comprehensive report encompassing all the aspects of a maritime fire suppression management system and bring together many areas of significant, yet often isolated research so as to provide a datum for progressing the field of fire management research.

The Assessment of Safety and Reliability of Electronically Controlled Engines
LIEUTENANT R. MCCOLL CN

The safety of merchant shipping is regulated by national administrations in keeping with agreed International conventions and codes, governed by the International Maritime Organisation. Particularly the Safety Of Life At Sea (SOLAS) Convention of 1974 which has the three goals of safety:

- Personnel.
- Machinery.
- The ship.

This is satisfied by the requirement for all ships to classified and to meet technical requirements developed by the classification societies.

In general these technical requirements have developed over many years based upon identification of a need as a result of failures and loss of life. Like many others the technical requirements pertaining to diesel engine prime movers have evolved over many years.

The fundamental question is whether the current processes and technical requirements remain relevant and sufficient to ensure the safety and reliability of modern electronic engines where a step change in technology is taking place. A high level, holistic review of the current process and technical requirements, has been performed to ascertain whether the they are sufficient to meet both the technical requirements and guiding philosophy of SOLAS.

The thesis commences with an overview of the background requirement for assessing safety and reliability of electronic engines, and a review the current process and technical requirements. The relevant technologies that apply to electronic engines are also discussed.

A HAZARD Operability (HAZOP) study is performed on two slow-speed 2-stroke propulsion engines from different manufacturers. Both engines are in service at sea and type approved but by independent classification societies. The results of the HAZOP and study of the Rules formation and philosophy is compared against the current process and technology requirements to identify any gaps in the methology.

An Investigation into the Design of an Unmanned Ship
P. Meirelles FREIRE. Private Student, Brazil

The shipping industry is again facing a shortage of manpower, a situation similar to the one experienced in the 1960's, which caused the first wave of widespread introduction of automation on board merchant ships, thereby enabling substantial crew reductions throughout the world fleet.

The automation process has continued at an increasing pace with the introduction of 'periodically unattended machinery spaces' and 'integrated bridge control systems', which have made 'one man on watch' operations possible aboard many merchant ships.

However, information overload being experienced by seafarers on highly automated ships, together with the life style due to working watches, limited onboard companionship and very short periods ashore, are seen as sources of stress, fatigue and psychological strain, which can compromise the effectiveness of a crew and consequently the safety of the vessel.

Further slimming of crews is therefore highly unlikely, despite the continuing high costs of manpower, and a new concept in ship design and operation will be needed, if the present manpower problems and further cost reductions are to be addressed.

The project aims were to investigate, from technical and economic viewpoints, the feasibility of a totally automated, unmanned ship as an option to solve the existing manpower difficulties at sea.

An analysis of the marine manpower forecast as well as the calculation of the true total cost of a crew in ship procurement and operation is presented. An engineering assessment has been undertaken in key automated systems and their operation philosophies needed in a ship designed to eliminate the crew in the key areas of navigation, propulsion and damage control.

Finally, a complete ship design is presented and the cost, profitability and safety of this new concept will be compared with those achieved by state-of-the-art conventional designs.

Electric Acuators for Ship Hydrodynamic Control Surfaces
LIEUTENANT J.B. SITTON RN

With the advent of Integrated Full Electric Propulsion (IFEP) and the realization of an Electric Ship there is a desire to replace hydraulic actuators with electric actuators. Particular candidates for this are steering gear and fin stabilizers. The Ministry of Defence is currently investigating aero-derived units for use in the marine environment/applications. This raises several issues regarding control, operation and regulation. Initiatives in industry, transport and aeronautical fields suggest that electric actuation of major systems in surface ships and submarines is a feasible idea that could prove extremely beneficial when applied to control surfaces.

Electric actuation systems tend to be more compact than equivalent hydraulic systems and only require an electrical cable to provide power and control. This simplifies the arrangement of supplies and connections through bulkheads and provides additional potential to mount the actuators outside the hull.

(FIG.1) shows a block diagram of an Electric Actuator (EA) system. The dashed box contains the four main parts of the systems components. These are the converter, motor, actuator and the control system that contains the sensors. Although EAs are considered to be a mature technology and are used throughout the aircraft industry, they remain a high to medium risk in the marine industry. Candidate EA technologies are reviewed from the commercial markets and assessed for their suitability in the marine environment. The associated components that configure the system, shown at FIG.1, are also considered for this study.

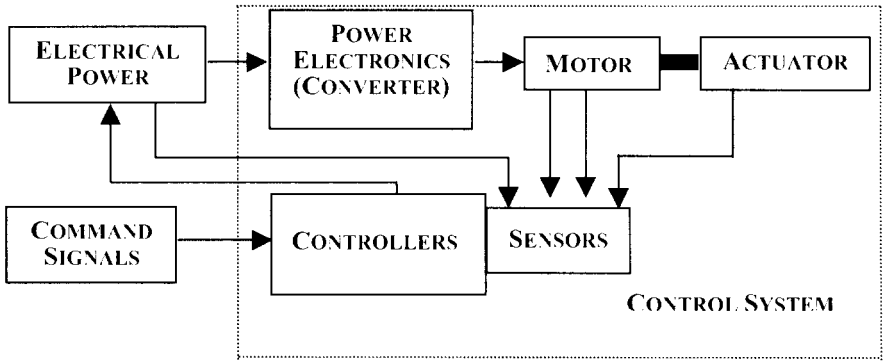


FIG.1 A BLOCK DIAGRAM OF AN EA SYSTEM

The study investigates current steerage and stabilizer systems used in the Royal Navy, in particular, highlighting the Type 23 and how EAs could be integrated into the current design. Torque and duty applications for specific platforms were also calculated using methods prescribed by Lloyds, DNV and the MoD. The

results were scrutinized and compared with experimental data gained from an in service vessel to ensure correlation between the Classification Societies theoretical results.

Additionally, the study also describes the applicability of using novel control methodologies for motion stabilisation. The potential applications of using an integrated advanced control system were also considered, by utilizing the Platform Management System and the Combat System with the aim of improving the operational effectiveness of the platform. Finally, a concise summary of potential control system controllers are reviewed and compared for use with electric actuators as part of an Advanced motion Control System.

****

The full reports are held at the University and further information may be obtained from:

The Professor of Naval Architecture
Naval Architecture and Marine Engineering Office
Room 119
Department of Mechanical Engineering
University College London
Torrington Place
London
WC1E 7JE