UNIVERSITY COLLEGE LONDON

POST GRADUATE PROJECTS 1997/98

NAVAL ARCHITECTURE

Hullform selection criteria for fast craft
by LIEUTENANT P.J.M. DUARTE Portugese Navy

Due to the rapid evolution in technology, ship design is no longer confined to classic monohulls. Since the late fifties, new hullforms have made their appearance, including:

- Hovercraft
- Planing craft
- Catamarans
- Trimarans
- SWATH ships
- Hydrofoils
- Surface Effect ships
- HYSWAS as well as others.

Due to this wide range of hullform types, today's designer faces a crucial problem—the choice of criteria for fast craft conceptualisation.

This project is an effort to address this issue by means of a comparative study of the main advanced marine craft and the experimental powered trimaran concept. Firstly the different types of advanced marine vehicles are introduced by means of the lift triangle tool. Then the advantages and disadvantages of each concept are dealt with, allowing for the consequent comparison of the different types of vehicles for the selected parameters; seakeeping, manoeuvring, building costs, general layout and transport efficiency.

Transient stability of a submarine during flooding
by LIEUTENANT A. GREGORY RN

The stability and motion of a submarine is normally only studied in the intact state. This project investigated the feasibility of modelling, by using experimental techniques, the hydrostatic stability and motions of a submarine on the surface, which has been subject to internal flooding.

A submarine during refit is docked down in a dry dock and has access holes cut in the pressure hull. Unplanned, rapid flooding of the refit dock, due, for example, to gate failure, could cause the vessel to lift off the blocks, heel over or remain upright and to assume it's surface characteristics such as metacentric heights, trim and draught. The submarine could begin to take on flood water via the refit cuts. It is from this point that the feasibility study begins.

It is believed that this modelling has not been previously conducted. BPP Technical Services Ltd, London, an independent company, have developed a software simulation of this flooding scenario. It is against these results that the physical model's performance was compared.

The model and supporting rig were built in the department within the constraints of available resources. The associated problems with conducting the model tests were sequentially overcome. The metacentric height, initial heel angle, level of roll damping and flooding rates were varied to establish their effects on the model's dynamic behaviour.

The tests indicated that physical modelling is feasible and general compatibility with the BPP results was observed. Further work and modelling is required to increase the degree of confidence in this method if it is to be used to predict full-scale behaviour. At this stage of development the software model is more reliable than the experimental techniques in this project.

Trimaran Fast Ferry design procedure
by N. HANCE MoD UK

The undergraduate Naval Architecture course at UCL contains a ship design exercise in the third year, which can be either a warship or a containership. The aim of this dissertation is to write a similar design procedure for a trimaran fast ferry. The trimaran lends itself well to this task due to its low resistance at high speed and good seakeeping.

The information for such a procedure has been derived from trimaran design and research work, most of which has been carried out at UCL, and public domain data on fast ferry designs. It must be emphasised that unlike the other two procedures, no full size trimarans exist yet, so the designs produced will still be very theoretical.

The actual design process follows the same format as the warship and containership procedures. The student begins with initial sizing then moves on to the parametric survey phase and finally carries out design development.

The initial sizing phase takes the payload to be carried and balances the design in an iterative manner to arrive at a set of dimensions for a given set of hull parameters. The powering and stability are covered in more depth as a result of being a trimaran design. The parametric survey investigates:

- The car deck arrangement, e.g. inclusion of a mezzanine deck
- The wet deck clearance, which is particularly critical with a trimaran ferry
- The systematic variation of hull parameters set in the initial sizing phase.

The design development phase develops the preferred solution further, including:

- Hull form design
- General arrangement
- Stability
- Structural design
- Propeller design.

The process is very simplistic in places due to lack of trimaran expertise or just to simplify the process for students. However, other areas of the design, like the stability analysis are more complex. The process lacks any real design data but the process itself should be allowed to develop as using it produces more designs of trimaran fast ferries.

To summarise, the procedure encompasses all the basic design principles required to design a ship that are included in the other design procedures with the added complexity of designing an unusual hull form as well.

Design of a Trimaran box structure when subject to transverse loads
by LIEUTENANT M.S. KHALID Pakistan Navy

This report presents the individual research carried out in the third part of the MSc Naval Architecture course at UCL. The research comprised investigations into shear and bending stresses in two trimaran configurations to support outriggers ((*a*) box structure (*b*) beams) under transverse loads by using finite element analysis with I-DEAS software. Following research carried out, a procedure is proposed for use by the trimaran structural designer. To avoid the finite element analysis during the initial phase of each ship design, a correlation is presented for the prediction of effective breadth of deck and bottom plating of the trimaran box. This effective breadth correlation will enable the use of simple bending beam theory on trimaran box structure for predicting the right stresses while catering for the shear lag effect. A number of attempts for validation of this correlation are also presented, but still more research and work is required to improve and validate the correlation. Interesting research on the damaged trimaran beam is also presented in the report.

Wave calming measures in an LPD dock
by C.J. MALTHOUSE MoD UK

Waves generated in the dock of the current LPD warships make dock operations, particularly recovery of the LCUs, difficult. This restricts the time that the dock can be utilized for deploying troops and vehicles in the LCUs.

The second generation of LPDs, currently under construction, has made no changes to the design of the dock and will therefore suffer from the same problems and restrictions. This project investigates the possible addition of wave calming devices that could be fitted into the docks of the new ships and which could reduce the large waves that surge along the length of the dock.

This project continues work carried out by PROFESSOR RYDILL, who undertook, using a basic 1:50 scale model of the dock vicinity, tests to demonstrate that wave activity could be supressed using a hinged flap. The experiments undertaken in this investigation used a 1:60 scale model of the whole ship. The tests were carried out in the large wave tank at UCL and induced accurate ship motions in which large waves were generated. A variety of wave calming measures were evaluated for their effectiveness in a series of sea conditions.

This report covers the work carried out through the three month project phase of the MSc. The experiments undertaken have been described and the results are discussed and conclusions have been drawn. The annexes provide a full copy of the experimental results.

Laminar flow assessment model experiments
by LIEUTENANT C. MASON RN

With the quest for greater knowledge about our environment, it is necessary to improve our understanding of the oceans and their effect on the world's climate. The oceans have proved to be a difficult and expensive environment in which to collect data; however, one proposed solution is to use Autonomous Unmanned Vehicles (AUVs). The traditionally shaped torpedo is ideal for short missions but has too great a power requirement and therefore not enough internal volume to carry enough batteries as well as the sensors needed for longer missions. A low drag or laminar flow shape has been designed to reduce the drag on the body and hence the power requirements.

This laminar flow body has been designed for a laminar boundary layer over 70% of the body length with turbulent attached flow over the final 30% of the body. In laminar flow conditions it has been shown that the drag coefficient is significantly lower than that for a similar traditionally shaped torpedo. It is recognized that the flow conditions at the bottom of the ocean may not be laminar and that the body would have to pass through turbulent environments on its way to the ocean floor. It is therefore of interest to compare the drag on a laminar flow body in turbulent conditions with that of a traditionally shaped model.

The results obtained during this experiment on a 1/6 scale model tested in the Circulating Water Channel at DERA Haslar, found that boundary layer separation occurred up to a Reynolds Number of 2.5×10^5. Above this speed the drag coefficient steadied at about 0.0346. When compared with other streamline bodies this result proved to be favourable.

The report also contains further discussion on the yaw and yaw moment coefficients and provides a comparison with results from wind tunnel tests on a 2 scale model.

Design criteria and guidance to avoid parametric rolling
by LIEUTENANT S. RIBEIRO e SILVA Portugese Navy

A theoretical and experimental study of the ship capsize phenomenon due to parametric resonance is conducted for a monohull and a trimaran vessel with the aim of identifying the conditions leading to capsize in head seas.

The main objective of this work is to formulate the problem in a way that enables both an analytical and a numerical solution to be obtained from the equivalent linearized equation of motion using experimental model test data. Hence, from these results a method of assessing the possibility of ship capsize due to parametric rolling is proposed.

Development of weapon arc evaluation system
by R.K. SKARDA MoD UK

Topside design is a complicated subject and one of it's many elements which require careful consideration is the placement of weapon systems. Due to interactions such as electromagnetic interference, a compromise often has to be made in the placement of these systems to ensure that other systems can carry out their roles with a minimum of degradation.

As part of research work carried out at UCL, it was envisaged that some form of engagement scenario program could be used to analyse the weapon

placement. This would be one analysis tool of many to allow the naval architect to design a ship, fully aware of the effects of spatial conflicts.

In order to investigate the information requirements for an engagement scenario, a program was written. This program uses a database of weapon systems to set up a model of ship's defensive weapons. An engagement scenario is run and using probabilities assigned to each of the weapon systems an overall probability of hitting a target missile is calculated. The engagement is run at all angles around the ship giving the naval architect a visual reference of poor defensive arcs.

The database allows easy access to large amounts of information on ship weapon systems and is easily updateable and expandable. The database prevents the need to search around for the required information and aids fast analysis.

The program was written to be user friendly and to provide a 'stand-alone' tool. The information on arcs and coordinates has to be entered manually but has been eased using a Graphic User Interface.

The report covers the database design, the program structure and the testing of the program. The annexes provide full listings of the program code and database records together with example analyses and a copy of the user guide.

How Much Stealth?
by K. SLATER MoD UK

Stealth has received lots of publicity recently, much of which came out of the Gulf War coverage, where stealth was shown to be used successfully by US aircraft. This has made stealth a fashionable word that has been misused and has led people to believe it is possible to make a craft invisible. This view of stealth is obviously incorrect as every vessel has trace signatures that cannot be made to vanish.

It is possible that stealth can aid the susceptibility of a vessel in a hostile situation by delaying it's detection. This can be achieved in a number of different ways, at various levels of cost, where some methods are relatively cheap whilst others are expensive. It can thus be difficult for a design team to decide how much to spend and what measures to use.

This project will examine how a cost benefit analysis tool can aid a project team in the early stages of ship design. It will then address the effectiveness of the various stealth options through the use of engagement scenario modelling.

Mesh generation for multihull ships
by LIEUTENANT P.G. SUNILKUMAR Indian Navy

The concept of having more than one hull for a ship is an area where a lot of research is being undertaken by various agencies around the world. Twin hull ships like catamarans, SWATH, etc. have been in operation for some time. A more recent concept is the trimaran. The hydrodynamic performance of a trimaran is still being evaluated by model tests and its numerical prediction is more difficult when compared to a monohull. This is mainly because of the hydrodynamic interference between the waves generated by the individual hulls.

This project is aimed at developing a computer program for the generation of a three dimensional boundary element mesh for the underwater region of a multihull ship. A program was developed in 1994 for monohull ships and certain aspects of the present program are adopted from this existing program.

The program generates three output files. An intermediate output file containing the supplied and interpolated data is initially generated and this can be used to check the supplied data. After generating the mesh, a file is created which contains the data on the physical shape parameters of the elements—i.e. the internal angles and the aspect ratios of each element. The user can check this file and if elements are found to have excessive distortion, corrective measures can be undertaken. The final output file contains data of the mesh, the position of the nodes and the sequence in which the elements are assembled.

MARINE ENGINEERING

Planning and scheduling of maintenance pipelines
by S. ARONIS Private Student, Greece

The main purpose of this project was to investigate methods of planning and scheduling for the inspection and maintenance for a marine pipeline.

Initially, information on the possible techniques and procedures for inspection and maintenance was gathered. It was necessary to consider statistical data concerned with the probability and the consequences of offshore pipeline failures.

Different analytical methods to assess the reliability of the pipeline structure, which have been developed or are still under development, were reviewed and adopted for the purpose of planning maintenance for pipelines. One type of analysis that was investigated was structural reliability analysis. For this purpose, the setting of appropriate reliability levels related to the consequences of failure and failure type as well as the effect of inspection and repair was required. An alternative analysis method for explaining the effects of several factors on the reliability of pipeline systems is based on a discriminatory analysis. This was also reviewed and the results were used for estimating the probability of failure within a certain time period. These methods are expected to predict the probability of any pipeline or part of a pipeline failing and also to support a pipeline prioritization scheme. Such a scheme would allow a pipeline operator to make decisions related to the sequence and time intervals for inspection, repair or replacement actions for a pipeline or pipeline segments in order to maintain the integrity of the structure.

A procedure for planning and scheduling for the inspection and maintenance is to be proposed. A search tree is created to allocate all the possible inspections and after maintenance actions for the network to a five year inspection period. An example pipeline network to which the above reliability analyses could be applied is used to show the procedure. The scheduling will be based on a five pipeline network case (where every pipeline will be divided into several intervals) requiring inspection.

Wing ground effect machines
by LIEUTENANT I. ATKINS RN

Wing Ground Effect (WGE) vehicles were pioneered by the Soviet Union during the Cold War as a high speed craft for maritime operations. The so called CASPIAN SEA MONSTER aroused a great deal of interest when it was unvieled to the world looking to be much the same size as a C-130 HERCULES, yet travelling at nearly twice the speed with a far greater payload.

To fly submerged in any fluid, lift is generated by means of a pressure differential between the upper and lower surfaces of a streamlined shaped body. Whether in free flight or ground effect the platform places a footprint press-

ure on the supporting air called wing loading. In the case of Ground Effect craft, their lifting surfaces generate a low pressure by virtue of curvature, while underneath is a cushion of super compressed air. This is effectively rammed in as if a filling in a sandwich between the wing and the ground.

Climbing out of the ground effect allows expansion of the filling resulting in loss of lift. The only way to regain this is to increase the wing span but this changes the WGE craft into an aeroplane. The lift to drag ratio of Wing ships is significantly higher than conventional aircraft that in effect means less power to achieve a comparable speed or greater speed for the same power.

This report considers civil applications but concentrates more on military applications in addition to Ground Effect aerodynamics and craft control. Also examined are infrastructural requirements for the vessels and problems associated with operating and maintaining the craft. The report also overviews the intended IMO regulations for Wing in Ground Effect Craft and investigates the issues of actual and perceived safety. It concludes by summarizing the points made and includes the author's thoughts as to the future of these craft.

Shock testing of Rolls-Royce marine gas turbine recuperator
by LIEUTENANT P.C. CARROLL RN

The WR21 Propulsion Module utilizes complex cycle gas turbine operation to obtain lower levels of fuel consumption. One of the primary elements in the module is the spiral wound recuperator which facilitates counter-flow, gas to gas heat transfer in the precombuster/exhaust gas streams. The recuperator is a complex structure which due to the nature of its manufacture is only relatively lightly supported by welds at intervals at internal orifices (known as Header Holes) and sheet edges. It was identified during the design process that such a structure could be susceptible to failure when subjected to shock. This project uses Numerical Global Dynamic (MATLAB) and Finite Element (PATRAN/NASTRAN/SC03) models to predict the response and stresses experienced by the recuperator subsequent to a shock event. The sensitivity of these models to the assumptions made in their creation was examined using data obtained from a physical shock test on the first recuperator. This test was conducted at DERA Rosyth. The test comprised ten vertical/ horizontal shocks up to a maximum base acceleration of 18g without any visible material failure of the recuperator. The project culminated in the partial validation of both models such that the susceptibility of the recuperator to shock damage could be simulated in a simplified manner.

Modelling an Intercooled Regenerative (ICR) Gas Turbine using MATLAB/ SIMULINK
by I. CHIJUKA Private Student, Nigeria

The objective of the project was to develop software that could predict the performance of an ICR gas turbine from the performance data of the components that form it and also the transient response of the engine subject to some input. To achieve this, two methods were analysed:

(*a*) The transfer function/state-space model.

(*b*) The thermodynamic/state-space model.

Though the transfer function/state-space model has been the most common form of modelling, the thermodynamic/state-space model was explored. This has a direct correlation with the particular gas turbine in question and the form of the model ensures that only the performance data and the dimensions of the engine are required to simulate the response. The theory on which the matching procedures of the engine is based (for use with the second method),

has already been developed. The work involved applying it in the form of computing instructions, since the process involved a great deal of iterations and interpolations for a great number of data points, rendered it impossible to be performed by hand. The state-space equations have been derived using D'ALEMBERT's law, using the turbine torque as input to the equations.

It should be understood that the response of the engine given in this work is not accurate due too a lack of data from engine manufacturers, but the principles applied have been proven to be correct by virtue of the results obtained using arbitrary data.

MATLAB and its dynamic simulation software, SIMULINK, have been used because of their interactive and user-friendly characteristics.

A computer based engine data logging system using LABVIEW
by LIEUTENANT COMMANDER J.R. DARGAINS Brazilian Navy

The Internal Combustion Engine (ICE) is one of the most successful methods of mechanical power generation ever produced by humankind. The impressive number of generators, ships, locomotives, heavy trucks, lorries and passenger vehicles powered in this way attests this success.

Measurement of various parameters is required to evaluate the performance and fuel consumption of ICEs. With the rapid advance of microcomputer technology, the traditional limitations due to the small storage and slow processing speeds found in early personal computers have largely been eliminated. Powerful PC based data logging systems are now a practical proposition. Hence information like power output and mechanical power losses, regularity of combustion and detection of knocking combustion can be evaluated.

This project developed a computer based engine data logging system based on the LABoratory VIrtual Engineering Workbench (LABVIEW—release 5.0 f2) software to be applied for performance and operational analysis of ICEs.

The design requirements of the system were the ability to log 500 cycles of cylinder pressure data at 1500 rpm engine speed with a point at each 0.5 degree crankshaft angle. Inlet manifold pressure, temperature and other data could be logged as well. The pressure-volume, the Indicated Mean Effective Pressure (IMEP) and maximum peak pressure angle diagrams are some of the results expected.

Four Virtual Instruments (VI's) or logical programming codes were developed to meet these requirements. Two will be used for data aquisition and the others for display and analysis of acquired information.

The data acquisition code capacity is associated with the eight analogue channels available in the cardboard PCI-MIO-16E-4 used. Hence up to six pressure and two temperature engine signals can be measured simultaneously. Acquisition sampling rate can easily reach 18,000 samples per second per channel and binary code files were used to store the data.

Review of stress/strain and crack inspection systems
by S. DESPOTIDES Private Student, Greece

The main purpose of this study is to investigate stress/strain and crack detection and inspection systems. These form the basis for structural integrity maintenance and therefore a concise understanding of the methods available is imperative for the safe and economic operation of structural components. The study considers not only commercially available systems, but also methods and devices, which were proved effective under laboratory conditions but never exploited commercially.

The report is divided into two main sections, which represent its two areas of study (stress/strain and crack detection/inspection systems). In the beginning of each of these sections there is an extensive analysis of all possible theoretical techniques followed by a detailed analysis and description of the commercially available systems in an accompanying annex. Specifically, within the report there is a detailed analysis, among others, of the preceeding stress/strain and crack detection methods:

- Mechanical strain gauges
- Surface coating methods
- Photoelastic coating technique
- Grid method
- Optical methods
- Fibre optic
- Acoustical
- Semi-conductor and electrical strain gauges.

and also the following residual stress measurement methods:

- Magnetic
- Ultrasonic
- Eddy current
- X-ray
- Liquid penetrant.

The study made the following conclusions:

(a) There is no single available technique capable of measuring effectively stress/strain or crack size for all materials, environments and applications.

(*b*) In order to maximize the effectiveness of inspection systems, future devices should incorporate more than one sensor type. These hybrid inspection systems will involve complex data fusion techniques in order to consolidate information from different sources.

Non-linear analysis of the shock response of a simple structure
by LIEUTENANT COMMANDER K.M. HOOD RN

This project investigates the use of the ABAQUS finite element software package in representing the response of a mass loaded cantilever beam under shock input conditions. The aim of the investigation has been to identify the key features required of the ABAQUS representation of the beam to enable an accurate finite element model to be produced for use under a range of shock conditions. Theoretical, finite element and experimental results, using the cantilever test rig, are compared to validate the accuracy and level of finite element modelling required to produce a suitably accurate and usable model. The ABAQUS model response of the beam is compared with the experimental and theoretical response using both linear and non-linear analysis, the latter including plasticity and strain rate effects. It is expected that the findings of the project will be used for future research into the more accurate prediction of the shock response of ship structures and the effects on shipboard equipment.

Computer model of an underwater explosion
by E. KALLIGERIS Private Student, Greece

A first attempt to produce a computer model of an underwater explosion is made while taking into consideration the sound speed profile in the sea and the effect of the sea bottom. The model is based on various techniques developed in order to simulate the propagation of either seismic waves in seismology or ultrasonic rays in non-destructive testing of materials, by a series of researchers from as early as the 1960's. The programming language is FORTRAN 90 which is thought to be the most appropriate language for this kind of application, because of the relative ease of programming if offers when it comes to complex mathematical calculations. The model is provided with an explosive source, the depth and wavelength of which is defined by the user, and then uses two previous time steps to define the displacements at the next time step with the help of a centred finite difference scheme. The boundary conditions for the model are stress free surfaces at top and bottom and absorbent at the sides, since the latter are computing and not physical boundaries. The sound speed profile used is the so-called canonical model as developed by MONK (1974). Apart from the input regarding the source, the user also defines the number of nodes (i.e. grid size), the size of the spatial increments and the time after which the final results are produced. It is an interesting experiment as it can highlight any possible limits the formulations developed for solid matter have, when applied to a liquid. Also of particular interest is the opportunity this model presents to the user to investigate the effect that the sound speed profile has on the relative position of the source (i.e. source depth when placed either side of the minimum of the profile).

Fuel cell simulation
by LIEUTENANT M. LUNN RN

Fuel cells have recently attracted the attention of the marine industry because of their non-polluting nature together with high thermodynamic efficiency and low noise levels. The solid polymer fuel cell is generally accepted as the most appropriate cell for marine applications. Practical marine systems will use a fuel processor to produce a hydrogen rich gas from diesel or another liquid fuel. The gas produced will then require processing to meet the standards required by the fuel cell. The cell will then produce DC electricity directly from an electrochemical reaction between the hydrogen and oxygen. The only waste product being pure water. The oxygen would normally be provided directly from the air using an air compressor. Finally the electricity produced will require conversion machinery as the fuel cell voltage will vary with load.

The project aims were to conduct a literature search to determine the current state of technology and determine the most appropriate fuel cell system for ship propulsion. After the literature search the aim was to produce a modular model of a fuel cell power plant. The model would then be used to examine the steady state and transient response of the system.

A MATLAB toolbox, SIMULINK was used to produce the model. Each of the power plant components has a module linked with the program. The hypothetical power plant was developed using a partial oxydation reformer with a Pd pressure swing absorber used to separate the hydrogen in the reformate gas. The hydrogen separator is required since the nitrogen and carbon dioxide, in the refomate gas, reduce the effective partial pressure of hydrogen at the anode to an unacceptable level. The fuel cell module was based on an empirically modified mechanistic method for determining cell voltage developed by a Canadian team. Verification of the model was achieved via comparison with published fuel cell performance data. Having verified the model

a sensitivity study was conducted to determine the relative importance of the physical parameters. The model was then used to predict the performance and efficiency of a 1.6MW solid polymer fuel cell stack.

The computer simulation developed gives an insight into the operation of a fuel cell power plant in a user-friendly environment.

Selective Catalytic Reduction for the PAXMAN VALENTA diesel engine
by LIEUTENANT P. MARSHALL RN

The introduction of high profile legislation on emissions has led to the Royal Navy conducting detailed surveys of available and predicted technology in this field. Whilst gas turbines meet current requirements, diesel engines will require modification or exhaust gas treatment.

Concern has recently focused on the reduction of NO_x levels in exhaust gases as these have a wide-ranging impact on environmental and human issues. Primary methods of reduction, such as water injection or variable valve timing, degrade engine performance. Selective Catalytic Reduction (SCR) is a two stage exhaust gas treatment system which has minimum impact on engine performance.

The SCR process involves a nitrogen carrier, such as urea, being injected into the exhaust stream. This quickly undergoes pyrolysis to form ammonia and cyanuric above 275°C. In turn, the cyanuric acid reacts with water in the exhaust to form more ammonia and CO_2. The ammonia reacts with the NO_x in the presence of a proprietary $DeNO_x$ catalyst, reducing the pollutant to nitrogen. The now benign reactants are exhausted. Reduction of emissions of NO_x, hydrocarbons, and CO are of the order of 90% with a corresponding increase of particulate emissions of approximately 17%. The process is summarized as follows:

$$2(NH_2CO) \xrightarrow{275/\,C} NH_3 + HNCO$$

$$HNCO + H_2O \xrightarrow{Heat} NH_3 + CO_2$$

$$2NO + 2NH_3 \xrightarrow{Heterogeneous\ Catalysis} 2N_2 + 3H_2O + CO_2$$

This report details the investigation of the SCR system as fitted in the exhaust of a PAXMAN VALENTA 12RPA200Z diesel engine at HMS *Sultan*. The setting to work and pass off testing was conducted in association with ABB Fläkt Marine and Lloyds Register. These are discussed in detail and include a critical analysis of the system when related to the operating profiles of HM Ships and a comparison with other available technologies.

The main conclusion is that further enhancement of the system is required to fully comply with future legislation.

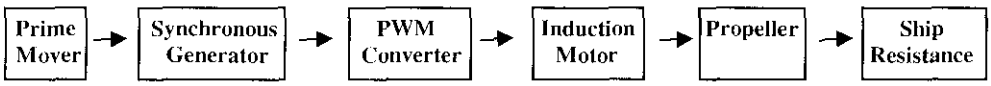
Note: The main report is classified as COMMERCIAL-IN-CONFIDENCE.

Modelling of a Full Electric Propulsion System using MATLAB-SIMULINK and Power Systems Blockset
by LIEUTENANT P. METHVEN RN

The next major development in marine engineering within the Royal Navy is likely to be the adoption of Integrated Full Electric Propulsion (IFEP) systems. The IFEP concept is well advanced but many technical issues remain unresolved. To develop the concept further and to de-risk the strategy, extensive simulation will be necessary. The ultimate IFEP modelling goal is an environment where designers can change system components and parameters

with ease to allow rapid optimization. This project has taken the initial steps towards this modelling goal.

The aim of the project was to model a single line electric propulsion system, as shown below, and investigate various responses. A key objective was to model the whole system from prime mover to propeller, achieving compatibility between component models.



MATLAB-SIMULINK was chosen as the modelling tool and, within this, the relatively new Power Systems Blockset (PSB) was also used. Initially, it was intended to use PSB to build a reasonably detailed model of the system and to use this single model to examine all forms of propulsion and electrical response. However, the complexity of such a model resulted in excessive computation and extremely slow run times. Thus, two separate avenues were explored based roughly on short and long term responses. PSB was used to examine the short-term electrical parameters such as fault currents and a separate SIMULINK model, less detailed in electrical terms, was developed to examine long term power transients.

Where possible, each model element was validated by comparison with published results and all elements were validated independently before coupled together. Finally, the model elements and completed models were reconfigured using MATLAB-SIMULINK masking and plotting features to provide an easy interface for the user and to allow the swift display of response plots.

Shipboard Vibrations
by P. PAPADOPOULOS Private Student, Greece

The main objective of this project dictates the approach of the final design of a ship so as to provide safe vibration characteristics. Generally, excitations on board ships are due to:

- Propeller excitation
- Propulsion plant and auxiliaries excitations
- Sea—swell excitations.

The present project concerns the measurement and analysis of shipboard vibration on two different vessels.

- For the first measurement the task was to find the reasons for and the extent of vibrations at which the deckhouse and accommodation on an Italian yacht, named M.Y. *Sagittaitre* were affected.
- For the second measurement, under registry's request, torsional vibration measurements were measured in order to determine the new critical speed of M.V. *Platytera's* main engine due to the new propeller displacement.

For the first measurement the measuring procedure was done according to ISO 4867. A vibration analyser of Brüel and Kjaer was used at four different shaft speeds (618—978—1380—2070). The vibration levels for each of the above speeds were measured at the:

- Front-top part of the engine (at Vertical, Longitudinal and Athwartships directions) *point 1* on figure.
- Ball bearing of the V-drive (at V and L directions) *point 2.*
- Main section of the ship, the hull girder (at V and L directions) *point 3.*

Forty tests in total were executed. All the results of the vibration analysis had very good operating conditions and were under the surveyed limit.

For the second measurement, two different methods were used.

1. Installed strain gauges on the intermediate shaft forward of the second bearing shafting system.
2. Installed accelerometer at the same position on the shaft and measured the deviation angle of torsional vibration for the whole running speed range.

Measurements were carried out at ahead and astern mode. From the results of the measurements, we concluded the first natural frequency of the system, the critical speed of the ship and the speed range that should be avoided. The results are valid for the ahead and astern mode as well.

Automated inspection of ship appendages
by S. SILIVRIDIS Private Student, Greece

At present propeller divers inspect blades when the ship is alongside. The water quality in harbours is usually very bad with visibility down to a few centimetres and as a consequence the diver deploying an NDE sensor relies on touch for positioning. This is not a satisfactory arrangement. The alternative to dry dock the vessel is very expensive and time consuming. Therefore other solutions should be proposed and examined.

This project is part of a proposal describing the basic steps toward the development of an ROV suitable for automated inspections of metal surfaces (i.e. propellers) immersed in murky liquid. The ability to inspect easily and regularly propellers would allow monitoring of the development of corrosion erosion and cracks. In particular this project will deal with the following problems:

(*a*) Navigation of the ROV towards the propeller disc. In the sections focusing at this aspect various solutions are proposed in relation with the overall conditions present at the inspection sight. In some cases when the ship undergoing the propeller inspection is in light condition, the tip of the blade is visible and the inspector can navigate the vehicle by sight. However this is not always the case and alternative methods are examined. A dead reckoning approach is followed in the absence of currents. This is achieved by propelling the vehicle close to the propeller disc and then diving it to the required depth, which is known. Other navigation schemes are based on conventional vision systems (i.e. underwater cameras) or acoustic imaging techniques, depending upon the degree of visibility. Finally, a solution based on an acoustic positioning system is proposed.

(*b*) Indexing around the propeller. Indexing of the ROV around the propeller appendages is required since the sensor is not large enough to inspect the propeller blade by a single placement. Two aspects were investigated, initial positioning and relative movement with regard to the initial point. The solution regarding relative movement will depend on how the ACFM sensor pad is deployed. If it is a 'pick and place' operation then the ROV loses its reference on any deployment and relative movement is not easily measured. Other solutions were investigated including the one using a marker to which the ROV is attached by a wire. Polar co-ordinates relative to the marker could then be obtained. Lastly a surface mounting system can be introduced.

Development of verification schemes of safety critical elements
by T. TOULOUMTZIS Private Student, Greece

The recommendations of the 1990 Lord Cullen's report on the Piper Alpha disaster of 1988 were fully accepted by the UK Government. As a result, responsibility for regulating offshore safety was transferred from the Department of Energy to the Health and Safety Commission (HSC) and the Health and Safety Executive (HSE) from 1 April 1991.

From that time HSC/E has carried out a programme to replace and/or renew offshore health and safety legislation. Two such regulations are the Safety Case Regulations (SCR) and the Design and Construction Regulations.

The objective of the above is to provide the mechanism and tools that will ensure a systematic inspection of the units 'Safety Critical Elements' in way of suitability, integrity and condition—throughout their life cycle. It is constructed to allow freedom of movement within the survey works already established for international trading, and as a further objective, to identify and fill gaps in the inspection inventory. A key feature of the scheme is the use of Independent and Competent persons to ensure impartiality and it works in consultation with such persons at all times. Vehicles within the scheme are tasked with the tracking and proper handling of any issues raised by the independent and competent persons.

Modelling of a Hybrid DC Circuit Breaker using advanced solid state semiconductors.
by LIEUTENANT D.A. WOODRUFF RN

The concept of an Integrated Full Electrical Propulsion (IFEP) design for the future warship is now under very serious consideration and with it the use of a DC ring main to supply ships systems with power. One of the major drawbacks of this system is the bulky nature of the DC switchgear. This is due to the requirement at present to have a large arc chute to contain the arc caused when the switch is operated. LIEUTENANT SANSFORD RN, carried out a 6 month project last year where he designed and tested a Hybrid Circuit Breaker. This used a combination of electromechanical switchgear and solid state semiconductors to avoid the generation of an arc and hence the need for an arc chute. He used MATLAB to simulate the breaker before actually building a device in the Lab at UCL. However unwanted voltage spikes hindered the evaluation of this design.

This project initially concentrated on producing a more accurate model of a simple circuit breaker using MATLAB. This model was developed to represent a hybrid breaker using a GTO and then a thyristor (utilizing resonant turn off) in turn as the solid state part of the breaker. The effect of using a varistor to remove the unwanted voltage spikes was also modelled on each of these circuits. Finally the various models were compared in terms of size, cost, and complexity in order to find the most suitable for use in a marine environment. It is proposed to use these results as a base for practical investigations.

Reliability analysis for structural maintenance
by I. ZORZOS Private Student, Greece

In the last two decades, great attention has been given to the reliability analysis of offshore structures. The role of modern reliability methods in engineering applications is as decision-supporting tools. For example, scheduling inspection and maintenance actions can be based on structural reliability analysis; inspection and maintenance is important in ensuring the safety and integrity of structural systems in and beyond their intended design life. This project reviews structural reliability in general and various reliability methods

used by the offshore industry. Additionally, this thesis investigates the application of Level II FORM and SORM techniques (First and Second Order Reliability Methods) on pipelines to aid in maintenance decisions.

It is well known that pipelines provide one of the safest, most-reliable and most economic means for the transportation of large quantities of liquids and gases, such as oil or natural gas. But pipelines are subjected to combinations of various loads, such as internal or external pressure, bending, shear force, etc. and also environmental loads such as winds, waves and currents. Hence, there is an essential need to perform an assessment of the structural reliability of pipes over time, based on theoretical models of deterioration.

One important element in the analysis is the limit-state function. In this project the most important failure modes with respect to maintenance of pipelines are identified. Moreover, there are many issues and problems in attempting to establish the corresponding failure functions and these are also discussed.

A major obstacle in the application of direct probabilistic methods has for a long time been the absence of efficient computational tools. This project carries also a study to demonstrate the use of the STRUREL program, (STRUctural RELiability) developed by RCP, and example failure functions for pipelines. Simplified failure functions are computed using FORM and SORM techniques, and reliability analysis is carried out.

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

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