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THE NAVAL ARCHITECT
International Journal of The Royal Institution of Naval Architects

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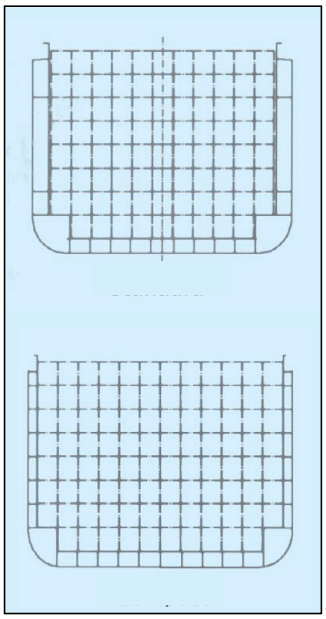
Printed in Wales by:
Stephens & George Magazines
Merthyr Tydfil

A one-year subscription in 2004 to *The Naval Architect* costs £95 (UK), £100 (Europe), and £110 (Rest of the world).

Audited Circulation 9838
JAN - DEC 2003

THE NAVAL ARCHITECT



Very interesting claims are being made by Aker Ostsee for its proposed new Baltic CS 5600 container ship design. This is said to have approximately 10% more TEU slots and can carry 10% more loaded 14tonne containers than competing designs - and still pass through the Panama Canal. Some of these achievements have been secured by using very narrow side casings, as seen here (bottom), compared with a standard design (top). More details appear in our special Germany feature which begins on page 24.

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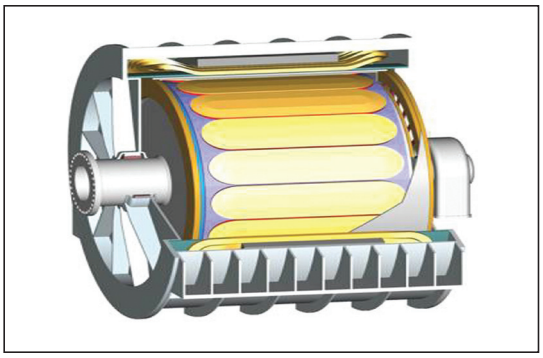
Electric ships running on high voltage

THE present appeal of electric ships is not, of course, new. They have been around for many years; famous examples include the French Transatlantic passenger liner *Normandie* of 1935, also numerous T2 tankers and submarines of the Second World War and afterwards. Over the second half of the 20th century, a sprinkling of trawlers, tugs, ferries, and special-purpose vessels such as cablelayers and icebreakers have also featured this machinery, all generally using diesel-alternators as their prime electric current generators (although *Normandie* and the T2 tankers celebrated the steam turbo-electric concept).

Generally, electric propulsion is chosen where operating conditions demand a high level of manoeuvrability or a lot of slow-speed sailing or loitering, and where the variable-speed characteristics of the electric motor - and the optimum-efficiency constant speed of diesel engines driving alternators - can be used to their best advantage. In most cases, owners probably paid - and still pay - a premium for their 'marine power stations', with their associated complex motors, cabling, and control technology; however, the benefits generally justify the costs.

It was the infinitely variable propeller control that is possible, combined with the huge demand for hotel loads, which first appealed to owners of modern-generation cruise liners - especially those in the Caribbean trades, where much overnight slow steaming was involved. The first ships began to appear at the end of the 1980s, eg, *Star Princess* (planned to be *Fairmajesty* prior to the P&O acquisition of Sitmar), built by Chantiers de l'Atlantique (*The Naval Architect* May 1989, page E174). Most attractive possibilities were put forward for the then CGEE Alsthom (today Alstom) for its synchro-converter system and double motor windings, which respectively made stepless FP propeller operation down to zero revolutions possible, plus a good level of redundancy on half a motor.



Technology for the future: this 36.5MW superconducting motor being developed by American Superconductor Corp, initially for naval vessels, could also be used in merchant ships. Several technical benefits are claimed.

Later owners preferred the cyclo-converter technique, for which the Finnish electrical giant ABB claimed several benefits. Cyclo-converters were fitted in the celebrated eight-ship series of *Fantasy*-class cruise vessels from Kvaerner Masa-Yards for Carnival - a most successful class that helped convert other owners.

At the same time, considerable advances in control technology were being introduced, and today it is practically obligatory to specify an electric propulsion plant for new cruise tonnage. Really progressive owners even opt for gas turbine-driven alternators, such as pioneered by RCI and Celebrity with the *Millennium*-class ships from Chantiers de l'Atlantique, while the technical control detail advances made by specialists such as Vacon, Imtech, and Bakker have launched the industry to new levels.

The arrival of the ABB Azipod concept has given a further boost to electric protagonists, particularly on cruise liners (notwithstanding other technical problems with which some owners have had to contend), and a great many systems are now in operation. This technique proved attractive enough to tempt other competitors, such as Rolls-Royce Kamewa in association with Alstom, into the field, although one or two have not fared so well. A notable, and quite successful variant is the Siemens-Schottel pod with its interesting propellers fore and aft of the hub (to recover energy from the forward blades), while ABB has advanced into contra-rotating proposals, installing - in its prototype contract for the brand-new Japanese ferry *Hamanasu* from Mitsubishi (entering service around now) - an Azipod behind a mechanically driven CP propeller.

New-generation LNG carriers have provided a further boost for electric drives as owners seek alternatives to the traditional steam turbines of such tonnage. The first mainstream ship with a dual-fuel diesel-electric power plant, but traditional shaft lines, will enter service late this year. The 74,000m^3 *Gaz de France Energy*, with her dual-fuel Wärtsilä-driven alternators and Alstom electric motor is nearing completion at Chantiers de l'Atlantique; two similar but much larger vessels, also for Gaz de France, are on order at the same yard, and it seems quite likely that such plant will become more common-place in the currently buoyant LNG market.

Our new special supplement, *Design and Operation of Gas Carriers*, which accompanies this issue, notes that almost all the major contenders for future LNG carrier contracts feature an electrical option in their ship designs - although this will have to compete with mechanical proposals.

While most marine people think of LNG tankers as being large vessels, there are still openings at the opposite end of the scale, where last year the 1100m^3 mini LNG tanker *Pioneer Knutsen* was completed by the Bijlsma Shipyard in The Netherlands. Although twin electric motors are used to drive the propellers here, the layout is a mechanical Z-drive from the Schottel stable. In the same scale are F T Everard's new 3750dwt product tankers with Imtech electric systems; the first should be delivered early next year from the Qingshan Shipyard in China.

One of the principal benefits to naval architects of any electric-power concept is the huge flexibility that is offered in positioning machinery, coupled with quite substantial savings in installed power, plus the possibility of releasing extra space for cargo, or cabins on a passenger ship. The Finnish consultancy Deltamarin believes that as much as 6.5% extra cargo space can be realised for a typical product or chemical tanker by adopting a vertical-position concept.

At the same time, such ideas have given impetus to the two competing manufacturers of gas turbines, GE and Rolls-Royce, since the light weight and high power density of gas turbines make their installation high up in the hull, or even the superstructure, a distinct possibility - as one or two cruise liner companies have already realised. For example, *Queen Mary 2* has her two 25,000kW GE/Brush turbo-alternators mounted in the base of her funnel.

Still to come are the highly interesting prospects for superconducting electric motors - Japanese work was first reported in this journal in November 1991 (page E509). Principal benefits include smaller size and volume and reduced weight, plus greater efficiency, especially at part loads. In the USA, the American Superconductor Corp is currently working on development of a 5MW high-temperature motor, in association with Alstom, for the US Navy; this will be followed by a 36.5MW version. The company anticipates that the weight of its larger motor could be 69tonnes, compared with more than 200tonnes for an advanced induction design, and notes that such a design would also be suitable for large cruise liners and cargo ships.

A special feature on Electric Ships begins on page 13.

Major new vessel program launched at BC Ferries

A LONG-term new vessel construction program is set to begin this autumn, BC Ferries recently announced. The Canadian company wants to ensure its fares are as low as possible and has thus decided to build its Super C class vessels abroad.

It plans to rebuild its fleet, replacing 22 ships of varying size over the next 15 years, and is nearing completion of a comprehensive tendering process for up to three Super C class ferries, for firm design-build contracts. The majority of these newbuilds will be small to medium sized open car deck ferries.

Despite the fact that three Canadian shipyards were invited to submit tenders, to date none have been chosen. Last time BC Ferries used a Canadian yard, for the construction of two Sprite class vessels 10 years ago, it had to assume design construction risk, and all the cost overruns of the project. The ferries were eventually delivered late and over budget. BC ferries does still use local yards for the construction of smaller vessels, and repairs however.

Tendering for a new 125-car intermediate ferry is also still underway, and competition is between two local yards, and a Polish yard. It is expected that the contract will be awarded at the beginning of next year.

Great achievements in the production of medium-sized container ships are being made today by the united Kvaerner and Aker yards in the former East Germany, now collected known as Aker Ostsee. This is partly due to a huge investment in modern fabrication and assembly facilities but also by building the forward half of current CS 2500 container ship hulls at the Warnow site and then floating them round the coast to Wismar for final assembly. Seen here is one hull being floated out of the covered hall at the Warnow yard. More details appear in our special feature on Germany, which begins on page 24.

NEW LARGE CONSTRUCTION VESSEL FOR SOLSTAD/SBM - Ulstein Verft is to build a construction vessel for Solstad/SBM, a joint-venture company owned by Solstad and the Monaco-based Single Buoy Moorings (SBM) group. This vessel will be one of the largest single projects that Ulstein Verft has gained so far, and is worth around Nkr650 million. The Vik-Sandvik-designed vessel has been slated for delivery in January 2006.

The vessel will be 123.8m long, have a width of 28m, and involve 6000tonnes of steel. The ship will be equipped with a moonpool, anchor handling winches, an A-frame, and a heave-compensated 250tonne offshore crane. It will be fitted out for 100 people. In total, the vessel will be able to produce almost 24,000kW.

Purchasing and planning has already begun, but steel cutting will commence in the middle of November this year. Ulstein Verft's Vanylven division will build the superstructure, with a start date of December. The forepart and aft of the ship will be built at one of Ulstein's partners in Poland, Maritim Ltd. The forepart will arrive at Ulstein Verft in May 2005, and the stern in July.

HOPPER DREDGER TO BE BUILT BY ALABAMA SHIPYARD - A contract has been signed between Alabama Shipyard and Manson Construction Co to build a hopper dredger. The 5575m^3 dredger, designed by Hal Hockema & Associates, of Seattle, has a length of 118.8m, a breadth of 23.16m, and a depth of 9.14m.

Engineering and planning on this vessel has already begun at Alabama's facility on Pinto Island. Steel cutting will begin in November 2004, with delivery of the dredger in October 2005.

DUBAI DRYDOCKS TO BUILD LARGE SHIPS - Dubai Drydocks plans to begin building mid-size vessels, such as small and medium-sized tankers, as part of an investment programme of US$100 million. It currently builds smaller sized vessels such as tugs. See our sister publication *Shiprepair and Conversion Technology* 1st Quarter 2004, page 8. The company will have annual capacity to build one or two tankers.

BMT ENABLES DESIGN OF SHIPS FOR IMPROVED EVACUATION - Pioneering trials measuring the ship evacuation performance of passengers in conditions including smoke and rolling motion, are being conducted as part of a research project led by British Maritime Technology Ltd (BMT) and co-funded by the European Union FP5 Competitive and Sustainable Growth programme and Precarn (funding for Canadian partners). This follows earlier work carried out in the UK and Canada, as detailed on several occasions in this journal.

The aim is to produce a FIRE-EXIT simulation tool which will equip the marine industry with a ship evacuation, fire and abandonment simulation tool that is a significant improvement over the level of reliability, realism, and design utility available from existing systems. The software will enable the design of safer vessels, optimisation of ship layout and emergency procedures and will also assist in ensuring that, in the event of a fire, passengers move as quickly and safely as possible to their assigned lifeboat stations.

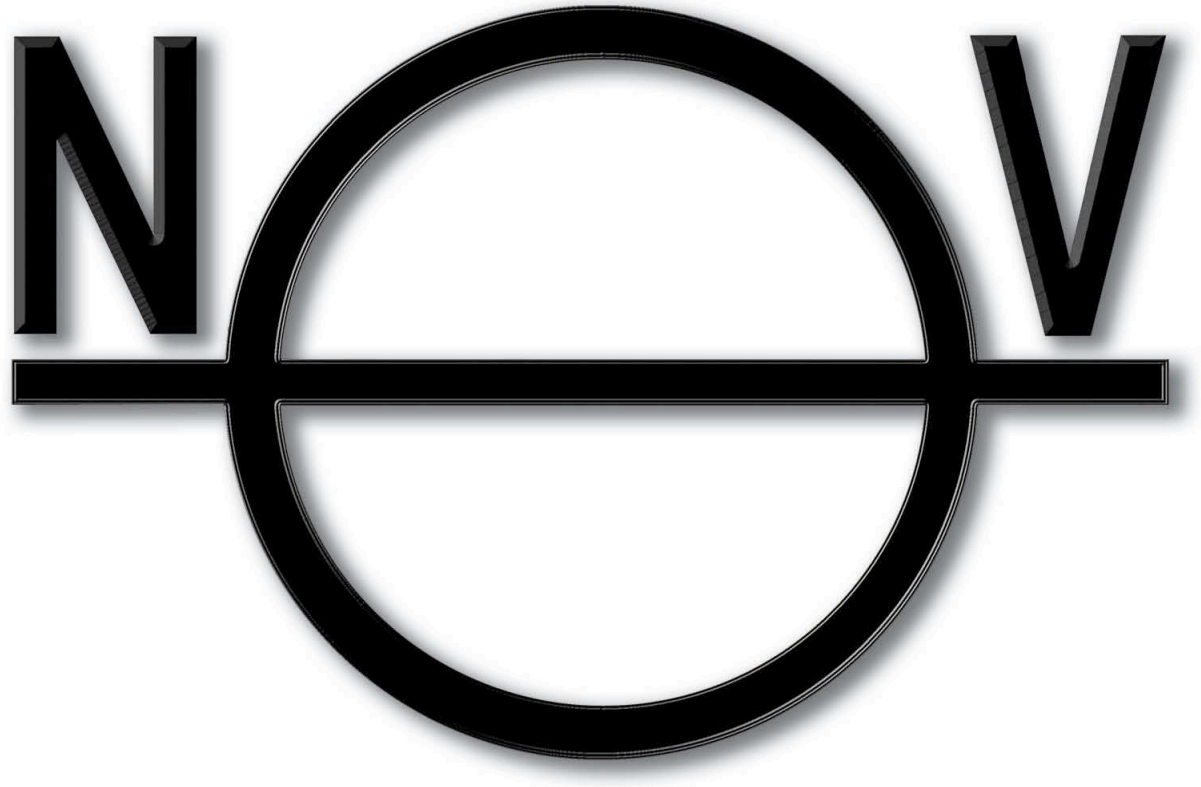
For the first time a large-scale, smoke-filled test facility capable of dynamic motion superimposed over an angle of heel is being used with volunteer 'passengers' for live trials. This follows major enhancements to the Ship Evacuation Behaviour Assessment (SHEBA) facility which provides a uniquely realistic insight into the evacuation process.

This represents a pivotal stage for the EU FIRE-EXIT (formulation of immediate response and evacuation strategies through intelligent simulation assessment and large-scale testing) project, aimed at improving ship safety. Full-scale abandonment trials are also being conducted in Canada. Volunteers are timed and behaviour videotaped as they escape from muster stations via inflatable slides and vertical chutes as they cross a collection platform and enter life rafts and lifeboats. Model tests have been performed to measure lifeboat launching performance in high sea states.

Data collected from these trials is being incorporated within the maritimeEXODUS ship evacuation software and the fire simulation software SMARTFIRE, both of which are developed by the Fire Safety Engineering Group (FSEG) of the University of Greenwich, which is also part of the research consortium.

Work to date has also highlighted the fact that the software will be useful not only in incorporating higher levels of safety at the earlier stages of design, but also in enabling

The 100 m grt milestone



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owners to re-assess plans for passenger movement. With potential for use in planning routine movements such as boarding or movement at meal times on large passenger ships, this could lead to smoother onboard operations in general.

The three-year FIRE-EXIT project is scheduled to finish in August 2005 and demonstrations are likely to be available by the end of the year. FIRE-EXIT will be of particular assistance in meeting the more rigorous legislative measures seeking to increase maritime safety, which have recently been established by the EU. For example, Council Directive 98/18/EC sets out requirements for new class B, C and D ro-ro passenger ships to have escape routes evaluated by an evacuation analysis early in the design process.

The FIRE-EXIT consortium also includes the University of Greenwich, AVEVA AB, BMT Fleet Technology Ltd, Det Norske Veritas, the METTLE Group, the Marine Institute at the Memorial University Newfoundland, and the Institute for Ocean Technology at the National Research Council of Canada.

AWARD PRESENTED FOR WORK ON *QM2* - Two awards have been presented to Designteam for its work on *Queen Mary 2*. Firstly, the 2004 ARCHI.TECH AV award in recognition of the *Queen Mary 2* best overall for outstanding achievement in technology integration. This award is for illuminations, which has also been awarded to Nautilus, for the integration of technical equipment within the architectural design of the space. The other award is the ShipPax award for outstanding cruise lounges of 2003, again in the category of illuminations, for the world's first afloat planetarium.

NEW CONTRACT FOR CARGO/ CONTAINER SHIP - Shipyard Koninklijke (Royal) Niestern Sander, Delfzijl, The Netherlands, has recently signed a contract with Setramar, of Italy, for the construction of a 14,650dwt general cargo/container ship. The vessel is set for delivery at the end of April 2006. Both Conoship International and Navimar SA - Shipmanagement are supporting this project.

The hull design is based on two previously delivered (2002 and 2003) IMO II type chemical tankers. Length overall is 139.95m, breadth 21.00m, depth 10.60m, maximum speed is 14knots, and the hold has a volume of 16,300m^3.

The ship has two cargo holds with pontoon type hatch covers. Hatch covers are operated by two small gantry cranes. Accommodation is arranged for a crew of 16.

The engineroom will equipped with a 4400kW engine running on heavy fuel. There are also two auxiliary engines of 320kW, together with a shaft generator of 800kW. This design specifically takes into account the requirements of the customer regarding limitations of draught and range of quay cranes.

10-VESSEL CONTRACT WON - Damen Shipyards Cargo Vessels has won an order for 10 CF800 container ships. Five vessels are for KG's of Reederei B Becker and the other five to KG's of Reederei J Kahrs, both from Jork, Germany. The total value of the order is approximately €160 million. The first two vessels of this new series will be delivered in September 2005, and the last two beginning of January 2007. These new vessels are almost identical to two ships currently under construction for the German ship owner J Köpping.

These container ships have a length overall of 140m, a beam of 21.80m, a depth of 9.50m, and a maximum draught of 7.30m. A total of 803 containers can be carried, and the intake of containers, each with a weight of 14tonnes, is 518TEU. The vessels are optimised for the transport of 20ft, 40ft, and 45ft containers on deck and as well as in the hold. In addition, 329 containers of 45ft can be transported. Containers with a width of 2.60m can be placed at almost every position. On deck 120TEU reefer positions are available, and in the hold, another 60.

For propulsion, an 8400kW MaK 9M43 main engine will be installed, driving a CP propeller, giving the vessel at maximum draught a service speed of 18knots. For manoeuvrability, a bow thruster of 700kW and a stern thruster of 500kW will also be onboard. The vessels will be classed by Germanischer Lloyd and strengthened for sailing in ice, notation E3. The vessels will also be equipped with hydraulic folding hatches and removable cellguides.

SECOND LNG TANKER ORDER CONFIRMED - Gaz de France, in partnership with NYK Line, has recently confirmed to Alstom the order for a 153,500m^3 LNG carrier, which will be delivered at the end of 2006. For more information on this type of vessel see our special supplement *Design and Operation of Gas Carriers* published with this issue.

This LNG carrier will be similar to *Provalys*, the vessel already ordered by Gaz de France, which is currently under construction at Chantiers de l'Atlantique, and which is due for delivery in the autumn of 2005. Like her sistership, this new order will, it is claimed, have the largest capacity in the world for this type of vessel, and will integrate technologies such as diesel-electric dual-fuel propulsion, and the latest type of membrane-type tank insulation – the new GTT CS1 containment system.

Meanwhile, Chantiers de l'Atlantique is continuing with construction of a 74,000m^3 LNG tanker, *Gaz de France Energy*, which is to be delivered at the end of this year.

BALTIYSKY ZAVOD CONTRACT FOR ICEBREAKERS - FSUE Rosmorport has contracted Baltiysky Zavod JSC to build a diesel-electric icebreaker, with an option for a second ship. The first vessel will be delivered in November 2006, and the second in November 2007. Construction will begin later this year to the Russian Maritime Register of Shipping regulations.

These ships will be used for icebreaker support of large tankers in the Gulf of Finland, during winter, for towing of vessels, and rescue operations, as well as for cleaning oil and chemical spills. The vessels will have 18MW shaft power, and two rudder propellers. They have been designed by the Iceberg Design Bureau. Length overall is 116m, beam is 29m, depth is 8.5m, displacement is 15,400tonnes, and the vessels will have a cruising speed of 17knots. There will be a crew of 20.

The special hull design on these vessels is intended to reduce power input for breaking ice, and to update such operational parameters for vessels. Special electrochemical (cathodic) protection, in combination with paint coating, is provided for underwater hull corrosion prevention. United automated control systems for all tasks is also envisaged for these vessels.

REVITALISATION AGREEMENT SIGNED - Royal Caribbean International and Kvaerner Masa-Yards have agreed on a revitalisation project, including a midbody lengthening, for the cruise ship *Enchantment of the Seas*. The midbody will be built in Turku, and the lengthening will take place between mid-May and early June 2005 while the ship is being drydocked at the Keppel Verolme Shipyard in Rotterdam.

This project, worth around €40-€45 million, includes revitalisation of public areas, a 22.2m lengthening, cutting, inserting, and joining of the midbody, as well as final outfitting, powering up, and recommissioning. After the ship has been extended, she will be 301.8m overall, and will have an additional 151 cabins.

JSC VYBORG UPGRADES FORAN INSTALLATION - Vyborg Shipyard has used FORAN since 1993. When the yard was taken over in 2000 by the Russian company AKO BARSS, a complete re-organisation and renovation programme was carried out on the shipyard facilities. This renovation includes the modernisation of the yard's design office installing it with the most advanced tools, such as FORAN's V50. FORAN V50 is currently being used by Vyborg Shipyard in the detail design of an ice strengthened stationary platform for the Prirazlomnoye (Barents Sea).

In other news, Severnaya Verft, one of the leading shipbuilders in Russia, has also recently upgraded its FORAN installation, resulting in an increase of work stations. This will allow the shipyard not only to cope with the current navy orders, but also to develop new projects.

FIRST EUROPEAN MITSUBISHI ENGINE DELIVERED - IZAR's two-stroke diesel engine factory recently tested and delivered a Mitsubishi 6UEC50LSII engine of 8670kW running at 127rev/min, that will be installed in a 25,000dwt chemical tanker that is building at the Turkish shipyard Celik Tekne, for Italian owner Mediterranea di Navigazione. IZAR-Manises Propulsion and Energy is the only licensee of Mitsubishi in Europe at present, and this engine is the first Mitsubishi engine to be delivered in Europe.

Besides normal tests, in which the correct general functioning of the engine at different power and its consumption is verified, special tests for emissions were carried out. This was to verify that this engine complies fully with all international regulations and is environmentally friendly.

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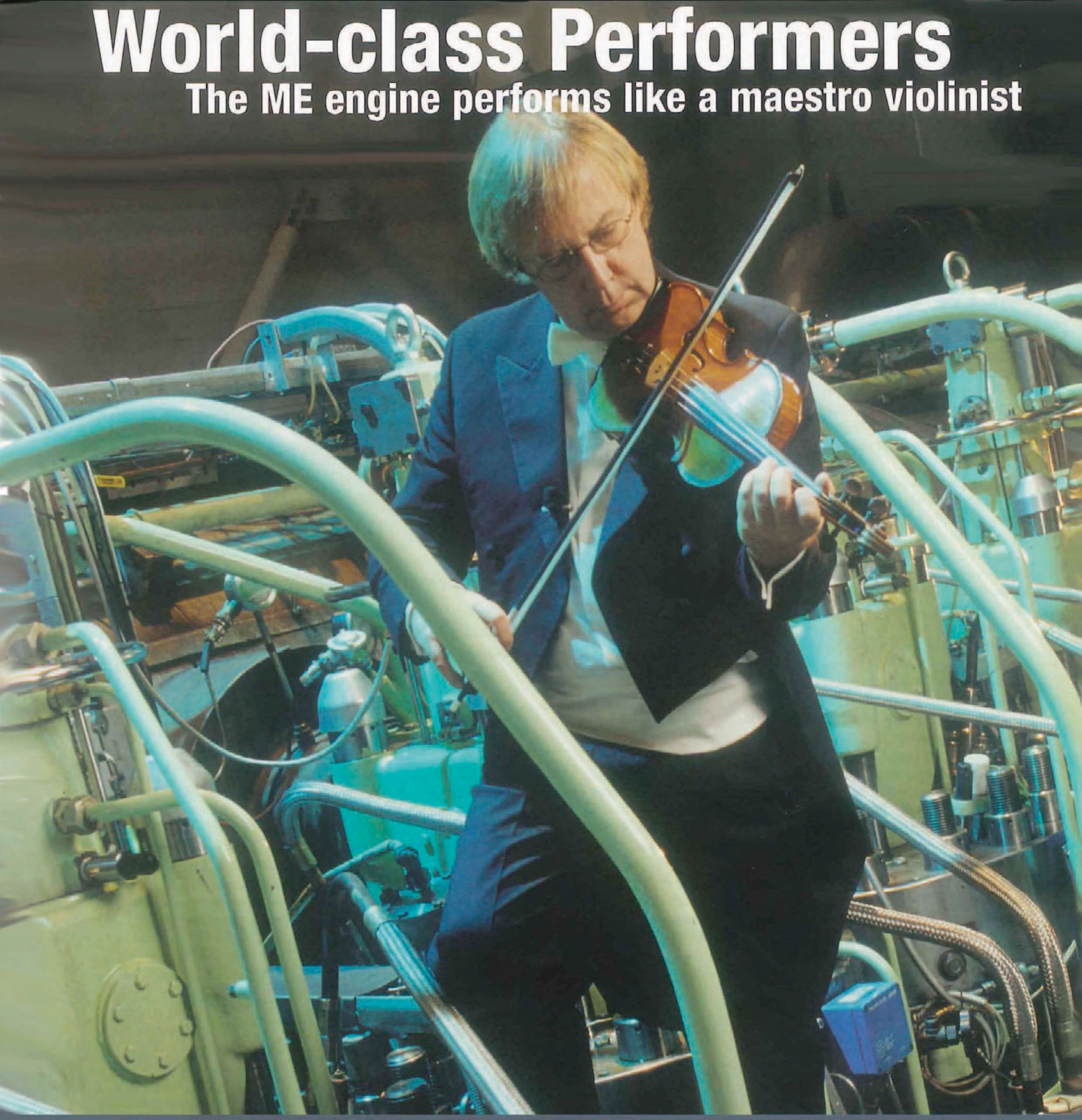

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Numerical methods for the design and analysis of marine propulsors

For a number of years MARINTEK (the Norwegian Marine Technology Research Institute) has been developing efficient tools for the design and analysis of modern marine propulsors. Current computer programs enable calculations of various arrangements including open propellers, propeller/rudder systems, and pod propulsors using approaches based on lifting surface theory and boundary-element methods. Here Aage Berg and Vladimir Krasilnikov from MARINTEK discuss a new type of software.

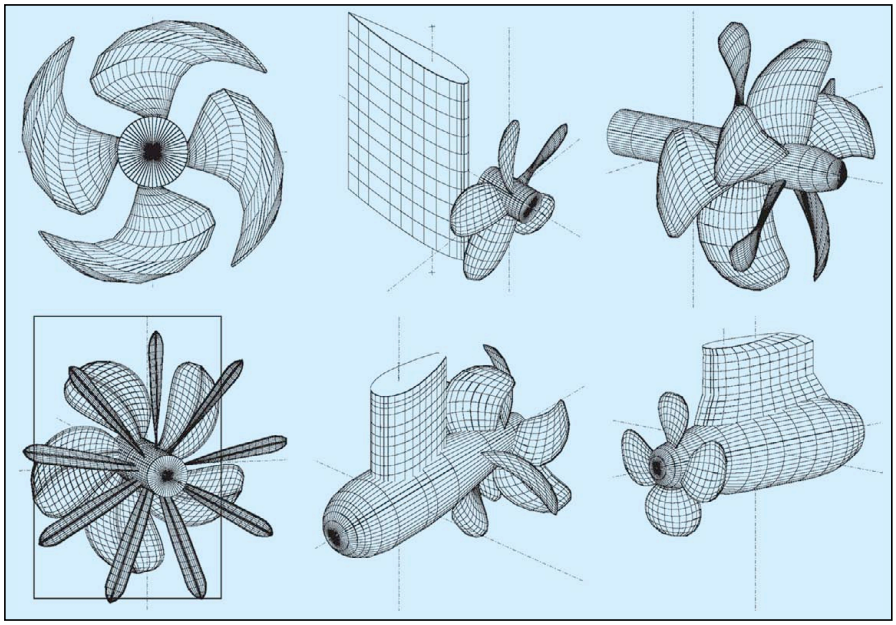

Fig 1. Different arrangements handled by the AKPD/AKPA programs.

THE application of numerical methods to the design and analysis of marine propellers has become virtually standard procedure in research institutes and design offices. Using a wide range of software, from the simplest diagram-based and lifting-line methods to advance boundary-element methods (BEM) and Reynolds Average Navier-Stokes (RANS) codes, MARINTEK has always paid close attention to the development of numerical methods that can be accurate and sufficiently universal on the one hand, and suitable for every day design practice on the other.

These efforts have led to the development of the AKPD/AKPA software, which features a non-linear lifting surface method for propeller design and a boundary element method for analysis, and allows for the simulation of various arrangements, such as those shown in Fig 1.

The AKPD design program implements a hydrodynamic design calculation that provides the user with blade pitch and camber distributions at prescribed main propeller elements (diameter, rev/min, number of blades, blade chord length, thickness, skew, and rake distribution) to satisfy required design points (J, K_T) or (j, K_Q).

Design calculations can be preformed either in uniform flow or in a pre-set radially variable velocity field as specified at the propeller plane. The following two main design variants are supported:

- calculation with prescribed span-wise circulation distribution
- design of the optimum wake-adapted propeller.

The latter calculation employs the generalised optimum condition, which takes the tangential velocity component into account when defining optimum calculation distribution, which is important in multi-stage applications.

Pitch and camber distributions are defined on the basis of non-linear lifting surface theory, taking account of the radial velocity component, which may reach significant values for highly skewed/raked propellers and blade rows in strong radial cross flow, due to shaft inclination or the effect of a highly conical centre-body.

Propeller design is an iterative process that involves successive runs of the design and analysis programs. MARINTEK's program is claimed to save time. The propeller viewer tool - a link between the design and analysis codes - allows for visual control, checking and manual correction of geometries at each stage if design and analysis.

The AKPA program, which is based on the original velocity-based BEM, performs steady -state and nonsteady-state calculations of propulsors in prescribed external velocity fields and features special cases of oblique flows due to shaft inclination or heading angle. The main outputs for the analysis code are:

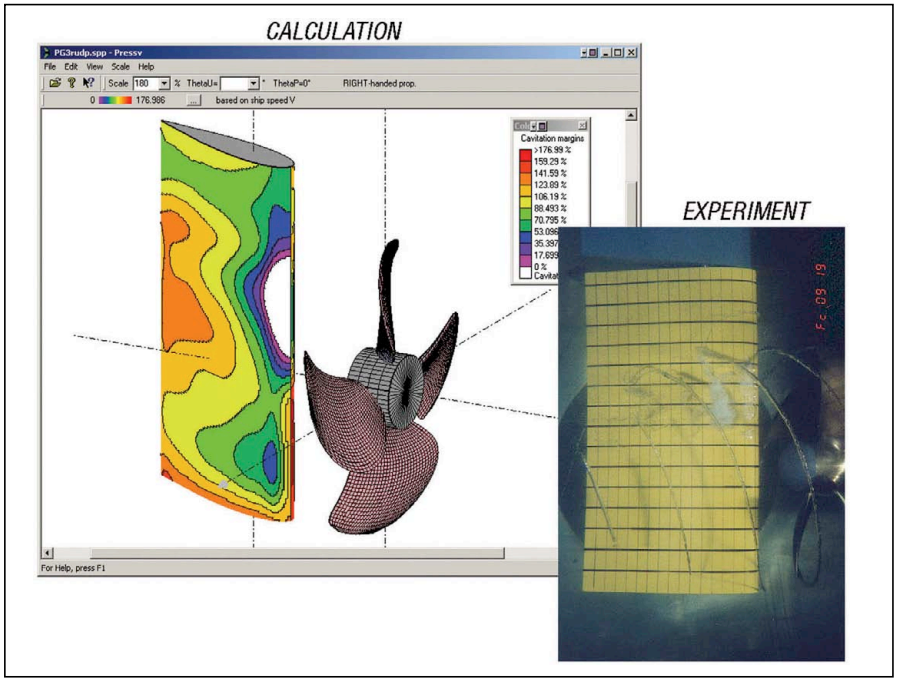

Fig 2. Example of prediction of cavitation domain on the rudder behind the operating propeller.

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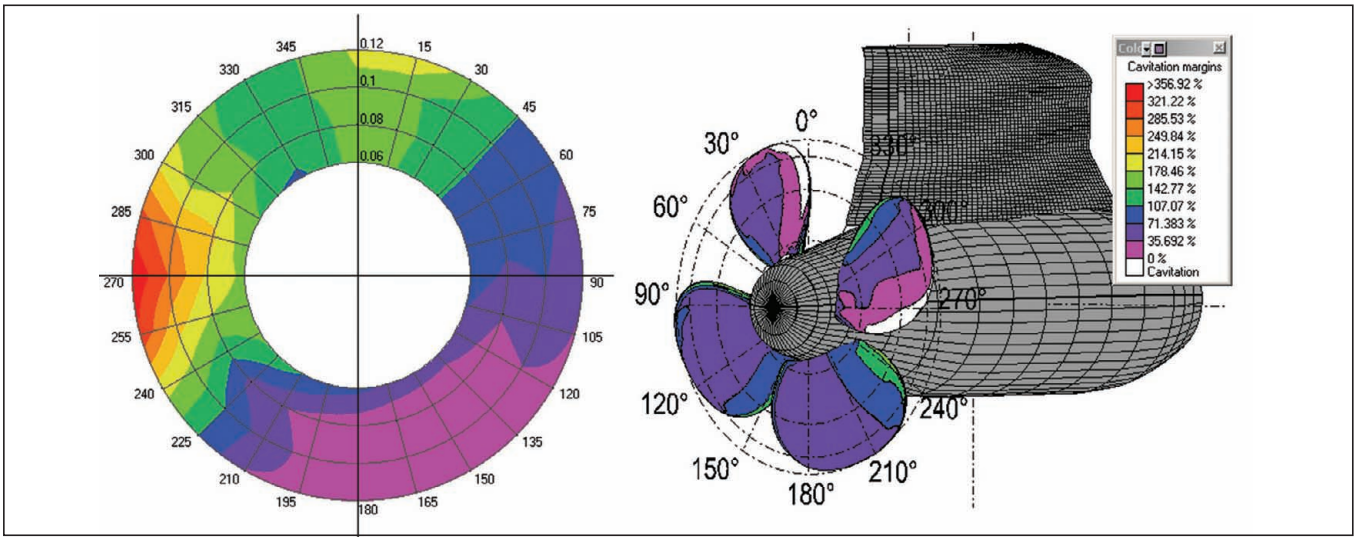


Fig 3. Cavitation on the podded propeller in a non-homogenous flow. Shaft inclination -3deg. Heading angle: -20deg.

- propeller integral performance (K_T, K_Q, efficiency, force, and moment Cartesian component), which are presented for each stage separately and as total figures in the case of two-stage propulsors
- total horizontal, vertical, and side component forces on the unit
- blade pressure distributions
- cavitation domains estimated from the comparison of the local pressure coefficient with local cavitation number.

In the case of non-homogenous flow, propeller forces and blade pressure versus blade turn angle are given. Used in conjunction with visual animation tools, these show changes in the aforementioned characteristics with propeller rotation.

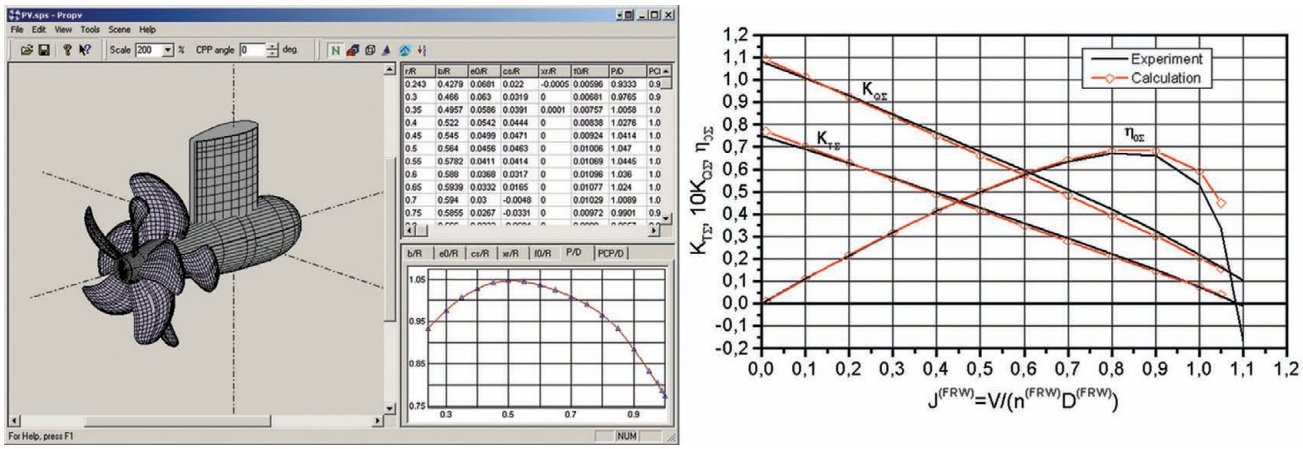
The AKPD/AKPA software offers a wide range of tools for visualisation of the pressure distribution on the propulsor components, viewing and editing of geometries, and propeller blade drawing.

The 3D blade-surface model produced by the 3DXYZ tool is ready for blade manufacture on milling machines. It imposes higher requirements in the accuracy of the blade surface than that is used in the calculations. For this reason the program includes special interactive tools that allow more accurate control of blade section geometry, including the most frequent cases of round, sharp, and cut edges.

Both the design and analysis programs have passed through detailed numerical/experimental verification showing good accuracy in terns of propeller and rudder forces, blade pressure distribution, cavitation domains, and induced velocity fields.

MARINTEK is currently focussing its efforts on modelling CP propellers under off-design conditions, ducted/tunnel thrusters, and extension of the analysis algorithm on the prediction of cavity volumes and propeller-induced pressure pulses on the hull.

Fig 4. General view of a pushing thruster with CRP propellers in the propeller viewer and its total integral performance predicted by the AKPA program.



MARINE SOLUTIONS

In the highly competitive marine sector, increased demand for efficiency is the main reason for using AC drives in fan, winch, propeller, and various special applications. This is equally true of all vessel types, from large luxury liners and cargo ships to small workboats.

SAVE FUEL AT SEA

The hardware and the software in Vacon's new NX series of frequency converters are based on a concept of complete modularity.
The modular construction with separate power and control units provides options for both air and purpose-designed liquid cooling technology.
The compact design allows space savings of up to 80% compared with air cooled drives.

The benefits of Vacon AC drives

- energy savings up to 40%
- space savings up to 80%
- less electromechanical stress for electrical system
- process control according to demand
- flexibility in power generation and distribution
- flexibility in ship design, providing more freedom in layout
- very little noise production

The plug-and-play modules allow easy maintenance and simplified logistics.

The NX range up to 3 MW, rated at 400 to 500 V and 525 to 690 V.

More about Vacon and marine at:
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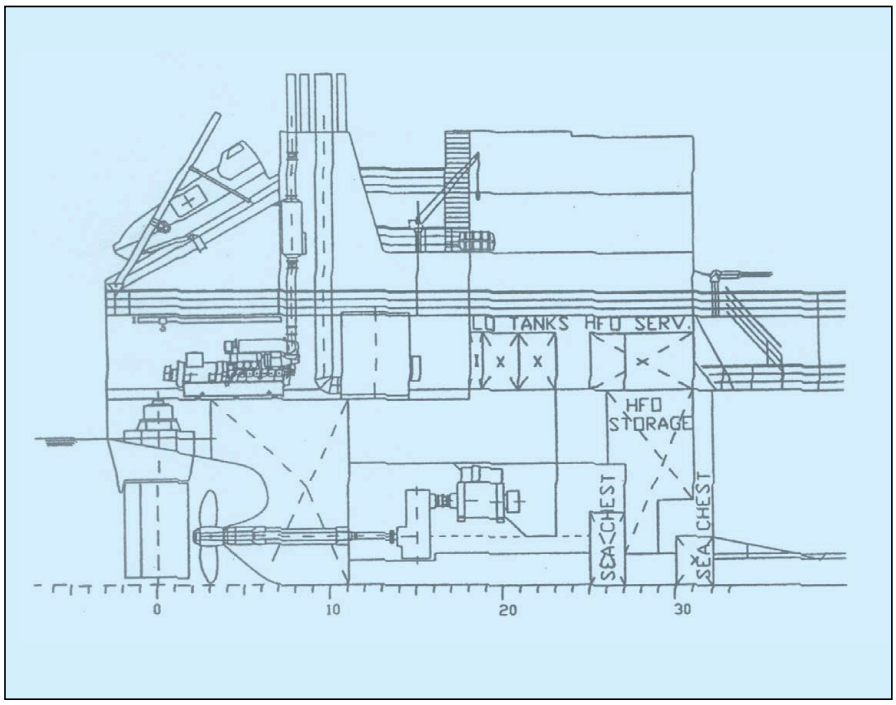
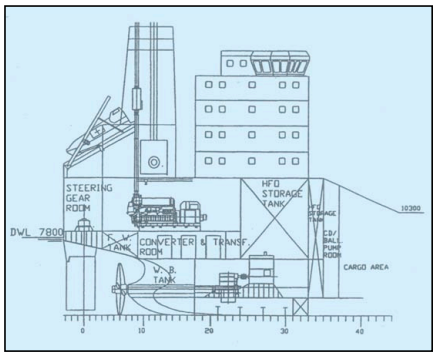
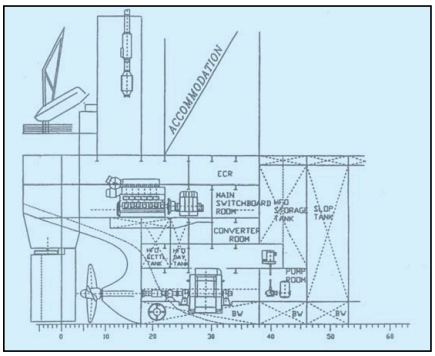
Electric propulsion exerts stronger pull

Continuing advances in power generation systems, drive technology, and power electronics are strengthening the case for electric propulsion in a widening range of tonnage. Integrated full electric propulsion is now standard for cruise ships and specified for a growing number of commercial and specialist vessel types, which can tap the operational and installation benefits of a central power station concept. Doug Woodyard examines the latest technology and prospects.







Three typical diesel-electric propulsion plant arrangements in a tanker, as proposed by the Finnish consultancy Deltamarin, indicating the short and direct routing for cables and piping.

With electric propulsion, the propulsor (propeller, thruster, or pod) is not directly connected to the prime mover but via highly flexible cabling. Eliminating the traditional shaftline allows naval architects to locate the main gensets and support systems in the optimum hull position to create extra cargo, crew or passenger space from a given hull size, or to reduce the ship length while maintaining the desired capacity.

Higher plant availability and fire safety are fostered by arranging the key power station elements in separate self-sufficient watertight compartments. Intrinsically modest noise and vibration levels from electric machines can be minimised by locating resiliently-mounted gensets in compartments more remote from accommodation and amenities.

A valuable contribution to the wider adoption of electric propulsion will come from motor and generator developments pursuing increased efficiency, compactness, and lower weights.

Prospects for superconductors

High-temperature superconductor (HTS) technology enables motors and generators to be designed which are not only smaller and lighter but also achieve higher efficiency and a more favourable operational response than conventional synchronous machines.

Siemens, for example, is working on an HTS generator which will be able to yield a power output of 4000kW at 3600rev/min. A test programme planned for 2005 will see its installation in ships and on offshore platforms. On completion, the generator will be tested and certified by Germanischer Lloyd, which has assisted Siemens with the performance and delivery specifications required for shipboard applications.

Driven by a diesel engine or gas turbine, the HTS generator will have multiple overload capabilities and be less sensitive to load variations than conventional machines. HTS conductors with very low electrical resistance replace the normal copper windings in the rotor. Cooled down to -246°C, they underwrite an almost loss-free current transmission and a current density over 10 times greater than with copper. An economical and maintenance-free cooling system has been successfully tested in a 400kW HTS motor.

Power output can be more than doubled compared with conventional electric machines, it is reported, or the same output produced from a machine only half the normal size. The compactness releases space which can be exploited for extra cargo or passengers in commercial tonnage.

Alstom is also involved in developing an HTS propulsion motor with the American Superconductor Corp, whose plans envisage versions with ratings up to 40MW as well as HTS generators. Warships are initially the prime candidates but merchant ships could well benefit further down the line. Naval applications are also sought by Rolls-Royce for its high-density Transverse Flux Motor development.

Tanker designers value space-saving potential

Numerous tankers of various classes are now in service with diesel-electric propulsion, their designers seeking to exploit the advantages over mechanical propulsion installations cited here by Finnish consultancy Deltamarin (some of this information is discussed in more detail as part of another article on environmental issues in this edition):

Arrangement and cargo volume

The power generating machinery can be freely located for optimised cargo-carrying capability. Several studies and newbuilding designs have shown the optimum arrangement is to locate machinery vertically, with the propulsion motor on the double bottom, systems and electrical equipment on the intermediate deck level, and the diesel gensets, boilers and other large units on the upper deck level.

A straightforward and short routing for associated cabling and piping is facilitated, but the most important benefit of this layout is that the engineroom can be made more compact and shorter, releasing valuable space for cargo

tanks. Some 3% to 6.5% additional cargo volume is achievable within the same main dimensional envelope and displacement. For 13,000m³ and 40,000m³ chemical carriers, this equates to an extra 800m³ and 1300m³ respectively.

The extra volume released from the engineroom can be exploited by adding an extra tank or pair of tanks, or by adding the volume into existing tanks (cost-wise, the third option is the cheapest and easiest).

Increasing the volume in the aft part automatically shifts the longitudinal centre of cargo aftwards when fully loaded, giving more freedom for hull form design and thus also improving loading capabilities.

Hull form and powering

It is possible to reconsider the principal type of hull form and related parameters, especially the longitudinal centre of buoyancy, in a non-typical way. The shift of machinery and cargo aftwards facilitates a position of longitudinal buoyancy aft of midships, thus avoiding a pronounced forward shoulder and reducing the required propulsion power.

It requires, however, a good aftship hull form to avoid any flow separation and additional viscous resistance. The pram-type hull form (barge type) with a centre skeg offers a good basis. The centre skeg will only accommodate an electric propulsion motor with a gearbox, giving much more freedom for the skeg dimensions and for the aftship buttock angle than with a conventional low-speed engine installation. The propeller diameter can also be optimised.

The possibility of a hydrodynamically-optimised longitudinal position of buoyancy and propeller diameter promise a power saving in a range from 5% up to 12% compared with a well-optimised conventional machinery and hull form configuration. This is based on model tests and studies for typical product and chemical carriers from 7000dwt up to 40,000dwt, the larger percentage typically reflecting the upper capacity tonnage.

A power plant principle allows the installed power to rotate the propeller and drive the cargo pumps. The number and size of the diesel gensets can be selected to meet the different power requirements at optimum loading in all prevailing service conditions. A clear power saving - as much as 15% - in the installed total power of a 40,000dwt product carrier can be realised, taking into account the lower required propulsive power, transmission efficiencies and the electric cargo pump drives.

Power availability is very high from a typical configuration of three diesel gensets. Propulsion systems are either a single-motor arrangement with double winding or a two-motor arrangement, in both cases geared through a dual-pad/two-step gearbox to a FP propeller. The only single elements are the shaftline and the propeller. High safety and redundancy are secured by locating the gensets above the waterline in separate fire-safe compartments.

Fuel costs are lower or at least the same, thanks to the optimised main parameters, hull form and propeller, despite the lower transmission efficiency with the diesel-electric configuration. Maintenance costs are 20%-30% lower due to the reduced installed power and the lower number of elements (especially cylinders) to be serviced. Construction costs can also be cut through efficient planning, allowing swift installation of machinery at a later stage in the schedule, modular arrangements and a reduced amount of piping.

Stena's 10,000dwt C-Max class product tankers feature diesel-electric propulsion with four main gensets (2 x 2200kW and 2 x 650kW) serving two 2200kW frequency-controlled azimuth thrusters with FP propellers. Twin thrusters and an optimised hull allowed the designers to create a short (120m) but wider ship of very shallow draught (6.1m), a beam of 23.8m contrasting with the 17m-19m of tankers of a similar draught.

A keen proponent of diesel-electric propulsion for tankers, Rederi AB Donsötank, this year ordered another 19,500dwt product/chemical carrier from Shanghai Edward Shipbuilding in China with a Siemens-Schottel SSP podded propulsor and a generating plant based on Wärtsilä medium-speed engines.

An SSP pod with a rating of 5100kW was specified for each of three earlier tankers commissioned by the Swedish owner from the same yard. Propulsive and other electrical power requirements on the latest newbuilding will be provided by a 9300kW power station comprising four gensets: three driven by Wärtsilä 6L32 engines, each with a maximum continuous rating of 2880kW, and a fourth by a Wärtsilä 4L20 engine rated at 685kW.

Stena's novel C-Max 9996dwt product/LPG tankers from Gdynia Shipyard (*Stena Calypso* is seen here) are each propelled by twin electric azimuth thrusters.

Diverse solutions for LNG carrier power

Medium-voltage power systems for steam turbine-driven LNG carriers have been a strong growth market for ABB Marine, which now anticipates increasing business for electric propulsion drives in the sector. A breakthrough for the Finnish group came with a contract to supply the complete electric propulsion drive system for the 153,000m³ dual-fuel diesel-electric LNG carrier *Provalys* building for Gaz de France at Chantiers de l'Atlantique for delivery next year. Electrical power will be supplied by one Wärtsilä 6L50DF-driven and three 12V50DF-driven gensets with a combined rating of 38.5MW. An order for a second ship of this size has recently been confirmed at Atlantique but it is not yet known if the same power arrangement will be adopted.

The key elements in a redundant configuration will be a pair of 14MW ABB medium-speed propulsion motors, medium-voltage frequency converters (ABB type ACS 6000) and a propulsion control system. The frequency converters will exploit direct torque control (DTC) technology for motor control, which is said to deliver improved performance and controllability of propulsion as well as a simpler electrical power system without harmonic filters.

Various dual-fuel diesel-based propulsion plants are proposed by Wärtsilä for LNG carriers, the electric drives including single or twin FP propellers, twin podded propulsor, and contra-rotating propeller (CRP) solutions.

Due for handover later this year from the same French yard to Gaz de France is a smaller LNG carrier which earned a debut in the sector for both dual-fuel diesel engines and electric propulsion. The 74,000m³ tanker, to be named *Gaz de France Energy*, is specified with a power station based on four 5700kW Wärtsilä 6L50DF-driven gensets. Electrical power will be supplied to a pair of 9550kW Alstom synchronous propulsion motors which are geared to a single FP propeller.

Variable-speed drives, says Alstom, ensure that FP propellers operate optimally and that the maximum torque is always available, whatever the rotational speed, fostering reduced fuel consumption and maintenance. In addition, electric propulsion achieves improved efficiency at low speeds and during manoeuvring, and high acceleration at low speeds.

Operational flexibility is similar to that of a steam turbine plant, but electric propulsion facilitates a swift astern mode with 70% of the rated torque available. Furthermore, electronically-smoothed torque control yields significant advantages, such as high manoeuvrability and the possibility to operate over the total propeller speed range from -100% rated speed to +100% rated speed. Investment cost savings over a traditional steam turbine propulsion plant are also promised by an electric drive, according to Alstom.

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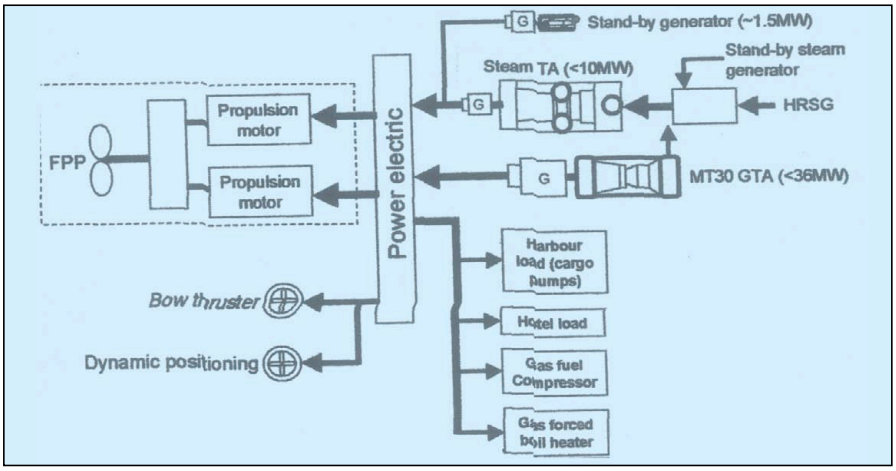


A COGES-electric power system proposal for an LNG carrier based on the new Rolls-Royce MT30 gas turbine.

Various electric propulsion configurations can be offered, Alstom citing:

- a geared single-shaftline with high-speed synchronous motors coupled to a gearbox
- a single shaftline with low-speed synchronous motors
- twin-screw shaftlines with two low-speed synchronous motors.

A podded propulsor solution based on the Mermaid pod developed by Alstom and Rolls-Royce is also proposed to deliver even better space-saving and manoeuvring merits.

Mini electric LNG carrier already in service

Electric propulsion has already logged a seagoing reference in the LNG trade, with an installation serving the 1100m^3 *Pioneer Knutsen*. Delivered early this year by the Dutch builder Bijlsma to Knutsen OAS, the world's smallest LNG carrier distributes gas along the Norwegian coast.

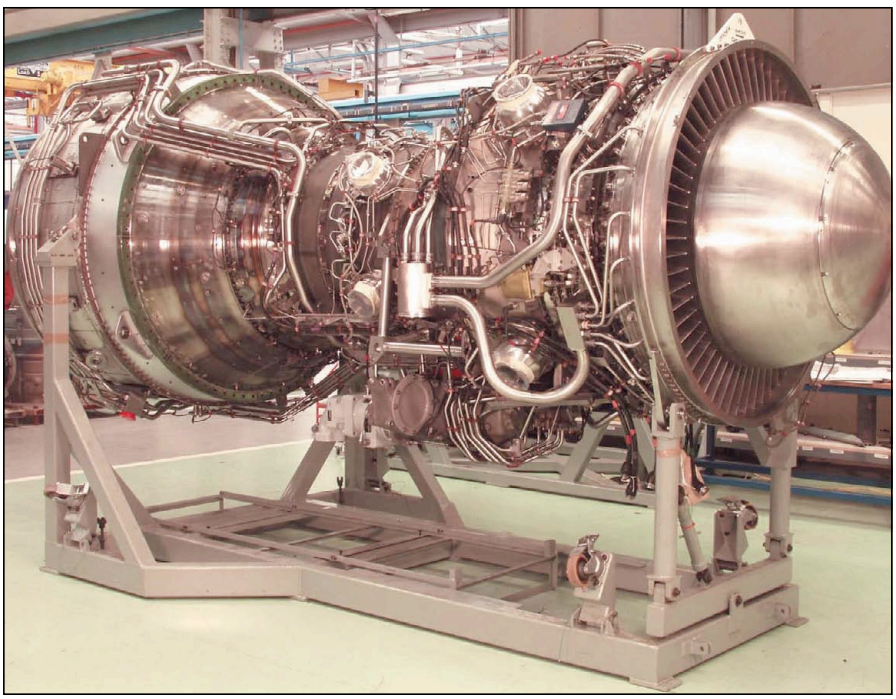
A pair of Mitsubishi GS16R-MPTK-driven gensets supply power to two 900kW Schottel azimuthing propulsion thrusters, each driven by an ABB frequency-controlled motor. These cargo boil-off burning engines are supported by a pair of 640kW Mitsubishi diesel-burning gensets housed in a separate machinery room. All four gensets incorporate Stamford alternators.

A number of electric and semi-electric plant configurations are proposed for LNG carrier propulsion by Siemens, with diesel and/or gas turbine prime movers arranged to burn cargo boil-off gas. The German group highlights the better layout flexibility compared with a mechanical transmission, particularly when a podded propulsor is specified. Additional cargo tank capacity can then be gained in a membrane containment ship design by moving the bulkhead further aft, or the same capacity provided with reduced steel and hence investment costs.

A more radical step suggested by Siemens is to move the engineroom and the ship's superstructure to a well-forward location. Freeing-up additional cargo space in this way would be most appreciated for LNG carriers with spherical tanks: an extra cargo tank could be accommodated without enlarging the hull.

Improved performance, as well as more inboard space, is also achievable from podded propulsors, Siemens notes. Tests at CTO in Poland, and confirmed by HSVA in Hamburg, have shown a reduction in hull resistance and increased propeller efficiency by installing hydrodynamically-designed twin skegs in front of the propellers.

The new MT30 gas turbine is proposed by Rolls-Royce as the prime mover for LNG carrier electric propulsion systems.



New electric division for Rolls-Royce

Also targeting LNG carriers is Rolls-Royce, whose dedicated UK-based Marine Electrical Systems business was established last year in response to rising commercial and naval demand for integrated electric propulsion and motion control systems. The British group cites a trend in the commercial marine market towards more comprehensive electrical systems for merchant and offshore tonnage, following the full electric propulsion systems well established in cruise vessels.

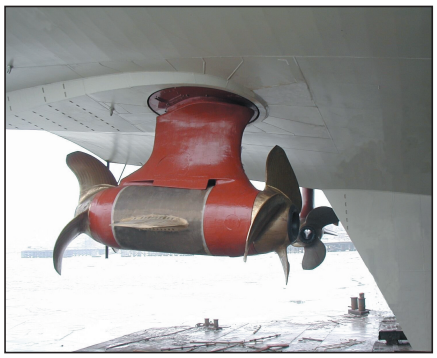
Significantly strengthened by the acquisition of VT Controls, the new business focuses on electric propulsion, automation and control, and motion control systems, tapping key in-house products such as diesel engine and gas turbine prime movers, propellers, and thrusters. Projects are executed in conjunction with specialist partners in electric motor, drive and generator technologies.

Recent projects have included the supply of full electric propulsion for the UT-Design offshore service vessel *Bourbon Tampen* and integrated diesel-electric and automation systems for the offshore wind turbine installation vessel *Mayflower Resolution*.

Among a number of alternative LNG carrier propulsion systems offered by Rolls-Royce is an electric drive based on its new MT30 gas turbine, arranged primarily to burn boil-off gas from the cargo tanks but with dual-fuel capability. Electricity generated by the gas turbine-alternator(s) is delivered to the distribution network on to high-voltage busbars. Power for the propulsion motor(s) is taken directly from the busbars and converted to provide a variable-speed drive.

Such a system meets requirements under all operating conditions, asserts Rolls-Royce, and secures redundancy both for propulsion and for the safe burning of cargo boil-off gas when this is not used for power production. Electrical power for loading, unloading and redundancy is provided by one or two small gas turbine-alternators (depending on the ship size and power requirement).

A combined gas and steam turbine-electric system (COGES) would incorporate a heat recovery steam generator in the exhaust stack of the MT30 turbine, the steam generated feeding a turbo-alternator set providing



Two Schottel SEP2 pods power the German Arctic research ship *Maria S Merian*.

additional electrical power to the ship and enabling plant efficiencies of over 50% to be achieved.

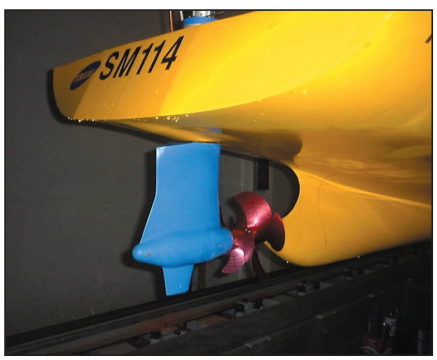
Pods enhance electric power attractions

The case for electric propulsion is strengthened when azimuthing podded propulsors are specified, a device pioneered by ABB Marine and the cruise ship builder Kvaerner Masa-Yards and launched in 1990. The success of this Azipod device and its market potential stimulated rival designs, notably the Mermaid pod from Rolls-Royce (Kamewa) and Alstom Power Conversion, and the SSP from Siemens and Schottel.

With its propulsion motor housed in a fully rotatable, submerged streamlined housing, the podded propulsor offers these merits:

- space within the hull otherwise taken up by the propulsion motors and shaftlines is saved or released for other purposes; combined with the power station principle, more flexibility is available in designing machinery and cargo/support equipment spaces
- steering capability is significantly better than with any conventional rudder system; and stern thrusters can be eliminated along with the rudder(s) and long shaftline(s)
- superior manoeuvrability and dynamic performance are delivered, even in harsh Arctic and offshore environments: in particular, excellent reversing capability and steering during astern navigation, and enhanced crash-stop performance
- low noise and vibration characteristics associated with electric propulsion based on propellers or thrusters are enhanced by the pod motor's underwater location; and hull excitations induced by the propellers are very low
- pod deliveries can be made late in the shipbuilding process, cutting 'dead time' investment costs
- reduced construction, installation and maintenance costs, and higher fuel economy, also excellent wake field due to improved hydrodynamics.

A model of a ship with an ABB contra-rotating (CRP) Azipod installation fitted.



Pods opened the door to some interesting contra-rotating propeller (CRP) proposals for powering large container ships, LNG carriers, and passenger vessels, promising simplicity and reliability. The pod is arranged in contra-rotating mode aft of a mechanically-driven main propeller, avoiding the gearing and bearing complexity associated with earlier co-axial shaft configurations.

Rotating in the opposite direction, the downstream propeller of the pod absorbs rotational energy from the main propeller's slipstream to gain a reported 10%-15% in propulsive efficiency, while the pod as a 'power rudder' yields enhanced manoeuvrability in adverse weather and sea conditions. Higher fuel economy, reduced emissions and propulsion redundancy are also cited for the concept.

A CRP-pod installation is said to require a significantly lower power demand than a conventional twin-shaft arrangement, thanks to the reduced resistance of a single-skeg hull form and the improved propulsive efficiency. The single-skeg hull also fosters a favourable wake field for the propellers. Dispensing with the traditional rudder, shaft brackets, and stern thrusters reduces appendage drag compared with a conventional ship.

ABB's CRP Azipod system debuts this year in a pair of 17,000gt ropax ferries completing at Mitsubishi Heavy Industries' Nagasaki yard for Japanese coastal service with Shin-Nihonkai Ferry (*The Naval Architect* July/August 2004, page 22). Propulsive effort is derived from what Wärtsilä terms a 'semi-diesel-electric' installation embracing a 25.2MW diesel-mechanical plant driving a forward conventional CP propeller, and a diesel-electric power station feeding an ABB Azipod mounted directly aft of and contra-rotating with its CPP partner.

Electrical power for the 17.6MW Azipod and the hotel load is supplied by two main diesel gensets supported by a 2700kW harbour genset. The Azipod features a 4.8m-diameter five-bladed FP propeller running at 175rev/min. Redundancy is secured structurally by dividing the main machinery between two separate compartments and operationally by the independent diesel-mechanical and diesel-electric drives.

Pod quality forum established

Pods have not been without their teething problems but an estimated 150 podded propulsion systems delivered for powering cruise ships, ferries, tankers, supply vessels and icebreakers have reportedly achieved a 0.2% unscheduled operational downtime. A Pod Quality Forum formed by leading suppliers aims to further improve pod quality and operational reliability by applying agreed common quality standards. The forum comprises ABB (Azipod), Rolls-Royce (Mermaid) and Siemens-Schottel (SSP), with Det Norske Veritas acting as secretary.

Operational experience gathered by the suppliers and DNV has been shared to enhance the overall quality of pods through a common internal quality standard. The Common Quality Standards are general and apply to generic pod units, the detailed technical differences between the different designs remaining.

Quality instructions address the production, post-production (including transport to yards and installation) and operational phases. They are additional to those normally required by classification societies and will be implemented as an 'industry standard' by each of the pod manufacturers involved.

ABB's contract with Mitsubishi called for shipsets comprising an Azipod, a system combining control of the pod and the main shaftline for optimised CRP efficiency in all powering conditions, the 27MW electric power plant with three alternators, and a 6.6kV main switchboard.

Original pod systems with ratings up to 30MW have been joined in the market in recent years by designs purpose-developed to bring the benefits of the concept to smaller tonnage requiring units with ratings from around 400kW up to 5000kW.

Launched in 2000, ABB Marine's Compact Azipod has logged numerous references in offshore supply vessels, survey ships, megayachts, and semi-submersible drilling vessels. The Schottel Electric Propulsor (SEP) has also attracted interest, with an early contract calling for two 2100kW SEP 2 sets to power the new German Arctic research vessel *Maria S Merian*. A pair of 5500kW SEP5 pods will serve the Royal Netherlands Navy's LPD-II *Johan de Witt*.

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Imtech and Vacon in drive for business

A SERIES of completely modular AC marine drives introduced by frequency-converter specialist Vacon has found favour in diverse shipping applications. Since entering the marine sector in 1997, this Finnish company has delivered well over 4000 air- and liquid-cooled frequency converters, its reference list embracing a range of tonnage from cruise ships and cargo vessels to fast ferries, workboats and yachts.

Among recent references are main propulsion drives for the Norwegian supply vessel *Havila*, the Finnish Maritime Administration's fairway maintenance vessel *Seili*, the US-owned megayacht *Limitless*, and four chemical tankers. Another contract calls for 1500kW propulsion drives for river barges designed to transport Airbus aircraft sections.

Beneficiaries of Vacon auxiliary drives include the all-electric hopper dredger *Mellina,* the cruise ship *Navigator of the Seas*, four tankers building for the Nordic energy company Fortum, a cable-laying vessel owned by Tycom, and Petro Baltic's offshore platform *59*.

Used for stepless speed control of asynchronous motors, Vacon's new NX series includes both air- and liquid-cooled units covering a power range up to 3000kW. Vacon claims to be the first manufacturer of high-power, low-voltage frequency converters to apply specially-designed liquid cooling to its products, a feature fostering maximum cooling efficiency and an extremely compact unit size. Experience with existing installations reportedly shows significant savings in space and operational economy.

NX frequency converters are based on a fully modular configuration with separate power and control sections, and easily-customised software; both air- and liquid-cooled units incorporate identical control modules. The liquid-cooled NX, however, has a power section with aluminium cooling elements, contrasting with solutions based on air-cooled drives with a redesigned cooling element.

Vacon NX liquid-cooled frequency converters cover a power range up to 3000kW.

Vacon summarises the key benefits as: a high cooling efficiency (up to 95%) as the heat loss can be dissipated outside the installation area; a low noise level; and a compact design promoting space savings of up to 80% compared with conventional air-cooled drives.

Due to its modular construction, the Vacon NX is claimed to be the most compact frequency converter on the market. A liquid-cooled 500kW unit, for example, is only 400mm in width and the 1500kW unit only 800mm wide. The product has reportedly become popular in main propulsion as well as shipboard steering, winch, pump, and fan drive applications.

Four chemical tankers ordered by the UK operator F T Everard & Sons from the Qingshan Shipyard in China will each be equipped with 1800kW AC propulsion drive systems from Vacon and Imtech Marine & Offshore, of The Netherlands. Vacon is supplying its liquid-cooled modular drives for Imtech to integrate into the complete system. The tankers' propulsion motor speed will be controlled by two 900kW liquid-cooled NX drives.

Low voltage, water-cooled frequency-controlled drives up to 4500kW purpose-designed for the marine market are offered by Imtech in co-operation with Vacon, the converters claimed to be resistant to shock, vibrations and high ambient temperatures. A very small footprint (3.25m^2 for a 4500kW/690V drive) underwrites highly compact installations.

Imtech's references were extended this summer by *Relume*, the Middle East Navigation Aids Service's new light tender from Damen Shipyards. An Imtech electric propulsion system - served by a Wärtsilä diesel genset outfit - is based on two 1500kW/690V motors and water-cooled frequency converter drives, whose compactness eased installation in a very tight aft ship. The main generators and propulsion motors (each of the latter driving a Rolls-Royce Ulstein Aquamaster azimuthing thruster) were subcontracted to Alconza for manufacture to Imtech specifications, the Dutch company then delivering and installing the system.

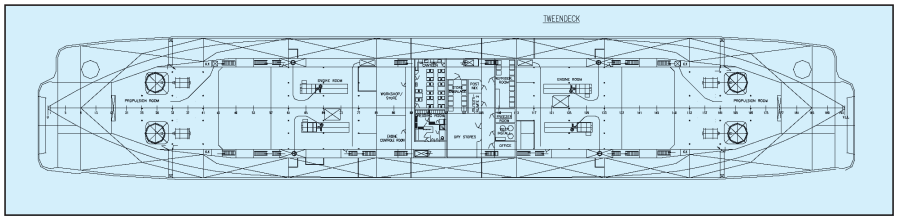
Turnkey systems from Bakker include DC drives

ELECTRIC propulsion for small-to-medium sized ships typically combines AC asynchronous motors with PWM (pulse width modulated) frequency converters. A very low acoustic signature requirement (comparable to submarines) for the multipurpose research vessel *Celtic Explorer* (*Significant Small Ships of 2003*), however, dictated another solution. Using asynchronous motors served by frequency converters results in a high electro-magnetic excitation in the motor, preventing the attainment of the specified underwater noise levels.

Delivered last year by Damen Shipyards to Ireland's Marine Institute, *Celtic Explorer* instead exploits two Indar low-noise direct current propulsion motors in tandem, each rated for 1500kW at 180rev/min.

Nevertheless, DC motors are also not free from electro-magnetic excitation, and special care was taken to limit the slot harmonic noise in the motor. The finite-element method was applied in designing the motor housing to avoid resonances in the low noise mode up to 11knots. Attention was also paid to the bearing arrangement of the motors and measures taken to reduce the noise of the air-to-water heater exchanger on top of the motor.

Machinery and propulsion arrangement of the new double-ended ferry being built by Damen for TESO, to serve the Den Helder to Texel route. This ship features a diesel-electric propulsion system engineered by Bakker Sliedrecht. Delivery is expected in June next year.



Electrical power is supplied by three Wärtsilä L20 diesel-driven Indar generators (two rated at 1875kVA and one at 1250kVA) to a 690V board, from which both propulsion and 720kW bow and 400kW stern thruster motors are fed. The 3000kW propulsion motors drive a five-bladed FP propeller at 180rev/min.

A turnkey electric propulsion and manoeuvring installation was executed by the Dutch specialist Bakker Sliedrecht Electro Industrie BV, whose outfit included the generators, thruster powering, switchboards, control consoles, alarm/monitoring systems and cabling. The main propulsion system is powered and controlled by tailor-made Bakker DC drives of modular design. Optimum availability is promoted by a black-out prevention system, Propulsion Power Limitation, created by Bakker and integrated in the main switchboard.

Another recent turnkey project will benefit the 130m-long TESO ferry ordered from Damen, with capacity for 300 cars and 1750 passengers and a maximum speed of 15knots. The Bakker-

supplied diesel-electric propulsion system embraces generators, transformers, medium- and low- voltage switchboards, drives, four 1800kW propulsion motors, control consoles and alarm/monitoring system. The four main gensets each provide 3077kVA, at 6kV.

Also commissioned from Bakker by Damen is a diesel-electric propulsion system for the Province of Zeeland's new SWATH ferries, designed by UK-based Nigel Gee & Associates. The plant features high redundancy in power generation, propulsion and control, and incorporates two main gensets and two double-rotor motors.

Turnkey diesel-electric systems were also supplied by Bakker for the Royal Netherlands Navy's hydrographic survey vessels *Snellius* and *Luymes*. Its other references include diesel-electric plant for a large cutter dredger for Jan De Nul, drive and energy systems for a cutter dredger for China, turnkey projects for the hopper dredgers *Prins der Nederlanden* and *Oranje*, and systems for the product tanker *Stolt Texas*.

Specialist vessels favour electric flexibility

RECENT years have seen the commissioning of multipurpose diesel-electric icebreakers designed and equipped to carry out arduous Baltic icebreaking duties in winter and provide North Sea offshore industry project support in summer.

A pioneering pair with 21MW ABB Marine power stations and cyclo-drives - *Fennica* and *Nordica* - was followed into service by ABB's Sami Megastar PWM-drive *Botnica*, which further benefits from twin 5000kW Azipod propulsors.

An open-water speed of 15knots is achieved by *Botnica*, with a bollard pull of 105tonnes, valuable in offshore towing projects. The frequency converter control yields smooth torque in either direction of rotation. In this application, the Azipods also foster accurate manoeuvring and mooring alongside fixed platforms, semi-submersible and jack-up rigs, drilling tenders and barges, often in heavy sea and weather conditions.

The first offshore tonnage to fully exploit Kvaerner Masa-Yards' interesting Double Acting operating concept - the ABB Marine-equipped icebreaking supply vessels *Arcticaborg* and *Antarcticaborg* - were commissioned to provide year-round drilling support in the northern Caspian Sea. In open water these shallow-draught vessels proceed conventionally bow first but in hard ice conditions are deployed stern first. Twin 1620kW Azipods help to achieve excellent icebreaking performance from a comparatively modest installed power.

The Double-Acting concept has also been employed in the new pair of Arctic 106,200dwt tankers for Fortum Shipping, *Tempera* and *Mastera* (*Significant Ships of 2003*). Each features a 16,000kW Azipod drive system, drawing power from four ABB/Wärtsilä diesel-alternators.

Diesel-electric propulsion has long been favoured for seismic research and survey vessels, whose operating profile may call for a very slow speed mode for extended periods and a normal navigation speed in reaching the area under surveillance. These diverse demands are satisfied by matching the number of gensets on line to the given load, a facility that not only enhances fuel economy but also reduces NOx emissions.

A high degree of manoeuvrability appreciated in research and survey vessels is further underwritten by electric propulsion, with smooth speed control of propulsion and thruster motors secured by an appropriate drive system. The low noise and vibration characteristics associated with electric drives are also valued, both within the accommodation and laboratories and in the external marine environment.

A number of advanced cableships commissioned in recent years enjoy operational flexibility with economy during normal navigation and when engaged in either cable laying or recovery and repair. High manoeuvrability and precise position-keeping dictated in executing the latter tasks is commonly secured by a DP system exploiting the main propulsor and thruster outfit. A diesel-electric plant solution allows the prime movers to be located remote from the propulsors facilitates the adoption of a full stern working arrangement for cable laying and raising operations.

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Germany - maintaining its position in the European marine industry

GERMANY'S maritime industries seem as buoyant as ever - that is the impression resulting from a recent visit to a number of the country's shipyards and manufacturers, and discussions with key figures in the industry.

Last year saw the delivery of some 70 vessels totalling around 1.35 million gross tons and this year is likely to see results close to these figures if delivery schedules are met. This level of output, representing around 3.5% of world output, has been maintained fairly consistently by the German shipbuilding industry since the mid-1990s - notwithstanding great concerns about the future only very recently.

In one area of shipbuilding, Germany is doing particularly well. Despite competition from yards in the Far East, it has a very healthy order book for container ships, with around 90 vessels contracted through to the beginning of 2007. Much of this may be due to Germany's traditionally strong showing in container vessel ownership, also to the high freight rates currently being experienced by this sector, causing demand to exceed the capacity in South Korea, Japan, and China.

It is true that yards feel they cannot compete for the very largest container liner orders, due to price disadvantages, but European Union subsidies and cost efficiencies have enabled German yards to win many orders for smaller units. Nevertheless, the ability of the country's shipbuilders to meet this demand reflects the inherent strength of the industry, and it is interesting to note that yards such as Blohm + Voss and Meyer Werft are both once again building container ships.

German success in the container sector - not just for new tonnage but also in ownership - is reflected in the commanding position which that country's Hamburg-based but internationally operating classification society, Germanischer Lloyd, holds in this field. In particular, GL is the leading society in the current building boom in Germany and abroad, especially for the many post-Panamax vessels building in the Far East.

Meanwhile, other yards such as Sietas and Lindenau continue with their highly successful feeder container and tanker designs respectively, which are being produced in considerable numbers. The only major yard that has had difficulties of recent times is Lloyd Werft, which was threatened with liquidation following, amongst other things, problems with the 81,000gt cruise ship *Pride of America*. Today, the yard has won the support of the majority of its creditors and has restarted work on the vessel, now due to be delivered in June next year.

In other sectors of the industry too, supplying the myriad systems and components that go to make a modern merchant vessel, production continues apace, even if order books do not extend so far into the future.

Only in the longer term are some worries being expressed. Many of those we spoke to are not certain whether the current success can be maintained into the far future. On the other hand, the view was also expressed by others that this was the time to consolidate and prepare for that future to ensure that Germany's maritime industries have long-term prospects. Only time will tell whether the industry can survive, in its current form and size, into that future.

This special feature has been compiled by John Barnes.

Merged yards enter new era of productivity

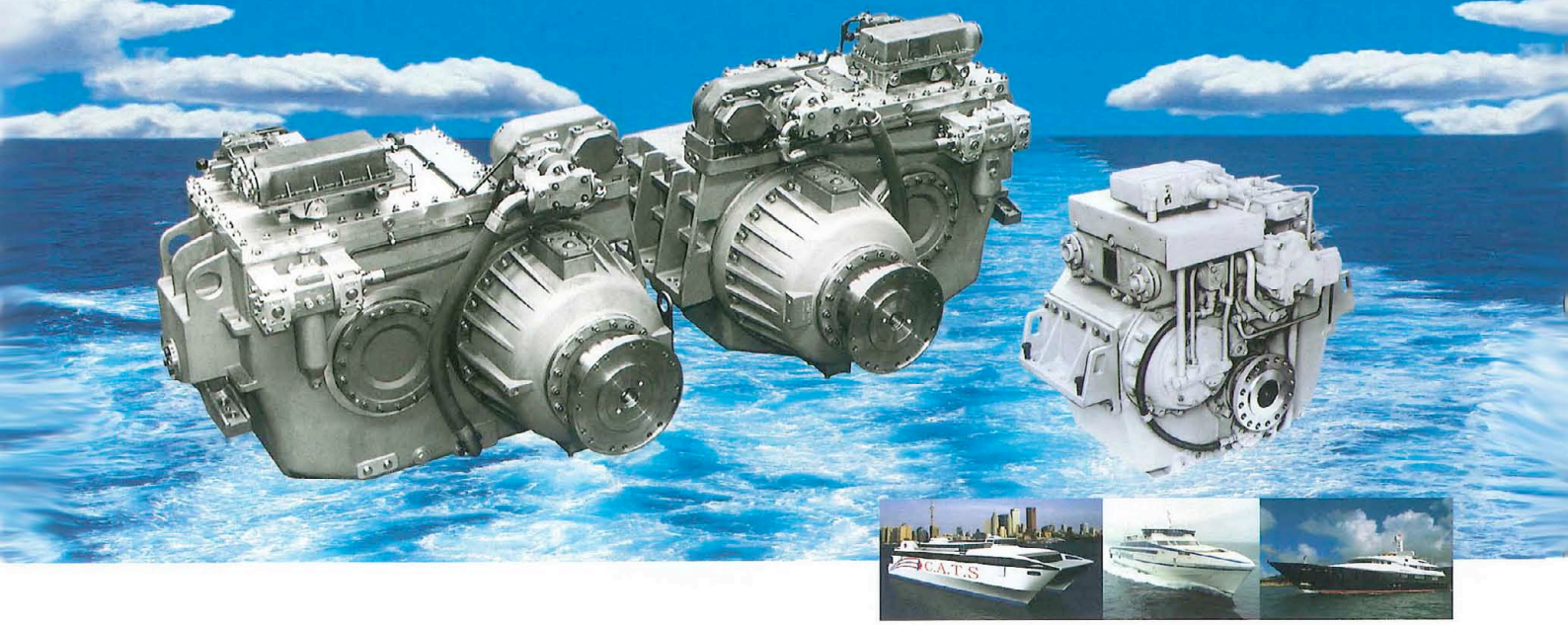
concepts including the CS 5500 Compact Panamax container ship design, which it believes could be another winner.

By increasing the number of rows of containers in the hold by one to 12 compared with traditional Panamax vessels but still within the beam constraint of 32.20m, Aker Ostee has raised TEU capacity by around 10% over existing designs - in addition it can carry 10% more loaded 14tonne TEUs than any other design, it is claimed. This has partly been achieved by specifying very narrow side skins.

A TEU capacity of 5600 units actually makes the design comparable to a post-Panamax vessel with a beam of around 40m but with a much smaller gross tonnage. This results in costs such as those for canal passage, tugs, mooring and harbour dues being similar to those for a 4900TEU vessel.

The 2500TEU *Cap Doukato*, for Hartmann Schiffahrts, is the lead ship in Aker Ostsee's new Baltic CS 2500 class. These ships have been evolved from the earlier CV series and have a service speed of 22knots.

High-Speed in Comfort?



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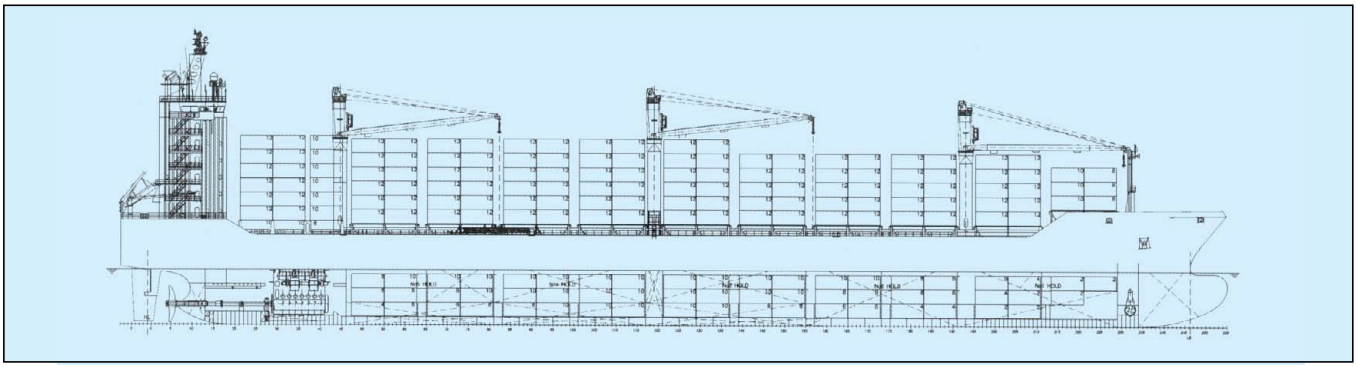
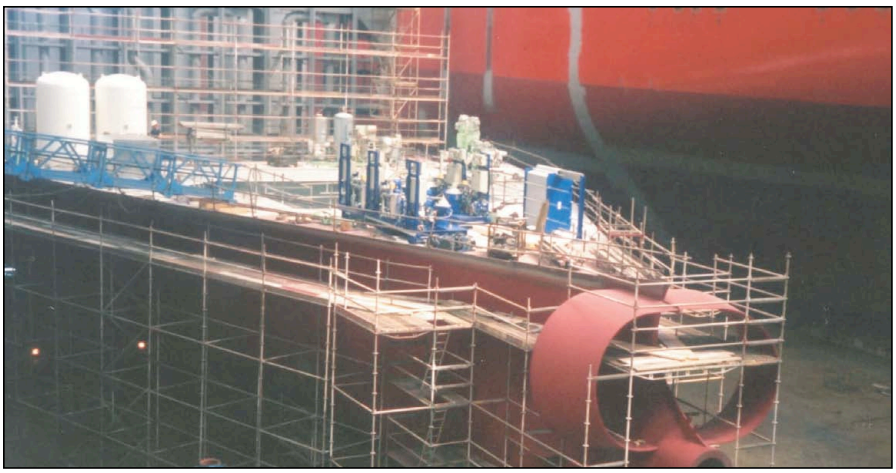


Profile of the Baltic CS 2500-class container ships. Owners wanting more containers can opt for the CS 2700 type.



Construction of a further container ship in the series at Wismar, revealing the Schneekluth wake-equalising ducts.

IN the middle of last month, the 2500TEU container ship *Cap Doukato* was delivered to her owner, Hartmann Schiffahrts GmbH, and immediately went on charter to Hamburg Süd. This vessel is the lead ship in the Aker Ostsee group's Baltic CS 2500 class and represents the first fruition of the merger of the Warnemünde and Wismar yards under a single ownership as well as the adoption of an integrated production programme.

Bringing the two much-modernised yards - visited recently by *The Naval Architect* - under one management has enabled production to be structured between the two entities. It has also enabled excellent and speedy production schedules to be attained, such that the joint organisation is now able to deliver one 2500TEU/2700TEU container ship every month.

Nevertheless, the enforced limitation of production by yards in the eastern part of Germany, agreed with the European Union (EU) in 1992 in exchange for substantial investment in facilities, prevents output of this size of vessel exceeding around 12 units a year. This was based on reducing the theoretical capacity of the yards to 60% of their former levels. When the limit is removed, at the end of 2005, Aker Ostsee believes it can expand production progressively to nearer 18 vessels a year, depending on their size and subject to winning the orders.

Handy-sized design

Cornerstone of production at the two yards, until at least the end of 2006, is the recently developed Baltic CS 2500/2700 container ship design, available in either geared or ungeared configuration, with 2500TEU and 2700TEU capacities respectively. A total of 27 further vessels of the two types are currently on order as follows:

- eight further CS 2500 for Hartmann for delivery up to spring 2006
- four CS 2700 for Norddeutsche Vermogen for delivery during the second half of 2005
- three CS 2500 for Schulte for delivery between spring and autumn 2005
- eight CS 2700 for Schöller for delivery between the middle of 2005 and the autumn of 2006
- four CS 2700 for Thien and Heyenga for delivery between the middle and end of 2006.

TECHNICAL PARTICULARS
CS 2500 AND CS 2700 CONTAINER-SHIP DESIGNS

	CS 2500	CS 2700
Length, oa	207.60m	221.62m
Length, bp	195.40m	209.60m
Breadth	29.80m	29.80m
Depth	16.40m	16.40m
Draught, design	10.10m	10.10m
Draught, scantling	11.40m	11.40m
Deadweight, design	27,580dwt	30,600dwt
Deadweight, scantling	34,180dwt	37,800dwt
Gross	25,350gt	28,050gt
TEU capacity	2478	2732
FEU reefer capacity	400	400
Main engine	MAN B&W 7L70MC-C	MAN B&W 7L70MC-C
Output	21,770kW	21,770kW
Speed	22.70knots	22.50knots

TECHNICAL PARTICULARS
CS 5600 PANAMAX COMPACT DESIGN

Length, oa	294.00m
Length, bp	283.25m
Breadth	32.20m
Depth	21.40m
Draught, design	12.00m
Draught, scantling	13.50m
Deadweight, design	55,950dwt
Deadweight, scantling	68,050dwt
Gross	54,200gt
TEU capacity	5597
FEU reefer capacity	300 on deck/ 240 in holds
Water ballast	20,750m^3
Main engine output	48,200kW
Speed	24.80knots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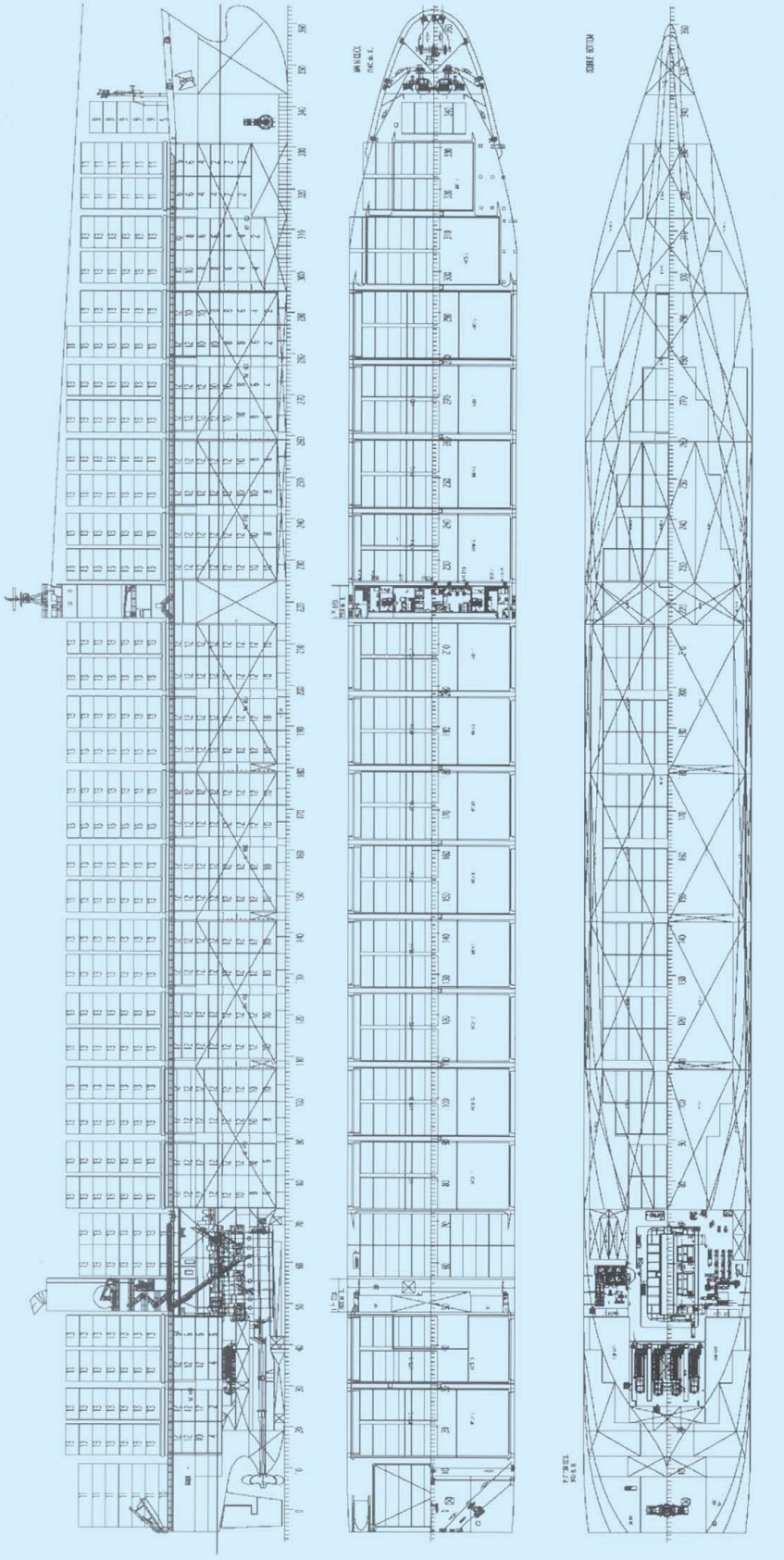
Planned for the future is the larger but still Panamax-sized CS 5500 class (5597TEU) with its distinctive wheelhouse and accommodation block forward. Service speed is 24.80knots. By increasing the number of rows by one to 12 in total and by having narrow side skins, Aker Ostsee claims a 10% capacity increase over competing designs. Even more interesting is the claim that up to 60% less ballast water is required.



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The second Baltic CS 2500 ship *Libra Santa Catalina*, also for Hartmann, is due for delivery this month.

including the first CS 2500 vessel, represents a total value of some US$1100 million.

The Baltic CS 2500/2700 has been developed out of the earlier CV design, and principal particulars are given in the accompanying table. It is a typical single-screw design with all machinery and accommodation arranged aft and a number of cellular container holds forward; construction is to GL class. Efficient container handling (as well as removal and replacement of hatch cover panels) is carried out, if required by the owner, by three MacGregor electro-hydraulic GL-2 wire-luffing cranes, with lifting capacities ranging from 36tonnes at 29.1m maximum outreach to 45tonnes at 25m outreach. The propulsion machinery, a single MAN B&W 7L70MC-C two-stroke engine, is rated at 21,770kW to give a service speed of approximately 22knots.

All the owners are German apart from Schöller, which is Cyprus-based, and the order book,

In order to achieve very quick production schedules, Aker Ostsee is operating a two-yard construction policy for its new container ships. The forward part of the part, as seen here, is fabricated at Warnemünde in the Warnow Werft hall and then floated round the coast to Wismar where union takes place. This practice is enabling the group to deliver up to 12 ships annually.

The design features an aft engineroom but separate deckhouse positioned fairly far forward; this is positioned over a central bunker deep tank. The forward deckhouse also gives a much improved line of sight over the bow, which is an invaluable aid for entering locks and passage through the Panama Canal; this is achieved with the loss of just 81TEU. Below deck there is a narrower double side-shell configuration to accommodate the extra row.

With more cargo in the hold, Aker Ostsee claims that an attractive 50%-60% less ballast water is needed, reducing the problem of ballast water handling and exchange; in most loaded conditions no water ballast handling at all is required in port. Further, with the arrangement of consumables, trim and stability are said to be more balanced and a need to pump ballast for trimming purposes is virtually eliminated.

Another claimed benefit for the design's configuration is that the lightship distribution, being closer to the buoyancy distribution, results in trim and longitudinal stresses being reduced, while the deep tank under the deckhouse is said to reduce twisting of the hull in oblique seas. If and when a CS 5500 is ordered, it will be built at the Wismar yard only, not with the 'split' construction technique being used currently.

New icebreaking tanker

Another new design which the yards hope to build in the future is a 70,000dwt ice-breaking tanker, though no details have been released so far. Nevertheless, there is some experience of this type of vessel, since previously a series of five 20,000dwt icebreaking tankers were built for the Russian oil company Lukoil Arctic Tankers, for operations in the Russian far north. The first, *Perm*, was delivered in December, 1997 with the remainder following over the next two years. *Perm* and her sister *Volgograd* were featured in *Significant Ships of 1998*.

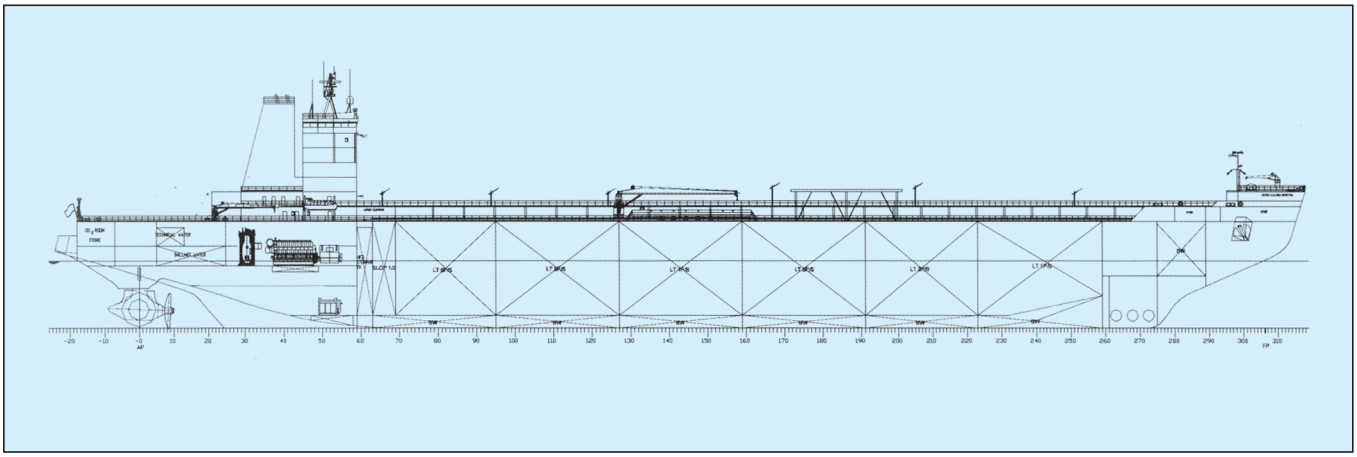
Complicated path to merger

THE coming together of the two yards that make up Aker Ostsee is a complex story. In the beginning, the two yards were established in what was then East Germany immediately after the end of the Second World War as Schiffsreparaturbasis Wismar (Mathias-Thesen-Werft Wismar from 1951) and Bootswerft Warnemünde (Warnowwerft Warnemünde from 1948).

Following German reunification both yards were privatised in 1992, the Wismar yard being taken over by Bremer Vulkan and Warnowwerft passing to Norway's Kvaerner group. Complete modernisation of both yards then took place, however the Bremer Vulkan group got into financial difficulties and was forced to sell the Wismar yard to the Aker Group, also of Norway. With both yards owned by Norwegian groups, and so close physically, it is not surprising that they began cooperating on a number of joint projects in 1999 and 2000. Following financial difficulties, Kvaerner was acquired by Aker in 2001 and in 2002 Aker Kvaerner Yards Management was established to run both former East German yards, taking on responsibility for joint management and marketing.

In 2003 a legal merger took place between the two yards, with Wismar taking 60% and Warnemünde 40% - the merger was finally completed earlier this year. Then in June, Aker Ostsee was designated as the Competence Centre within the shipbuilding group, Aker Yards, for merchant vessels. Today Aker Ostsee employs around 2250 people and has on its books 115 apprentices, with more to follow shortly. Sales income in 2003 was €618 million and it delivered one passenger vessel, an offshore living quarters unit, and 11 container ships.

Aker Ostsee is now set on a programme of cost reductions to improve competitiveness with Far East yards, where smaller container ships are around 15% cheaper, and larger post-Panamax vessels are as much as 25% cheaper. In the short term, the objective is to trim costs by around €2.5 to €3 million for a 2300TEU vessel. This will be achieved through the results of the merger, including improved production techniques and higher purchasing volumes, together with agreements with the workforce. On an annual basis, savings are planned to reach €30 million by the end of 2005 and we understand are already of the order of €20 million. Then, when EU restrictions are lifted, the long-term plan is to have increased sales value by 80% in 2010.



Another interesting design for the future is a 70,000dwt icebreaking tanker for the Arctic, which has been evolved from the earlier and smaller *Perm* class built a few years ago for Lukoil. Note the diesel-electric power plant and the azimuthing pod-type propeller proposed.

Modernised yards

Under the agreed EU plans, substantial redevelopment has taken place at both yards and today they stand comparison with the best in the world. Together with the other yards in the organisation in Finland and Norway, the Aker Group is ranked as the world's fifth largest shipbuilding group.

Investment in the Warnemünde site between 1992 and 1995 totalled €575 million, and today the yard has a 320m by 54m covered building dock together with a 600tonne gantry crane. The roof of the building hall is arranged with sliding sections to enable access by the crane for lifting ship sections while outside the dock and other buildings there is a large expanse of ground for the storing of units.

Other facilities include CAD/CAM systems, modern panel lines incorporating plasma and automatic cutting units and robot welding, and advanced coating facilities that meet stringent environmental requirements. The large coatings halls, for example, are large enough to accommodate a complete superstructure block for the Baltic CS 2500/2700 classes.

A similar situation exists at the Wismar yard, where investment between 1994 and 1998 reached €605 million. Here the covered building dock is slightly larger, being 340m long with a beam of 67m. Another difference is that the dock craneage, primarily an 800tonne capacity gantry crane, is contained within the building hall. In addition, with its extra width, the dock can accommodate two of the CS 2500/2700 class hulls side by side. Other facilities at Wismar mirror those at Warnemünde although the site is much more compact.

Series production

Taking advantage of the specific features of each yard, Aker Ostsee has developed a production programme for the vessels which sees the fore end and superstructures fabricated at Warnemünde and transported by sea round the coast to the Wismar yard. This transfer, by barge in the case of superstructure blocks, takes between six and eight hours.

In the building dock at Wismar, two vessels of the CS 2500/2700 types are constructed side by side almost as far forward as amidships with as much advance outfitting carried out in the engineroom as possible. When the fore end arrives from Warnemünde, the two parts of the vessel are floated together and the joint between the sections of hull welded.

With this construction arrangement, the two yards are able to achieve an impressively high level of productivity. During our recent visit to the Wismar yard we noted *Cap Doukato* alongside preparing for sea trials early in August prior to hand over, and the second Hartmann 2500TEU unit, *Libra Santa Catalina*, also alongside in the latest stages of outfitting and due for delivery this month. In the yard's building dock were the third Hartmann vessel, shortly to be floated out, and the fourth awaiting its fore end which was nearing completion at Warnemünde. The fifth of the class was in the early stages of fabrication.

Squeezing the max out of Panamax

While the CS 2500/2700 series represents a steady base load of work for the next two years and more, the group is nevertheless not only seeking new orders for existing designs beyond 2006 but has come up with ne

Baltic boom for other yards

AKER Ostsee is not the only shipbuilding company from the former East Germany that is currently full of orders. In Stralsund, Volkswerft Stralsund, owned since 1998 by the AP Möller Group following the insolvency of previous owner Bremer Vulkan, is also busy building container ships and has orders stretching out to early 2007. Another extensively modernised yard, it is equipped with a building hall 300m long, with a width of 108m, and a height of 74m, and served by an 800tonne lift gantry crane, together with a shiplift rated at 21,735tonnes.

This yard is capable of building vessels up to Panamax size and currently has orders from its parent for seven 53,400dwt container ships for delivery between December next year and January 2007. Other orders include the last of three 22,890dwt box ships for Safmarine, a series of five 33,500dwt units for various German owners to be delivered in 2004/2005, and two 34,000dwt vessels for Orion, also scheduled for completion in 2005.

At Wolgast, Peene-Werft GmbH has also been building a series of container ships. This yard, owned since 1992 by Detlef Hegemann GmbH, is equipped with a 110m by 34m shipbuilding hall and a 172m by 30m drydock, enabling it to build vessels up to 170m length and with a beam of 27.5m. The current series of vessels being built there each has a capacity of 1200TEU and dimensions of 155m length and 24.5m breadth - virtually the largest hulls the yard can build today. The remaining four vessels of this type on order are due to be delivered by the spring of next year.

The yard is however facing something of a problem - the local Mecklenburg-Vorpommern government is planning to designate sections of the river on which the yard stands as an environmentally protected area. As a result, dredging of the river, which would allow the yard to build the much larger vessels it wants to, would be prohibited. It is rumoured that if it cannot build larger vessels, the yard may be closed, with a resulting increase in the already high local unemployment. As yet, this dilemma has not been resolved.

Schiffko-designed container ships for Chinese yards

TWO more Chinese shipyards have signed contracts for the construction of the successful CV1100TEU PLUS container-ship design created by the Hamburg consultancy Schiffko. These contracts bring the number of ships completed or on order to this design to well above 60.

The new contracts have been concluded at Qingshan Shipyard, at Wuhan - four plus three hulls for Universal Marine BV, based at Groningen, in The Netherlands, and three further vessels at Kouan Shipyard, in Taizhou.

More than 60 examples of the Schiffko-designed CV 1100TEU PLUS container ship design have now been ordered. One example, *Victoria Strait*, is seen here. Total container capacity is 1118TEU.

TECHNICAL PARTICULARS SCHIFFKO CV1100TEU PLUS

Length, oa	148.00m
Length, bp	140.30m
Breadth, moulded	23.25m
Depth, to main deck	11.50m
Draught, design	7.30m
Draught, freeboard	8.51m
Containers	
In hold	334TEU
On deck	784TEU
Reefer plugs	220

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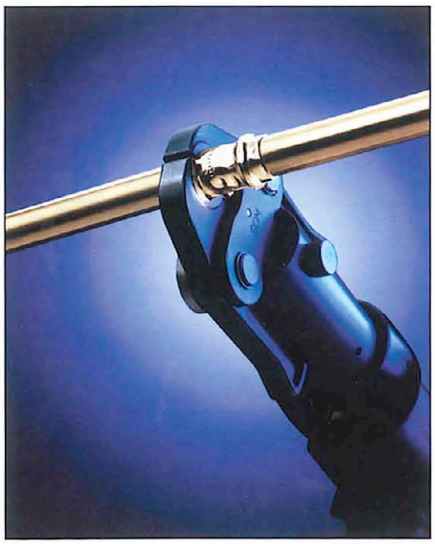
The decisive advantage lies in the joining technique, however, which does away with the need for laborious inert-gas welding in favour of a cold press-fitting technique. Depending on the sizes of fittings involved, this method cuts the required work time by 30%-70% in comparison to welded connections, while at the same time offering a substantially stronger non-positive joint in longitudinal direction.

The Seapress pipe system, from Viega, is suitable for fire fighting, as well as a number of other applications.



Lindenau keeps its tanker series rolling off the berth

THE Lindenau shipyard, at Kiel-Friedrichsort, continues to build its successful series of Safety Tanker Class 2010 product tankers of approximately 32,300dwt. The latest delivery is the *Searay*, in May this year, with the next vessel, for the same owner, German Tanker Shipping GmbH & Co KG, of Bremen, being launched in June for delivery at the end of the year. Two more vessels of modified design, for Seychelles Petroleum, are scheduled for delivery in the spring and summer of 2005.

TECHNICAL PARTICULARS SAFETY TANKER CLASS 2010

Length, oa	177.75m
Length, bp	168.00m
Breadth, moulded	28.00m
Depth, moulded to main deck	16.80m
Draught	11.00m
Deadweight	approximately 32,300dwt
Cargo tank capacity (100%)	37,400m³ (including slop tanks)
Main engine output	7510kW
Speed, at 11.00m draught	14.70knots

The technically highly sophisticated class, built to Germanischer Lloyd class and SeeBG requirement, has a length overall of 177.75m with a moulded breadth of 28.00m. Speed, at 11.00m draught, is 14.70knots.

The design, whose pedigree stretches back to the early 1990s, claims to set new standards for the safe, ecologically friendly, and economic seaborne transportation of oil and oil products. It has a complete double hull in the cargo area, also in the area of the fuel tanks, as required by MARPOL. Some ships in the series are constructed to Ice class 1A according to the Finnish Maritime Administration Regulations 2003, and with the hull coated with ice-resistant Inerta paint. Internally, epoxy coatings are used in the cargo spaces and water ballast tanks.

The cargo space normally comprises five pairs of tanks, separated from each other by longitudinal and transversal bulkheads. All stiffeners are arranged outside of the cargo tanks on deck to ensure smooth tank surface internals with the following advantages:

- short discharge time
- minimal cargo residues
- extra safety against cargo contamination
- rapid tank cleaning time.

On the newest ship, a newly developed separate, fixed emergency discharge system enables complete discharge of the cargo under closed condition in case of cargo pump failure. The central, electro-hydraulically operated remote control system for the cargo pumps, cargo valves, ballast pumps and ballast valves, is installed in the cargo control room.

Hydraulically driven submerged pumps and a high-efficiency tank washing system combine to give very short discharge times and - in combination with the tank washing system - short lay-over period at a terminal. The installed stripping system ensures that the cargo tank volume of 37,400m³ can be unloaded with a residue of less than 10litres/tank.

The main engine installed on the newest ship, a MAN B&W 6L58/64 unit rated at 8340kW and fitted with a 1400kVA shaft generator, plus the three 1200kVA generator sets all meet the latest - though not yet mandatory - requirements of MARPOL, Annex VI (Regulations for the Prevention of Air Pollution from Ships).

An integrated engine control system and the automatic load sharing and power management system for the auxiliary diesel engines and shaft generator ensures economic and safe operation of the engines.

New professional rope catalogue from Gleistein

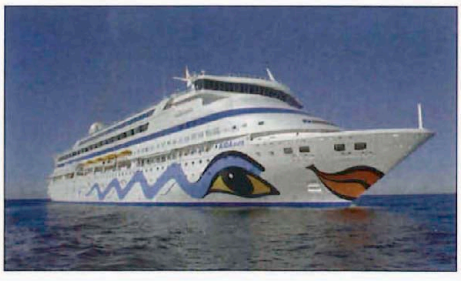
MORE than 3500 rope products are showcased in the 82 pages of the Bremen-based ropemaker Geo Gleistein's new industrial and marine ropes' catalogue. The company, founded in 1824 by Capt George Gleistein and his son, has introduced a new naming system which enables all buyers from the industrial and marine markets to examine a complete product overview and, at the same time, find the appropriate solutions for their needs. It is claimed that the new system makes it easier and quicker to recognise the raw material and construction of the rope, enabling speedier identification of the correct product.

The new Gleistein product naming system has two parts - the first element represents the family of raw materials, the second represents the rope construction. 'Mega' describes all load-bearing rope elements made from high modular chemical fibres (such as Dyneema, Vectran, and Kevlar). 'Geo' stands for the rope elements made from high-strength chemical fibres (including polyester. polyamide, polypropylene, and polyethylene). In addition, 'Geo' ropes are coded with the respective colours of the DIN EN norm (such as blue for polyester and green for polyamide).

The rope constructions are divided as follows:

- mooring: made from load bearing cores with protective coating
- twin: made from plaited core with coating
- one: round braid with or without inner core
- square: eight strand square plait
- twist: machine-laid, twisted ropes.

With this system, Geo Gleistein has simplified the selection for all the needs of its customers, while the catalogue provides detailed product information accompanied by diagrams and comparison tables. The new professional catalogue is available from Gleistein and can also be found on the Gleistein homepage at www.gleistein.com.



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Preferred for innovation

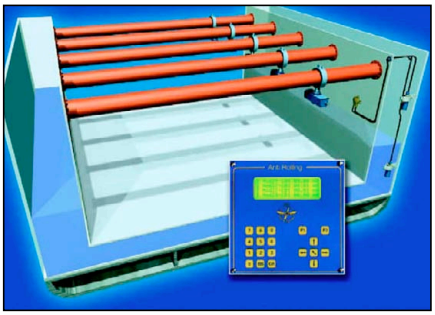
Solving roll and water ingress problems at Hoppe

HAMBURG-based company Hoppe Bordmesstechnik has been in business for some 50 years, having been founded in 1949. Today, it specialises in the design and manufacture of a number of ship operating systems including a roll-stabilising equipment and the now mandatory water ingress detection systems for bulk carriers.

The MOCON ART anti-rolling system is energised by the roll movement of the hull, water oscillates in a U-shaped tank but is controlled to counteract the roll motion, thus stabilising the vessel.

The efficiency of the U-tank is optimised by using a newly developed measurement and control technology, advanced numerical calculation, and CFD simulation with the vessel's dimensions. The MOCON ART technique is said to ensure highly efficient roll reduction in both regular and irregular sea conditions. The system is self-regulated and shuts down automatically in case of malfunction or negative roll-damping effects.

The combination of continuous measurement of the dynamic tank level and a ship's roll movement allows a proportional water flow control. Based on measurement results, the U-shaped tank frequency is continuously adapted to the hull's rolling frequency. The main advantage claimed for this dynamic system over conventional static control is that the water flow is harmonic instead of 'jerky'. This leads to a more harmonic roll motion.



An impression of one of Hoppe's MOCON ART roll-stabilisation systems, with its control console.

According to Hoppe, the MOCON ART can also be used to overcome parametric rolling as experienced by some large container ships. In operation the system 'disturbs the harmonics' of the roll before parametric movement sets in. In this way, far less water needs to be used to achieve the effect than if the parametric roll had already built up.

Use is made of standard butterfly valves with Hoppe fast-acting pneumatic actuators to give high control accuracy and reliability, while a specially developed tank level sensor measures the oscillating water column. The Teflon-coated diaphragm with a large surface and special pressure transfer technology to the piezo-resistive sensor should make the Hoppe transmitter resistant against encrustation, fouling, and overpressure. A powder-coated casing of stainless steel prevents the sensor from galvanic and material corrosion.

Water ingress detection and dewatering system

The HOWID water-ingress detection system, developed by Hoppe, is unusual in that it also incorporates a dewatering system. Other features of the system include:

- permanent level indication
- permanent hold temperature indication
- bus sensor technology
- flexible and easy installation
- minimised cable work
- no fixtures inside cargo hold
- suitable for all bulk cargo.

The system meets the requirements of SOLAS Regulations XII / 12 and XII /13 and is type-approved by Germanischer Lloyd, Lloyd's Register, ABS, and the Korean Register.

Container ship orders for Blohm + Voss and Nordseewerke

THE Blohm + Voss shipyard, in Hamburg, which had been without commercial shipbuilding work for some time, has won orders for two 2700TEU container ships in conjunction with its sister yard Nordseewerke, in Emden, which is also to build two identical vessels.

The order for the four container ships has been placed by GEBAB (Gesellschaft für Konzeption und Betreuung privater Investitionen mbH, Meerbusch). Design of the four ships has been carried out by Nordseewerke.

Work is underway on the first Blohm + Voss ship, which is due to be launched in December for completion in May next year, while the first vessel from Nordseewerke is scheduled to follow in June.

Possible union?

In May this year, ThyssenKrupp and One Equity Partners (OEP) signed a non-binding letter of intent to combine ThyssenKrupp Werften, which comprises Blohm + Voss GmbH, Blohm + Voss Repair GmbH, and Nordseewerke GmbH, with Howaldtswerke-Deutsche Werft (HDW) in a new group under the control of ThyssenKrupp Werften GmbH. The alliance will create a group with a strong naval shipbuilding presence. The reciprocal due diligence reviews have now been successfully completed and the basic outlines of the new structure are in place.

Keel-laying ceremony at Blohm + Voss for the first of the new container ships.

TECHNICAL PARTICULARS
2700TEU CONTAINER SHIPS

Length, oa	215.45 m
Length, bp	205.28 m
Breadth, moulded	29.80 m
Depth, moulded	16.50 m
Draught, load	11.55 m
Draught, design	10.10 m
Deadweight at 11.55m draught	37,950dwt
Container capacity	2702TEU
Main engine	MAN B&W 7L70MC-C
Output (MCR)	21,770kW at 108rev/min

According to Dr Olaf Berlien, chairman of the executive board of ThyssenKrupp Technologies AG, 'Under the new structure all existing locations will be retained'. The new group will concentrate on four product areas - submarines, naval ships, merchant vessels, and repair. The sites in Hamburg, Emden, and Kiel will each be developed into centres of excellence with clearly defined product responsibility which, it is hoped, will safeguard the locations long-term and create a balanced development perspective.

Hamburg will concentrate on naval surface ships and megayachts, as well as the repair business. Emden will be the location for naval surface ships and merchant vessels, while submarine activities will be concentrated in Kiel.

The merger agreement was scheduled to be signed by the end of this month and, subject to the approval of the relevant supervisory bodies of both partners and the competent authorities, be completed by the end of December.

Refinement rather than revolution from Schottel

IN September 1998, German propulsion technology specialist Schottel began the integration of the former WPM Wismarer Propeller und Maschinenbau GmbH into its international group. Today, Schottel Schiffsmaschinen GmbH (previously WPM) and Schottel Antriebstechnik GmbH, recently established at the same location, are integral parts of that group.

Following a capital investment of around €20 million, the Wismar facility, visited recently by *The Naval Architect*, now has the capacity to develop and manufacture propulsion and manoeuvring systems for vessels of all types and sizes. Large systems such as the SEP (Schottel Electric Propulsor) and SSP (Siemens-Schottel Propulsor) pod drives, and Rudderpropellers with power ratings well in excess of 2000kW, are built here (the company's other main plant at Spay am Rhein is not large enough to handle the more substantial units), as well as the CP propellers and rudder systems traditionally built in Wismar.

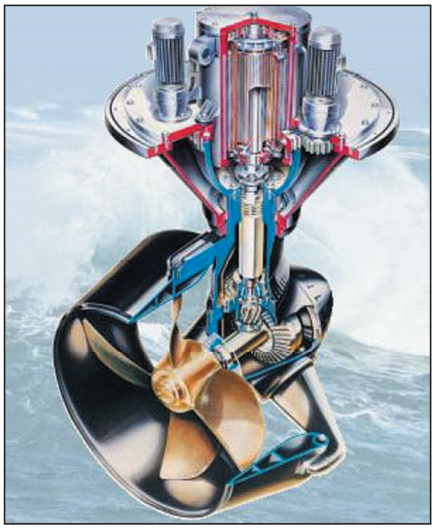
In general, recent activities of the organisation have concentrated more on the refinement and improvement of existing products rather than the development of new concepts. For example, the Schottel Combi Drive (SCD), which is available with power ratings from 1900kW up to 3800kW, is based on the company's successful Rudderpropeller designs but incorporates an electric motor that is integrated vertically into the support tube without either an above-water gearbox or cardan shaft, thus saving height in the installation. It is available in a single-propeller version with nozzle or as a twin-propeller version, and is particularly suitable for vessels such as offshore supply vessels where space in the after hull is limited.

Another development, the Schottel Electric Propulsor (SEP), evolved as a response to increasing market demand for electric drives with power ratings under 5MW. This pod-drive system is said to be an ideal supplement to the existing product range of both azimuthing and conventional propulsion and manoeuvring systems.

The SEP makes it possible to install various types of electric motor in the drive's underwater pod, irrespective of the shipbuilder's other electrical equipment. It is offered in single or twin-propeller, pull or push propeller, free-running or nozzle format to suit different types of vessel and operating conditions.

The SEP is initially available in five sizes from 1MW to 5MW and potential areas of application include ro-pax and double-ended ferries, offshore supply vessels, tankers, container ships, and even yachts.

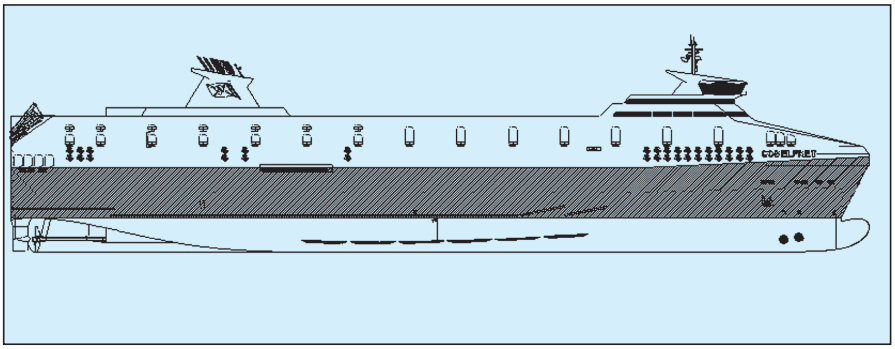
The company has also introduced new, improved tunnel drives, with particular attention paid to sealing systems, while on the propeller and shafting front it has been successful in recent years with deliveries to builders such as JJ Sietas and Flensburger, and has carried out naval work as well. It was also involved in the supply of replacement CP units for the Norasia vessels in 2003, as described in *The Naval Architect* September 2003, page 30.



The relatively new Schottel SCD propulsor is based on the Rudderpropeller but has its electric drive motor incorporated vertically in the support tube. Powers up to 3800kW can be transmitted.

New orders provide work for Flensburger through to 2007

FULL employment has been secured until the beginning of 2007 at the Flensburger Schiffbau-Gesellschaft yard until the beginning of 2007 with the signing of contracts for two so-called ConRo freight ferries. The order, which continues Flensburger's remarkable success in the freight ro-ro sector, has been placed by the Belgian shipping company and logistics operator Cobelfret NV and was first reported in *The Naval Architect* July/August 2004, page 4.



Profile of the new five-deck ro-ro ships for Cobelfret, to be built at the Flensburger yard.

TECHNICAL PARTICULARS
COBELFRET FERRIES

Length	200.00m
Breadth	31.00m
Draught	7.40m
Main engines	2 x MaK 12VM43
Output	2 x 10,800kW
Speed, service	21.7knots
Containers	848TEU
Trailers	258
Cars	656
Trailer lane metres	approx 3900

These ConRo designs, designated by their owner as the Humbermax type and notable for their five cargo decks, will trade between Zeebrugge, in Belgium, Rotterdam, in The Netherlands, and British east-coast ports; they will replace the 150-trailer capacity *Celestine* and *Clementine*, currently on the Zeebrugge-Immingham run. However, the Immingham call will be switched to nearby Killingholme later this year. The new vessels will be delivered during the 4th quarter of 2006 and the 2nd quarter of 2007 respectively.

For Flensburger, the new contracts are further proof of its expertise in the design and construction of special ro-ro vessels. In the past five years, the yard has won orders 10 ships for UND RoRo, of Turkey, six for UK-based AWSR Shipping Ltd, and six for DFDS Tor Line, Denmark.

Neptun Stahlbau - small is beautiful

ADJACENT to the Warnemünde yard of Aker Ostsee is Neptun Stahlbau. Though a much smaller shipyard, it is actually one of Germany's oldest, having been established in 1850. Since 1997 it has been part of the Meyer Werft group, from Papenburg, and currently specialises in the construction of river cruise vessels as well as undertaking shiprepairs and the construction of steel structures, including linkspans for ferry terminals.

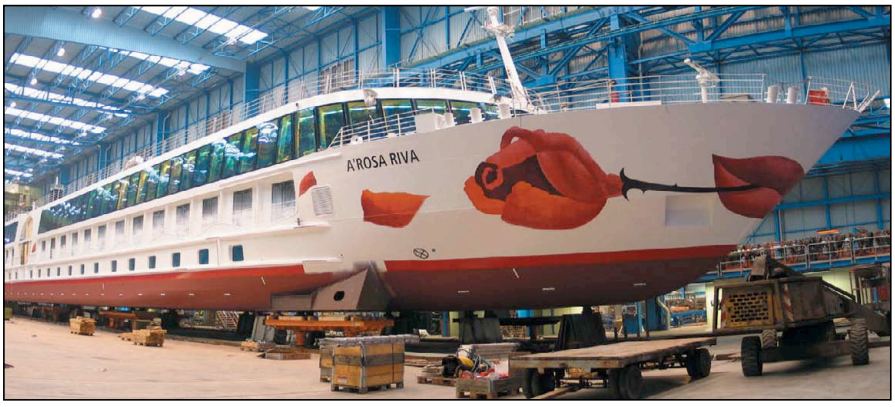
Since 2001, the company has constructed a number of river cruise ships since, in particular for the Seetours organisation, starting with *A'Rosa Bella*. She was delivered in March 2002 together with *A'Rosa Donna*, followed by *A'Rosa Mia*, delivered in March last year, and *A'Rosa Riva*, completed in March this year.

The ships are designed for cruising on the River Danube (although their beam prohibits them from passing along the Main-Danube Canal) and are outfitted with modern furnishings - all cabins are exterior - and to deepsea standards, with individually adjustable air-conditioning, radio/TV, safes, and hair driers. A large fitness centre is able to offer relaxation for passengers, with massages, sauna, or solarium.

The company now has orders for two further units for Seetours - in this case the vessels will have a narrower beam of 11.4m, enabling them to pass along the Main-Danube Canal which links the Rhine and Danube rivers. However, initially, they are to be deployed on the River Rhone in France. To maintain the high standard of accommodation in a narrower hull, the total number of cabins has been reduced to 86, with passenger capacity down to 172. Both vessels are scheduled to be delivered in spring of next year in time for the summer season of cruising.

In addition, the yard is to build a completely new type of river cruise ship for the Munich river cruise operator Premicon AG. This unit will be 135m long with a beam of 11.4m and will accommodate some 200 passengers. It is designed to operate on the River Rhine above Mannheim up to Basel, and will have a maximum operating speed of about 22km/h.

An unusual (but well-known) launch technique for *A'Rosa Riva*, using Neptun Stahlbau's floating dock. The company plans to launch all future ships by this method where possible.



The 124.50m long river cruise vessel *A'Rosa Riva* nearing completion in Neptun Stahlbau's covered hall.

Two-section design

What is unusual about the design is that it can be separated in two sections, a concept named Twin Cruiser. By means of a flexible linkage, the 25m long aft section, which contains the crew cabins and the propulsion machinery, is connected to the 110m long 'passenger section'. By this means, the fore section is noise- and vibration-free, and solely dedicated to passenger services. This new concept, for which a patent has been filed already, meets the latest shipping rules and regulations for the river Rhine. In addition, the configuration offers the operator an extremely high degree of flexibility and a high level of safety in service.

Neptun Stahlbau's facilities include a covered building hall measuring 180m x 45m and equipped with two twin 60tonne bridge cranes, giving a total coupled lift of 240tonnes. The yard also has a Panamax floating dock for carrying out ship repairs. This can accommodate vessels with a maximum length of 230m and beam of 39m, and has a lifting capacity of 23,000tonnes. It is equipped with two 16tonne tower cranes.

The latest example of the river cruisers, *A'Rosa Riva*, was launched in an unusual way, using the company's floating dock. By bringing the dock round and mooring it end-on in way of the building hall, the river vessel can be winched out and onto the dock from where it is then lowered into the water, thus ensuring a smooth, 'stress-free' launch. The yard now intends to use this technique for future buildings where possible.

Other activities at Neptun have included the construction of the linkspan for the Airbus Hamburg Finkenwerder site where sections of the giant A380 airliner are being fabricated and then moved by sea to Toulouse for final assembly .

TECHNICAL PARTICULARS
A'ROSA RIVA

Length, oa	124.50m
Breadth, oa	14.40m
Number of cabins	100
Number of passengers	242
Crew	50
Propulsion machinery	1600kW
Speed	24km/h

Latest advances in Voith Schneider propulsion systems

THE vertical axis cycloidal or Voith Schneider propeller (VSP) has by no means reached the limit of its development, according to engineers from Voith Turbo Marine, who presented a paper in March this year at the International Tug and Salvage Convention, held in Miami. Although much of the presentation concerned tugs, which are outside the scope of this journal, it is interesting to note that for owners wishing to incorporate the VSP system on other ship types such as ferries - a popular market sector, modern design tools such as the latest computational fluid dynamic (CFD) methods enable hydrodynamics to be continuously improved, and new blade profiles with higher efficiency have been developed.

The latest Voith Schneider generation of propellers with higher maximum input powers is under development. For the re-design of each component, an industry-leading structural analysis FEM program is used. This provides the power of linear and non-linear capabilities to deliver reliable structural simulation results. New construction principles for key components such as blades and main bearings have been advanced, while the hull design of ships with VSP is subject to continuous research and improvement.

A further good example of enhanced cycloidal propulsion is the Voith cycloidal rudder. This modified VSP, with only two blades, is the latest propulsion and manoeuvring device acting in the passive mode at high speeds like a conventional rudder and in the active mode at slow speeds like a normal VSP with the proven high degree of manoeuvrability.

Tools for hydrodynamic enhancement

The hydrodynamic enhancement of the VSP is based on three pillars: CFD, in-house model tank experiments, and full-scale tests. Since the early 1950s, very comprehensive and detailed model tank tests were performed regularly with VSP in Voith's own circulation tank test facilities as well as at several independent research laboratories around the world. Considering the general limitations in model tank testing caused by scale effects, new additional hydrodynamic tools became necessary to explore potential possibilities for future performance improvements.

Such a highly sophisticated computer program (Comet) for CFD calculations allows the simulation of the 3D non-stationary flow around the propeller. The flow field is divided into approximately 1.5 million small volume elements. For each volume, the physical constraints including viscosity are estimated.

For Comet, the SPMD (Single Program Multiple Data) model is adopted. In this approach, each processor runs an identical program but only solves for its own set of data. To solve the global problem, the computational domain needs to be distributed over all the processors via domain decomposition. Space and time parallelisation are implemented in Comet using PVM (parallel virtual machine) and MPI (message passing interface) message passing libraries.

The permanent verification and calibration of CFD results with model tank test data and full-scale measurements will be essential. So far, the results of the numerical calculations, model scale experiments as well as sea trial measurements correspond promising well.

The global hydrodynamic propeller loads calculated by CFD methods are input data for a complex FEM analysis by ANSYS for the structural design of each propeller component. Dynamic loads are estimated for a simplified three-dimensional cinematic VSP model. An accurate mathematical model for the critical components is built up by the 3D CAD program IDEAS. Cut-boundary techniques are used for regions of special interest. Non-linearities such as contact surfaces are solved by applying the load gradually.

The efficiency of a VSP is significantly determined by the profile geometry of the blades, the blade length in relation to the propeller diameter, the blade angle curve and the blade number. In this way, Voith has succeeded in optimising a profile that clearly improves the hydrodynamics. With these new profiles, 5% more bollard pull has been measured in model tests as well as full-scale measurements. To avoid the tip vortexes on VSP blades, endplates have been introduced. Such endplates will further increase the bollard pull and will reduce vibrations and noise problems associated with highly loaded propellers.

Hull form optimisation with CFD

Based on the very positive CFD results for the optimisation of VSP key components, first steps were made in cooperation with the SVA Potsdam, Germany, to simulate the entire flow field around ship hulls. The flow around the hull is calculated using potential-theoretical methods as well as by solving the Reynolds Average Navier-Stokes equations (RANS). The program KELVIN, of the SVA, was used for potential-theoretical calculations of wave-making resistance.

For the calculation of the friction resistance and detection of separation, the program COMET has been applied. Model tank tests at the SVA Potsdam including thrust, wake and suction measurements with purposely-developed measuring equipment were performed to verify these CFD results. The first results conducted for VSP-driven double-ended ferries have shown very positive aspects of ship lines optimisation using this new technique.

In the future, flow calculations for hull optimisation will additionally include the VSP influence. For this, a special numerical model is developed together with the SVA Potsdam.

Voith cycloidal rudder

Based on the proven VSP, the Voith Cycloidal Rudder (VCR) continues to be under development (*The Naval Architect* April 2002, page 42, and July/August 2002, page 22). The VCR is a new propulsion and manoeuvring concept for ships requiring maximum manoeuvrability over the entire speed range even for speed ranges up to 30knots. It replaces the traditional rudder and operates as an independent auxiliary propulsion system at slow speeds. Two operation modes have to be considered for the VCR:

VCR passive mode

The passive mode is used for cruising speeds, whereby the VCR acts as a conventional rudder for manoeuvring ahead. The vessel will be driven by a conventional screw propeller designed for free running. Conventional rudders are designed for sufficient lift forces at relatively low speeds to guarantee the required manoeuvrability at the port entrance. Consequently, the rudder area is oversized for cruising speeds and an additional drag resistance is the compromise. Since the VCR is only used in the passive mode for high-speed operation, the rudder area may be designed much smaller with consequent reduced rudder resistance.

VCR active mode

In the active mode, the VCR operates like the above-described proven VSP. The well-known characteristics of the VSP will be also achieved on the VCR, including stepless and extremely fast and precise thrust adjustment in all directions, low acoustic and magnetic signatures, as well as the same efficiencies. The vessel's main propulsion plant will be in stand-by condition, eg, CP propellers will be in the sailing mode and FP propellers will windmill. The VCR can be driven by any diesel engine or electric motor depending on a ship's machinery layout.

The active mode will be selected for slow speed operation where a high level of manoeuvrability is required, such as approaches to harbours and restricted seaways, where conventional propulsion concepts, even with bow and stern thrusters or retractable drives, will have their limitations. For emergencies, including loss of main propulsion, the VCR guarantees a take-home capability.

As an additional function, the VCR allows roll stabilisation of a hull - the thrust direction of the active VCR will be electronically controlled to oppose roll motion. Unlike common fin stabilisers, the VCR controls roll motions even at zero speed.

Comprehensive model tank tests, CFD analyses as well as full-scale measurements, were performed to confirm the design parameters and the compliance with common international standards for manoeuvring requirements. Germanischer Lloyd has granted type approval for the VCR.

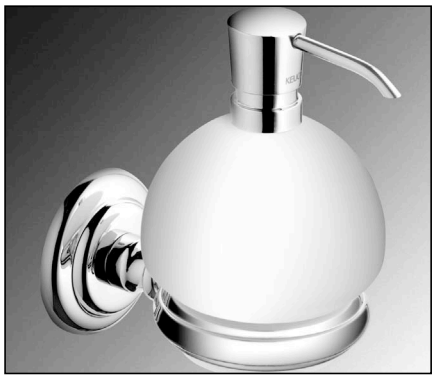
Jewel of the Seas equipped with Keuco sanitary accessories

WHEN *Jewel of the Seas* was delivered by Meyer Werft to Royal Caribbean International (RCI) in April this year, the bathrooms in all 1055 cabins and suites were equipped with accessories from Keuco's Astor series. In line with the elegant ambience of this state-of-the-art cruise ship, the luxurious bathrooms have been designed and equipped to meet the expectations of the most sophisticated guest.

Astor accessories have been developed to please an upmarket clientele, This fine range shares a rosette as a recurrent design element, while bi-colour versions, using gold-finished decorative plates, are matched with chrome and refined brass surfaces for an interplay of different finishes. *Jewel of the Seas* was the fourth bathroom accessories contract awarded by Royal Caribbean to Keuco following outfitting of the lead ship in the series, *Radiance of the Seas*, and sister ships *Brilliance of the Seas* (June 2002) and *Serenade of the Seas* (July 2003).

Jewel will be followed by a fifth and a sixth vessel of the even larger Ultra Voyager class accommodating almost 4000 passengers. Construction of this different vessel is under way at Kvaerner Masa-Yards' Turku site in Finland. The Ultra Voyager, which will be even larger than *Queen Mary* 2 in gross tonnage terms, is expected to be completed by May 2006.

Keuco accessories have also been fitted to *AIDA Blu*, previously *A'rosa Blu*, and prior to that *Crown Princess*. Renovation of this ship was completed in April this year. The company's fittings are also aboard the other three vessels of the AIDA Club fleet.



A hand lotion dispenser from the Astor series - one of many luxury bathroom accessories supplied to *Jewel of the Seas* by Keuco GmbH & Co.

SCR catalysts for NOx reduction

DURING the last few years, the problem of effective protection of the environment in the marine sector has gained ever more importance, and many different technologies have been developed to solve the problem. Today, selective catalytic reduction (SCR) is considered the most effective industrial-scale process for the reduction of nitrogen oxides (NOx) that are formed during combustion.

Argillon, which is based in Redwitz and came into existence in April last year, is the successor to the Siemens Power Generation Group's ceramic business. It produces the SINOx honeycomb and plate catalysts for the SCR process, which consists primarily of the catalytic converter, the control system, and the dosing system for the reducing agent. In an SCR system, the exhaust gas, at a temperature between 250°C and 530°C, is mixed with ammonia before passing through an SCR catalyst. The NOx is reduced to harmless gaseous nitrogen and water while some of the soot and hydrocarbons in the exhaust are also removed by oxidation in the SCR process reactor.

The installation of a SINOx system is a solution for shipping companies that is guaranteed to reach the emission limits fixed by the environmental authorities. In fact, according to the company, SINOx catalysts can achieve emission levels some 80% below the IMO Marpol Annex VI level. The main component of SINOx is a fine-celled honeycomb catalyst of titanium dioxide, which is treated with vanadium pentoxide as the active ingredient. The catalyst is characterised by high catalytic activity, high selectivity and high resistance to erosion.

Applications of the SINOx system have recently included the Staten Island ferry *Alice Austen* in New York, a first public-sponsored SCR project for ferries in the USA. The exhaust gas of the two Caterpillar 3516A engines, each rated at 1156kW, is being purified by SINOx technology and the required NOx reduction rate of 70% are said to be easily attained. Another application is on *Victoria*, a newly delivered ferry from Aker Finnyards, which entered service in June this year.

Coping with cavitation in high-speed propellers

PROPELLERS continue to be the most common propulsion system for fast ships; however, these are often combined with inclined shafts and variations in the transverse velocity in the oblique inflow. The latter can cause considerable changes in the profile angle of attack, resulting in cavitation, especially if the propeller rotates downward. A modern propeller series has therefore been designed and investigated by the Potsdam Model Basin (SVA), to acquire data for the pre-design of high-speed propellers and for propulsion prognosis at the early design stage of fast ships.

Under a research project, funded by the German Bundesministerium für Wirtschaft und Arbeit, a high-speed propeller has been designed and optimised in cooperation with AIR Hohen-Luckow. Both lifting surface (VORTEX) and viscous-flow methods (COMET, CFX5) (Fig 1) have been used in the design of the propeller.

Four propellers with different design strategies have been manufactured and investigated in open water and cavitation tests. In addition, the influence of a cup at the trailing edge at the propeller characteristic and the cavitation behaviour had been tested (Fig 2). The cup effects an increasing of the propeller thrust and torque coefficients. Small cavitation phenomena at the suction side of the cup resulted in an early thrust reduction of the propeller (Fig 3). That is why it was decided to design the propeller series without a cup.

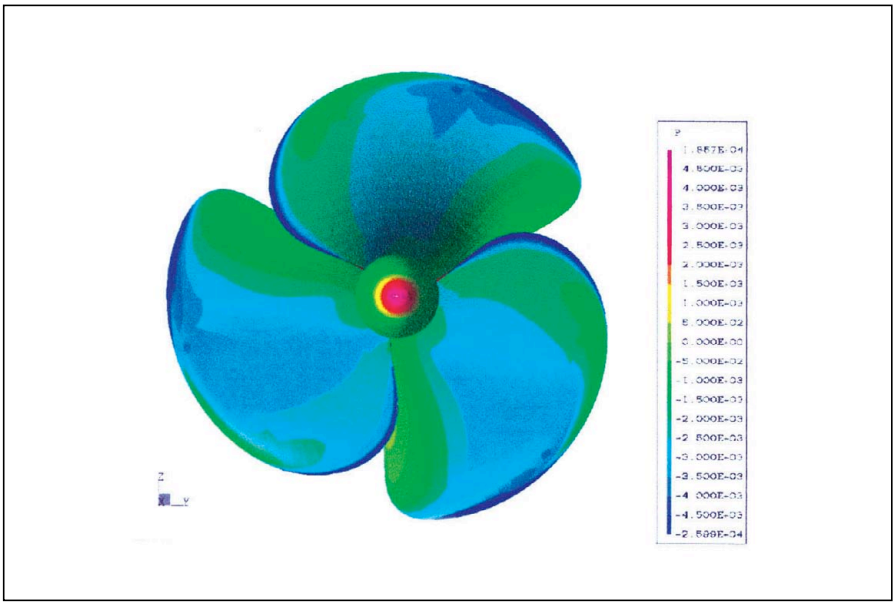
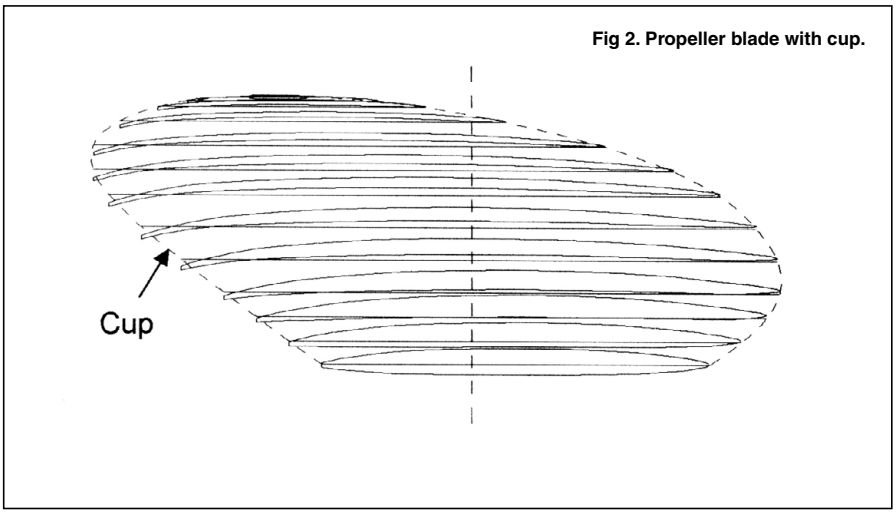


Fig. 1. Pressure distribution of the suction side (HSP 3.110 with P/D = 1.4 at J = 1.085, shaft inclination 0deg), calculated with CFX 5.

Fig 2. Propeller blade with cup.



Propeller series

The three-bladed SVA high-speed propeller series consists of 12 models (four each for expanded area ratios A_E/A_0 of 0.9, 1.1 and 1.3) with a diameter D of 220mm, a hub diameter ratio d_h/D of 0.1818 and pitch ratios $P_{0.7}/D$ of 1.0, 1.2, 1.4, and 1.6 respectively.

Open-water tests

Open-water tests were carried out in the towing tank and cavitation tunnel at shaft inclinations φ of 0deg, 6deg, and 12deg (Fig 4). The influence of cavitation on the propeller characteristics has been tested in a cavitation number range of $4.5 \leq \sigma_V \leq 0.75$ (Fig 5). The propellers are characterised by a high efficiency and good cavitation behaviour, and the erosion causing blade root cavitation can be avoided.

Analysis of test results

The open-water test results were faired and plotted in the conventional way with the thrust coefficient K_{TP}, the torque coefficient K_Q and the open water efficiency η_0 as a function of the advance coefficient J, the

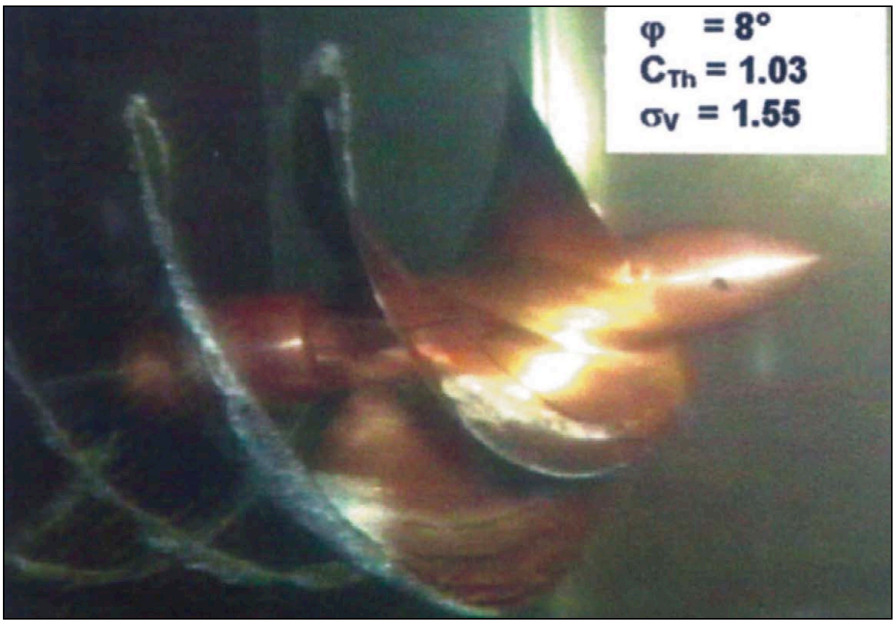


Fig 3. Cavitation behaviour of a propeller with cup.

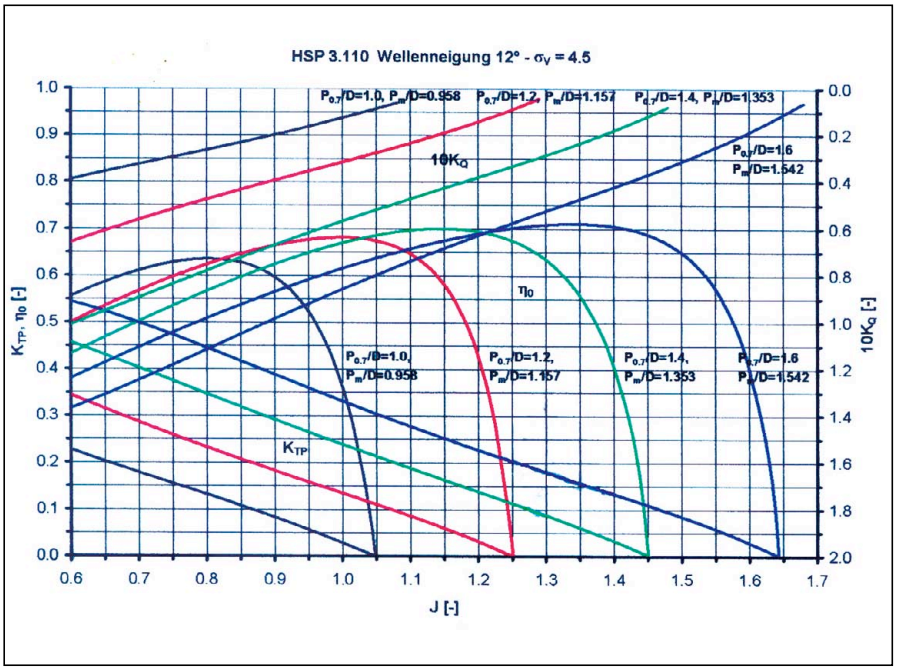


Fig 4. Open water characteristics HSP 3.110, φ = 12°, σ_V = 4.5.

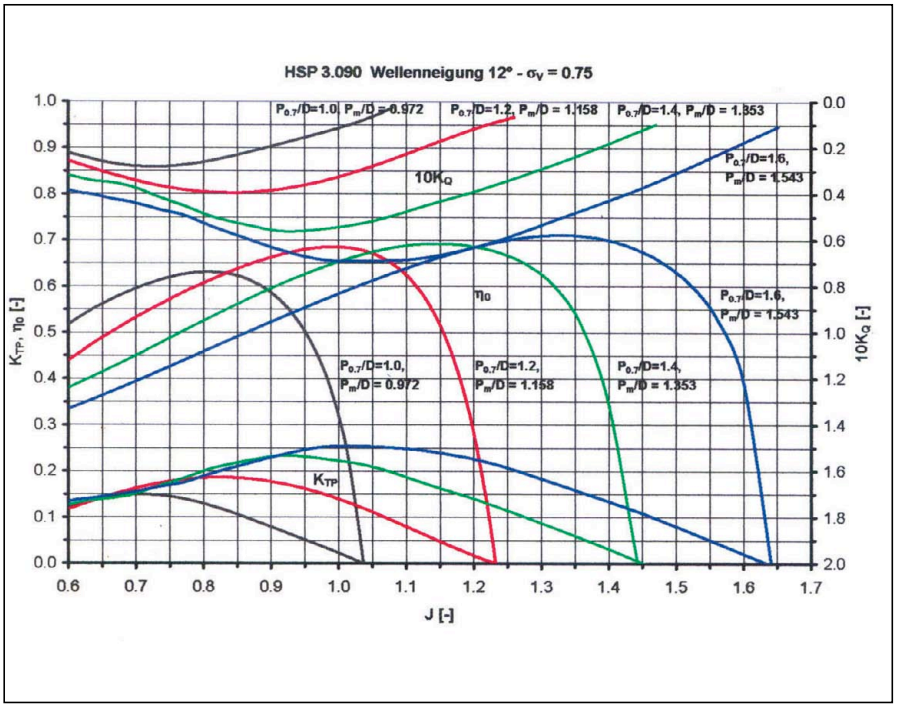


Fig 5. Open water characteristics HSP 3.110, φ = 12°, σ_V = 0.75.

shaft inclination φ and the cavitation number σ_V. A multi-dimensional Chebyshev approximation was used to calculate the polynomials of the thrust and torque coefficients as a function of the propeller pitch and area ratio, shaft inclination, and cavitation number. A computer program was then developed on the base of the polynomial to calculate the propeller characteristic for given propeller data and to select the optimum propeller for given operating parameters.

Hi-tech lighting for *Radiance*-class cruise ships from UK consultancy

IN 1988, the UK consultancy Project International, a specialist in lighting systems for cruise ships, was appointed to work on the detailed concepts for the *Radiance*-class Panamax liners ordered by Royal Caribbean International at Meyer Werft. This company was also employed to design the lighting on the new Cunard liner *Queen Mary 2*.

Previously the task was approached from the platform that had been achieved for the previous *Voyager* series and built upon that for this series, and where possible new techniques were introduced and refined where necessary. The final vessel in the four-ship series, *Jewel of the Seas*, includes some subtle revisions to the public areas, while further enhancements to the lighting, utilising the latest technologies available, ensured the last vessel continued the excellent appearance achieved in her earlier sisters.

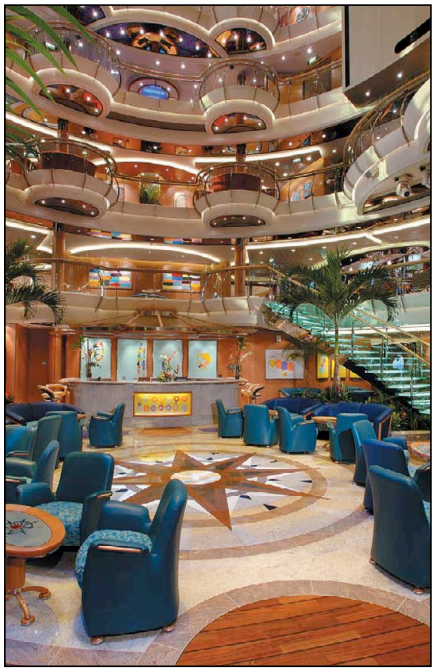
Encompassing Royal Caribbean's functional planning and impressive interior design provides an excellent base on which to plan and design a comprehensive lighting scheme, one which enhances the operation of each specific space. Project International's design role dealt with every aspect of the public spaces lighting, including cabins, the Royal suite and A & B suites, as well as all crew recreation spaces. Much of the detail concept design work was in fact pioneered for *Radiance of the Seas*, the first in the series. Refinements ensued through *Brilliance* and *Serenade*, resulting in *Jewel* being honed with the experience of the others.

Centrum features

One of the most impressive spaces particularly evident on entry is the eight-deck-high Centrum. Designed to allow natural light to permeate through large sections of glazing oriented on the port side full height with facing scenic lifts, this feature is unique to any vessel. On the opposite starboard side between decks 5 to 6, large glazed windows balance the natural light content radiating into the atrium. As customary with all RCI vessels, the atriums are adorned with a large suspended sculpture, which for *Jewel* depicts the Aurora Borealis (Northern Lights) in metallic form. This feature is suspended between decks 6 and 8, spanning almost the entire width of the atrium, and inclined. This sculpture is illuminated with an impressive array of technical lighting (termed as architectural effect lighting) for evening use when the whole Centrum is brought alive.

Cutting-edge technology

Jewel of the Seas represents the cutting edge of lighting technology, with the very latest lighting products being used to good effect, particularly with LEDs and fibre-optics, which are positioned in more remote ceilings such as the suspended Crown and Anchor platform on deck 12, which has fibre-optic Swavorski crystal lens set on the underside, all powered from remote accessible light source projectors on the deck above.



Three examples of public spaces on *Jewel of the Seas*, whose lighting was designed by Project International: the centrum atrium (above), Tides restaurant (above right), and the solarium fitness centre (right).

Throughout all the public rooms local consoles control the functionality of the lighting, and in many areas this is overseen by a central clock computer which enables various scenes to be triggered automatically at given times of day. The advantage of this with upwards of 50 remote panels located throughout the ship lighting scenes and corresponding levels between rooms are synchronised to avoid and light dark situations when walking through areas.

A significant advantage of this set-up is that much of the lighting load can be reduced overnight into what is termed 'economy' modes whereby rooms that cease to be used after a certain time or after cleaning can be 'set-down' to minimum levels, for example at 2.00am, thereby reducing up to 90% of the electrical load; this also has significant benefits for the ship's maintenance and lamp replacement. Similarly, areas can be brought up to correct daylight levels by programming the system to fade up at, eg, 6.00pm. In all cases, manual intervention is possible, which is most widely used for the theatre and nightclub where individual control is required for show events.

Throughout *Jewel of the Seas*, new LED lighting has been used for the theatre, and Pulsar Light, from Cambridge, provided RGB colour-changing floods for the decorative ceiling panels, with Martin QFX150 'intelligent' fibre-optic projectors employed. All this lighting is controlled via DMX512 protocol - the entertainment industry standard for lighting to ensure booth house lighting and show lighting have seamless control.

External lighting

Externally, the ship benefits from good floodlighting of the profile, mast and funnel, using 250W metal halide compact lights, IP67 protected. To accentuate the extended upper deck perimeter, TL5 fluorescent linear lights on the sun deck are installed at low deck height for navigation around the ship. The pool areas have indirect columns lights with diffusers with coloured diochroic applied to improve the ambience around the pool area.

Within the indoor/outdoor pool, clever use of integrating linear fibre optic 'side glo' PMMA material which is integrated within the pool level changes and all around the spa and jacuzzi areas. After sunset the area is transformed by 'cool pool lighting' and warm colours of the EXT200 color-wash exterior IP68 units concealed within high-level planters, which cast a dramatic color palette on to the water features. Within the solarium space, the lighting scenes are cued with the audio for background 'calming' sound effects which are again triggered at various times of day automatically by the Lutron system and AMX Interface provided.

Twisted spade rudders for large fast vessels

BECKER Marine Systems, of Hamburg, was established in 1965 and is best known for its flapped rudders. In 1971, it acquired the Kort nozzle design and more recently took over Schilling Rudder (in April last year), making it one of the leading suppliers of rudder systems.

Today the company's product range covers a variety of rudders and Kort nozzles for installation in all types of vessels requiring every performance characteristic from exceptional manoeuvrability at slow speeds to cavitation-free designs for high-speed applications, and including the requirements for severe ice class, dynamic positioning, and high bollard pull using nozzles.

Now Becker has introduced the twisted leading-edge rudder concept which, in its TLKSR spade rudder form, offers many benefits for large, high-speed vessels such as post-Panamax container liners. The twisted rudder, which is designed to eliminate rudder-induced cavitation, makes use of the fact that the blades of a propeller are moving in different directions above and below the propeller boss.

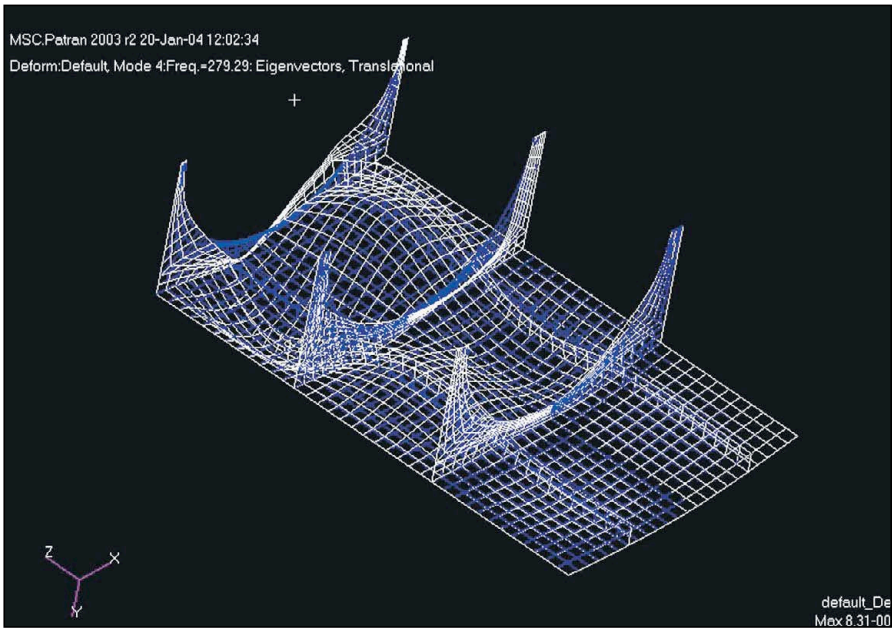
The leading edge of the rudder is twisted in the direction of the attacking propeller stream. With the leading edge twisted at different angles above and below the line of the boss, the velocity of the water over the rudder surface is optimised, reducing pressure peaks and cavitation, and the cavitation-free rudder angle can be significantly increased.

The Becker TLKSR model combines this design feature with the company's King Support Rudder bearing arrangement. In this arrangement, the rudder trunk is continued into the rudder blade so that the main neck bearing is positioned close to the hydrodynamic centre of pressure of the rudder blade. The result is reduced stresses and bending moments on the rudder blade structure, and reaction forces on the neck and carrier bearings are thus much smaller.

The natural frequency of the rudder is remote from that of the propeller so that resonance is avoided and vibration is reduced to a minimum. This KSR arrangement means that spade rudder size can be as large as necessary.

The combination of features in the TLKSR has enabled very large spade rudders to be adopted for large vessels, with the following claimed advantages over semi-spade designs:

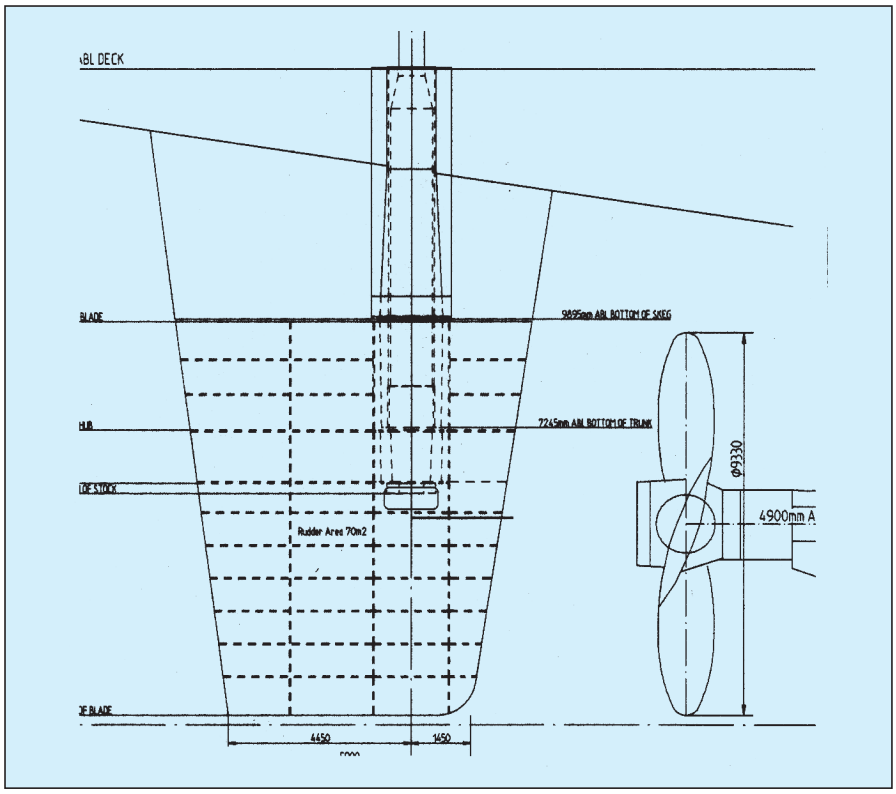
- no rudder horn so no gap cavitation
- optimised profile, eliminating sheet cavitation
- higher propulsion efficiency and resultant fuel saving
- extended uncritical rudder angle sector
- reduced profile thickness by 25% to 30%, reducing drag
- reduced weight
- less installation time
- reduced cost.



A finite-element analysis of the Becker TLKSR twisted rudder.

A typical very large trunk for a Becker TLKSR twisted rudder, ready for dispatch. The trunk is continued into the blade so that the main neck bearing is positioned close to the hydrodynamic centre of pressure on the blade. This results in reduced stresses and bending moments in the blade structure.

Extensive testing of the concept has been undertaken by HSVA, the Hamburgische Schiffbau-Versuchsanstalt GmbH (Hamburg Ship Model Basin), entailing CFD (computational fluid dynamics) studies to determine rudder forces and moments, and model tests to measures these and examine the manoeuvrability with the design. In one comparative test, the cavitation-free angle for a semi-spade rudder of 81m^2 moveable area for an 8400TEU capacity container liner was compared with a Becker TLKSR unit for the same ship, which required a moveable area reduced to 67m^2. The semi-spade design



Details of a 67m^2 KSR full spade NACA rudder with a twisted leading edge. This design will be fitted to an 8400TEU container liner being built at Daewoo in Korea for Norddeutsche Reederei Schuldt.

achieved a cavitation-free angle of ±3deg while the TLKSR reached an angle of ±10deg before the onset of cavitation.

Design work on the TLKSR concept began in May last year and Becker won its first order for a unit last October. Today, it has orders for a remarkable 38 vessels building in South Korean and Chinese shipyards. The first example is scheduled to enter service in March next year.

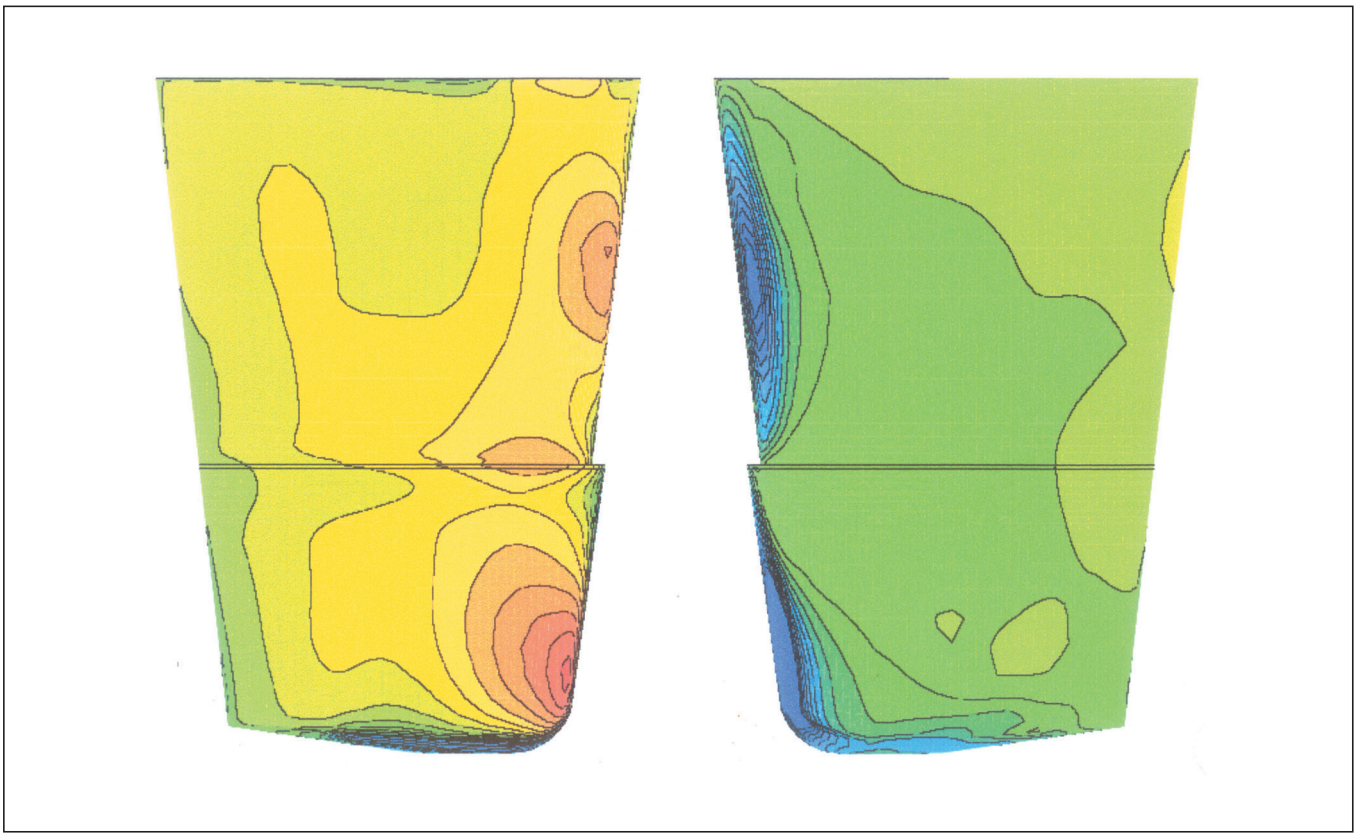
A typical installation is that for a series of 8400TEU vessels, as tested by HSVA. The TLKSR spade rudder for these vessels is said to be the largest yet manufactured but the complete installation has a weight saving of 250tonnes compared with the comparable semi-spade design.

Becker already has experience of the twisted leading edge concept, as applied to a flap rudder, with the installation on the Finnish-built Seafrance ferry *Seafrance Rodin* which entered service in November 2001 (*Significant Ships of 2001*). The 32,000gt vessel is 185m long, with a 28m beam, and is capable of transporting up to 1900 passengers, 120 lorries, or 700 cars. Service speed is 25 knots, making it the fastest full-displacement ferry on the Dover to Calais route.

Twin Becker twisted flap rudders are fitted and have proven to meet all expectations in service, with significantly reduced cavitation erosion. So much so that a second sister vessel, currently on order at Chantiers de l'Atlantique for delivery in February next year, is being similarly equipped. The new vessel's rudders will each be 14.7m^2 in area for the ferry, which will have a trial speed of 26.5 knots.

A vital point made by Becker is the importance of designing the propeller and rudder installation for a particular vessel as early as possible in the design process. Also that design of the after body, rudder and propeller must be coordinated right from the very beginning - indeed, the design of the rudder needs to be as carefully considered as that of the propeller.

CFD studies by HSVA, Hamburg, for pressure distribution on a Becker twisted rudder when turned to starboard at 35deg.



Numerical simulation of a ship and propeller

IN recent years, the numerical simulation department at the Potsdam Model Basin (SVA) has focussed much of its research work on the investigation of the flow around a ship with a rotating propeller, employing state-of-the-art CFD (computational fluid dynamics) tools, such as the commercial software packages CFXtascflow and CFX5. Some of this work was reported in the January 2002 issue of *The Naval Architect*, page 36.

The propeller behind a ship operates in unhomogeneous flow conditions, characterised in the case of a single-screw ship by the wake peak and the bilge vortex of the hull. For a twin-screw ship, the non-homogeneity of the propeller inflow is more moderate. In both cases the performance of the propeller blades becomes a function of the angular position of the propeller. This effect is more pronounced in a single-screw ship because the blades operate in a velocity field which changes in a radial circumferential direction.

Behind the propeller a complex flow field can be encountered, where the effects of both ship and propeller superimpose. Knowledge of the flow behind the propeller is of particular importance with respect to rudder performance and cavitation.

In most applications, ships under propulsion conditions are still calculated with body forces in order to reduce the computational effort. The effect of the (not present) propeller on the flow is approximated by distributing fictive forces, which yield the thrust and the torque, in a disc located at the propeller plane.

SVA's extensive research in the field of propulsion systems has enabled it to calculate the ship flow considering the rotating propeller in full detail. The numerical mesh around ship and propeller are connected via sliding interfaces, with the propeller mesh rotating relative to the ship mesh and dependent on time step and rate of revolution. In Fig 1, the numerical surface mesh is shown for a container ship with a five-bladed propeller. The unsteady RANS calculations are continued until the residuals are below a prescribed level and periodicity in time is reached.

In Fig 2, a snapshot of the pressure distribution on the ship and propeller is shown for a single- (left) and a twin-screw ship (right) [1], while in Fig 3 the pressure distribution is shown on a propeller and pod housing. The change in blade loading for the different angular positions of the propeller blade, and thus the eccentric thrust distribution (causing a bending moment), is particularly pronounced for the single screw ship.

Two major reasons for the difference in blade loading can be identified. One reason is that the propeller passes the wake peak of the ship, or regions being in the wake of other appendages. The other is due to the circumstance that the propeller blades operate against and with an upward velocity component (the flow follows the ship's contours), leading to different inclination angles of the blade sections during one revolution of the propeller.

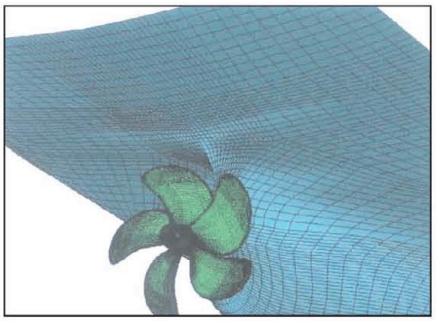


Fig 1. Surface mesh on ship and propeller for a five-bladed propeller on a container ship.

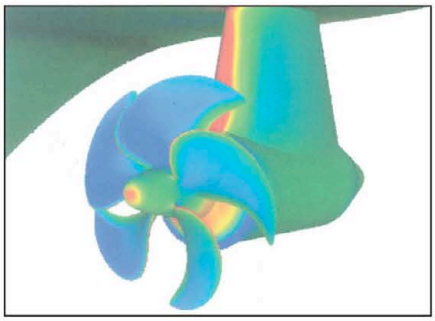


Fig 3. Pressure distribution on propeller and pod housing.

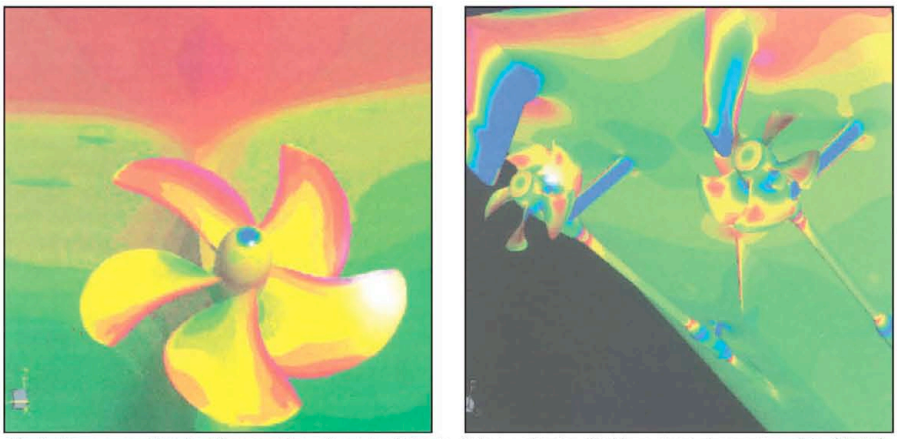


Fig 2. Pressure distribution on the aft part of the hull for a single- (left) and a twin-screw ship (right).

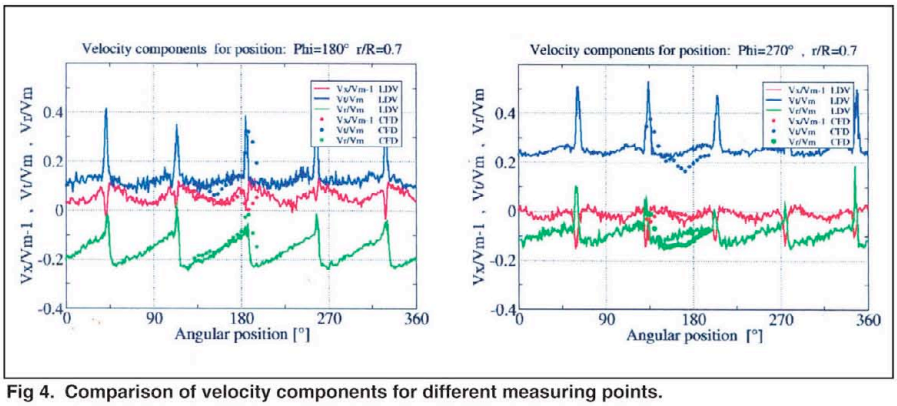


Fig 4. Comparison of velocity components for different measuring points.

SVA has carried out intensive measurements using a laser probe to validate and verify the computational results, not only on the basis of integral values but also on local velocity data. Angular-based measurements were carried out at 0.15 propeller diameter behind the propeller plane, while the propeller is running.

In Fig 4, the time history (set in relation to the position of one propeller blade) of the axial, tangential and radial velocity components are compared between calculation (CFD) and measurement (LDV) for different measuring positions. The general agreement between measurement and calculation is very satisfactory.

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Indonesian connection continues for Meyer Werft while container ships re-emerge

AT the end of June, Meyer Werft, in Papenburg, delivered its 23rd passenger ship to the Directorate General of Sea Communication, Jakarta, Indonesia. Before delivery, the 15,136gt newbuilding was named *Labobar* by the Indonesian State Minister for Women Empowerment. Although *Labobar* looks similar to her predecessors, she is substantially different, especially regarding the interior design.

The new vessel is 146.5m long, 23.4m wide, and has a depth of 8.2m. Draught is 5.9m. Up to 3084 passengers can be carried, comprising 26 first class A in double cabins, 40 first class B in four-berth cabins, and 3018 in improved economy class; officers and crew number 161. In addition the vessel can carry 640tonnes of cargo or 32 containers, and has a deadweight of 3482dwt. The two main engines produce a total of 16,800kW to give a speed of 22.35knots.

With the completion of this ship, the yard will have built a total of 29 ships (23 passenger ships, five cargo/passenger ships, and a gas tanker) for Indonesia. The first passenger ship in the series was built in 1983 and has since been upgraded to ensure the most efficient operation. Since 1983 some 60 million passengers have been carried on Meyer Werft ships in Indonesia.

In addition to the German-built tonnage, three ships with a carrying capacity of 500 passengers each, were constructed in Surabaya, Indonesia in close cooperation with the Indonesian PT PAL shipyard in 1995 and 1999 respectively. The cooperation between Meyer Werft and the island state of Indonesia is said to be one of the most successful German development projects.

Labobar **is the latest in a remarkable list of 29 ships (23 passenger designs, five cargo/passenger, and one gas tanker) that have been built by Meyer for Indonesia since 1983. Despite the long list, the newest delivery is substantially different in her interior design.**

Jewel of the Seas **is the fourth of the** ***Radiance*** **class liners for RCI. Like her sisters, she is powered by a COGES combined gas turbine-electric and steam turbine-electric arrangement.**

Cruise ships continue

Meanwhile, the yard continues to build cruise ships, with which it has become synonymous in recent years. The latest delivery is the 90,090gt *Jewel of the Seas*, which was delivered late in April to Royal Caribbean International. This is the fourth cruise vessel of the *Radiance* class to be built for Royal Caribbean by the yard and is 293.2m long oa with a beam of 32.2m. Accommodation is provided in 1055 cabins (817 of which are outside) for a total of 2110 passengers - officers and crew add a further 858 to the complement.

Propulsion is by a combined gas turbine/steam turbine electric system (COGES) comprising two General Electric gas turbines, each producing 25MW, and a Fincantieri steam turbine rated at 7.8MW. Exhaust gases from the gas turbines generate steam in exhaust-gas boilers which is then supplied to the steam turbine. Propulsion power is fed to two 20,000kW Azipods to give a maximum speed of 25knots.

The yard has now started construction of two new cruise ships for Norwegian Cruise Line/Star Cruises. *Norwegian Jewel*, to be delivered in the summer of next year, and *Pride of Hawaii*, scheduled for completion in the spring of 2006, will have a length overall of 294m and a breadth of 32.20m. The vessels will have a speed of 25knots and will be capable of carrying 2376 passengers in 1188 cabins. It is said that these ships will set new standards in both design and technology. They will be fitted with podded drives with power supplied by five diesel-generator sets and will operate for the brand NCL America under the US flag.

Container ships once again

In a break from its recent pattern of production and a reflection of the poor cruise liner newbuilding market, Meyer Werft has re-entered the container ship sector and is now working on two new vessels for Hansa Hamburg Shipping International. The new 20knot vessel design, to be operated in feeder service, is of 34,000dwt with a length of 169m, a beam of 27.2m, and a carrying capacity of 1600TEU.

They feature open-top midship sections for fast loading and unloading, will be built to the highest ice class specifications, as well as being capable of operating in all major ports of northern Europe. In total, four ships will be built, with the first two ready for delivery at the start of 2005.

Already, the first steel sections for the first two vessels have been delivered to Papenburg via the River Ems. They have been fabricated by Meyer subsidiary Neptun Stahlbau, of Warnemünde, since for a yard that specialises in cruise ships, it is more economical to outsource such steel work (more information on Neptun appears elsewhere in this feature).

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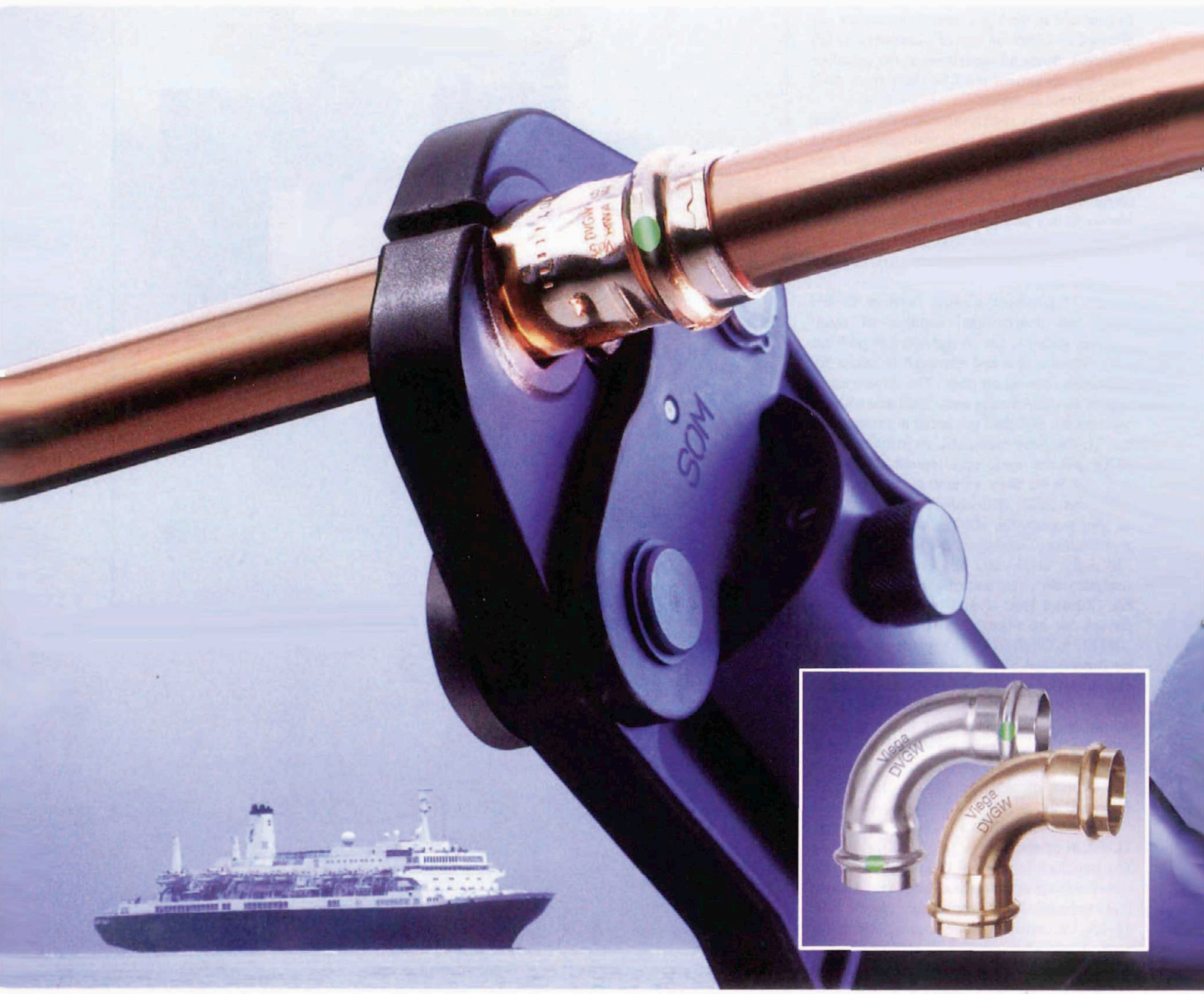

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New developed fully-automatic twistlock - the TL-FA

RECENT contracts for the construction of ultra-large container ships with total capacities up to 10,000TEU have highlighted the need for new technologies to boost productivity compared to smaller vessels, for example where containers are stowed in stacks on deck up to eight high, equivalent to 20m. Following implementation in 1999 of the OSHA Rules and Regulations in the USA, longshoreman are not allowed to climb on top of containers in US terminals, hence all operations of the container securing equipment must be done from deck level without exception.

The commonly used semi-automatic twistlock (SAT) meets the OSHA rules and regulations but manual opening of the SAT from deck level can only be done for stacks of up to five tiers. Where containers are stowed above this, the SAT has to be opened in a very time-consuming manoeuvre from the top of the stack with personnel brought safely to the SAT by special spreaders, cages or other devices.

Ship's Equipment Centre Bremen GmbH (SEC), an international supplier of cargo securing systems, has recognised this problem and evolved a new and advanced twistlock for containers stowed on deck. The development project was launched in early 2002 and within a two months SEC had produced a prototype of the TL-FA fully-automatic twistlock, which fulfills all the basic requirements. This was presented at the SMM exhibition in Hamburg in September, 2002, after which SEC concentrated on fine-tuning the design and seeking its approval from Germanischer Lloyd.

In April 2003, GL approved the design, strength, safety, and operating features of the TL-FA. Onboard tests in 40ft bays on deck were carried out on ships of different sizes (from 700TEU to 2700TEU), with the design meeting the expectations of owners, charterers, terminal operators, and stevedores. Last autumn the first ship (of 700TEU) was equipped with the TL-FA for all deck containers and has now been operating for 10 months without any problem. Many other owners have now changed over to the TL-FA or adopted it for their latest newbuildings.

SEC's new TL-FA twistlock is claimed to offer many benefits for all parties involved in container handling onboard ships.

TL-FA in operation

The twistlock is inserted in all four container corner castings at the quayside, and the container lifted onboard. Due to the special shape of the TL-FA, the container slews slightly around its vertical axis when positioned on the container below. When lowering is completed, the twistlock then self-locks.

The TL-FA is of asymmetric design, and its combination of inclined surfaces keeps the container safely in position during all expected operating conditions while at sea.

When it comes to unloading, the box can be picked-up without any handling or operation of the twistlock. The lifting procedure causes the container to again slightly slew about its vertical axis, so freeing it automatically from the one below.

All operations are performed by the twistlock without the need for any manual activity by stevedores, and the unit is said to function well, independently of external influences such as low temperatures, icy conditions, harbour swell, or heel and trim.

Lashing bars can be inserted at the upper and lower container corner while the vertical movement between containers is limited to 12mm in accordance with ISO 3874, thus avoiding possible overloading of lashings. The TL-FA also functions without problems during the twin lift of two 20ft containers stowed longitudinally, ensuring the simultaneous operation of two 20ft containers in block stowage (with ISO gap) at a significant cost saving for the terminal.

GL still in vanguard of container-ship technology

GERMAN classification society Germanischer Lloyd (GL) has further strengthened its position as the leading society for container ships. At a special meeting in Hamburg, it was confirmed to *The Naval Architect* that the society now classes 34% of the world's existing fleet of box ships and is the chosen society for 48.7% of the global newbuilding market in this sector. Even more impressive is the fact that approximately 75% of the new giants of 7500TEU and above will be constructed to GL class.

According to executive board member for technology, Dr Hermann Klein, in discussing GL's strength in this sector, 'We are well prepared for both current and future ships with capacities from 9200TEU to 12,000TEU and can offer both owners and yards well-founded support with their projects'. At present, the largest new vessels on the order book are several 9200TEU units for Claus-Peter Offen at Samsung.

Meanwhile, an example of the current strong position held by GL in this sector, across a broad range of vessel sizes, was the delivery in June of the largest container ship with GL class to be built so far in China. *MSC Queensland* is a 3400TEU vessel with a length of 230.90m and a beam of 32.20m. The design was developed entirely by the Shanghai Merchant Ship Design & Research Institute, and built at Shanghai Shipyard.

The new vessel is powered by a 31,920kW MAN B&W diesel engine and has a speed of 22.5knots. This is the first in a series of four vessels, with the remaining ships scheduled for delivery later this year to Norddeutsche Reederei Beteiligungsgesellschaft.

Leading the way

GL's rules are constantly being updated to include state-of-the-art findings and to take into account problems facing owners and operators, for example non-weathertight hatch covers, dynamic sagging moments caused by bow flare and speed, calculation procedures for large watertight bulkheads, reinforcements for aft structures with a flat bottom, improvements to the buckling rules, and prolonged, variable lifetimes for fatigue assessments. In many cases, the rules go beyond the IACS standard requirements if GL's experience of a particular ship type shows this to be necessary.

A key area in which GL has set standards is container stowage and lashing, and it is believed to have been the first society to publish rules for container stowage based on the results of direct rolling calculations. Hatch covers are another area where the society undertook pioneering work as the first to come up with rules, guidelines and software for hatch cover calculations. GL also carried out detailed tests and measurements on the substructure of bearing pads to ensure they would cope with the expected increase in stack load on the covers.

Given the importance of reefer containers, GL has focused resources on this aspect of container ship technology and come up with a special reefer bulkhead design for reefer maintenance, cell guide support for random stowage, guidelines for ventilation systems, and rules for electrical load balance.

Machinery is another area of its container ship expertise. It has already approved numerous 12-cylinder engines and is ready for the 14-cylinder two-stroke engines now being discussed for future vessels. As main machinery becomes more powerful, special attention has to be paid to forced vibrations, and as long ago as 1984 GL began applying main engine excitation in global vibration analysis. It is also believed to be the only class society to carry out integral shaft alignment calculations for large container vessels.

Steady growth in all areas

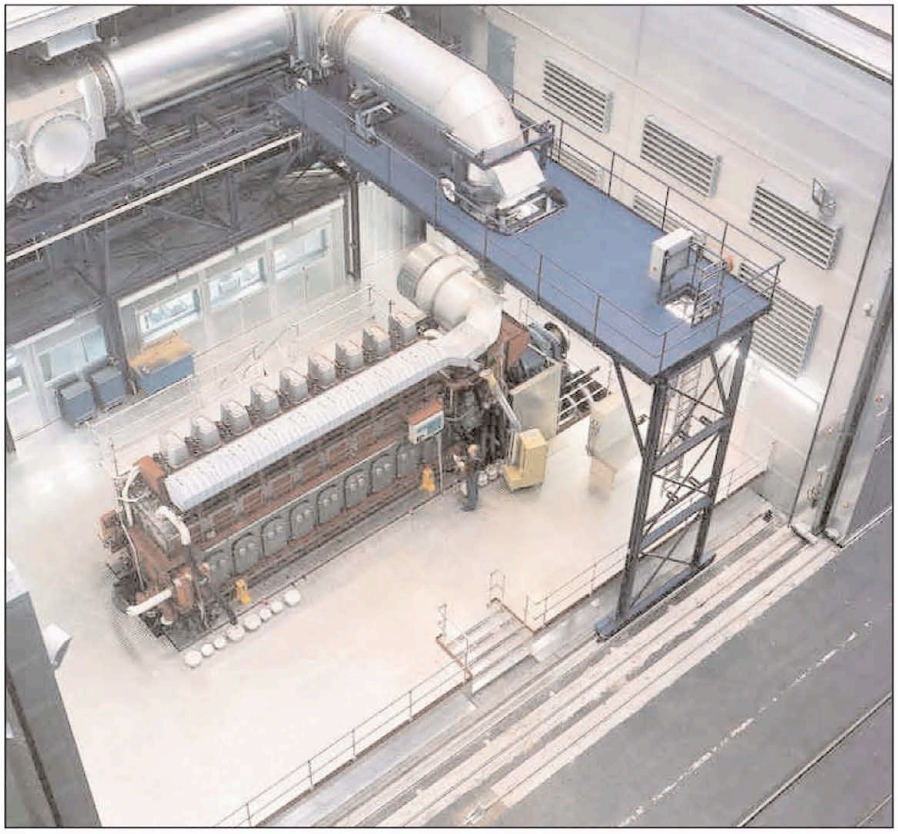
Today, maritime services represent around 75% of the society's activities, with the balance being operations in the industrial field. Of course, GL handles more than just container ships and it is active in all other areas of shipbuilding and ship operation. At the end of last year, it had in class 5357 vessels of 44.1 million gt. On order were a further 610 ships aggregating 10.3 million gt while during the year 263 GL-classed vessels were delivered totalling 3.5 million gt. The growth in the GL fleet in tonnage terms has been averaging 10% annually for the last few years while the order book has more than doubled since 1999.

Caterpillar MaK goes from strength to strength

IT is now five years since MaK, based in Kiel, took over the former Dieselmotoren Rostock (DMR) operation at Warnemünde, located between the yards of Aker Ostsee and Neptun Stahlbau. According to the company, the investments in Rostock have been a major success for Caterpillar's engine division (*The Naval Architect* May 2002, page 6). From the start, the workforce has proved committed, demonstrating flexibility, in training new members for the workforce and, most recently, in relocating the production of a further engine range (the VM32) into the plant.

Investment in Rostock has included the installation of a state-of-the-art test and painting facility alongside modern assembly stands, also stores and handling equipment. The sums involved are large as they include the purchase of flexible testbeds with up to 16MW power capability.

This investment has enabled Caterpillar to develop the larger engine range (vee and in-line versions of the M43, now producing 1MW/cylinder in diesel, oil-burning form) and to sharply expand production of the vee and in-line M32 ranges. Without the Rostock facility, the 2003/04 order book intake jump, which today includes four 12VM43 units for the new Cobelfret ConRo ferries ordered at the Flensburger yard, could not have been translated into such a sharp increase in output.



One of the five sound-insulated testbeds at Caterpillar MaK's recently renovated Rostock-Warnemünde works.

Turnkey HVAC systems from Imtech Schiffbau-Dockbautechnik

IMTECH Schiffbau-Dockbautechnik is a world leader in turnkey deliveries of HVAC systems for different types of ships. Based in Hamburg and with experience going back to 1915, the company operates in four main areas - cruise ships, merchant vessels, naval ships, and dock construction/offshore engineering.

During the last five years, it has undertaken the outfitting of a number of cruise ships, including *Olympic Voyager* and *Olympic Explorer* at Blohm + Voss, *Coral Princess* and *Island Princess* at Chantiers de l'Atlantique, and *Serenade of the Seas* and *Jewel of the Seas* at Meyer Werft.

New cargo ships represent a special challenge, and Imtech has successfully carried out projects at many German shipyards, including J J Sietas, Lindenau, Aker Ostsee, and Volkswerft Stralsund as well as at overseas yards such as Jiangnan and Qingshan in China.

Firefighting the Fogtec way

FOGTEC Brandschutz GmbH & Co KG is a leading supplier of high-pressure water mist systems for cruise ships and ferries, as well as local protection systems. For the offshore industry, Fogtec offers protection systems for gas turbines, other machinery spaces, and accommodation areas. Global engineering capability and a range of associated services are available through an international network of more than 45 firefighting companies, while Fogtec has its own offices in Malaysia and the USA.

Water-mist systems are an efficient and environmentally friendly alternative to sprinkler, deluge, and gas extinguishing systems for the protection of accommodation and machinery areas. Water mist leads to an immediate drop in temperature in case of fire and protects nearby objects and people from radiant heat.

Testing a Fogtec water-mist local-application firefighting system in a machinery space.

Pure water is no danger to people and can be activated immediately after detection of the fire. Fogtec systems operate at high pressures of 100bar to 200bar and fall within the Class1 definition of the NFPA 750 guideline. They have the advantage of combining small droplet size with high velocity, giving the finest and most thermally efficient water mist.

All systems are designed and installed in accordance to SOLAS Chapter II as well as IMO A 800(19), IMO MSC 913 and IMO MSC 668/728 rules. Deep-fat fryer protection systems are also offered in accordance with ISO 15371. Systems are type-approved by most classification authorities including Lloyd's Register, Det Norske Veritas, and and Germanischer Lloyd, while component tests are made by Factory Mutual.

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TTS

New environment-friendly propeller shaft seal

A new design in propeller shaft sealing technology, Eco-Seal, has recently been launched by the UK company Ocean Venture Seals. The environment-friendly Eco-Seal is claimed as a major advance in propeller shaft sealing technology because its design means there is no oil leakage from the propeller shaft and no contamination of the sterntube oil by sea water. Any small leakages of oil or water are contained in the Eco-Seal's casing and drained inboard, with any leaked fluids being handled as bilge water.

Another advantage of Eco-Seal is that it has a fully split construction, which allows all repair and maintenance activities to be carried out with the propeller and propeller shaft remaining in place. In many cases, the seal can be repaired underwater. This eliminates the need for any towing and drydocking expenses, which are always a large proportion of any repair bill. It also means that the vessel can be repaired much faster - on site in the water.

The seal is said to have an extremely high resistance to damage and failure from ingress of foreign material, and the design also allows large axial movements of the propeller shaft due to thermal expansion without any alteration in sealing face pressure. This enables the optimum balance between sealing function and low wear rates. The Eco-Seal can be adapted to fit onto almost any type of ship - ranging in size from ULCC to offshore support vessel.

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Access gear for largest-ever cruise ship

Swedish cargo access manufacturer TTS Ships Equipment AB, a subsidiary of Norway's TTS Group, is preparing to commence delivery of specially designed and built access gear for installation aboard the Ultra Voyager cruise vessel, currently under construction at Kvaerner Masa-Yards in Finland. At 160,000gt, this new vessel will be the largest cruise ship ever built. TTS has supplied similar systems to all five of previous slightly smaller Voyager-class ships, also built at this Finnish yard.

Under a turnkey contract, originally signed in January, TTS is fabricating side shell doors, hatch covers and lifting platforms for the vessel, which was ordered by Royal Caribbean Cruise Line (RCCL) last year. The mild steel equipment, which weighs a total of more than 140tonnes and has been designed in accordance with Det Norske Veritas regulations, will be delivered to the yard between July this year and February 2005.

Altogether, TTS will supply some 50 components for the vessel, together with the necessary hydraulic systems. The equipment will include access doors for passengers, luggage, provisions, and spare parts, also a series of foredeck opening hatches, used mostly for storage of the ship's mooring equipment. The Swedish company will also supply lifting platforms for spare parts and provisions.

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Bridge systems for new cross-Channel ferry

Northrop Grumman Corp has been selected to supply the bridge navigation and communication systems for a new SeaFrance high-performance vehicle-passenger ferry, which is being built at Alstom's Chantiers de l'Atlantique, in Saint-Nazaire, France. This new ferry, to be christened *SeaFrance Berlioz*, in honour of the famous French composer, is scheduled to enter service in February 2005.

The new ferry will be fitted with a multi-console voyage management system from Northrop Grumman's Sperry Marine business unit. Components will include a type-approved electronic chart display and information system, interswitched BridgeMaster E navigation radars, a networked self-tuning adaptive autopilot and main steering system, voyage data recorder, automatic identification system, gyrocompasses, and other navigation sensors and systems.

The bridge installation will include multiple navigation and control consoles utilising the latest high-resolution flat-screen LCD technology. Also included is a communications suite complying with the international requirements of the Global Maritime Distress and Safety System. Sperry Marine will work closely with the owner and shipyard to provide technical support, program management, installation, commissioning, and crew training.

The bridge installation for *SeaFrance* Berlioz will be similar to the system previously supplied by Sperry Marine for sister ship, *SeaFrance Rodin*, which was completed in September 2001 by Aker Finnyards (*Significant Ships of 2001*). At 185m long, 28m wide and 32,000gt, *SeaFrance Berlioz* will be able to carry up to 1900 passengers, 120 trucks, and 700 cars. With a service speed of 25knots, the ship will - like her sister - be one of the fastest on the Dover-Calais route.

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Tel: +1 434 974 2656.
E-mail: sales_commercial@sperry-marine.com

New range of Walker indicators

John Lilley & Gillie Ltd, the River Tyne-based manufacturer of navigational instruments and nautical equipment, is introducing a new complete range of analogue and digital Walker indicators for the commercial vessel market. The introduction of the new range of Walker Indicators comes just weeks after Lilley & Gillie launched the Walker wind speed and direction sensors (*The Naval Architect* April 2004, page 46), which was the first of the Walker products to be completely re-engineered and re-designed since Lilley & Gillie acquired Walker Marine in 2002.

Analogue wind direction indicators - typical examples from the new range of analogue and digital indicators introduced by John Lilley & Gillie for commercial ships.

The new range comes in both an analogue and a digital version, with 17 analogue models covering the indication of wind, log, clinometer, clock, rudder angle, and heading information, and four digital models which will cover wind, weather, nautical, and ship's head. The indicators will be available in two DIN-sized panel mount cases: DIN 144 x 144 for multiple users/large vessels and DIN 144 x 96 for workstations/small vessels.

The indicators have a 24V DC power supply and a simple installation of multiple indicator systems with plug/socket cable connection between instruments in the same console. They use solid-state principles with NMEA 0183 input and output, and no calibration is required. High-contrast dials to provide a clear distinction between primary and secondary information indicators have individual as well as grouped illumination control with both local and remote dimming facility. The controls for dimming and mode change are permanently readable. In addition, all Walker indicators are fitted with a sensor input failure alarm and a power loss relay contact.

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North Shields,
Tyne and Wear NE29 6LF, UK.
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Fax: +44 191 257 1521.

Automation for new Airbus ro-ro ship

Automation systems for the new Airbus parts transporter, *Ville de Bordeaux*, built at Jinling Shipyard in Nanjing, China, and featured in *The Naval Architect* June 2004, page 42, have been supplied by Kongsberg Maritime. The core of the system is the DataChief C20 alarm, monitoring and control system, and a power management system.

The DataChief system onboard consists of five operator stations with three in the engineroom, one in the cargo control room,

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and another on the bridge. The system utilises 150 distributed processing units (DPUs) throughout the vessel in addition to 13 serial lines, all of which process more than 4200 signals.

The vessel has two main engines, CP propellers, and two shaft generators, which are managed by two separate Kongsberg Maritime power management systems, divided on the port and starboard side of the main switchboard. This arrangement provides a fully redundant system that also covers the diesel-generators with double safety modules for each engine. This is the first vessel fitted with this configuration.

Ville de Bordeaux is a ro-ro design and will be operated as a joint venture company by Louis Dreyfus (France) and Leif Hoegh (Norway). It will carry parts for the A380, a new aircraft that can accommodate 555 passengers. The first example will be delivered to Singapore Airlines in 2006.

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E-mail: rita.krathe@kongsberg.com
www.kongsberg.com

Lifeboats for largest passenger ship

Leading lifeboat and davit specialist Schat-Harding has been chosen by RCCL to supply the lifeboats and davits for the Ultra Voyager project, which will be the largest passenger ship in the world when delivered in 2006. Now under construction at Finland's Kvaerner Masa-Yards, the Ultra Voyager is a lengthened version of the successful RCCL Voyager class, of which five have been built at the same yard, all with Schat-Harding lifesaving equipment. The new 340m long vessel will carry 5740 passengers and crew.

Under a turnkey installation, testing, and training programme, Schat-Harding will supply 30 MPC32 lifeboats, with VIP24FD davits, plus two fast rescue boats and davits, and 10 davits for 35-person liferafts.

Probably the market leaders in the supply of lifesaving appliances to cruise liners, Schat-Harding has a number of brands under its umbrella. Today, these also include Watercraft, Waterman, Fiskars, Davit-Co, William Mills Marine, and Mulder & Rijke.

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Tel: +47 53 48 36 00.
E-mail: endre.eidsvik@umoe.no

More NACOS orders for Sam Electronics

Hamburg-based SAM Electronics has received orders from Chinese, German, and South Korean yards for a further 13 NACOS navigation command systems. Worldwide sales of the integrated systems featuring radar-controlled trackpilots, ECDIS and other proprietary sensors, now approach 940 configurations.

The new contracts comprise eight 35-4 systems for a series of 95,000gt tankers being built by Samsung Heavy Industries for delivery to Evergreen Marine, of Taiwan, in 2005 and 2006; similar systems have also been ordered for two 29,000gt products tankers nearing completion at Jiangdu Yuehai Shipbuilding's yard in China on behalf of International Andromeda Shipping. Meanwhile, in Germany, three 21,353gt products tankers under construction at the Lindenau yard in Kiel for German Tanker Shipping and Seychelles Petroleum respectively, are to be equipped with Series 45-4 systems; the vessels are due for completion between 2004 and 2006.

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Numerous blinds orders achieved in Korea

The top four Korean shipyards will be building approximately 200 vessels between them in 2004, and Solar Solve Marine has been successful in positioning its Solasafe products on the majority of these newbuildings. March this year saw this UK-based company doubling its usual output of anti-glare roller screens and blinds.

Solar Solve Marine, 7 St Hilda Industrial Estate, South Shields NE33 1RA, UK. Tel: +44 191 454 8595. Fax: +44 191 454 8692. E-mail: info@solasolv.com

Ro-ro systems for largest Chinese-built car carriers

The largest car carriers ever built at a Chinese shipyard will feature MacGregor ro-ro access equipment. In addition, three ro-pax ferries currently on order in Italy will also be installed with these systems.

Construction work on the series of three 5000-car PCTC vessels begins in China at the end of this year. They are being built for Japanese owner K-Line by NACKS (Nantong COSCO KHI Ship Engineering Co) - a joint venture between COSCO and Kawasaki Heavy Industries. Ro-ro systems on this trio will include quarter ramp/doors, side ramp/doors, internal hoistable ramps, ramp covers, and bulkhead doors. These will be supplied in 2005.

The three 42,000gt cargo/passenger ro-pax ferries are being built by Fincantieri for Finnlines (*The Naval Architect* April 2004, page 15) and will be used to link Helsinki and Travemünde; there is an option for two sisters. These 9300dwt ferries can carry 300 trucks in 4200lane metres. These figures mean that these ships will probably be the largest ro-pax designs ever built.

MacGregor will supply a series of external and internal ramps, ramp covers, bow doors, hoistable decks, and shell doors. Delivery of the equipment is scheduled for the first half of 2005, and the ships are set for delivery in November 2005, May 2006, and June 2006.

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E-mail: karl-axel.persson@macgregor-roro.com

Firestop withstands three-hour fire test

A new version of the Dutch Firsto firestop with Actifoam fire-resistant foam rubber has successfully withstood a fire test lasting three hours. This test, carried out in the USA by Underwriter's Laboratories, is claimed to demonstrate that Beele Engineering's Actifoam firestop functions under the severest possible fire load. Even when a firestop with Actifoam is positioned completely on the exposed side, no smoke emission occurs at the unexposed side during the first hour of the test.

The certification for three hours fire resistance is valid for installations where the Firsto firestop is installed at the upper side of a floor or at both sides of a wall. When the firestop system is installed on the underside of a floor or at one side of a wall, fire resistance is two hours.

This system is suitable for marine use, but is currently pending approval. However, Actifoam foam rubber has been approved by Bureau Veritas and Det Norske Veritas for use as a temporary fire seal during ship construction work.

Firsto firestops are also capable of withstanding mechanical loads. The metal firestops are of modular construction, and are assembled around a cable tray against the wall, or on the floor. The stops allow cables to be added or removed at a later date.

The metal Firsto casing consists of a housing, attachment bracket, and a cover, which are fitted against the wall or on the floor. Fire-resistant packing is applied between the casing and the wall or floor. Inside the casing, inserts made of fire-resistant and thermally-insulating Actifoam rubber are placed all around against the walls and under the cover. The space around the cable tray and between the cables is filled up with Actifoam inserts and with Actifoam separation profiles respectively. These firestops are supplied fully assembled, which simplifies materials management.

Actifoam can be used for filling openings in constructions, and in the case of an outbreak of fire, the openings will be completely closed off by the expanding rubber. Due to its cell structure, volume expansion will occur only at the seat of the fire. This non-intumescent process ensures that the expansion is not accompanied by any large-scale smoke formation. As a result of this closed-cell structure, Actifoam also possesses good thermal insulation properties. It will not absorb any moisture and has been tested for 24 hours at 2.5bar water pressure.

Beele Engineering, Beunkdijk 11, 7122 NZ Aalten, The Netherlands. Tel: +31 543 461 629. Fax: +31 543 461 786. E-mail: info@beele.com www.rise-systems.com

More Trade and Equipment News can be found on page 154

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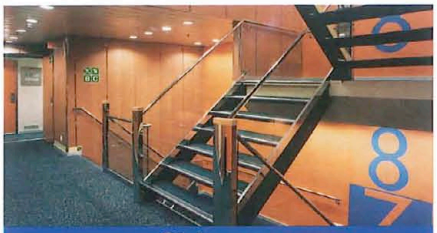
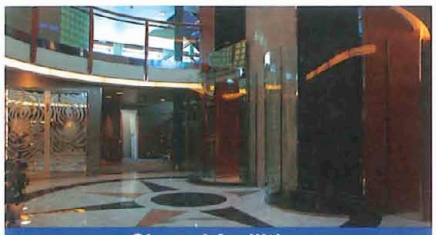
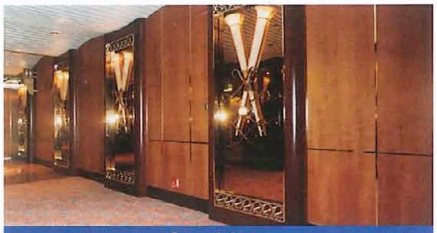


Staircases



Shared facilities

Cabins



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Coming soon to a port near you: the 126m trimaran

In this article, first presented as a paper at The Royal Institution of Naval Architects' Design and Operation of Trimaran Ships*, N A Armstrong, manager of research and development, Austal Ships, Australia, summarises the findings of a four-year investigation into the design of a large stabilised monohull or trimaran, and presents some of the characteristics of the vessel that have attracted an order for a 126m long 40knot passenger and vehicular ferry for operation in the Canary Islands.

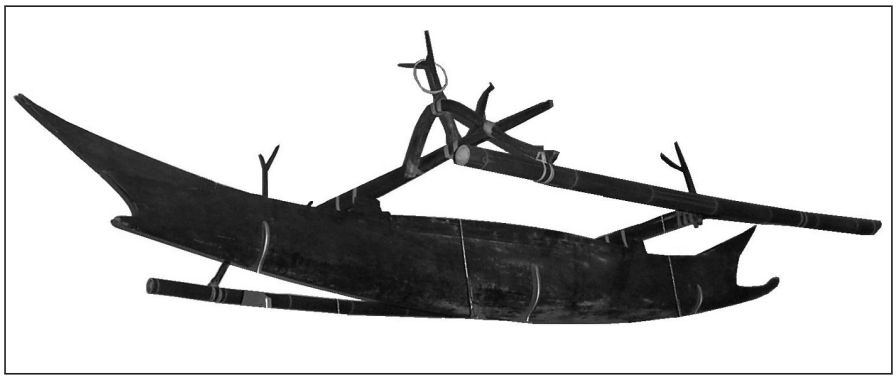

Fig 1. Minahasan canoe with amahs, 1944, from the Western Australian Maritime Museum.

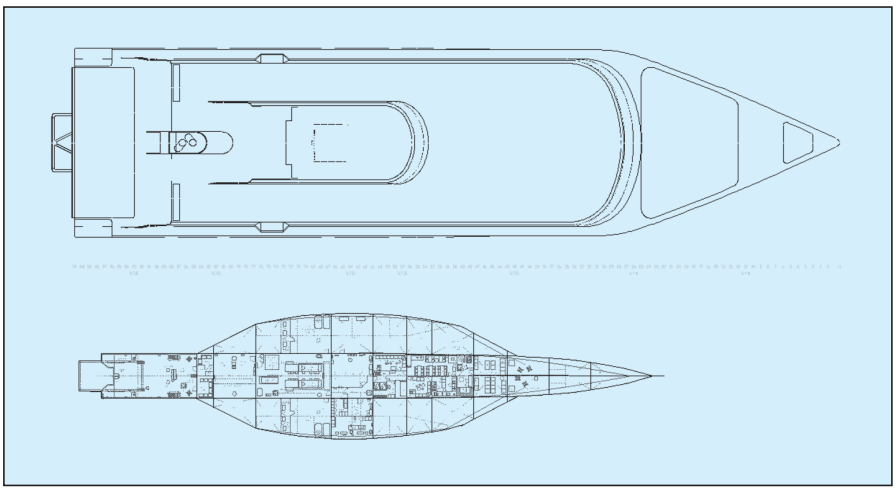

Fig 2. Comparison of the relative sizes of the 126m Austal trimaran and *Triton*.

WHY a trimaran? It certainly is not a new idea, as can be found from looking through patents at the start of the 20th century [10]; and of course there have been canoes built with outriggers throughout the Pacific Ocean for many generations. These native canoes were usually made from hollowed-out tree trunks - which naturally have a high length/beam ratio, and with a fisherman standing onboard the centre of gravity would be too high for the craft to stay upright. Therefore it was necessary to provide additional stability - an amah or two, which was frequently little more than a piece of bamboo, see Fig 1.

It is generally agreed that 'long and thin' provides a minimum of resistance, and generally good seakeeping. However, the stability characteristics are generally poor, and the layout is typically unsuitable for commercial or military use. There were lengthy discussions in the UK in the latter half of the 20th century over 'long and thin' versus 'short and fat' for military craft.

The trimaran provides a solution to the stability and layout issues that bedevil long thin monohulls. Nigel Irens was one of the first to demonstrate the advantages of a trimaran, which should more correctly be called a stabilised monohull, with *Ilan Voyager* in 1989 achieving a round Britain race victory [8], and subsequently with the 35m *Cable and Wireless* which circumnavigated the world in 1998.

There is a limited amount of published literature on trimarans. Results of research in Russia from the 1970s onwards [13] [14] [16] resulted in a number of patents [12] [17] [18] [19].

Kvaerner Masa-Yards, Finland, carried out a substantial research programme and published details of a variety of designs [11] [15]. Other shipyards known to have conducted research include Ateliers et Chantiers du Havre and Vosper Thornycroft. University College London [1] [22] has had a long association with other establishments [2] [21]. Nigel Gee has been promoting his modified trimaran design known as a pentamaran [9], and various Italian universities have recently published results of their research [4] [5].

*Design and Operation of Trimaran Ships was held on the 29-30 April 2004 at the Royal Institution of Naval Architects' London headquarters.

Examination of the published literature provides information on many designs including speed, and power, and deadweight. It is a relatively straightforward matter for a shipyard skilled in building aluminium catamarans to compare these claims against the equivalent catamaran, where equivalent means a vessel with the same deadweight capacity. This comparison suggests that a trimaran with the same installed power would have a higher speed than the equivalent catamaran by approximately 0.75knots to 2knots, depending upon the design.

There has been a certain amount of academic interest in optimising the location of the amahs to minimise interference effects on calm water resistance. These are informative studies, but we have found they may have limited practical interest to a shipyard. Optimum ship design is usually a matter of compromise, and the amah location is no exception to this observation.

Genesis of the 126m trimaran

The origins of the trimaran currently building at Austal Ships can be traced back through the first RINA Conference on RV *Triton* [20]. It appeared that the vessel motion on the Triton model offered potential as a concept that could give improved passenger comfort if developed further as a high-speed craft.

In October 2000 we were looking for an edge over our competitors in bidding for a passenger vessel for an operator of fast ferries in the Canary Islands, Fred Olsen SA. We chose the trimaran concept as a means to provide a substantial improvement in passenger comfort. Our initial work also suggested a possible speed improvement over an equivalent catamaran, and certainly over an equivalent monohull. We carried out model tests at small scale, and then at a large scale as the project developed, with the full support of Fred Olsen. An 11m manned model was also built in order to assess the manoeuvrability and seakeeping ability.

By early 2003, Fred Olsen had defined its exact requirements for a vehicle/passenger ferry, capable of carrying 1350 passengers and 341 cars, at a service speed of 38knots. Maximum speed at a light displacement was to be in excess of 42knots.

The design layout that evolved to meet these requirements was a somewhat smaller vessel than we originally started with, at 126m length

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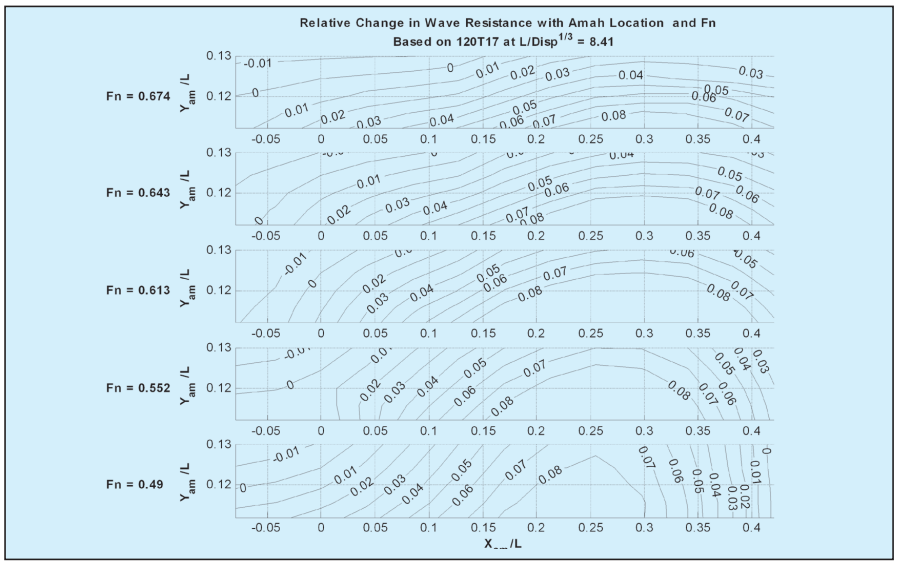

Fig 3. Contours of relative changes to CW for various locations of the amahs, for five ship speeds.

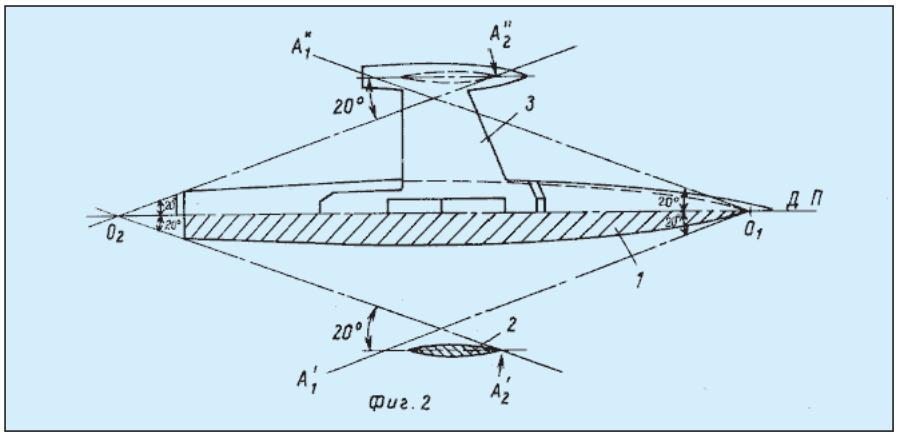

Fig 4. Illustrating the inner boundary for minimum interference effects resulting from the amah placement, from Rudenko [19].

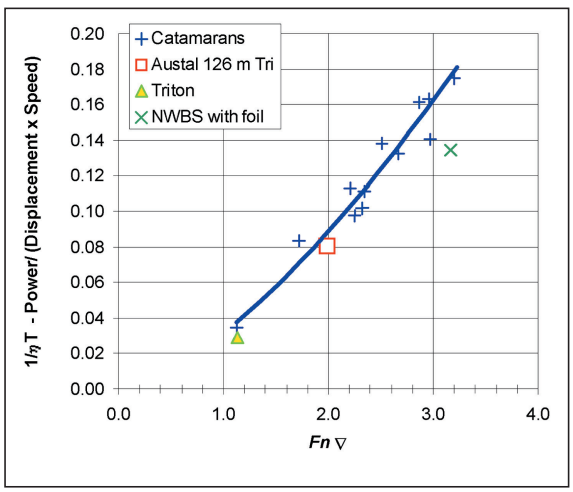

Fig 5. Inverse of transport efficiency for several catamarans, together with three trimarans.

overall. We then commenced a more thorough programme of research and development. The hull shapes were optimised using SHIPFLOW, a numerical analysis tool from Flowtech, with over 300 hull shapes and amah shapes and locations being developed before commencing a programme of numerical analysis and model tank testing, including both resistance and seakeeping. Details of the design process and tank testing are given in Armstrong [3]. A contract to build the 126m trimaran was signed in June 2003.

The vessel will be the largest trimaran ever built, as well as the longest high-speed craft ever built. A comparison with Triton to the same scale is illustrated in Fig 2.

Vessel characteristics

Resistance

A trimaran will generally have a long thin main hull and a low value of wavemaking resistance. A rounded hull shape will provide a minimum of wetted surface area and hence a low frictional resistance. There will be interference effects resulting from the presence of the amahs, and this can be estimated from published data such as [15], [7], and [6], or from systematic model tests such as that described in [3] from which Fig 3 is reproduced. Rudenko [19] illustrates an area to avoid in order to minimise interference effects, based on wave angles of 20deg from the main hull and from the amah, reproduced in Fig 4.

Just how efficient is a trimaran? It is difficult to judge, as only two large craft have been built. Fig 5 shows the transport efficiency of many successful catamarans of a variety of sizes built by Austal Ships, together with *Triton*, the 55m North West Bay Ships trimaran, and the current-building Austal trimaran. The North West Bay craft is fitted with lifting foils and so it may not be a meaningful comparison. All three trimarans show improved transport efficiency over the catamarans. Lindstrom [11] found a similar trend from investigation of several proposed designs.

A towing tank provided non-dimensionalised data of calm water resistance values for a wide range of monohull and catamaran designs operating at a variety of speeds up to 48knots. The data at a speed of 40knots is illustrated in Fig 6, and it can be seen that the Austal trimaran, represented as solid dots at three displacements, has the lowest drag per displacement for any of the monohulls, and is generally comparable with the best of the catamarans.

There are several parameters that have a major effect on the hull resistance. Table 1 (page 78) lists five such parameters for a catamaran, six for a monohull, and 10 for a trimaran. It is obvious therefore that the optimisation of a trimaran is a much more difficult task compared to an optimisation for a catamaran, with a catamaran having 3125 variations of the parameters, but the trimaran having 10 thousand million variations.

Model tank testing of a trimaran at high speed is not a simple procedure. Viscous effects resulting from the main hull bow wave are visible and are difficult to scale. Extreme care has to be taken to eliminate spray without causing additional drag, and turbulence stimulation is particularly difficult on the amahs, which are relatively short and have little immersion at the bow where the wave elevation may be minimal as a result of the bow wave from the main hull. Turbulence pins cannot be used as there is insufficient draught in which to place them. Furthermore, the main hull and amahs have differing lengths, hence different values of Rn, and so the standard ITTC scaling procedures cannot be used.

Seakeeping

High-speed monohull craft have generally good seakeeping characteristics in head seas, but they can be poor in stern quartering seas. Catamarans

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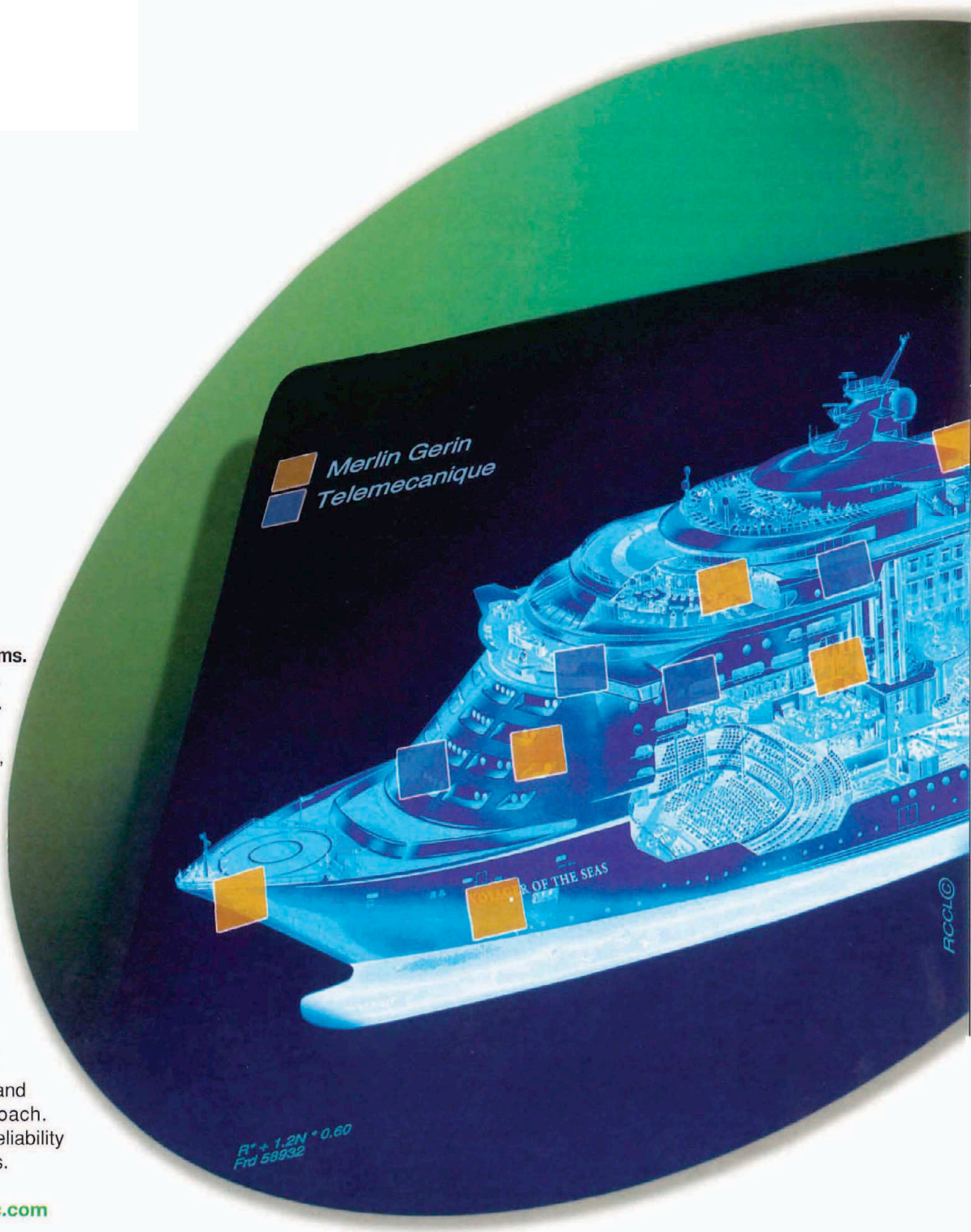

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are generally good in head seas, although they can be limited by slamming of the cross deck structure, and in beam seas the acceleration rates can be high, leading to discomfort. The trimaran appears to provide the best features of both catamaran and monohull, without the disadvantages, as illustrated in Fig 7. This diagram shows the result of an operability study for a monohull, catamaran and trimaran each designed to carry the same payload of 1000tonnes, when operating in a sea spectrum representing the Western Pacific area, and with pre-defined limiting criteria on acceptable motions.

The poor performance of the monohull in stern quartering seas, and the relatively poor performance of the catamaran in beam seas is apparent, with the trimaran skirting along the top of both. Ride control systems are fitted to the Austal trimaran to minimise the amplitude of the motions, rather than to minimise the accelerations.

An operability study was carried out on the 126m trimaran and a 98m existing catamaran on the proposed route of the client. Such a study required the vessel response values for all degrees of freedom at all headings (the RAOs), which were obtained from numerical analysis using strip theory, and correlated against limited model tank testing results. Information was also obtained on the distribution of wave directions throughout the year, a wave scatter diagram relating wave height and period occurrences throughout the year, and the choice of the limiting criteria. The chosen criteria were a motion sickness MSI limit of 10% over a two hour exposure, a maximum roll angle of 3deg rms, and a maximum lateral force LFE value of 0.05g.

By integrating this information, it was a relatively simple matter to determine the percentage of time that the limiting criteria would be exceeded. On this particular selected route, the trimaran was found to have an operability level of 94.2% without exceeding the criteria, and the existing catamaran had an operability of 74.7%. This represented an increase in operability of 27% by changing from a catamaran to a trimaran.

The optimum position for the amahs for maximum seakeeping benefit are generally found with the amah transoms located forward of the main hull transom. Begovic [4] and Brizzolara [5], provide some comparative information. Parametric rolling, where the roll period may be some function of the wave encounter period, resulting in rolling in head seas, has been investigated, and has not found to be of significance for this design.

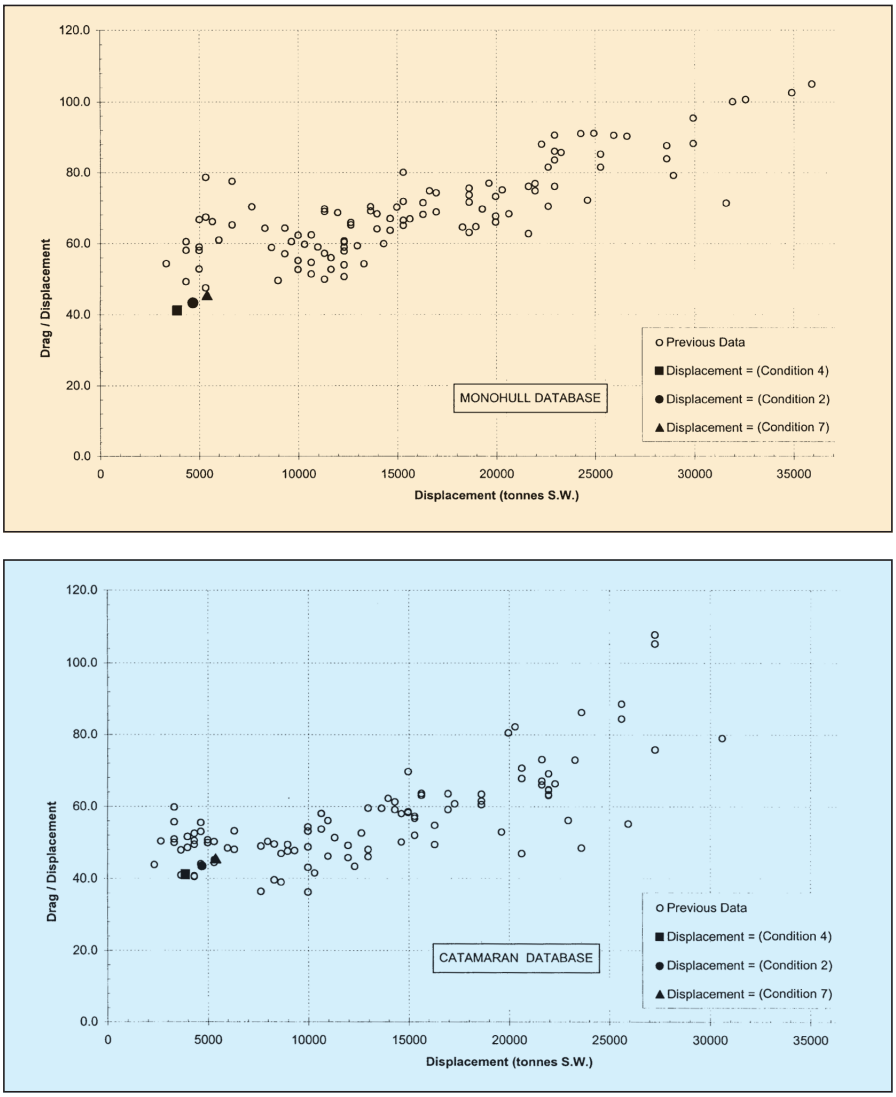


Fig 6. Non-dimensional results from a wide range of model test results of calm water resistance for monohulls (top) and catamarans (bottom), at 40knots, compared with the Austal 126m trimaran at various displacements.

Motions and comfort

The trimaran hull shape allows the regulatory stability requirements to be separated from the seakeeping, comfort, and desired motion requirements. It becomes possible to design a trimaran with a negative GMT value and to still meet the regulatory requirements of the area under the GZ curve. The minimum allowable GMT value for commercial vessels is 0.15m, so there is plenty of scope to design a trimaran with the required GMT value for the most comfortable roll motions.

The starting point for the hull shape developed for the Austal 126m trimaran was to first define the required GMT and GZ curve characteristics to provide particular motions, and the hull shape was then developed to provide these stability curves. This is probably a unique approach to hull design, made possible by the characteristics of the trimaran.

Stability

For commercial craft, IMO standards are applied, usually those for high-speed craft contained in the HSC Code 2000. One challenge faced in the design stage concerned passenger-crowding moments. It may be desirable to limit the width of the passenger cabin, such as was done on the North West Bay Ships' craft, so that the passenger-heeling lever is limited.

A challenge in the design of a trimaran is damage stability, where a maximum allowable heel of 10deg after damage is legislated for passenger-carrying craft. Classification societies do not permit cross-flooding after damage on a high-speed craft. Furthermore, cross-flooding is generally not a satisfactory solution, because if one amah is damaged, resulting in a heel to the damaged side, and the opposing amah is then cross-flooded, then an undesirable situation can arise if all the passengers subsequently move across and crowd on the undamaged (but cross-flooded) side.

Generally for a large trimaran there is insufficient reserve buoyancy in the amah to prevent the heel exceeding 10deg after the legislated amount of damage. This factor is a function of the amah shape, and additional bulkheads provide no benefit. One solution is to make the amahs considerably larger than they otherwise might need to be, but for a high-speed craft this is not a good solution.

Manoeuvring

Trials in the towing tank and on the 11m manned model suggested that manoeuvring would be at least as good as a catamaran. Fig 8 illustrates the results of an analysis of dynamic station-keeping ability of the 126m trimaran and a 98m catamaran. The trimaran has two

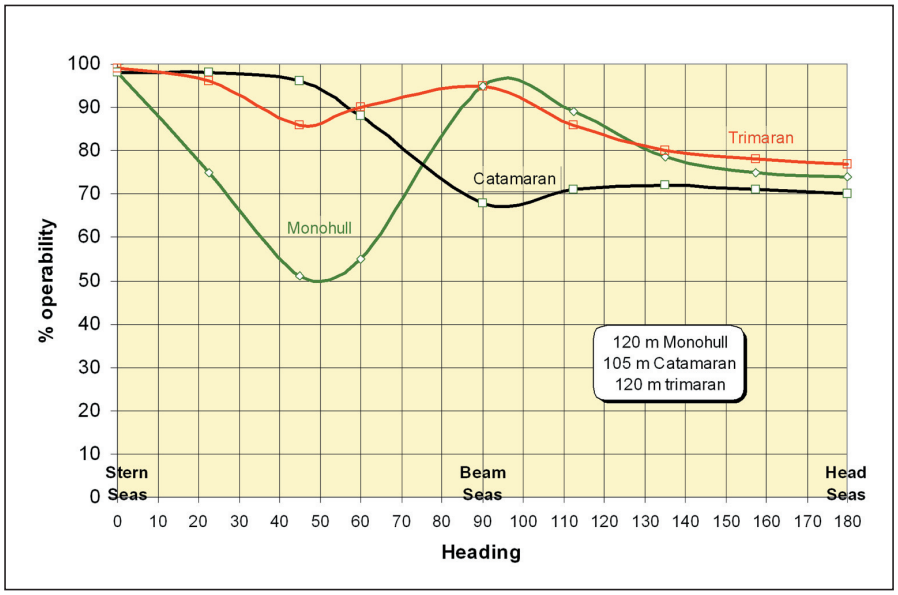


Fig 7. Results of an operability analysis of the equivalent monohull, catamaran and stabilised monohull designed for 1000tonne payload, in the Western Pacific area, for a selected number of motion criteria. The superior operability of the trimaran is clearly illustrated.

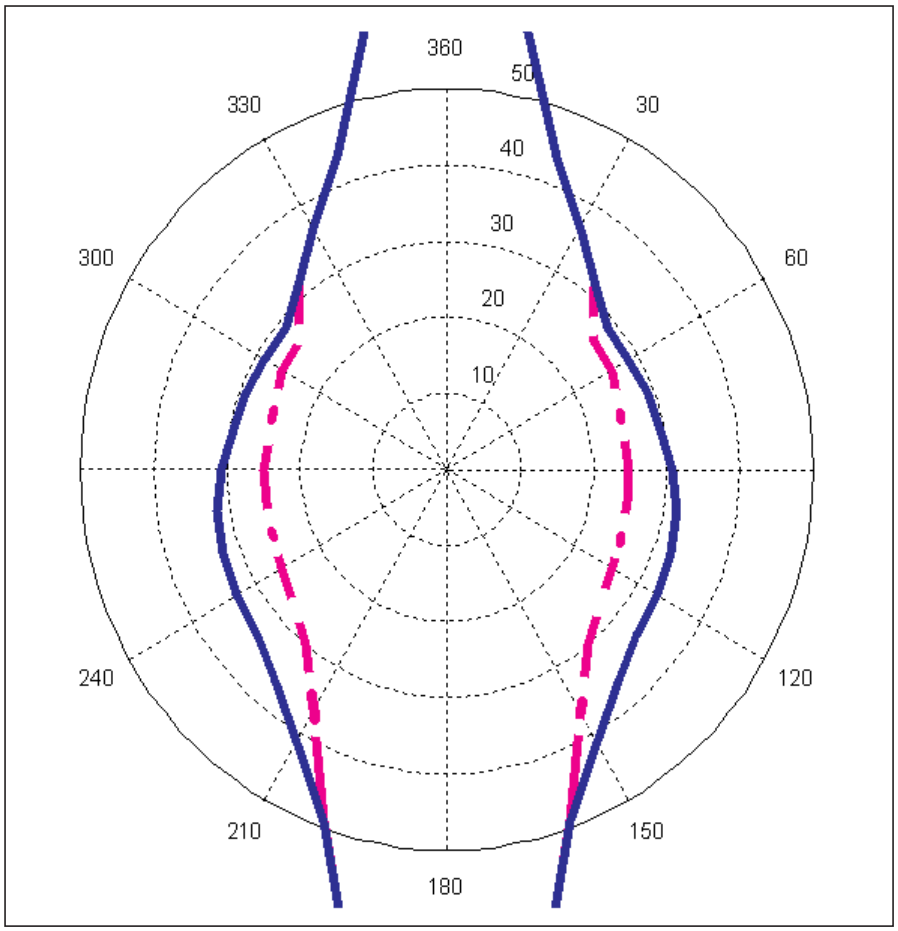


Fig 8. Polar diagram of the dynamic positioning capability of a 98m catamaran (chain dotted line) and a 126m trimaran with two bow thrusters. The polar axis is wind speed in knots.

azimuthing and retractable bow thrusters in order to meet the client's requirements for manoeuvring in a confined port area. Dubrovsky [6] illustrates the effect of amah location on manoeuvrability, reproduced in Fig 9.

Internal layout

Trimarans provide a good and useful deck layout. However, in order to limit the passenger crowding moment for regulatory stability it may be necessary to restrict the width of the passenger cabin relative to the overall beam of the boat.

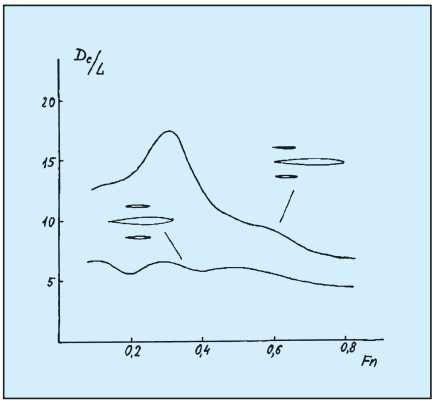


Fig 9. Tactical diameter resulting from 30deg rudder angles, of two identical trimarans with amahs at different longitudinal locations, after Dubrovsky [6].

Many design sketches of fast ferries have been produced where the main cargo area extends out to the ship side extending forward from the after end to about two-thirds of the ship length, and forward of this the vessel is narrow and consists of only the main hull. However, in the commercial world there is substantial pressure to provide a maximum deck area. Therefore the Austal 126m trimaran continues the vehicle deck very far forward, which consequently substantially increases the risk of slamming of the underside structure forward. The relatively narrow main hull was anticipated to cause difficulties in accommodating the main propulsion system, however this did not prove to be a problem.

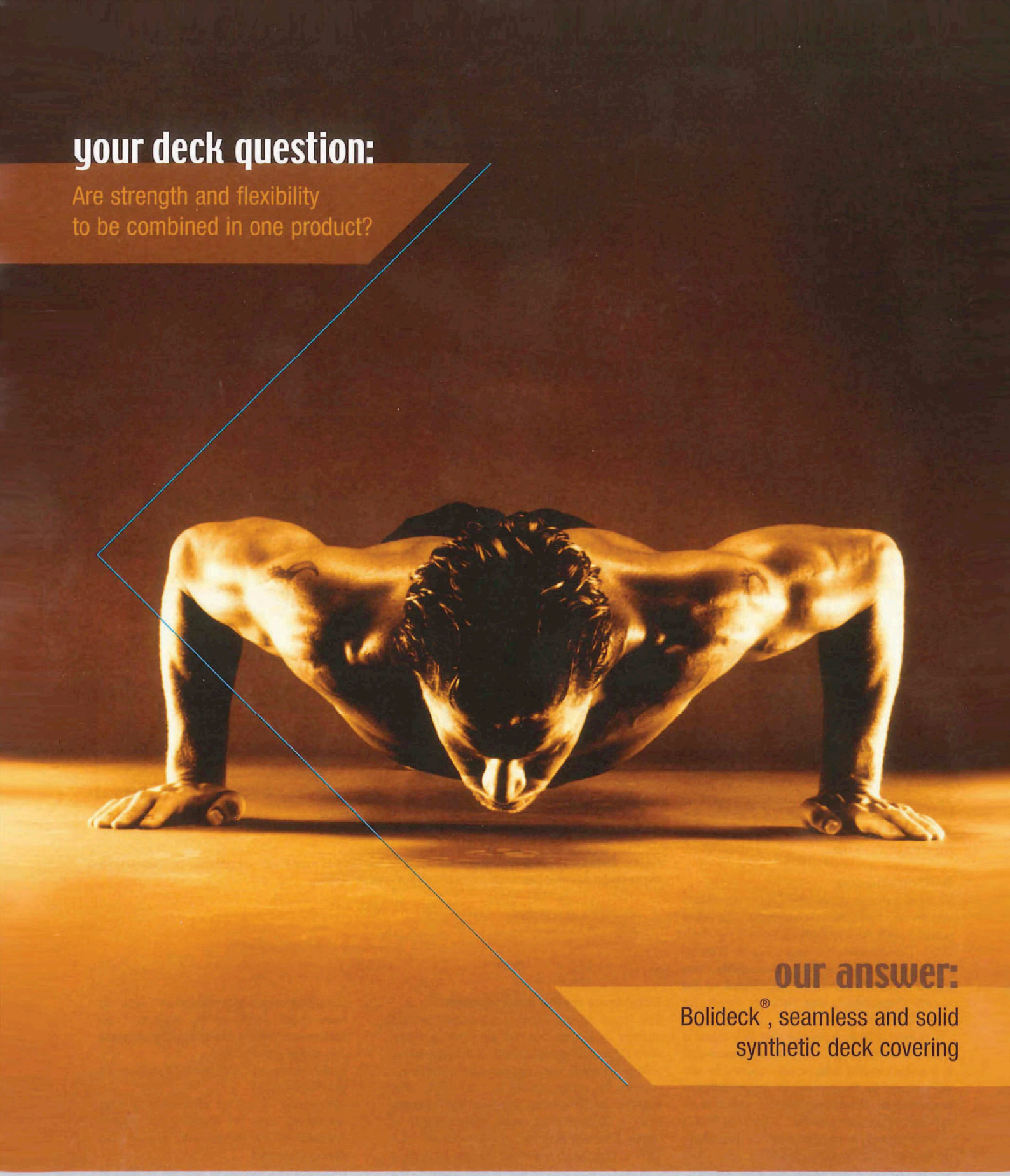
Structure

The structural design has been a challenge, mainly because of the novelty of the concept. Global loads from operation in a seaway have obviously played a major part in the structural design and in the shaping of the hull above the waterline. Numerical analysis has been used to determine the loadings, including the slamming loads.

As is normal practice with vessels certified under the High Speed Craft Code 2000, the vessel is limited in operation to a specific area and to a maximum sea state given in the regulatory Permit To Operate. This limitation is 5.2m significant wave height at 24knots, dropping to 3.0m significant wave height at 42knots.

Global load scenarios have included longitudinal bending, transverse bending, and torsional loads. The shape of a trimaran with a large deck area has a neutral axis in longitudinal bending that is highly offset towards the deck. Fig 10 illustrates a frame in the forward quarter of the vessel which clearly illustrates that the 'upper flange' of the equivalent girder is considerably larger than the 'lower flange', with the result that the bottom plating has a substantial thickness. One of the structural challenges has been to fit two retractable and azimuthing bow thrusters into the bottom plating at this location where there is very little bottom plating in which to cut the two holes.

A simplified midship section is shown in Fig 11. The hull and superstructure consists of aluminium extruded material (6082) and aluminium shell plating (5383). Extensive use is



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made of shaped extrusions, including hollow sections, to Austal's own design. High-tensile steel is used for some of the truss members contained in the vehicle deck, which is a normal practice on large catamarans in order to simplify the construction in case of fire in the vehicle space. The entire passenger deck superstructure is mounted on flexible mounts in order to reduce vibration and noise, and to minimise any structural loadings from the hull.

Appendages

Appendages cause drag. A ride control system is however considered to be necessary for a high-speed trimaran, in order to extend the operability of the vessel into higher sea states. Roll fins and a forward T-foil will be fitted to the craft.

Lifting foils have not been considered. It is our opinion that these devices certainly work for some sizes and weight of craft, and can allow for reduced power for a given speed, however they come at a high capital cost, and a high cost to maintain. We have not yet found an operator who was willing to pay the additional costs for the extra speed that lifting foils can provide.

Safety regulations

We have had some difficulties with interpretations of the safety regulations, which have not been written with any thought towards a vessel having three hulls. We have been able to clarify with IMO that the 126m trimaran is considered as a monohull for purposes of stability, despite being a craft with multiple hulls. The stability characteristics are more similar to those of a monohull.

Passenger evacuation has been a challenge. Lifeboats or liferafts must not be allowed to come close to the amahs when the vessel is rolling during evacuation. Even something as simple as the regulatory definition of length of the craft can be a challenge for these craft, for example in a design where the amah transom is located behind the main hull transom.

Building schedule

To meet the high speed of 40knots, aluminium was the only hull material considered. The vessel is built to SOLAS and the High Speed Craft Code 2000. The build programme is relatively short for such a novel craft, as the initial contract was signed in June 2003, launch is scheduled for this month (September), and delivery is set for November 2004.

It is important to recognise that this vessel is NOT a research project. It is not a demonstrator. It is a real contract with penalty clauses for late delivery and for failure to meet the performance requirements. Being a novel craft, this gives us exposure to considerable risk. There has been a constant process of problem solving, particularly on issues of interpretation raised by class, flag, and the process of fabrication of a novel structure.

The vessel is being built in modules, as shown in Fig 13, with four of the modules being built in-situ. Building modules in aluminium is very different to building in steel, because the weld shrinkage and distortion is much larger and much more difficult to predict. Our modules are generally limited in size for this reason, which suits the small capacity cranes used in aluminium shipyards. The largest module was about 24tonnes.

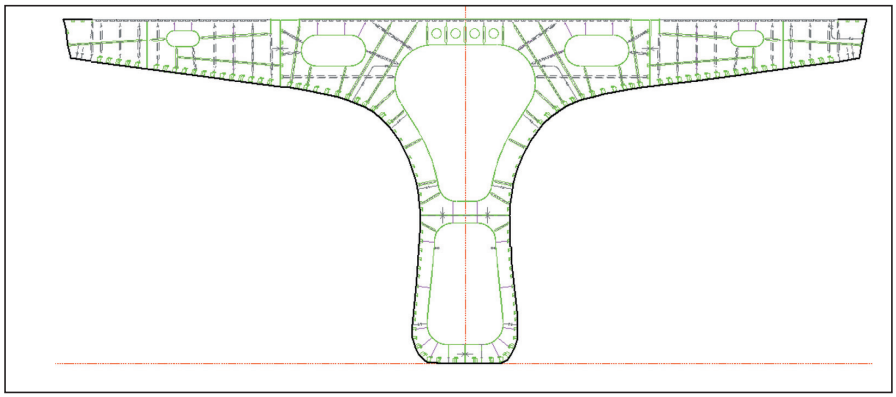

Fig 10. A frame in the forward quarter of the vessel.

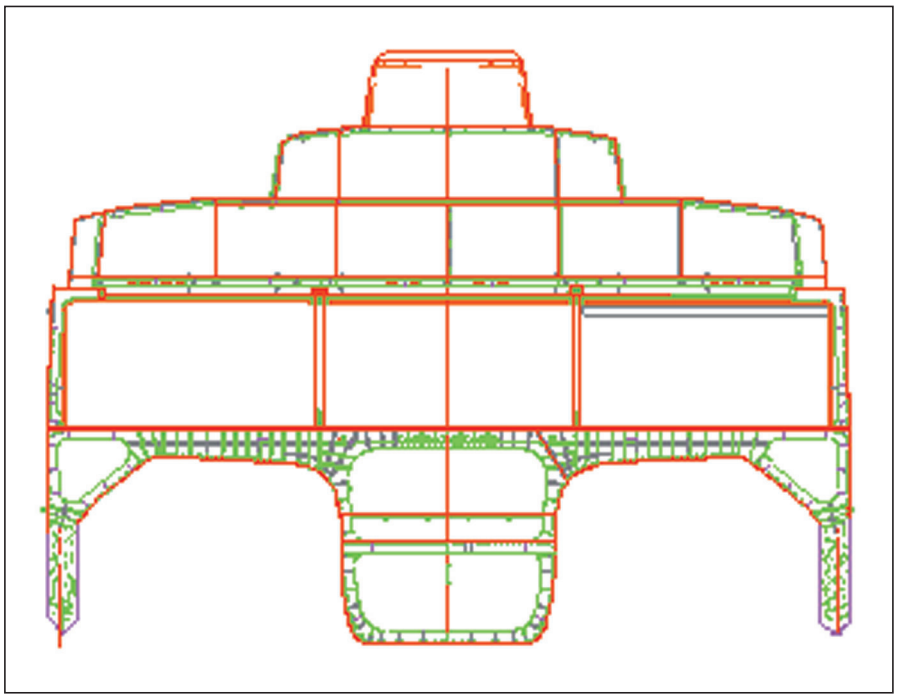

Fig 11. Structural concept. Mezzanine levels in the vehicle space are not shown. Two passenger decks and a wheelhouse are located above the vehicle space.

Comments on the amah design

The length of the amah is dependent upon a number of factors, but will generally be quite short relative to the main hull. Consequently at a high speed it may appear that the Froude number Fn of the amahs is very high. For example on this vessel, the main hull operates at Fn = 0.62, but the amah, with a length of about 40m, appears to have a value of Fn = 1.04. This high value of Fn may tempt a designer to consider a planing hull shape for the amah, but this would be a mistake, as the amah is not able to rise under the planing forces, being physically attached to the main hull. Furthermore a flat planing bottom is undesirable, as it will generate slamming forces and noise as the vessel rolls. The best shape for the amah is consequently a Vee or rounded shape. The best location for the amahs is not a simple matter. There are at least 12 issues that have to be considered:

- if the deck area is to be carried well forward, then there needs to be support from underneath, and the amahs must be extended forward to provide this
- speed: there are interference effects as previously noted
- seakeeping: there are advantages in stern quartering seas in locating the amahs forward of the main hull transom, as previously noted
- manoeuvrability: there are advantages in placing the amahs forward of the main hull transom, as previously noted
- stability: the amah location and size obviously plays a major part in the stability characteristics of the craft, particularly in damage stability
- strength: the global strength of the craft is affected by the size and location of the amahs, in both a longitudinal, transverse and pitch connection sense

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Fig 12. View looking aft, March 5 2004.

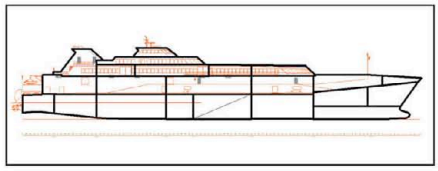

Fig 13. Major modular breakdown. The transverse breakdown including the amahs is not shown.

- slamming: if the amahs are positioned far from the main hull, to minimise resistance interference for example, then this increases the risk of slamming of the wet deck between the hulls
- internal layout: the layout of the interior of the craft is interrelated with the stability, and hence affects the amah location
- safety: the launching of passenger evacuation systems may impact on the size and location of amahs
- berthing: coming alongside a wharf may dictate the size and location of the amahs on a commercial ferry
- amahs located aft of the main hull transom will provide some degree of protection to the waterjet installation on the main hull
- aesthetics: it is possible that some operators may like specific locations of the amahs, such as well forward or well aft.

LCS

Similar technology is being employed by Austal for the Littoral Combat Ship (LCS), a fast, manoeuvrable, surface combatant geared to supporting mine detection/elimination, anti-submarine warfare, and surface warfare (particularly small surface craft). Some of the key characteristics of the LCS include the following:

- modular payload with rapid changeover capability to switch from one focused mission to another
- up to 50knot sprint speed and maximum ranges exceeding 5000nm
- very low core manning (15 to 50) for all ship navigation, engineering and self-defence functions
- very shallow draught to allow operations in littoral (near the shore) regions.

The US Chief of Naval Operations has declared LCS to be his top priority, and the program is moving forward very swiftly. Six 90-day concept studies were awarded in November of 2002 for the Focused Mission High Speed Ship (FMHSS) study. General Dynamics led one of those studies. Proposals have been submitted for the seven month preliminary design phase. Three awards were made in mid-July of 2003 and General Dynamics was again selected for the next phase of the project. Final design and first ship contracts are expected in the second quarter of 2004, with a seven-ship low rate initial production (LRIP) to follow. The Navy ultimately contemplates a fleet of 30 to 60 LCS vessels.

A design team was established in 2002 using the expertise from General Dynamics, Austal, BAE Systems, CAE, and MAPC. Austal are the platform designer and builder. The platform that has been submitted to Navy is a trimaran similar in concept and overall size to the 126m commercial trimaran.

Conclusion

A programme of research and development has demonstrated the general superiority of a trimaran over a monohull and over a catamaran. A reduction in resistance and an increase in

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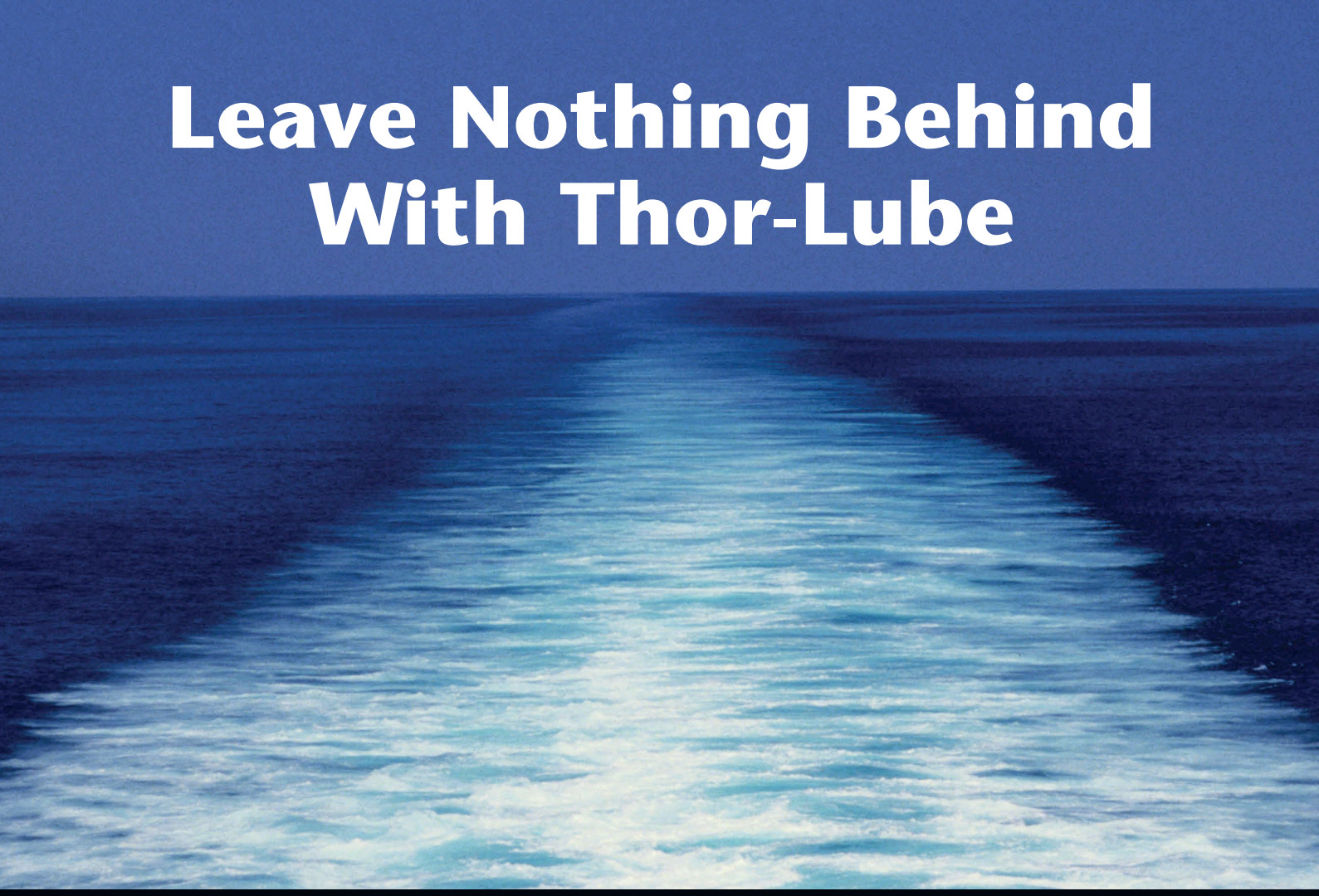

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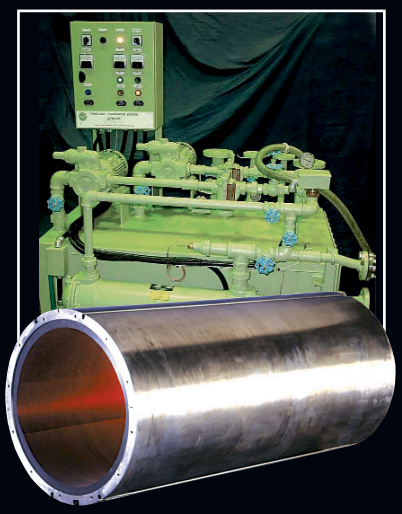
Developed by Thordon Bearings, the environmentally friendly Thor-Lube stern tube bearing system offers ship owners a proven alternative to oil lubricated stern tube bearings. The Thor-Lube system consists of non-metallic Thordon XL bearings, TL3G biodegradable water-based lubricant and a lubricant circulation and monitoring package.



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	Monohull	Catamaran	Trimaran
Waterline length	✓	✓	✓
Displacement	✓	✓	✓
Trim	✓	✓	✓
Legth/ Beam ratio	✓		✓
Angle of entrance at waterplane	✓	✓	✓
Wetted surface area	✓	✓	✓
Warterline length of amah			✓
Displacement of amah			✓
Longitudinal location of amah			✓
Transverse location of amah			✓

Table 1. Characteristics of the hull geometry having the most impact on the resistance.

seakeeping operability have been found, and some of the issues resulting from the detail design of a trimaran have been disclosed.

The trimaran concept allows for stability requirements to be decoupled from comfort requirements and readily permits 'bespoke' stability characteristics. A major ferry operator in Europe has been convinced of the superiority of a trimaran, and has ordered a large fast ferry, with a nominal design speed of 40knots. The design has been used as the basis for a tender to the US military for the Littoral Combat Ship, which is confidently anticipated to be ordered in the first half of this year. ⚓

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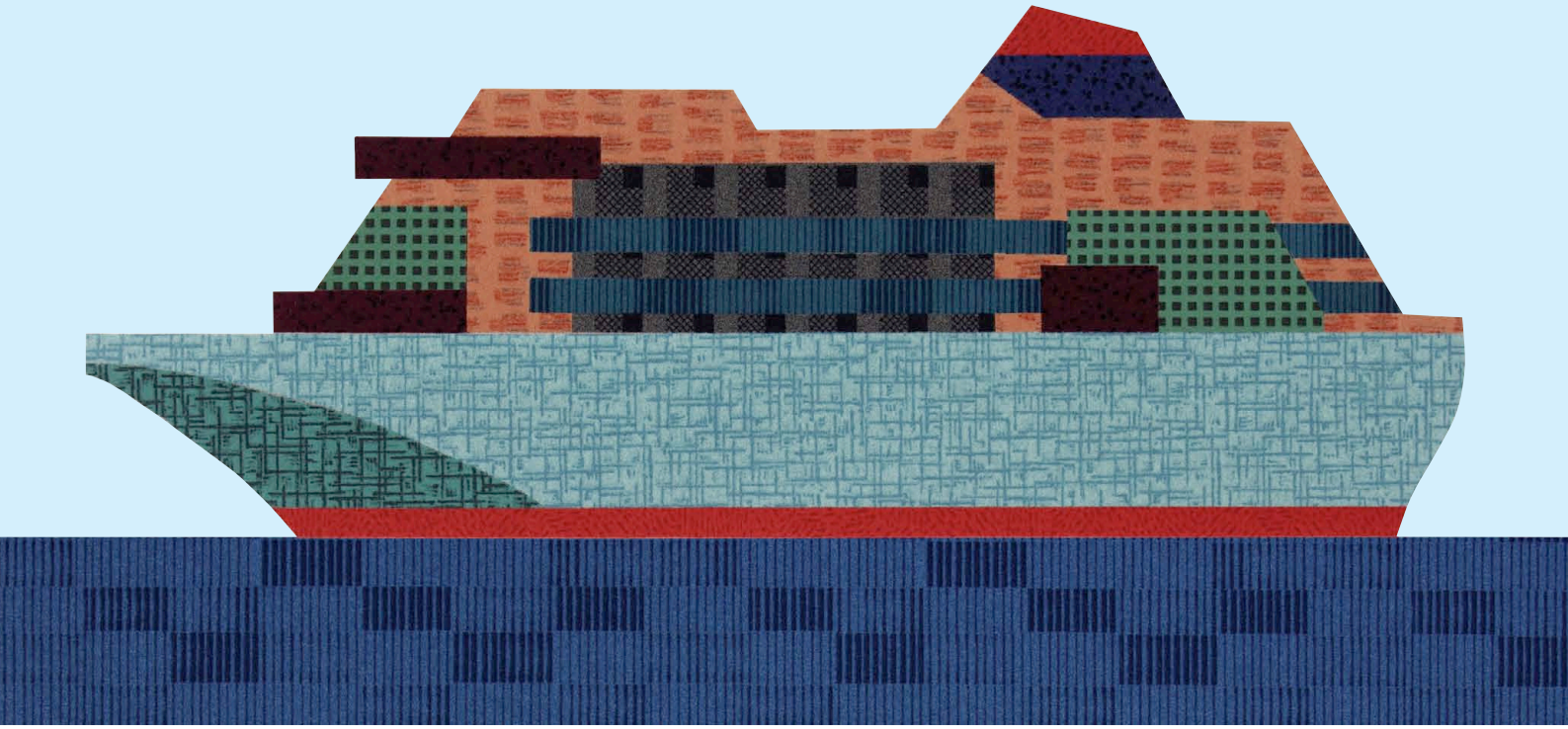

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In high traffic areas of ferries and cruise liners, no other floorcovering comes close to Flotex Marine.

While ordinary carpet or textile floors can quickly lose their appearance, Flotex Marine stays shipshape even in the most demanding conditions. Flotex Marine will withstand the heaviest wear, the most intense foot traffic and frequent spillages, giving it a distinct advantage over conventional carpets. Flotex Marine is uniquely constructed, with no twists or loops to trap dirt or stains. And with a drying time of only 4 hours, cleaning is quick, easy and effective.

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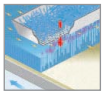
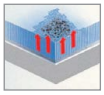
- Easy to maintain and repair
- Certified anti-microbial and anti-fungal
- The warmth of carpet, cleanability of vinyl

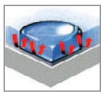
Construction



Uniquely manufactured from Nylon 6.6 fibres for durability, soil resistance and appearance retention



The smooth, straight fibres release dirt easily when cleaned – unlike conventional carpets



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Ro-ro design set to beat Europe's road jams with speed and economy

Rolls-Royce Marine has designed a fast, sleek, steel monohull cargo vessel, economical to build and set to revolutionise freight transport in Europe. This high-speed proposal follows from the P2500 class of fast roll-on/roll-off passenger ship and naval logistics designs conceived by this Norwegian company.

An impression of the new Rolls-Royce fast cargo design.

SLEEKER, faster yet economical monohull vessels appear set to revolutionise the ro-ro market in Europe, challenging conventional ro-ro ships as well as land transport. Today, congestion caused by dramatically increasing road traffic has turned Europe's roads network into a serious transport bottleneck (*The Naval Architect* July/August 2004, page 3). European Union research points out that, on average, the region's road traffic will more than double by 2010.

The prospect of mounting transport costs, lifted by soaring road taxes needed to cover the socio-economic price of Europe's traffic-strangled highways, is pressing the case for alternative transit corridors. However, while shifting road cargo from land to sea will help alleviate traffic congestion and benefit the environment, there is new demand for high-speed sea vessels and more efficient harbour logistics.

Many different forms and configurations have been developed to meet high-speed sea transport needs, each with benefits and drawbacks. Among the developments is the Rolls-Royce P2500 family of 'fast logistics vessels', offering both favorable powering characteristics and high crew and passenger comfort levels through improved sea-keeping.

Fast ro-pax hull development

During the 1990s, Rolls-Royce Marine (NVC-Design - formerly Nordvestconsult) was contracted to design a fast roll-on/roll-off passenger vessel (ro-pax type) able to carry a large deadweight, while still economic to construct and operate. To deliver good transport economics, an extremely low resistance hull-form with various innovative design features was developed. The design incorporated large water jets and two 32MW Rolls-Royce MT30 gas turbines. Economic construction was achieved through the use of high-tensile steel, making it suitable for many more yards worldwide to handle.

The first P2500 design had dimensions of 151m x 22.4m and delivered 42knots with an installed power of 64MW. The ship carried 1500 passengers, 38 trucks, and 245 cars.

This article is based on the paper 'Fast and economic - an impossible combination?', presented by Per-Egil Vedlog, design manager, merchant ship technology, Rolls-Royce Marine, at RoRo 2004, held on May 25-27, 2004 at Gothenburg, Sweden. Organised by Lloyd's List Events, 69-77 Paul Street, London EC2A 4LQ, UK.

Hull hydrodynamics

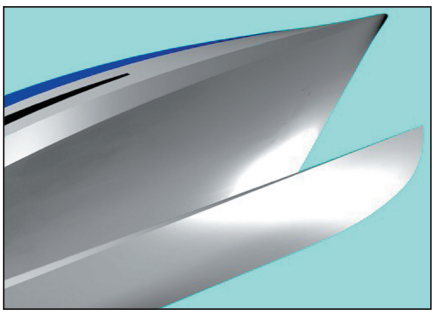
Hull lines were optimised in a systematic computational fluid dynamics (CFD) study carried out by Marintek. The resulting vessel has a slender bow shape with an extended wave-piercing bow. A special stern shape to minimise transom stern resistance is particularly important on water jet-propelled vessels of this size and speed.

By combining a wave-piercing bulbous bow with a monohull form, a longer waterline was achieved with a very low angle of water entry at the bow. This has reduced resistance and minimised slamming, while producing better motion in waves. The stern has been developed with a demi-hull shape, giving lower base drag and reducing the effect of stern waves while also reducing wake wash problems. A stern wedge produces lift at full speed, producing a slight trim to the bow. That helps reduce resistance, so increasing speed for a given power.

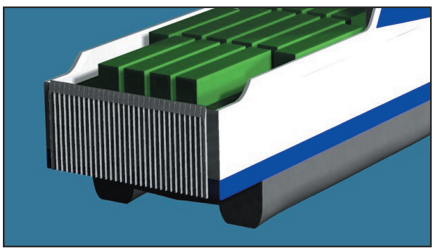
The hull-form has a relatively low KMt, which gives a lower GM. This improves motion and reduced acceleration compared with catamarans, so removing the need for a sophisticated ride control system. As the vessel is very slender, control of the roll motion is essential, to ensure passenger comfort and reduce the risk of air ingestion through the outer water jet inlets. Four stabilising fins ensure a high level of roll damping under all circumstances, and also control pitch motion and to reduce the speed loss in waves. The control system operates to avoid excessive load on the hull girder structure.

Hull structure

During the ship's design, emphasis was put on producing a reliable, lightweight structure, and extensive global longitudinal strength and fatigue studies were conducted. The P2500 was designed using the following standards and methods:



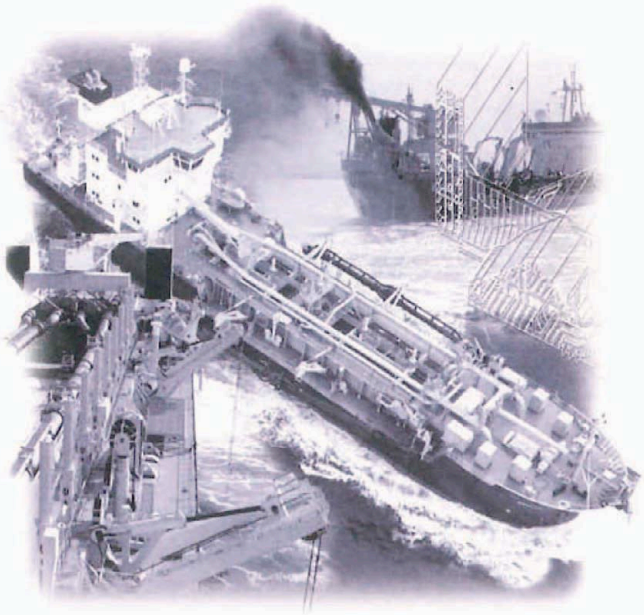
The vessel's wave-piercing bow helps reduce resistance and slamming, improving motion through waves.

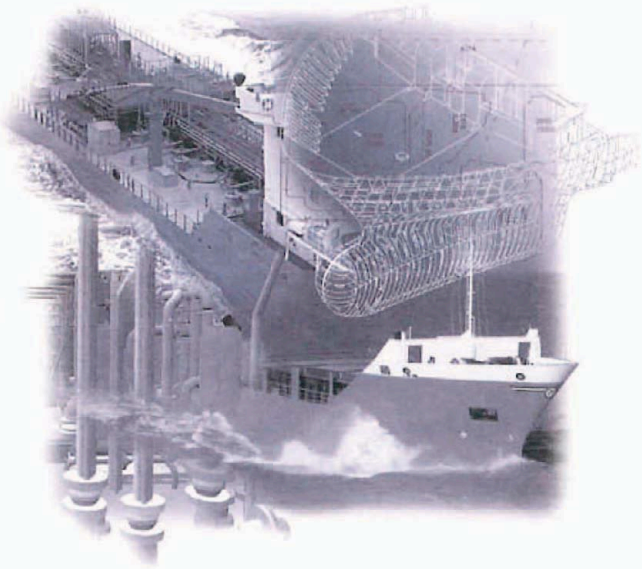


A demi-hull stern shape gives lower base drag and cuts the effect of stern waves.

- Det Norske Veritas class, +1A1, HSLC, Passenger and Car ferry, International Code of Safety for High-Speed Craft 2000, CAT B
- a significant wave height Hs=13m at manoeuvring speed was used in global moment calculations
- global vertical bending moments were estimated using Veres software, with DNV HSLC rule design loads applied for scantlings
- deck scantlings are estimated using DNV Wheel Load software.

Extensive dimensioning work was carried out, and a detailed 3D Napa Steel model was developed to verify the structural weight. This





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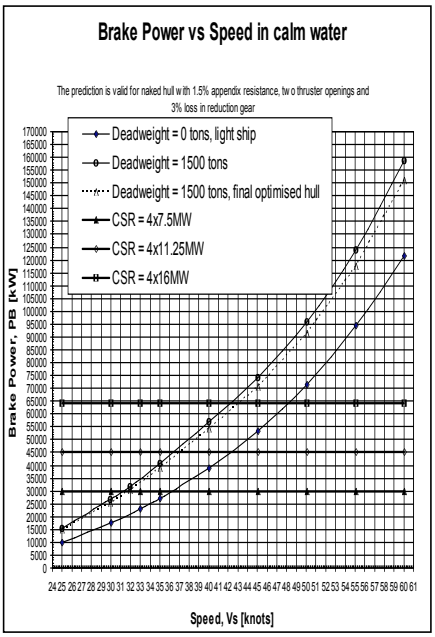
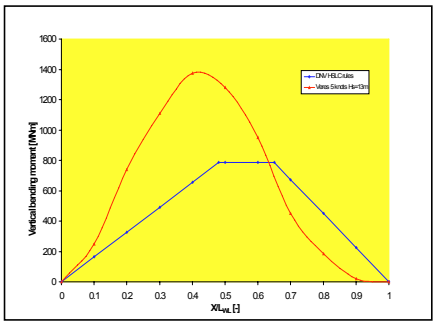
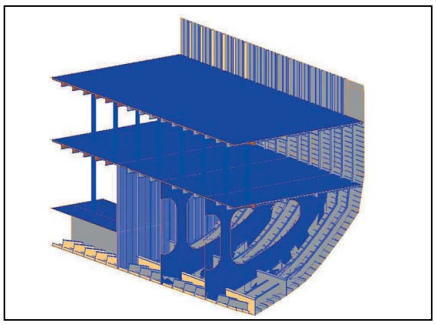


A graph showing brake power plotted against speed and payload in calm weather for the P2500 ro-pax design, on which the new cargo proposal is based.



Design vertical bending moment curves for the fast cargo version.

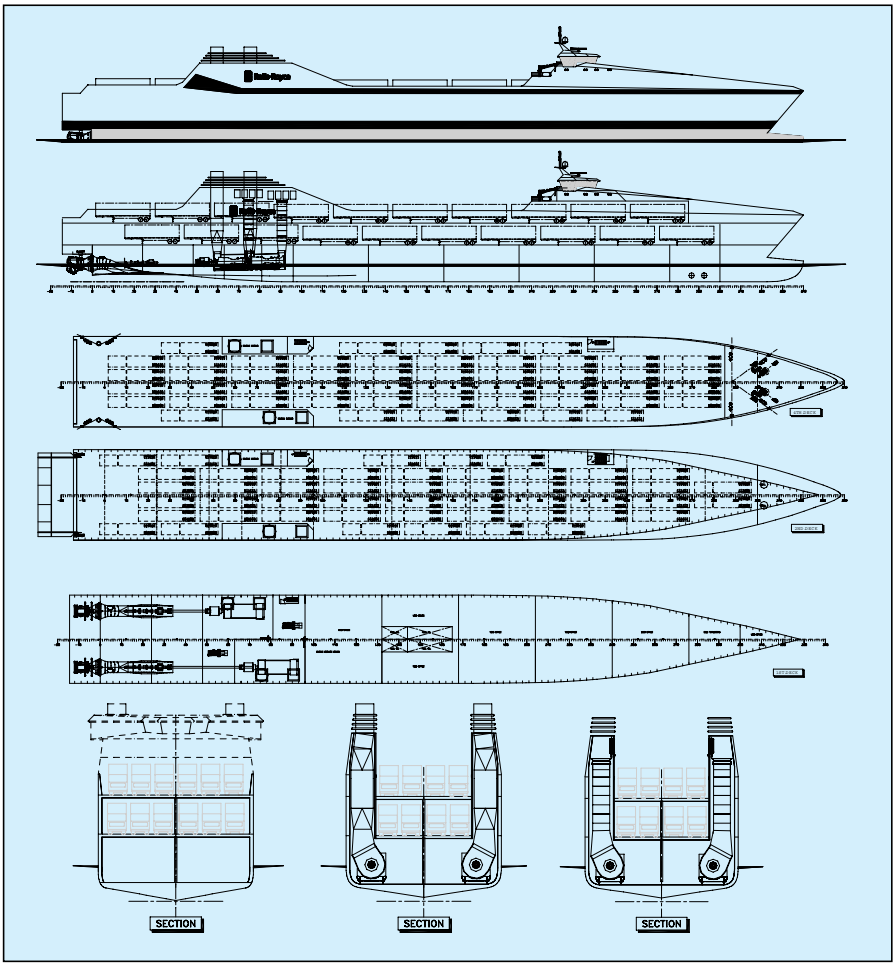


A typical local structural steel model for the P2500 ro-pax version.

work was completed ahead of model testing to ensure the displacement used was accurate. The hull girder system was dimensioned using DNV 3D-Beam software.

Loading conditions were developed with vehicles on deck to define sea and slamming pressures. The hull and superstructure, up to the accommodation deck were dimensioned based on the use of high tensile steel (NV-36). The accommodation deck and bridge are built of aluminium alloy. The structural weight was calculated by building up a complete 3D model in Napa Steel software, providing the structure weight and centre of gravity with high accuracy. Following this, a design review to the High Speed Code 2000 was carried out with the French classification society Bureau Veritas, evaluating the P2500 as a passenger vessel to category B class.

Profile, plans and cross-sections for Roll-Royce's new 2800dwt fast cargo monohull, which has a deadweight of 2800tonnes.



High-speed cargo proposal

The first pure cargo variant of the P2500 ro-pax design was a large fast ro-ro vessel, featuring a geometrically scaled version of the ro-pax hull form at 177m length. As the design can be easily scaled for a variety of ship sizes, Rolls-Royce can match the design to a customer's operational, range, and load requirements.

The baseline cargo design is capable of carrying 2800tonnes (deadweight) at a speed of 38knots, using two Rolls-Royce MT30 gas turbines for a power plant. The vessel can achieve higher speeds at lower deadweight or when operating light. Its two cargo decks are intended to take 100 trailers with an average weight of 25tonnes.

To avoid green sea damage and to reduce air resistance, the forecastle deck is entirely enclosed. The wheelhouse provides a 360deg view and includes covered bridge wings, two conning positions, a chief engineer's control desk, and navigation console.

Two decks are arranged for ro-ro cargo, with a hinged ramp at the stern providing access to deck 2. Deck 3 can be served by on-shore linkspan facilities, but if required, can also be accessed by a hinged internal ramp from deck 2. The superstructure and enclosed garage at the forward end of deck 4 forms good protection for cargo on the open aft section of deck 3.

Below deck 2, there are two separate enginerooms, with fuel tanks arranged amidships to avoid change in trim during a voyage. No fuel tanks are exposed to the ship's side or bottom. Other dimensions of the design include a beam of 20.80m, a design draught of 4.25m, and a depth to deck 2 of 8.80m.

This vessel is also planned to be constructed from high-tensile steel throughout the main hull, with only superstructure levels in aluminium

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alloy, so maximising the ship's strength while minimising overall weight. This use of materials helps reduce build costs by allowing construction at yards using less sophisticated techniques than required for a wholly aluminium structure. In addition, the use of steel makes the ship safer and more reliable in bad weather conditions.

The monohull design provides a higher level of damage stability than multi-hull vessels, because flooding should occur in a near-symmetrical manner, in case of any damage. The monohull shape also gives the vessel a relatively low GM in loaded conditions; this leads to lower acceleration levels in rough weather, improving conditions for crew and cargo.

Structural design

This cargo ship proposal has been designed using the following standards and methods:

- Det Norske Veritas +1A1, HSLC, R0 (300 300, 300), CARGO
- a significant wave height Hs=13m at manoeuvring speed was used in global moment calculations
- global vertical bending moments were estimated using Veres software with DNV HSLC rule design loads applied for local scantlings.
- high-tensile steel (NV36) applied
- design max vertical bending moment: 1375 MNm
- based on an expected maximum in a 3h sea state
- corresponding section modulus requirement: 5.65m^3

Plating and stiffeners:

- high-tensile steel (NV36) applied
- deck scantling estimated with DNV Wheel Load software
- local scantlings elsewhere based on DNV HSLC rules

Girder system:

- high-tensile steel (NV36) applied
- simplified 3D model of girder system extended over two compartments
- loading conditions including trailers on deck, sea - and slamming pressures.

To verify the steel weight and weight of the vessel as early as possible in the design phase is important. Therefore a Napa Steel model was developed to define an accurate displacement and centre of gravity.

General arrangement and propulsion plant

The forward section of deck 6 contains permanent accommodation for the vessel's crew and officers as well as the galley, mess, day rooms, and stores. Personnel accommodation was positioned as far aft as possible to provide better motion conditions for the crew. Rescue equipment located here includes rafts and a man-overboard boat.

Complementing the ship's lightweight design theme and so maximising the potential payload, the propulsion system features superior power density through the use of the latest aero-derivative gas turbine technology.

The baseline propulsion system for this cargo design comprises two wholly independent shaft lines, each based on a 36MW MT30 gas turbine. These are each close-coupled to a main reduction epicyclic gearbox, transferring power through composite transmission shafting to independently driven size 250 waterjets.

This arrangement suits the typical 'fast ferry' operating profile, where the vessel spends less than 10% of its operational time at low speeds. The system offers the lightest, most compact solution to match necessary power, yet with fuel consumption close to that of high-speed diesel engines. It provides 72MW to give a speed of 38knots.

Some inefficiency of trailing waterjets is acceptable with this type to ship, but the arrangement does allow considerable damage tolerance. During any loiter period at low speed, one line can be used alone.

Rolls-Royce claims that this newest proposal is a highly cost-effective way of transporting 2800tonnes of cargo at service speeds over 38knots, using design, techniques and equipment readily available within current technology. With its wealth of naval and commercial maritime experience, the company believes its fast steel monohull vessel offers a serious challenge both to road transport and to conventional ro-ro ships.

However, a major assumption for the success of this type of design are the logistics at either end of the route. Port facilities have to be specially prepared for fast cargo handling, since there is no sense in shifting seaborne operations to high speed if cargo is more or less brought to a halt in the harbour terminals.

Assessing the potential of roll-on/roll-off trades in China

but still the economical distance is unlikely to increase beyond 500km. In this environment, there is a need for an alternative medium to long distance option for lorry-sized loads, and ro-ro systems could fulfil this well.

Provision of waterborne logistics

Logistics in the Chinese context includes the transport and control of goods in a complex system which includes inland production sites, regional distribution centres, near-coastal production sites, secondary ports, and hub ports.

The opportunities for overseas investors or equipment suppliers in China are more than those which a quay-to-quay ro-ro service would provide. Beyond the basic provision of high efficiency ro-ro services, there is a demand in China for higher added-value transport services - an extended transport service which includes electronic documentation and clearance procedures, port equipment provision, inland logistics, and provision of better systems and communications.

At the highest level, there is some demand for the kind of seamless logistics service (including ro-ro) now familiar in Europe. There will be an increasing demand in China for highly-tuned systems providing just-in-time (JIT) deliveries and continuously available information on cargo availability.

What routes?

Following on from the above, it seems reasonable to propose that there are a number of quite different ways in which the ro-ro mode will develop in China. These may be summarised as:

- inland waterway/river trades
- north/south coastal trades
- intra-Asia trades
- continent to island trades
- local trades.

Inland waterway/river trades

The introduction of ro-ro ships or barges to the rivers of China will provide an opportunity to move goods to or from production centres far inland to the West in a seamless manner through entry ports without the need for troublesome delays, double or treble handling, or re-stuffing, of containers. Delays at rail marshalling yards can be avoided and hopefully customs clearance procedures can adapt to the trade.

Ro-ro also provide the means to efficiently move goods between distribution centres up and down the length of these great rivers. There are obstacles, of course, ranging from river navigation issues such as marking for night navigation and river traffic control, to bureaucracy in import/export documentation and inspection. However,

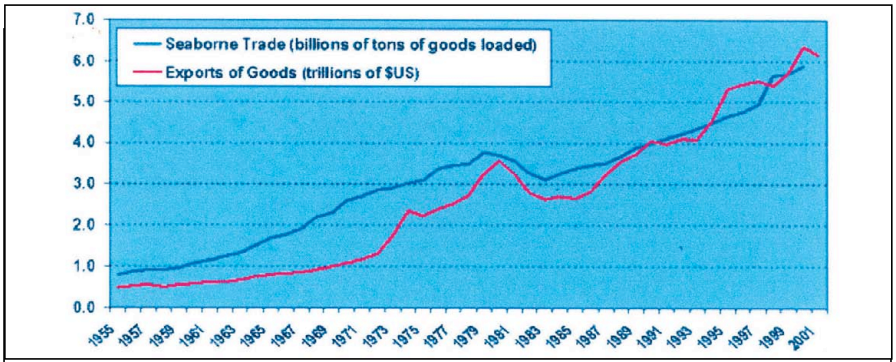


Fig 1. World trade growth.

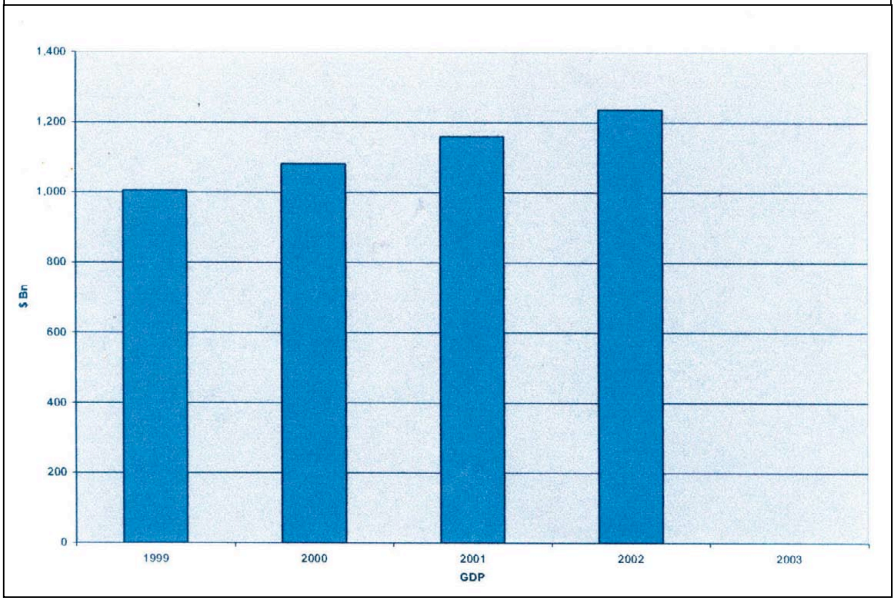
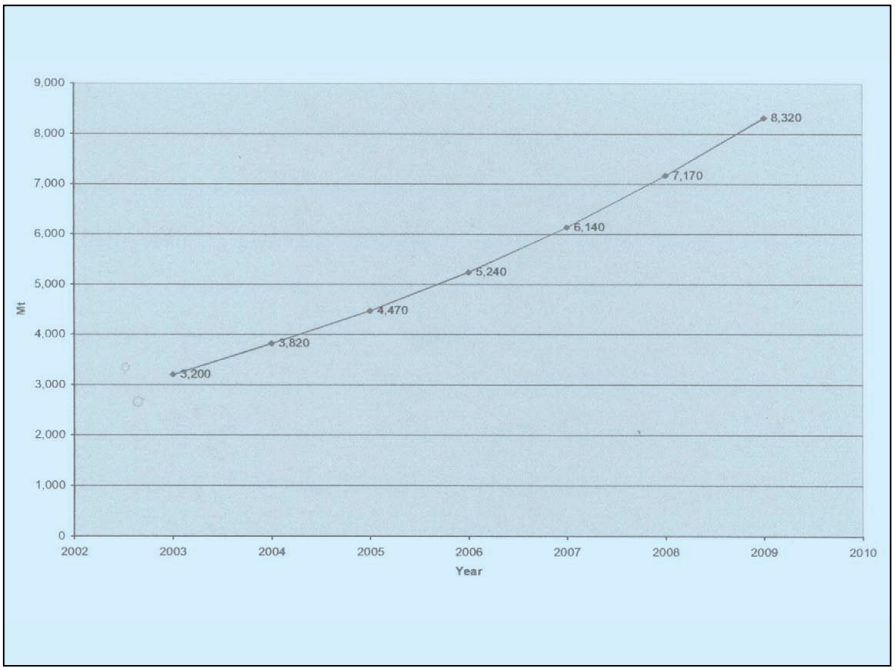


Fig 2. China's dramatic growth in GDP.

the economic imperative to provide better logistics for the vast production and consumption

Fig 3. Waterborne freight growth.



Extracts from the paper 'The Development of the roll-on/roll-off mode in China - an assessment of the growth potential', presented by David Byrne, from Transmarine Consultants, at the RoRo 2004 conference, held in Gothenburg, Sweden, on May 25-27, 2004, and organised by Lloyd's List Events.

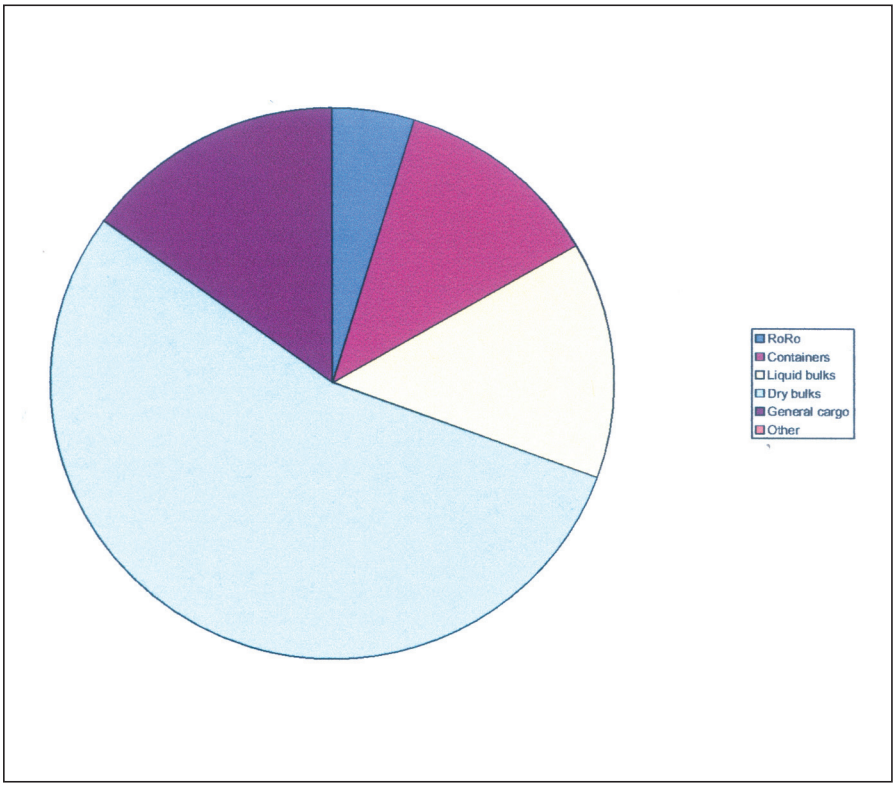


Fig 4. Cargo breakdown.

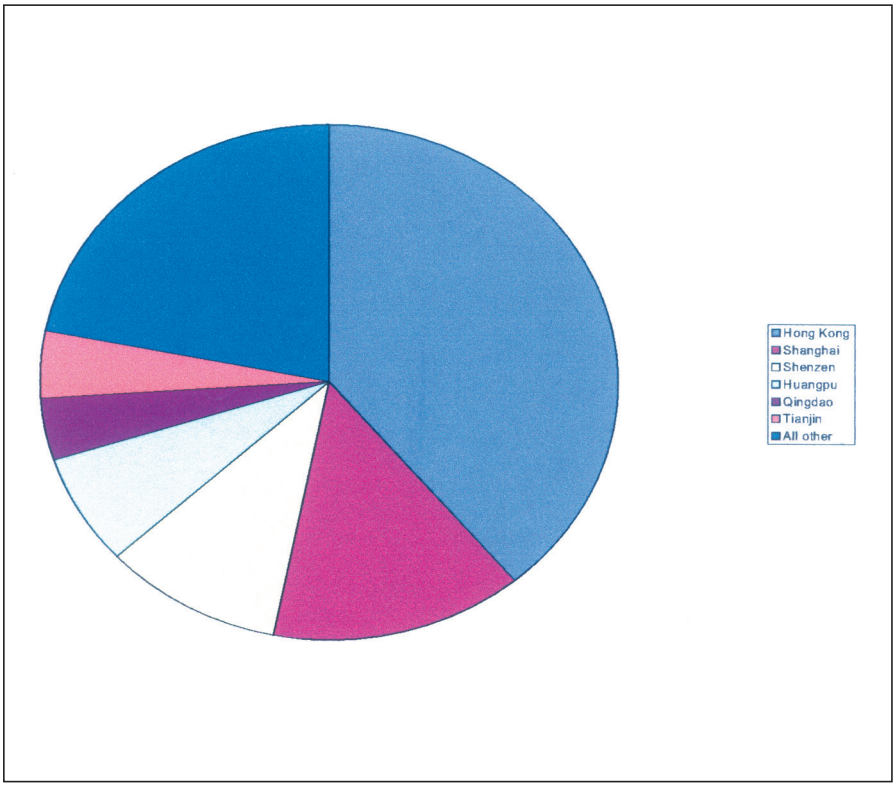


Fig 5. Trade breakdown by port.

David Byrne, from Transmarine Consultants Ltd, considers the economic and commercial environment, as it now exists in China, as a basis for assessing the growth potential of ro-ro services in the coastal, riverine, and near-international trades, particularly in the face of competing rail and, road services. Some projections are presented which support the view that, as in so many other areas, China presents a stunning picture of growth potential, but not without complexities and pitfalls for the unwary.

IT is difficult not to be overwhelmed by the statistics we need to use when trying to get to grips with the phenomenon which is modern China. Growth rates and development investments are all on scales which are not found elsewhere. This rate of growth is not without its difficulties - control of a galloping horse is far from simple, especially if you are tied to its tail.

The ports of China are being overloaded and port and transport infrastructures are struggling to keep up with the demand for freight movement, whether this be containers or bulk cargoes. There has been colossal investment by China in ports and rail systems over the past decade. Now, there is a need for new sources of investment and an input of logistics expertise in order to improve the flow of cargoes away from the congested ports.

The new liberalisation of the Chinese economy has created opportunities for foreign involvement on commercial terms which are of interest. This process of liberalisation which is opening up ports to overseas investment started in March 2002 has recently been further encouraged by the 'First Law on Ports' passed in January 2004. Under this new law, foreign investments in port construction and management are not only encouraged but legal rights and interests are also protected. The government sees its role in such circumstances as supervisory and coordinating - foreign companies would run facilities in a 'transparent and unbiaised manner'.

Although most of the published discussions on growth and development in ports and freight movements in China are focussed on containers and bulk cargoes, there are, in principle, growth opportunities for roll-on roll-off shipping within the Chinese context. At present the capacity of the roll-on roll-off is quite modest. The object of this article is to consider what the future might hold for the roll-on roll-off mode - in this case, the future has been defined as the five years to 2009: long enough in terms of China's rate of change.

As illustrated in Fig 1, world seaborne trade has grown, and continues to grow, on a long-term trend that mirrors the general growth in world population. China's share in this world trade has increased to about 8% (2003).

China has continued its dramatic growth in GDP in the past five years, as indicated in Fig 2, and now accounts for about 4.7% of world trade, having nearly doubled in five years. It is now the fifth largest economy in the world. During 2003, trade grew by 25%!

Waterborne freight within China is projected to increase by about 16%-17% per annum over the next five years, as shown in Fig 3, from a basis of 3200 million tonnes in 2003.

This economic growth has stressed its logistics infrastructure to the limit - ports, roads, railways, and waterways have all been affected. In addition, logistics and freight handling systems are often of insufficient capacity and quality.

The 10th Five Year Plan recognises this as a brake on economic prosperity and lays a great emphasis on improvements to national logistic

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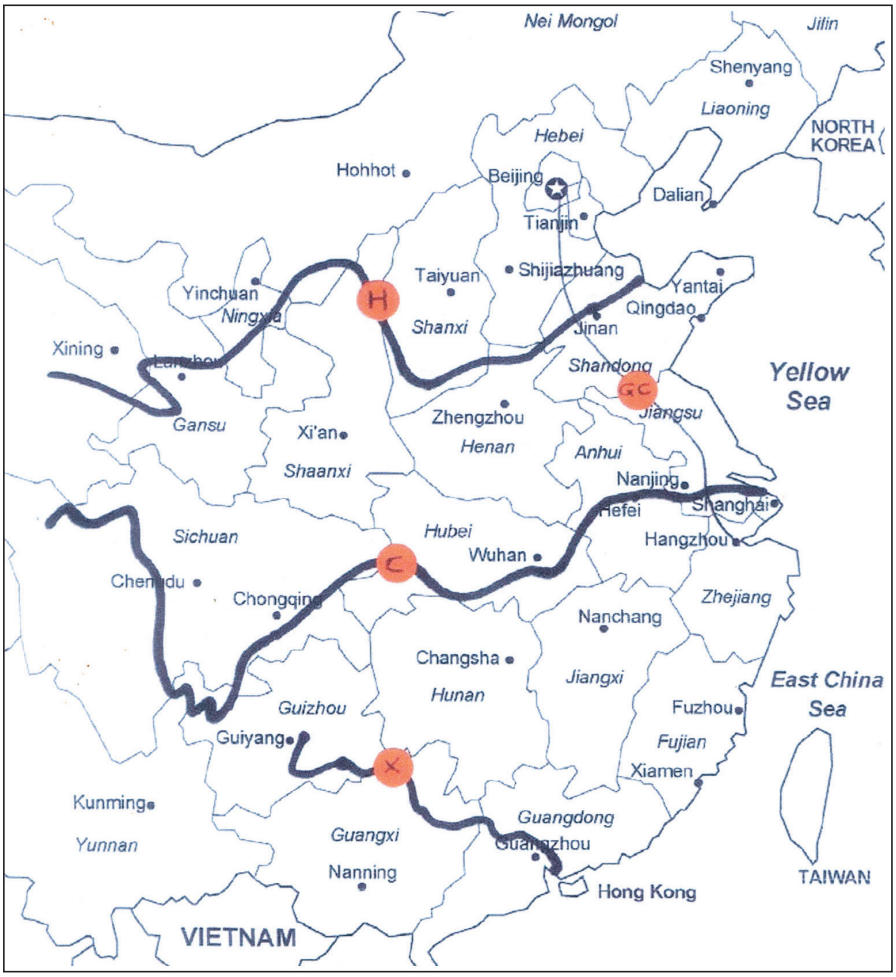

Fig 6. China, showing major navigable rivers and the Grand Canal.

systems. There are structural difficulties which will be encountered, including the continuing re-adjustment of state-owned enterprises.

This huge and painful change has, up to now, been without obvious social upheaval. If successfully accomplished it will be a major achievement. Similarly, the legacy of earlier internal banking practices has been a very large level of non-performing loans. However, the gradual exposure of the banking and legal sectors to overseas practices, following the WTO agreement, is expected to result in pressure to reduce non-performing loans to acceptable levels without risking economic instability. Recently, there have been concerns expressed about the level of credit being raised but firmer controls are expected in order to reduce overheating in the economy.

Sea and river freight

In 2003 the carriage of freight by water within China reached 3200 million tonnes, an increase of over 16% on the previous year. Fig 4 illustrates the breakdown between different cargo groups.

Of the above cargoes, around 38.4% was carried on the inland waterway system and 61.6% on coastal routes. On the Yangtze and Pearl river systems, about 30% of the trade volume is currently carried in containers - around 5 million TEU each year.

Over the next five years China needs to build or renew at least 150 major terminals along the coast and to build or improve 200 inland river berths. As part of its 'Develop the West' initiative, the Chinese government has targeted the great rivers, particularly the Yangtze, for development. At present, although large volumes of cargo are moved on the river, the demand for efficient movement of containerised cargoes is rapidly increasing. There are hurdles to be overcome, of course: the forces of nature, poor infrastructure, including poor river marking and traffic control and an entrenched bureaucracy, combine to give typical passage times on a vessel from Chongqing to Wuhan of up to five days; to Nanjing, eight days, and 12 days to Shanghai – but still better than total time by freight train.

There is a need for efficiencies in each of the following:

- port infrastructure
- transportation methods
- management and freight information flow.

In 2004 some US$3.6 billion dollars will be invested in China's ports. It seems that the conditions exist for the low pollution, large volume, efficient door-to-door handling provided by roll-on roll-off transportation; coupled with improvements in documentation, control and tracking of goods. *continued*

The Chinese government is actively encouraging foreign-investment in port-related logistics in order to raise the capital for this mammoth undertaking. Industry sectors in which foreign investment restrictions are being liberalised include logistics (efficient transport, freight forwarding, port systems, information technology, warehousing, and storage) and port management. The planners have recognised that the logistics infrastructure in China has not kept pace with the very rapid expansion of trade - overseas logistics operators, with developed management skills, professional staff, experience of efficient transport operations and with capital strength are being sought to contribute to future growth.

In the longer run, over the next 20 years an ASEAN Economic Community of 520 million people is foreseen - an enhanced FTA is envisaged, but not a political community on the European model. However, the development of even an approximation to the aspired goal, coupled with close trading links with the four major economies of China, India, Japa, and South Korea would inevitably lead to a rise in demand for an extended Intra-Asian transport demand, much of it requiring the exchange of finished goods or sub-components by reliable, high-speed door to door deliveries.

Ports in China

China is has 280 ports, including 165 coastal ports and 115 inland river ports (some sources refer to 1302 inland ports, but it has to be assumed these include many very small facilities).

Sea ports

There has been very considerable expenditure on port improvements in China over the past five years; a total of about US$13 billion of which about US$2.5 billion was spent on inland waterway ports.

The coastal ports are formed into three major groupings;

- Gulf of Bohai (North) -
  Tianjin
  Dalian
  Yantai
  Qingdao
- Yangtze Area (Central) -
  Shanghai
  Ningbo
- Pearl River Area (Southern) -
  Shenzen
  Guangzhou
  Hong Kong.

The total trade volume of imports and exports passing through the coastal ports is about 14.5 billion tonnes. The breakdown of trade volume for each port is shown in Fig 5.

These ports have experienced an average annual growth rate of 9.7% over the past five years. Container handling reached 50 million TEU in 2003 and growth is expected to continue at about 6% per annum for at least the next five years.

Other regional ports are less well-developed but have potentially interesting futures as distribution centres towards the great hub ports and as gateway

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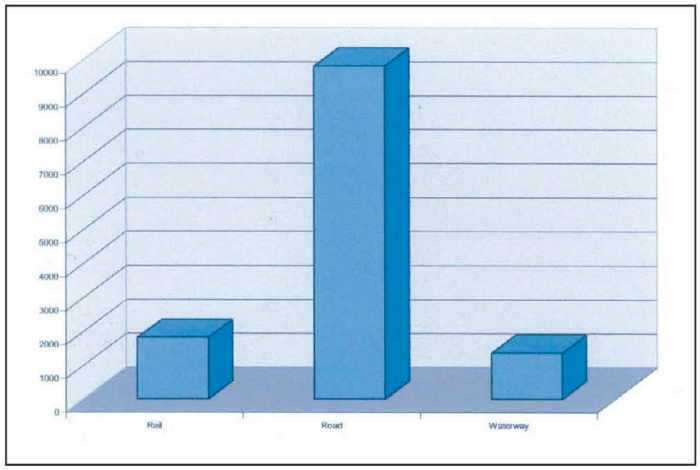

Fig 7. Total freight (million tones) in 2003 (China National Statistics).

300km are less economical than rail in many areas. However, a number of expressways are now open (for example, Beijing-Tianjin), and more are appearing but still the economical distance is unlikely to increase beyond 500km. In this environment, there is a need for an alternative medium to long distance option for lorry-sized loads, and ro-ro systems could fulfil this well.

Provision of waterborne logistics

Logistics in the Chinese context includes the transport and control of goods in a complex system which includes inland production sites, regional distribution centres, near-coastal production sites, secondary ports, and hub ports.

The opportunities for overseas investors or equipment suppliers in China are more than those which a quay-to-quay ro-ro service would provide. Beyond the basic provision of high efficiency ro-ro services, there is a demand in China for higher added-value transport services - an extended transport service which includes electronic documentation and clearance procedures, port equipment provision, inland logistics, and provision of better systems and communications.

At the highest level, there is some demand for the kind of seamless logistics service (including ro-ro) now familiar in Europe. There will be an increasing demand in China for highly-tuned systems providing just-in-time (JIT) deliveries and continuously available information on cargo availability.

What routes?

Following on from the above, it seems reasonable to propose that there are a number of quite different ways in which the ro-ro mode will develop in China. These may be summarised as:

- inland waterway/river trades
- north/south coastal trades
- intra-Asia trades
- continent to island trades
- local trades.

Inland waterway/river trades

The introduction of ro-ro ships or barges to the rivers of China will provide an opportunity to move goods to or from production centres far inland to the West in a seamless manner through entry ports without the need for troublesome delays, double or treble handling, or re-stuffing, of containers. Delays at rail marshalling yards can be avoided and hopefully customs clearance procedures can adapt to the trade.

Ro-ro also provide the means to efficiently move goods between distribution centres up and down the length of these great rivers. There are obstacles, of course, ranging from river navigation issues such as marking for night navigation and river traffic control, to bureaucracy in import/export documentation and inspection. However, the economic imperative to provide better logistics for the vast production and

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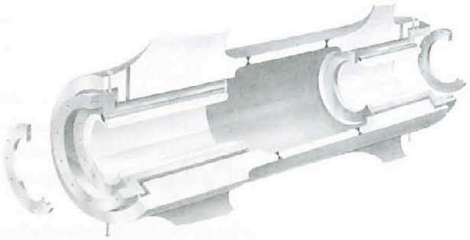

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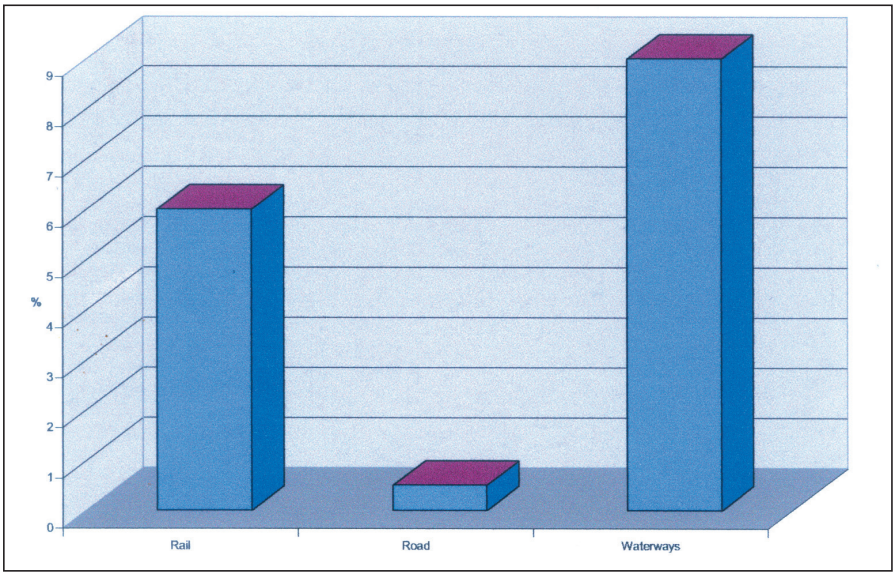

Fig 8. Increase in usage during 2003 (China National Statistics).

centres is such that the rivers will treated as under-utilised assets and change will be welcomed.

A fairly recent example of such a trade is the APL joint venture, CMWAL, which operates a ro-ro service from Chongqing, a major centre for car production. This provides a national distribution chain for trade cars and car components in a seamless river/land supply chain. The JV partner responsible for the ro-ro operation, Minsheng, already operates a ro-ro service from Chongqing to coastal areas via Shanghai. Minsheng started its first ro-ro service in 2002 and now moves 95% of all cars produced in Chongqing. The number of cars being sold in China is expected to reach five million annually by 2005.

North/South coastal trades

The provision of basic ro-ro services between ports strung out at more or less equal intervals along 1500nm of the China coast is also seen as inevitable.

The opportunity of linking coastal centres and their hinterland production areas by efficient ro-ro freight services is evident. Whether ro-pax services along the coast have any future is not as clear, based on relatively low passenger movements at present. Comparative costs and total transportation time between rail over long hauls, up and down the Great North Rail route, and short-haul lorry transport between adjacent ports suggests that ro-ro routes could be profitable which call at intermediate secondary ports, but including Shenzen, Shanghai, and Qingdao as key links to the international system.

If very large container carrying ships are introduced in the future, as is expected, calling at only two or three hub ports, then the demand for efficient distribution of unitised cargoes will further increase. KKK and China Shipping Group formed a joint venture late in 2003, which starts a ro-ro service for Chinese coastal areas, which was planned to link with international ro-ro services, in the first half of 2004. Presumably such JVs permit otherwise difficult cabotage rules to be avoided. Obstacles to a smooth-running system could include unwillingness of individual ports to work cooperatively together with other ports, possibly out of a sense of competition or ambition for hub status.

As observed earlier, the national economic imperative will, in due course, overcome such difficulties.

Intra-Asian trades

There is clear logic in continuing the North/South coastal ro-ro concept to include extensions to South Korea ports such as Pusan, also Japanese ports, at the northern end of the route. The 'Asian Corridor' from Singapore, via Thailand and Vietnam connecting with the North/South coastal system will also be exploited in due course for door-to-door unitised cargo transportation by truck, avoiding cargo handling in ports.

The trade is currently reported to be about 10 million TEU annually. Probably beyond the five years of the projections in this article, logical links could be projected to North Korea and Russian Far East ports. Although the take-up of passenger spaces is difficult to predict, there is reason to suppose that on some routes, such as China/Japan/South Korea, a ro-pax service could be sustainable, including some private car carryings. There are discussions already on some specific routes; for example, such as Incheon to Dalian, including rail ferry links, although obstacles to such ideal transportation systems include, at present, cumbersome customs, documentation and inspection processes which act to retard progress.

Continent to island trades

Hainan Island, as a special economic zone, is separated from the continent by a arrow strip of water, some 20miles across. A truck/rail and passenger ferry service was inaugurated early last year, linking Haikou with Guangdong province. Two new and very substantial ports were created, connected to the rail and road networks. The ships can load up to four strakes of 10 rail freight wagons, each of 80tonnes, plus trucks and cars on the upper deck. There will hopefully be other opportunities for growth in ro-ro traffic from the island as the improved connections generate economic demand.

Taiwan is, of course, a particular case, and predictions on a five-year scale are likely to be risky. However, taking only the geographical logic into account, there is a mind-numbing opportunity for ro-ro trade between the mainland ports of Xiamen, Fuzhou and Hong Kong, if the trade were to be opened up.

Local trades

There are specific ro-ro services which can be identified, other than very small local ferries, which would include, for example, services across and along the Gulf of Bohai, between Dalian, Yantai, Qingdao or Tianjin. Where these 'local' services are targeted on passengers, cars and light freight, they need to be of high quality, including the terminal facilities. But above all, after some terrible recent ferry losses in the Bohai Gulf, they need to be demonstrably safe and serviced by newer vessels, not secondhand cast-offs from elsewhere.

There are well-advanced plans to introduce a rail ferry service between Dalian and Yantai, on broadly similar lines to that between Hainan and the mainland. This will provide a strategic link in the North/South rail main artery, avoiding a long detour round Beijing. Other 'local' services could include routes between the Zhoushan Islands and the mainland, and between the islands which would also be targeted on passengers and cars - part of the tourism industry and therefore requiring high quality vessels and shore facilities.

Conclusions

This brief account of what is a gigantic and complex transport system has necessarily been superficial. However, the key observations support the view that there is a huge potential for ro-ro business in China, and the rate of development is very fast indeed. There are benefits for all those who are stakeholders in the transport system.

The worldwide movement of production to China is continuing (it is estimated that 15%-20% of all production jobs will move from Europe to China in the next few years). There will be a huge demand for quick and reliable logistics services to support this increased production, both in the existing coastal/urban zones, and the accessible western regions. Efficient and reliable ro-ro facilities will be required in ports, both coastal and on the great rivers. Likewise, ro-ro ships of all sizes will be required to support the essential marine operations, and it will be necessary to demonstrate that the ferries which are introduced are designed, built, and operated to the highest international standards of safety.

There are obstacles to the simple introduction of commercially desirable systems - not least bureaucracy and perhaps obstructive local and national regulations. The management of change is always a challenge. However, the potential economic, social and environmental benefits which flow from the rational introduction of ro-ro services to China are such that change and growth are inevitable.

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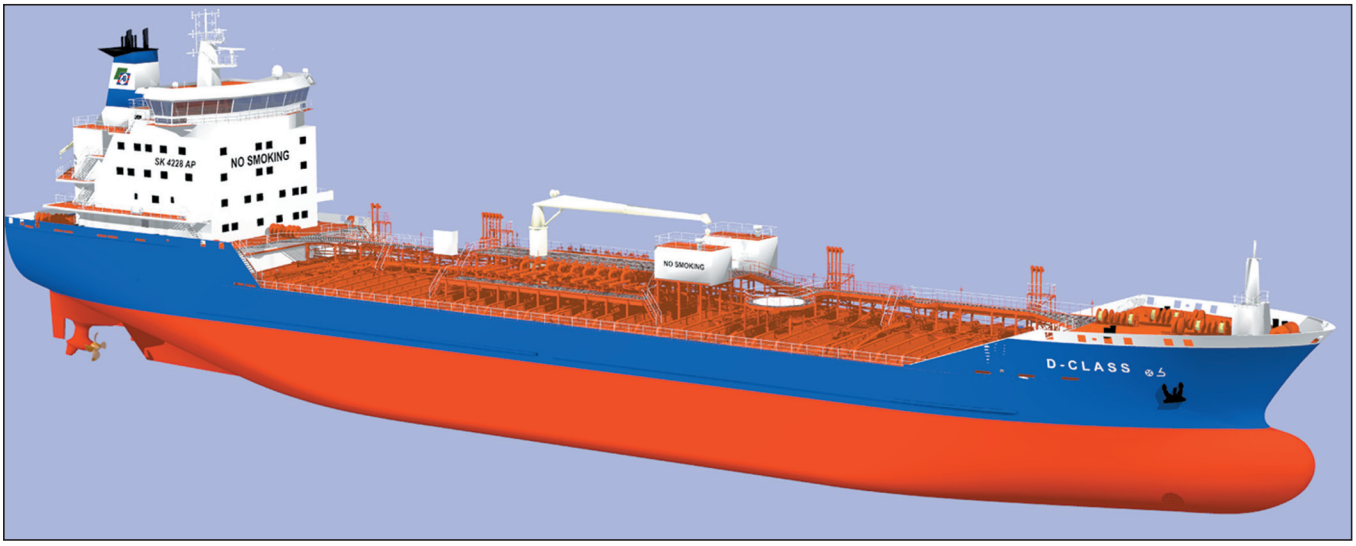

An impression of the new SK4228AP tanker design from Skipskonsulent. Four of these 14,500dwt ships are on order at the Jinling Shipyard in China. An important feature is the specification of twin azimuthing propulsion units - the new Rolls-Royce Azipull pulling design developed in Norway.

Norwegian naval architectural consultancy Skipskonsulent has again augmented its tanker portfolio and extended its involvement in new construction in China by preparing the design for a twin-skeg, 25,000dwt IMO Type II/III chemical/product tanker ordered by Tarbit Shipping, of Sweden; this is in addition to other important contracts in that country, which include four tankers with Azipull propulsion. David Tinsley reports.

IN opting for a redundant propulsion system based on two main engines and two CP propellers, coupled with a relatively high speed of 17knots, Tarbit has responded to the increasing competitive requirements for high levels of service dependability, safety, and ship productivity. Entrusted to Shanghai Edward Shipbuilding - which has already earned good references from the European market for product tankers, the new ship will be to Skipskonsulent's SK4226 type designation, and will offer a cargo capacity of 27,100m^3 for oil products and 'easy' chemicals within a hull envelope defined by main dimensions of 176.10m length oa, 26.00m moulded breadth, and 12.50m depth.

The Swedish vessel will be built to Germanischer Lloyd's E3 ice class standard, and will meet the society's stipulations for the RP2 50% redundancy notation. Anticipated service speed engendered by the pair of 5400kW prime movers is 16knots, for a daily fuel consumption of around 35.5tonnes. Manoeuvring and self-sufficiency in port will be enhanced by a bow thruster of 1450kW.

Turnround performance, such a vital ingredient in product carrier economics, will be a factor of the equipping of each of the 16 cargo tanks with a submerged cargo pump of 375m^3/h capacity. Maximum discharge rate will be 3000m^3/h, on the basis of eight pumps running simultaneously. Segregation will be achieved by a centreline bulkhead and transverse bulkheads, giving two pairs of eight tanks, and up to eight cargo grades. As has become typical of the latest generation of SK designs, a weathertight trunk will encapsulate deck cargo lines and associated equipment.

The project is the second placed with the Shanghai Edward yard by Tarbit, which had also used Skipskonsulent's technical know-how for the earlier newbuild contract. The 13,650dwt *Bit Oktania*, the first outcome of the business link between the Chinese shipbuilder and the Swedish owner, and embodying the SK4092S design, made her service debut in the May this year.

Azipull units for new Broström tankers at Jinling

Redundancy and environmental compliance have also been pivotal considerations in a tanker newbuilding contract recently awarded in China by prominent Swedish shipowning group Broström, using the SK4228AP design drawn up by Skipskonsulent. The four 14,500dwt product/chemical carriers assigned to Jinling Shipyard will provide a new showcase for Rolls-Royce Azipull azimuthing thrusters as main propulsors, driven by two MAN B&W Alpha 7L27/38 medium-speed engines of 2380kW apiece. This arrangement should provide a service speed of 13knots.

The unusual choice of propulsion system, in a tanker context, reflected the owner's requirements for extremely good reliability, as well as redundancy and inter-related safety factors, and conforms with DNV's requirements for its RP notation. The twin propulsors, incorporating pulling propellers, afford an independent steering capability as well as redundancy from independent fuel systems.

It is expected that the precision handling imbued by the means of directing propulsive thrust over the full 360degrees, coupled with the availability of a 1000kW bow tunnel thruster, should enable the vessels to dispense with tug assistance in most circumstances.

Munters selective catalytic reduction (SCR) units will be applied to each of the main engines as well as to four MAN B&W 6L16/24 auxiliaries (the latter to be built in China under licence), promising a cut in emissions of oxides of nitrogen (NOx) by as much as 98%. Each system is to include an oxidation catalyst stage to ensure that no emissions such as carbon monoxide (CO) increase over the converter. Furthermore, an integrated silencer section has been included in the specification, in line with Broström's exacting criteria governing noise levels.

Engineering arrangements have been selected against the backcloth of the intensive operating profile characteristic of European coastwise and distributive trading, the theatre in which the four tankers will be deployed, and growing environmental pressures on shipowners and industry. It is understood that the vessels will be the first tankers to be built to DNV's Clean Design notation. Low noise levels have been specified, since the tankers will spend 50% of their lives in port.

The SK4228AP offers a product transportation capacity of 18,700m^3 in 13 epoxy-coated cargo tanks, each served by a 385m^3/h cargo pump. The compact design has a length overall of 145.50m, breadth of 22.00m, and fully-laden draught of 8.00m. Deliveries are scheduled over the course of 2006 and 2007, and it is anticipated that the new tonnage will replace 1980s-built tankers used in the north-west European traffic.

More tanker contracts

So far this year, Skipskonsulent has signed a brace of further contracts covering its SK5054-series design for tanker newbuildings placed by north European owners with Jiangnan Shipyard in Shanghai. Bergen-based Rederiet Stenersen

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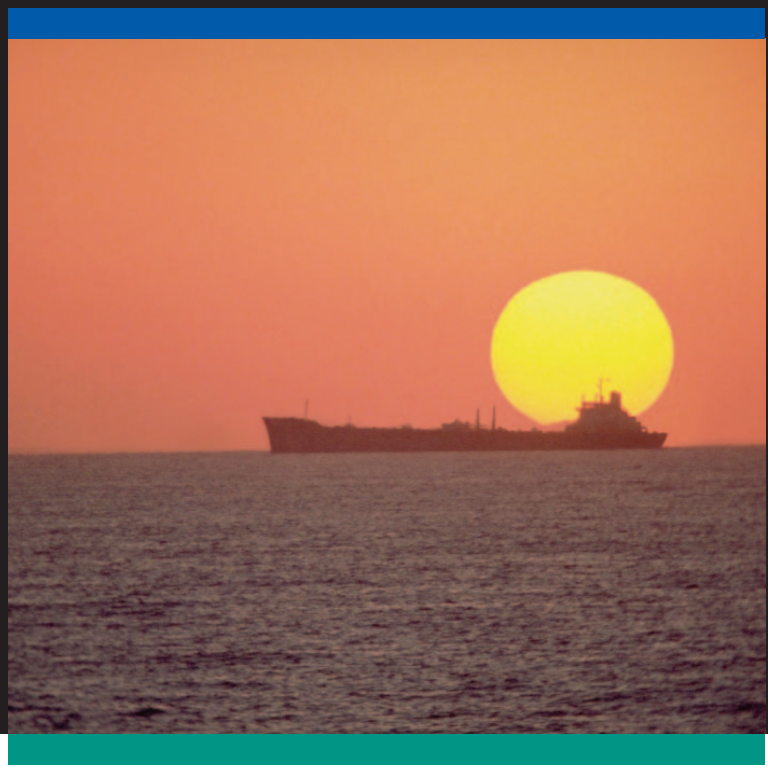

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in Shanghai. Bergen-based Rederiet Stenersen confirmed an order for a fifth example of the SK5054CT class of 16,600dwt IMO Type II chemical/products carrier. Stenersen's existing fleet is composed wholly of SK designs, and the first of the SK5054CT breed commissioned by the Norwegian operator was *Sten Idun*, completed by Jiangnan towards the end of 2002, and put into service under timecharter to Navion.

The SK5054 design family has also been nominated this year by Harren & Partner, of Germany for a repeat, two-ship contract at this Chinese yard, and for three newbuildings booked from A P Möller group yards. Besides the earlier Stenersen and Harren projects, the design has also been employed by various owners for newbuildings from yards in Indonesia, Spain, and the USA.

A slightly enlarged version of the SK5054 series, known as the SK4056 type, was expected to make its debut in June this year, in the form of the 18,750dwt *Algoscotia*. Ordered by Algoma Tankers from the prolific Jiangnan yard, *Algoscotia* offers 21,800m^3 of capacity for oil and chemical products. She has been developed to meet the specific operational and environmental needs associated with trade on the Canadian east coast and into the St Lawrence Seaway and Great Lakes system. This Canadian tanker is slightly longer and beamier than the SK5054CT design as embodied in the Stenersen series, and has the requisite strengthening to 1A ice class standard.

The Skipskonsulent design connection with current tanker construction in China is also manifested in a fourth 14,800dwt product/chemical newbuilding of the SK4092 type from Shanghai Edward for Tärntank Rederi of Donsö, which received the third-of-class earlier this year. Moreover, the consultancy has provided the SK4210 design for the 4550m^3-capacity, diesel-electric shortsea tankers in hand at Qingshan Shipyard for F T Everard & Sons, of the UK. The first of these is expected to be complete early next year.

Thrusters installed on Chinese crane pontoon

IN April of this year, China Harbour Engineering Co Group (CHEC) completed and took into service a 2600tonne crane pontoon. The ship, called *Si Hang Fen Jin* has a length of 100m, a beam of 41m, a maximum draught of 4.8m, and has a lifting capacity of 4 x 650tonnes. *Si Hang Fen Jin's* first operation area will be at the building site of the Dong Hai bridge, between Shanghai and Shanghai new harbour.

HRP supplied three azimuth propulsion units, each rated at 550kW, giving the ship a free sailing speed of 3knots. The thrusters are driven by constant-speed electric motors at a speed of 1500rev/min. HRP's branch office in Singapore, HRP Asia Pte Ltd, performed the majority of work related to supervision during installation and commissioning.

Between the electric drive motor and the HRP unit, there is a hydraulic slipping clutch which enables the captain to control thrust fully proportional between zero and 100% speed. Two thrusters are located aft and one is located forward to control the bow. Each thruster is provided with a 1400mm Ni-Al bronze four-bladed propeller in 19A nozzle to achieve maximum bollard pull.

The steering hydraulics and cooling system were all built on the top plate of the thruster unit as an integrated package. The thrusters were built and certified according the rules and regulations of the China Classification Society (CCS). The control of each thruster is from two locations on the bridge, from the main panel and from the auxiliary panel. Both stations are provided with controllers for full follow-up steering and speed control, local indication, and alarms.

***Si Hang Fen Jin,* a 2600tonne crane pontoon was installed with three HRP azimuth propulsion units.**

Chinese-built tanker designed to German specifications

THE International Naval Architecture, Engineering & Consulting company, INEC GmbH, was founded 1993 and is located near Kiel in northern Germany. For more than 10 years INEC has been delivering ship designs to Chinese shipyards, mainly for European shipping companies. Reportedly, up until recently INEC has been the only German engineering office delivering basic designs for oil/chemical tankers to China.

In 1999 INEC was involved in creating the general arrangement plan as well as the technical specification for an 18,500dwt oil/chemical tanker to be built in China for the Belgian WEGA Shipping Co. The order was placed at Qingshan Shipyard located in Wuhan, in January 2000 – the first stainless steel IMO Class II tanker ever built in China on a foreign account.

INEC was requested by the yard to deliver the complete basic and conceptual design for the vessel, and to remain as an engineering consultant handling technical problems and the communication between yard, classification society (Germanischer Lloyd), suppliers, and the owner over the entire construction period of the vessel.

A great deal of interest was shown in the 18,500dwt tanker and subsequently five newbuildings have been ordered at Qingshan shipyard. One of the ships is a slightly modified copy, also for WEGA Shipping Co. Four vessels are for Hanseatic Lloyd Shipping Co. On all these projects INEC acts as a consultant for the yard and the owners.

Resumption of cooperation with the enterprising Chinese trading house SUMEC (*The Naval Architect* February 2000, page 45) brought more successful design work, this time for an Italian owner. INEC and SUMEC worked together in the mid-1990s for the building of a huge series of container feeder vessels in China.

SUMEC, together with Chengxi Shipyard, located in Jiangyin-Jiangsu, received a newbuilding order in July 2001 for a 25,000dwt oil/chemical IMO Class II tanker for Italian shipping company Amoretti Armatori. INEC was in charge of delivering the basic ship design and the complete basic design of the machinery and cargo equipment, as well as acting as a consultant and mediator between yard and owner. *Bianca Amoretti* (which can be seen in more detail in *Significant Ships of 2003*) was delivered in 2003.

***Angelina Amoretti*, a 19,000dwt oil/chemical tanker on sea trials. She was designed by INEC and built at the Yangxijiang shipyard in China.**

Another order for the 19,000dwt oil/chemical tanker, *Angelina Amoretti*, followed soon in 2002. This agreement was made between SUMEC and Yangxijiang shipyard in Jiangyin. Again INEC functioned not only as supplier of basic design and technical consultant, but also as the link between yard and owner.

Both vessels are equipped with the most modern propulsion and cargo handling technology to fulfil the RINa regulations, with additional class notations of Star Hull, Star Mach, Clean Sea, Clean Air, Covent, In Water Survey, VCS, and AVM-APS. The vessels also comply with ExxonMobil requirements.

Extensive model tank test and the optimisation of ship lines resulted into economic operation conditions. Measurements of pressure pulses took a deciding influence on the propeller design so that vibrations could be radically reduced.

High quality equipment and monitoring, a double hull in the cargo area and oil tanks, the possibility to retrofit an urea-plant for NOx reduction, and an electric emergency propulsion ensures safe and environmental-friendly operation.

All tanks have smooth surfaces in the transversal and longitudinal bulkheads as well as on the bottom and main deck so that easy cleaning is possible. Tank washing machines have been installed for this purpose. High heating capacity allows the transport of a wide range of high viscosity cargoes.

Largest GL-classed container ship delivered

THE 3400TEU container ship *MSC Queensland* was recently delivered from Shanghai Shipyard to Norddeutsche Reederei Beteiligungsges MbH & Co KG. The vessel, the first in a series of four for the same owner, is the largest container ship built to Germanischer Lloyd class in China. The design of this series of ships was developed entirely in China, the concept having originated in the design offices of Shanghai Merchant Ship Design and Research Institute (SDARI).

MSC Queensland is 230.9m long and has a beam of 32.20m. The ship's 31,920kW MAN B&W engine enables a service speed of 22.5knots. In terms of its cargo-carrying capabilities, the ship has connections for 500 reefer containers and is licensed for the transport of dangerous goods in accordance with Chapter II-2 Regulation 19 of the Safety of Life at Sea (SOLAS) convention. The remaining three ships in the series will be delivered by the end of this year.

MSC Queensland **is the largest container ship classed to Germanischer Lloyd in China so far.**

Germanischer Lloyd has been represented in the People's Republic of China by its own office since 1988. However, this class society's initial activities in the country date back to 1869. Today, Germanischer Lloyd has seven offices serving its Chinese clients, located in Shanghai (country head office), Dalian, Guangzhou, Jiangyin, Hong Kong, Nanjing, and Wuhan. There are currently 142 ships in 20 Chinese shipyards being built to GL class, including container ships of up to 3400TEU, bulk carriers up to 27,000gt, multi-purpose ships up to 24,000gt, and oil tankers up to 160,000gt.

New security alert system to combat terrorism and piracy

A DIVISION of the Canadian company EMS Technologies, EMS SATCOM, recently announced the launch of a ship security alert system (SSAS). This has been designed to meet the demands of SOLAS Chapter XI-2, Regulation 6, which requires all Class 1 and 2 international trading vessels to be provided with such equipment. Some 20,000 Class 1 vessels worldwide will be required to install a SSAS on or before June 30 2005, while Class 2 vessels, numbering 25,000, have until June 30 2007.

With an independent power supply and covert activation points, the EMS Satcom SSAS will automatically send an alert via the COSPAS-SARSAT network. This alert is then routed to the appropriate authority. Operating over the COSPAS-SARSAT network is claimed to give EMS's SSAS design a distinct advantage over other systems on the market, namely cost savings due to the absence of airtime charges for utilising this network.

Features of the EMS SSAS unit include an independent power supply with a seven-year, long-life battery, a simple interface for external GPS input, and low weight (1.27kg). The equipment will, it is claimed, also have a significantly lower price than comparable alternatives.

Role of the damage consequence diagram in modern passenger shipping

Three Quays Marine Services' research and development work in conjunction with its passenger and shipping clients has led to a significant new tool in the field of passenger shipping damage stability. In this article, Jack Woodhouse, project naval architect with Three Quays, describes the damage consequence diagram and its applications.

IT has been well documented that certain ship types are prone to a lack of reserve stability in a damaged condition. With cargo ships, the major area of post-damage concern often lies with structural integrity and cargo spillage. In passenger ships the arrangement of watertight subdivision can result in marginal or insufficient reserve stability. Disasters occurring during the last 25 years, such as *European Gateway*, *Herald of Free Enterprise*, and *Estonia* have highlighted this problem.

A ship designer's task is to ensure that adequate damage stability is achieved in future new ships, and where possible, for existing ships. At the same time, it is also important to quickly provide the crews of vessels with adequate onboard support and information together with shore-based support in damage situations.

In the event of damage to a ship, the exact impact of the damage on the vessel's stability can be accurately assessed by shore-based emergency response services (ERS) carrying out detailed calculations on pre-prepared computer models. With increasing passenger numbers on modern vessels, resulting in greater pressure to meet evacuation times (60-80minutes), it is important to provide the crew with a rapid early assessment of damage scenarios. Past experience has demonstrated that the time required for a damaged vessel to react does not always permit detailed calculations to be performed. It is also important for crew to have an understanding of the survival characteristics of their ship, allowing them to plan their damage control in advance, according to different incidents

The damage consequence diagram

The 43rd meeting of the sub-committee on Stability and Load Lines and on Fishing Vessel Safety (SLF 43) discussed methods of presenting the impact of damage on ships' stability. As a result of proposals by various countries, the most cost-effective and practical solution suggested was agreed to be the damage consequence diagram (DCD).

Fig 1 illustrates a typical DCD. The damages are represented by compartments, defined by transverse watertight bulkheads and the illustration presents a quantitative indication of survivability for each case. Compartmental damages are further divided by transverse and vertical extent, namely:

- transversely to either the B/5 line or to the centreline
- vertical extents covering either baseline upwards or from the tank-top upwards.

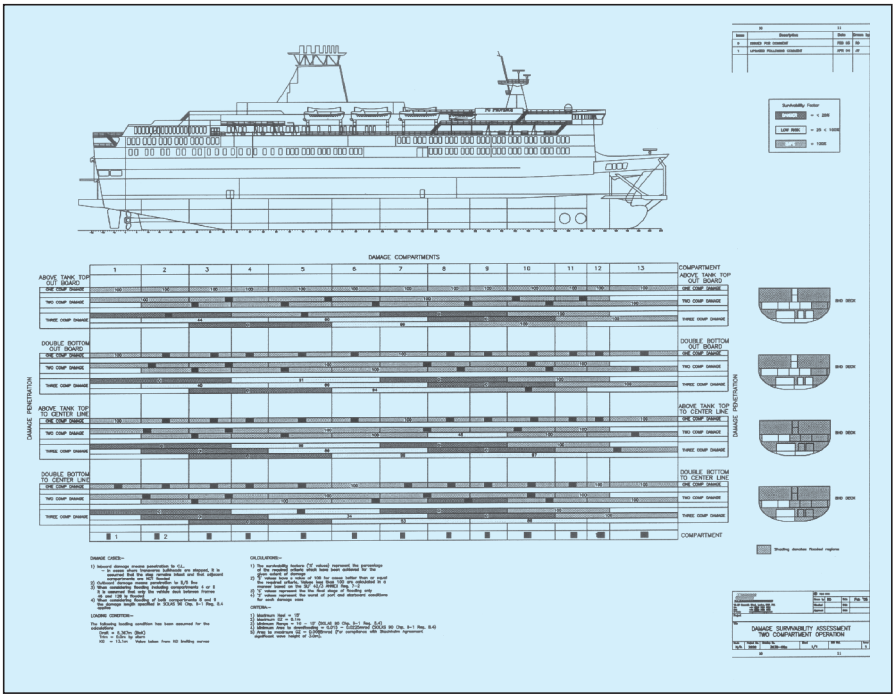

Fig 1. A typical damage consequence diagram.

The results illustrate sequential damage situations for one, two, and three compartments, thus covering scenarios within and in excess of the statutory requirements.

The DCD presents the calculated worst-case survivability for each damage case, using a factor of survivability that shows the percentage of damage stability criteria that are satisfied. The calculation method allows either conventional statutory damage stability criteria to be applied or other selected criteria reflecting the performance of a particular ship type.

To aid interpretation, the damages use a 'traffic light' colour code, with either a red, yellow, or green coloured background, reflecting the severity of the damage. The colour system represents the following results:

- green: 100% of damage stability criteria satisfied
- yellow: 25%-99% of damage stability criteria satisfied
- red: less than 25% of damage stability criteria satisfied.

Assumptions

The DCD presents a range of what is seen to be worst-case damage stability results. In reducing the number of results and presenting the information in as clear a manner as possible, the following assumptions are made:

- damages have no limit on the vertical extent of damage
- single compartment damage cases are defined by adjacent transverse watertight bulkheads
- full compartment damage is always assumed. No lesser damage extents are analysed
- a single initial condition is applied to all damage cases, reflecting the maximum subdivision draught at level trim, with the corresponding maximum permissible KG (or minimum GM)
- all cross-flooding devices are activated
- only the final stage of flooding is considered
- the survivability factor presented on the DCD reflects the worst-case for port and starboard damages.

Application to ro-ro ferries

Due to the configuration of ro-ro ships, with large, non-subdivided vehicle decks, the effect of flooding of these decks is often a critical issue. Floodwater on the vehicle deck can dictate the survival of a vessel more than any other single damage factor, due to the large free-surface effects and water volumes involved.

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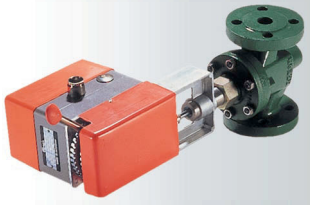
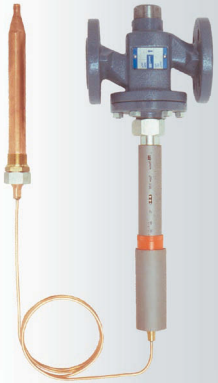


Electric valve motor



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Following the *Estonia* ferry disaster, the stability regulations for ferries operating in north west Europe were amended, in the form of Stockholm Agreement (SOLAS annex 3, resolution 14), which accounts for the effects of flooding on the vehicle deck. Extension of compliance with the Stockholm Agreement, to become a statutory requirement for all ferries operating within EU waters in the future, is also being discussed by the International Maritime Organisation (IMO).

When calculating the survivability factors for such ferries, in addition to the conventional statutory damage stability criteria, the results of the Stockholm Agreement analyses are also included in the DCD presentation. This ensures that the predicted survivability of the vessel includes the effect of flooding on the vehicle deck.

Application to cruise ships

With their complex general arrangements, the statutory damage stability performance of cruise ships is dictated by the positioning of openings and partial subdivision of decks on and above the bulkhead deck as well as the tank and void arrangement.

By examining the effect of these progressive and down-flooding points on the damage GZ curves, it is possible to enhance the stability performance of the vessel with minor modifications in way of these areas. In cases of both new and existing ships the DCD provides a valuable tool in visualising the effect of modifications and providing numerical input into cost benefit calculations.

Certain cruise operators, such as Princess Cruises, have used the results of the DCD analysis to optimise survivability beyond the statutory requirements. It has been found that further stability improvement can be gained by incorporating relatively simple modifications. For example, in cases where the range of positive GZ limits the damage stability, sills can be placed around certain stairwells, resulting in significant improvement in the reserve stability. The DCD then allows the naval architect and operator to observe whether other damage cases are adversely affected by such modifications, leading to the optimum solution.

Limitations of the DCD

Three uses of the DCD have been discussed. The primary use of the diagrams is to provide the master and crew with a useful and concise source of information regarding survivability in damage conditions. In this role a limitation of the DCD is the lack of information regarding the resulting increases in shear forces and bending moments experienced by the ship's hull as a result of flooding.

Furthermore, the damage stability calculations supporting the results presented in the DCD are only performed for the bare hull (all tanks empty), at the maximum draught, level trim and the associated maximum KG. Whilst for the majority of ships this will represent the worst case scenario, there will be vessels with more onerous damage stability performance at draughts lower than their maximum. In such cases further work can be carried out to ensure that the DCD represents the most onerous results.

Conclusions

- Three Quays has found that the DCD provides valuable information to masters and crew of passenger ships and their shore based support staff, providing them with a rapid first indication of the implications that damage will have on the ship's stability performance
- IMO MSC Circular 919 guidelines for damage control plans recommend the DCD as a useful aid to the master in damage scenarios
- a ship's staff are able to gain a thorough understanding of their ship's survival capabilities, allowing them to prepare their damage control in advance. Short sea ferry operators are using the DCD to prepare for particular emergency scenarios where extreme lack of stability is likely to be a critical issue
- previously, the only method of gaining a concise understanding of the damage stability performance of passenger vessels in an emergency situation involved the use of specialist software and a skilled user. With basic training, crew and passengers can greatly benefit from the inherent simplicity of the DCD
- the DCD can be tailored to the particular needs of the ro-ro type, a ship type whose flooded vehicle decks can result in a significant loss of stability in the event of damage. Incorporating the results of Stockholm Agreement calculations or model tests into the survivability factors ensures that the detrimental effect of water entering the vehicle deck has been accounted for
- naval architects and operators can use the DCD as a useful tool when investigating the impact of stability enhancement measures. The diagram allows the assessment of not only the improvement to the particular damage case they are analysing, but also visualises the knock-on effect of adjacent damage cases
- the DCD is not designed for use on its own; the greatest benefits will be gained in conjunction with other stability support measures, such as shore-based emergency response services, and onboard damage stability computers. The more usable information provided to the crew of a damaged vessel, the more likely they are to be able to make the correct decisions, while under the extreme stress of an emergency situation.

Specialised interior design for cruise ships

LOCATED in Pianezze, Italy, Sadi offers integrated solutions for false ceilings, decorative elements, and other interior accessories for public areas, cabins, suites, and corridors. Sadi provides fully comprehensive engineering, from the development of the concept design to the final project.

All production and special work, such as finishing, is carried out in Sadi's facilities and the company can work with metal, plaster, and composite materials. Sadi specialises in using compounds for particular applications, such as to yield specific characteristics such as strength, lightness, resistance to fire, and simulation of other materials.

Materials used by Sadi also include wood (or perfectly identical wood substitutes that are less of a fire hazard), glass, with the use of special glazing for skylights, the creation of special lamps and chandeliers, as well as plastics for the production of minor accessories for assembly and finishing. In addition, the company can carry out protective surface treatments such as galvanising, painting, chrome-plating, and passivation, as well as aesthetical treatments such as painting, wood and marble imitation, scenic effects and patterns.

Sadi's latest projects include a mock-up of *Carnival Liberty's* main lounge. This cruise ship is set for delivery in mid-2005 and is currently building at Fincantieri's Monfalcone yard (Trieste). The interiors were designed by the architect Farcus. Sadi is acting as a subcontractor of Fincantieri for in this project.

Other cruise ships recently built by Fincantieri and worked on by Sadi include: Carnival's *Costa Fortuna* (delivered in November 2003), notably the Grand bar with plaster decorative elements; and P&O's *Caribbean Princess* (delivered in April 2004), of which the aft lounge was furnished with metal panels with special finishes. These 'kites' were treated with a galvanising process that was created by Sadi. Such a process, carried out through high performance in pipe joining, is particularly different as far as chromatic effects are concerned. In both these projects Sadi supplied most of the ceilings and decorative elements in several public areas.

This spring Sadi was involved with *Diamond Princess* and *Sapphire Princess* both built at Nagasaki by Mitsubishi Heavy Industries for P&O. In both of these ships, Sadi supplied all ceilings and decorative elements in the public areas. Noteworthy is the waved decorative element (light cove) located above the dance floor in the centre of the disco. It is made of transparent material (laser-cut) held by tie-rods and decorative bosses in galvanized metal, with a polished brass finish. Particularly interesting is the escalator tunnel with its backlight glass panels fitted with optical fibres, held by blue coloured steel cassettes and frames.

New cavitation tunnel for Vietnamese shipbuilding centre

The shift of the maritime industry to the east - initially to the Far East - has lasted for over 20 years, and the expansion to South Eastern Asia countries, unknown on such a scale, has been evident for over 10 years. These countries, well-known for design and manufacturing technology as well as production, have recently initiated the last development stage - the know-how related to model tests. This will enable these places to reduce shipbuilding costs, train their own scientific personnel, and gain complete independence from countries and research centres, which have traditionally been involved in this field. In this article Alicja Koscinska and Leszek Wilczynski from Centrum Techniki Okretowej (CTO) discuss a new test centre that this Polish model basin is designing and installing for the National Shipbuilding Laboratorial Centre in Hanoi, Vietnam.

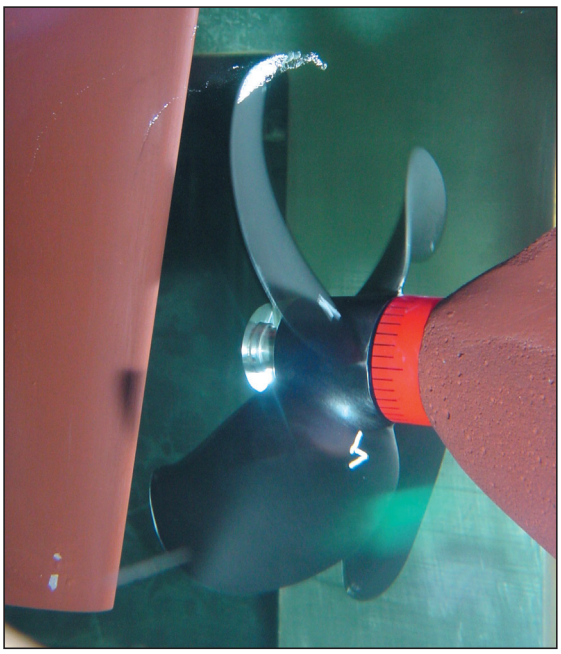


Fig 1. Cavitation model tests of a propeller model in simulated behind conditions. This picture was taken in CTO's cavitation tunnel.

CENTRUM Techniki Okretowej (CTO), the model basin and research facility, is, in partnership with the Shipbuilding Science and Technology Institute VINASHIN, Vietnam, organising the National Shipbuilding Laboratorial Centre in Hanoi. Part of the work includes design, construction, and assembly of a cavitation tunnel. Before the commissioning of the tunnel in Hanoi, control tests will be carried out in Poland. The division of cavitation tests consists of the following:

- the building and supply of overhead crane, control and service rooms
- a cavitation tunnel together with a pump imposing the water flow inside the tunnel, power transmission systems, control systems and measuring equipment.

The stainless steel cavitation tunnel is composed of welded segments, joined by means of bolted flanges. Its length between vertical axes is 16m, and its height between horizontal axes is 8m. The cross-section of the test part is 500mm and length of the test section is 2500mm. The maximum flow velocity in the test section is 12m/sec, and the volume of water inside the tunnel is 135m^3. The tunnel has a four-bladed axial flow pump diameter of 1.4m, with a rotational speed of 200rev/min, and its maximum pump propeller power is 90kW. The tunnel is also equipped with a high speed degassing system.

Standard model tests to be conducted in the tunnel cover cavitation model tests of propellers carried out in a homogeneous velocity field including determination of cavitation inception conditions as well as hydrodynamic characteristics, tests of propellers and rudders carried out in simulated behind conditions, including pressure and hydro-acoustic effects measurement, and tests of hydrofoils. Experimental research to be conducted in the cavitation tunnel includes cavitation inception, interaction and transitions of various cavitation forms, and correlation between cavitation and hydro-acoustic emission.

The design of the cavitation tunnel, together with its supply and control systems, have been developed by the ship design and technology department of CTO. The staff of this division are experienced in the design of ships and their devices, systems, and equipment, and similar systems.

CTO turned to YLec Consultants, France, for assistance in the development of the cavitation tunnel. This company is a highly experienced designer of cavitation test facilities. YLec Consultants developed the study of principal tunnel parameters, internal geometry of particular sections of the cavitation tunnel, and analysed hydrodynamic phenomena influencing the tunnel operation.

CTO then made further amendments to the technical design documentation on the basis of the aforementioned study. The investigation covered the complete scope of tunnel design together with its auxiliary systems. The scope and insight of this design enabled preparation of detailed design and workshop documentation by ABB Zamech Marine, from Elblag, Poland, a tunnel construction manufacturer. The Polish classification society, Polski Rejestr Statków (PRS), certified the meeting of the design contract requirements and correctness of the technological processes during tunnel manufacture.

The cavitation tunnel is a closed, vertical water loop, entirely filled with water. The crucial element of the tunnel is its correct operation, and the reliability of the examined phenomena is a contraction section.

Contraction section is an element of the upper part of the tunnel loop, imposing water flow acceleration. Its lower and side walls are shaped to obtain the best velocity distribution in the entire test section. Severe tolerances of construction manufacture, particularly tolerances of linearity, perpendicularity, flatness, and parallelism are of crucial importance for tunnel operation as well as the connection of the contraction with a test section located downstream.

Test section is a part of the tunnel in which the examined objects, mostly propeller models, are placed and where the cavitation phenomena are observed and recorded. The test section enables excellent visibility of cavitation phenomena either during the open water propeller tests or when the propeller models are tested in simulated behind conditions. The outlet of the test section is connected to a long diffuser assuring smooth, silent, and cavitation-free deceleration of the circulating water. The test section and diffuser have been designed and manufactured with the highest tolerances concerning their geometry and surface roughness.

Dynamometer, supplied by British company Cussons Ltd, can be assembled in the test section and is used to carry out standard experiments with propeller models in the cavitation tunnel.

Elbows are equipped with hydrodynamically shaped guide vanes placed inside, which change the water flow direction. The profiles, location, and number of the vanes are adjusted for each elbow separately.

An axial-flow pump induces the water flow in the tunnel and provides pressure at the outlet

that exceeds the pressure drop in the tunnel. The pump must provide noiseless operation, in other words it must be free of cavitation over the whole range of revolutions and pressure. The pump speed is smoothly regulated.

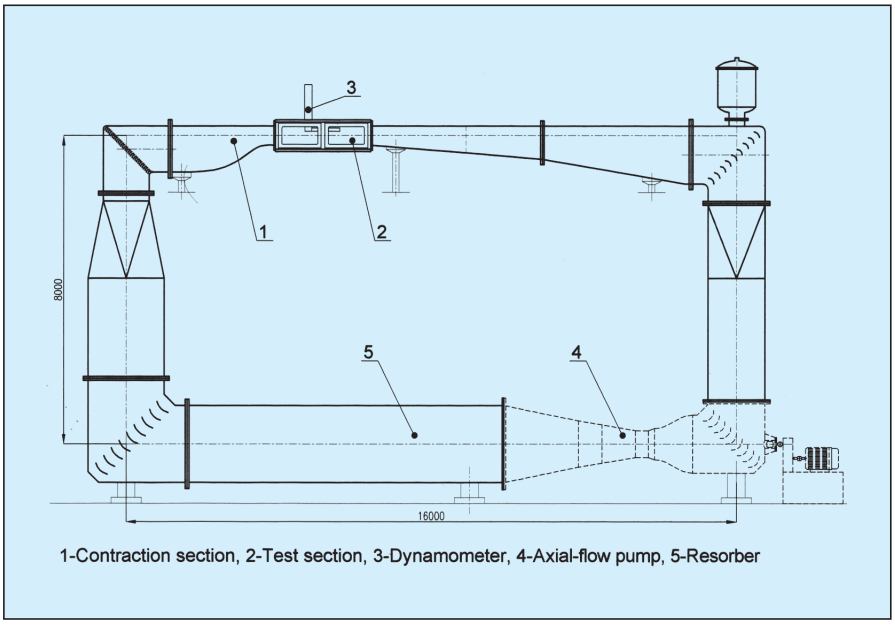
Resorber provides suitable conditions for air-vapour bubbles absorption and prepares the water stream for entry into the tunnel ascending section, maintaining uniform velocity distribution without rotation. Therefore additional honeycomb material is located inside.

The correct operation and reliable results of the trials carried out in the tunnel may be gained only when the facility is equipped with adequate accompanying systems. These systems eliminate inconvenient phenomena occurring while tests are carried out. The most important system is a water supply system. It is a closed water system, in which, apart from the tunnel, the following components are installed: filters capturing impurities, and demineralising and deironing system.

These devices assure the water purity requirements. The water supply and storage system is equipped with auxiliary water tanks, in which the water is stored during the change of the examined object in the test section.

Another important system in the tunnel is a quick degassing system. This system is essential for appropriate water de-aeration. In the conditions of reduced pressure and high water velocity, the air dissolved in the water forms bubbles which may disturb the cavitation phenomena in the vicinity of tested objects. Therefore before starting the cavitation research the water should be degassed.

In order to start the tunnel and to assure its correct operation, the following control tests and measurements are made: examination of the tunnel construction stiffness and watertightness, and measurements of the water velocity in the test section, accompanied by observation of the pump impeller behaviour.



1-Contraction section, 2-Test section, 3-Dynamometer, 4-Axial-flow pump, 5-Resorber

Fig 2. Overall view of the cavitation tunnel.

A proposal: modular sailing rigs to provide wind assistance for larger vessels

The re-introduction of sails on larger vessels in order to conserve fuel and reduce environmental damage could be encouraged by the development of sail modules that are leased to ship operators. Dr Richard Dryden, of Transistion Sailing Rigs, believes these could be attached to certain classes of ships to provide wind assistance on certain routes and removed when not required.

WHEN oil prices rise, the interest in wind assistance for larger vessels tends to rise too. In response to oil-supply crises in recent decades, several ships were fitted with experimental sailing rigs, although with different degrees of success and with little impact on current patterns of sea transport. At current levels, it is unlikely that fuel costs alone will provide sufficient motivation for the re-uptake of sail assistance for larger ships. Ship operators can see no immediate economic benefit in developing specialised windships at high cost and with relatively small savings from reduced fuel-use.

However, another factor has entered the equation and has the potential to change this situation - the growing concern about environmental damage and climate change being caused by the use of fossil fuels, including their unregulated use at sea. MARPOL Annex VI, adopted in 1997 and coming into force in 2005, tackles air pollutants emitted from ships such as ozone-depleting substances, nitrogen oxides, sulphur oxides, and volatile organic compounds, and is a first step towards tighter regulation.

The aim of this article is to propose that there is a way of fitting sails to existing larger ships to bring benefits for operators as well as for the environment. Wind assistance could be achieved by fitting folding sail modules to ships such as tankers, some bulk carriers, and the top tier of part-loaded containerships, raising the rigs when required for wind assistance and then folding them away when not required. The sail modules could be removed from the ship for servicing or when not required on a subsequent stage of the voyage. The purpose would be to provide wind assistance to reduce fuel consumption rather than to eliminate the need for engine power completely.

Several rig modules may be attached to the same ship to provide the requisite sail area. This arrangement provides redundancy, so that if one rig fails the remaining rigs can still be used. In potentially dangerous situations such as storms or equipment malfunction, the rigs can be folded to deck level to reduce windage. Similarly, the rigs can be lowered if the wind is unfavourable.

The modular rig approach could be developed, provided, and serviced by companies other than the ship owners and operators. Funding for the research and development phase would need to come in part from governments firmly committed to the reduction of carbon emissions and environmental impact. A leasing approach would reduce the financial burden on ship operators to a level that would encourage them to take up wind assistance earlier than if they were left to develop specialised wind ships at their own expense.

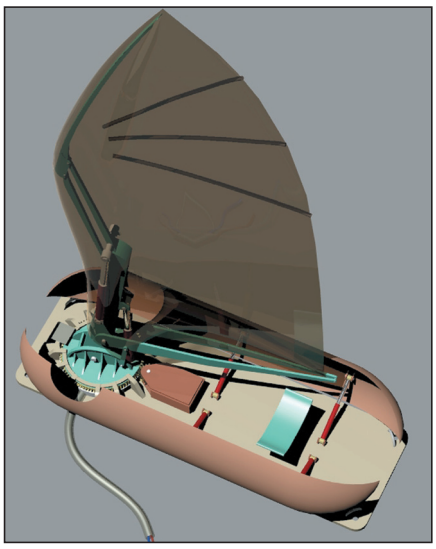
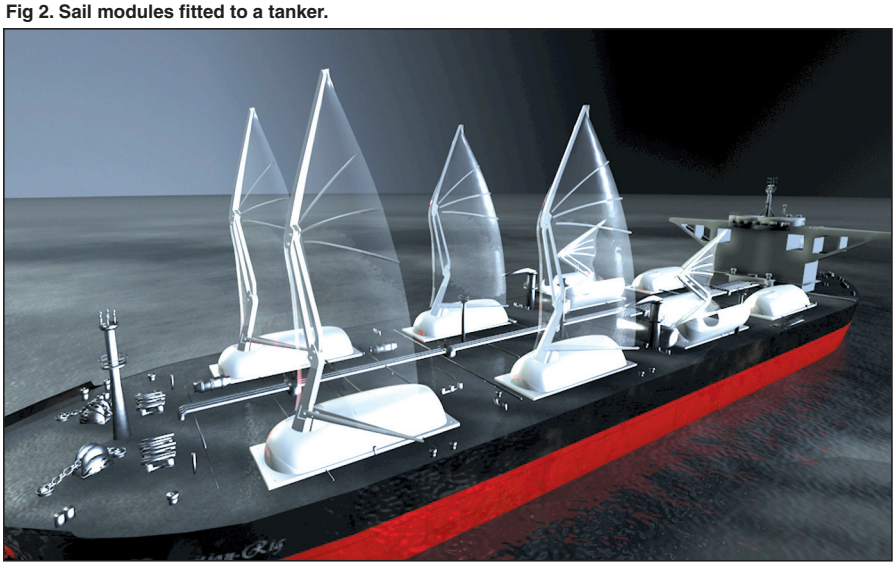


Fig 1. General arrangement of a sail module.

Proposed rig modules

Each module consists of a substantial base plate, a jointed rotating mast that can extend upwards and fold downwards, and a pivoted horizontal boom to support the lower edge of the sail. The base plate of the module is attached to the deck of the ship or to underlying containers by a means that allows straightforward removal at a later time, for example by a through-bolt or clamp at each corner.

Fig 2. Sail modules fitted to a tanker.



The sail is made from a slightly extensible material that can accommodate the changes in mast geometry whilst at the same time being able to maintain a suitably aerodynamic shape when tensioned in use. The upper segment of the mast fits into a sleeve at the leading edge of the sail.

Radially-arranged battens support the upper part of the sail. The part of the sail below the battens is double-skinned, with the middle and lower mast segments located between the two skins. The mast and the operating equipment attached to it are thus protected from the elements by the sail.

The double skins come together at the leading edge of the sail between the upper mast joints and the mast foot, and the sail is tensioned downwards and backwards to maintain a good aerodynamic shape. The clew of the sail (lower trailing edge) is out-hauled to the boom. The base of the mast is pivoted about the vertical axis to allow the rig to be turned in relation to the ship and trimmed according to the direction of the apparent wind.

This is achieved by an actuator that drives the rim of the circular mast base. An optional braking system can be applied to the rotating mast base to lock the rig in the desired working position. A link between the rotating mast base and boom ensures that the boom remains horizontal during elevation and folding of the mast.

Two hinged doors attached to the sides of the base plate form a streamlined cover for the sailing rig in its folded configuration, and open to allow the rig to be deployed. When the rig is fully extended, the doors close around the base of the rig to protect the control and operating systems

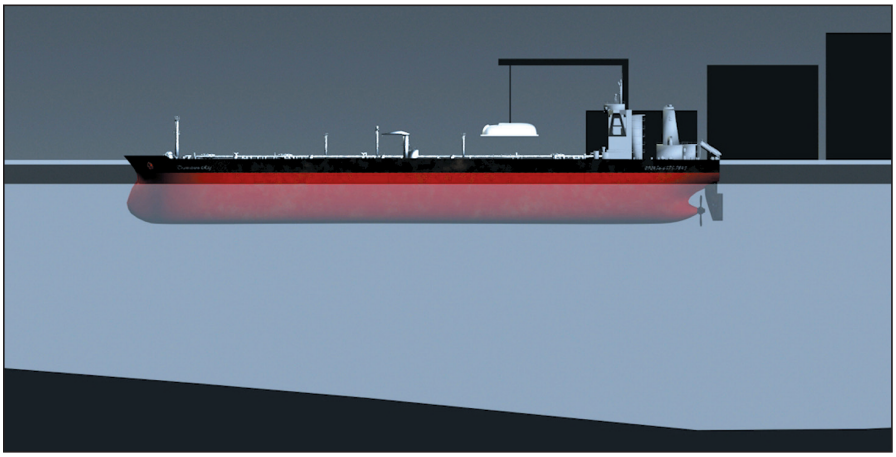


Fig 3. Sail module being fitted to the deck of a ship.

around the mast foot. Before the rig is lowered, the doors open again and the rig folds, with the doors collecting the folds of sail material before closing over them.

The actuators that open and close the module doors, and produce extension, folding, and rotation of the mast can be hydraulic or electrically powered according to the requirements of the ship. An umbilical from the module connects to the ship's power and control systems to enable deployment and control of the rig by the ship's crew.

Future concerns over oil

We are using oil at an ever-increasing rate, especially in the transport sector (International Energy Agency, 2003). The annual growth rate of global marine bunker consumption from 1993 to 2010 is estimated to be 2.8%, the highest growth rate of all primary energy sectors. Clearly, the transport of cargo by ship is very cost-effective when compared with other modes of transport such as air, road, or rail, but we must bear in mind that oil is a finite resource, and it has been predicted that oil production worldwide will peak during the present decade before going into irreversible decline (Deffeyes, 2001). It is appropriate now, as a matter of urgency, to look for ways of conserving the oil that remains, and to develop alternative sources of energy.

Attention is shifting away from simple economic evaluations of wind power in terms only of fuel saving towards a more sophisticated awareness of the environmental damage being caused by the largely unregulated use of polluting fuels at sea. Although the economic dimension will remain, especially with regard to acceptance of wind power by the shipping industry, the environmental debate will greatly influence future energy policies.

The most favourable use of wind power can be made by ships travelling longer distances and carrying low density, relatively low value cargoes for which there is a steady demand. Dry bulk cargoes were the last to be carried by the old windjammers, and could well be the best ones to be carried by a new generation of wind assisted vessels. Other possible applications for the early re-introduction of wind power are tankers, container ships, cruise vessels and research vessels.

A Danish study (Modern Windships Phases 1 and 2) has concluded that modern windships with high-lift wing masts would currently cost approximately 10% more to operate than conventional ships. Clearly, a rise in oil prices and the application of environmental 'taxes' would narrow this difference and potentially reverse it. Currently, fuel costs account for only 15% of the total operating costs of a modern bulk carrier, but if that figure begins to rise then wind assistance will become more attractive. However, it is proposed here that even before that point is reached, it will be beneficial to develop wind assistance by the use of rig modules that can be fitted to ships or removed as required.

Conclusions

Wind assistance for larger vessels has the potential to reduce fuel use and environmental damage. If ship operators are to be won over to this approach then they must perceive a direct economic benefit. At present, with fuel costs low, there is little incentive to invest in the necessary research and development required for modern windships. However, the planned introduction of fines for environmental damage caused by marine transport will begin to encourage the search for alternatives even before oil prices begin to rise as a result of diminishing supplies. The proposal made here to provide removable sail modules on a leasing basis for some types of existing ships could encourage the early re-uptake of wind assistance while a new generation of specialised wind ships is being developed.

Acknowledgements

The author is grateful for the support of the National Endowment for Science, Technology and the Arts (NESTA) while developing the variable geometry mast and sail concept (summarised at www.transitionrig.com), to Ben McNeilage (KCIRA) for computer modelling, and to A H Oele (chief engineering officer, P&O Nedlloyd, retired) for his helpful comments.

Patents

The intellectual property embedded in this proposal for folding sailing rigs is protected by: **GB Patent 2225760**: variable geometry rig with three mast segments and adaptable sail; **GB Patent 2368829**: control systems for unstayed variable geometry rig; **GB Patent Application 2381515A**: wind assistance for larger vessels.

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5. *Modern Windships, Phase 2*. (1999) Knud E Hansen A/S, 41-43 Islands Brygge, DK-2300, Copenhagen. (Available online at www.mst. dk/udgiv/publications/2000/ 87-7944-019 3/html / default_eng.htm or in print form from the publishers)*.

* The Modern Windships reports are a valuable source of information about weather routing issues, previous attempts at wind assistance, and a Danish project to develop a modern windship with high-lift wing sails.

Fig 4. Ship leaving port with rigs still folded.

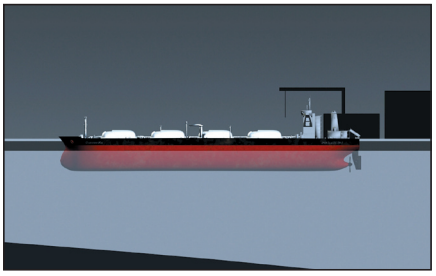


Fig 5. Rigs being deployed.

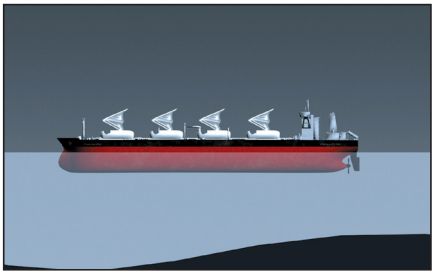
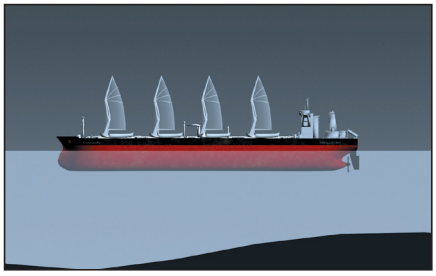


Fig 6. Sails providing wind assistance.



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New engine designs and concepts at CIMAC

will be covered by the triple-engine programme, with five- to nine-cylinder models offering outputs from 540kW to 2700kW at speeds from 720rev/min to 1000rev/min. Such ratings reflect the South Korean marine genset market demand over the past four years, hitherto largely served by licence-built engines.

Hyundai's swift penetration of the sector is reflected in sales figures for the two established HiMSEN designs: over 100 engines had been delivered and some 30 engines were in service at the end of 2003. Excellent performance and reliability results are claimed. Prototype test engines continue to operate under various programmes to confirm and enhance performance and reliability.

Benefiting from the design concept exploited in the pioneering HiMSEN models, the new 170mm bore H17/28 series reportedly has the longest stroke (280mm) of any engine in its class. Among the target markets for these sub-1000kW auxiliary engines are product carriers and tonnage of a similar size.

Current R&D on various cylinder versions and applications of the overall programme are complemented by work on common-rail fuel injection, fuel-water emulsion and charge air moisturiser systems, Hyundai reporting promising results in reducing emissions. Soot reduction and selective catalytic reduction systems are also under investigation.

New engine from China

China too is keen to secure business for home-grown engines from its blossoming shipbuilding industry, a new 12V190 high-speed design from Jinan Diesel Engine Co (JDEC) targeting propulsion and genset drive opportunities as well as drilling rig applications.

JDEC has manufactured diesel and gas engines since 1920, its Chidong series 190 design reportedly the main power source in the Chinese petroleum industry. Demand for a more advanced engine with higher power and efficiency influenced the company to commission Austrian specialist AVL List to design a completely new model.

The development project also sought to foster technology transfer to JDEC, with as many parts as possible sourced locally in China. The resulting V12-cylinder 190mm bore/215mm stroke design has a rated output of 1740kW at 1500rev/min, and its performance is claimed to be 'considerably better' than that of most domestic competitors.

Test results reportedly met or surpassed goals with regard to fuel economy and emissions, the trials including a successful 1000-hour durability run. Good performance and high reliability, coupled with competitive manufacturing costs, aim to underwrite the success of the engine, whose first three examples are now in land-based genset service.

Inheriting the pedigree of the long-established DK-series, Daihatsu's DC-17 medium-speed engine was designed mainly as a genset drive for bulk carriers, addressing operator requirements for heavy fuel-burning capability, high reliability and durability, and low maintenance. Minimal external piping and ease of access for servicing were also addressed by the Japanese designers. Prototype testing demonstrated acceptable levels of noise, vibration and NOx emissions, and the first engines in service are said to have performed without trouble (Daihatsu's new DC-32 model is discussed elswhere in this issue).

Niigata's 6MG17HX high speed engine - designated the Blue Marine 1100 - was developed by the Japanese designer to meet demand for small vessel propulsion plant with a high power output from compact and lightweight installations. The six-cylinder 165mm bore/215mm stroke model yields a maximum rating of 809kW at 1703rev/min. Among the features is a twin turbocharging system contributing to acceleration performance and favourable smoke characteristics in the low load and transitional ranges.

A fire ring at the top of the cylinder liner helps to secure consistently low lube oil consumption and protect the lubricant from fouling and degradation. Excellent operating experience is reported from the first installations, which entered service in 2002, while overhauls have demonstrated component durability and a sound condition.

Progress with steam injection

Progress with the development of a steam-injected diesel (STID) engine was reported by researchers from Chalmers University of Technology in Sweden and Wärtsilä Finland. A quantum leap forward in efficiency, high power density, low emission potential and low capital and development costs are promised for a wide range of applications. Tests have been carried out on a Wärtsilä 32 medium-speed engine-based prototype operating without any changes to the fuel injection but with a compression ratio reduced from 15.9 to 15:1.

Steam is injected by two electrohydraulically-controlled injectors arranged on opposite sides of the cylinder, which fit into a ring separating the cylinder head and liner. Tests were executed using low pressure/low temperature steam but the main focus of investigation was on high pressure/high temperature steam with supercritical parameters (24MPa and 417ºC).

Steam is generated using all the available waste heat resources (air cooling, engine cooling, and exhaust gas heat) of a diesel engine. Injection into the cylinders is effected when the piston is close to top dead centre to increase the power and actively change the combustion without disturbing ignition. In this way, a steam bottoming plant is obtained without actually building a steam engine as both diesel and Rankine cycles are realised in the same cylinders at the same time.

A simplified and lower cost system is underwritten, while reduced maximum temperatures and increased charge turbulence foster lower emissions. Other cited benefits are a reduction of the dew point by increasing the vapour contents of the exhaust, decreasing engine heat losses and boosting the power of the exhaust turbine (thus promoting higher charging pressures). A disadvantage is that a large amount of demineralised water is required, but this is reportedly overcome by a maintenance-free, multi-effect distillation plant exploiting a small fraction of the waste heat available.

In spite of problems with slow opening of the steam valves and too low a steam temperature - preventing the full potential being realised - a reduction in fuel consumption of 22.5g/kWh and a cut in NOx emissions by up to 50% were reportedly achieved on the test engine with supercritical steam injection. These results were accompanied by an acceptable increase in soot, carbon monoxide, and unburned hydrocarbon emissions.

Tests have clearly shown that an engine operating according to the STID principle is feasible and can achieve the predicted performance, the developers assert. Developing such an engine for practical applications is nevertheless a challenging task dictating further research.

A more radical concept, the isoengine, is described by UK-based developer RWE Innogy as a novel high efficiency reciprocating design in which compression and combustion are performed in different cylinders. Compression is carried out quasi-isothermally by injecting a large amount of water into the cylinder to cool the air. The water is not evaporated but remains in liquid form and is separated from the discharged air-water mixture, cooled and then re-injected using the pressure of the separator to drive the flow. A water injection pump is not required.

Heat is recovered from the turbocharger intercooler and the engine cooling system to preheat the compressed air; and a recuperator recovers heat from the exhaust gases and heats the compressed air further to around 700ºC. Fuel is injected into the combustion cylinder simultaneously with the induction of pre-heated, pre-compressed air through the combustor air inlet valves.

Fuel is burnt at approximately constant pressure, determined by the pressure of the supplied hot compressed air. The air inlet valves close at around 40degs after top dead centre and the gases expand. Following expansion, the hot exhaust gases pass back through the recuperator and then flow through the turbocharger turbine to the atmosphere.

A 3000kW prototype isoengine was built by Ricardo in the UK and some initial test data obtained. A partnership agreement signed last August between Mitsui Engineering & Shipbuilding and RWE Innogy covers continued testing and development based on the prototype, which has been rebuilt at Mitsui's Tamano works in Japan.

Future testing will focus on increasing speed and power to design levels. Calculations of the benefit of longer term design improvements indicate that an efficiency of 60% could be achieved but that 57% is a more realistic target for the near term.

Own-design models from Asian four-stroke enginebuilders were presented at the recent CIMAC congress in Kyoto, where progress with European steam-injected diesel and isoengine developments was also discussed. Doug Woodyard was in Kyoto for the event and reports.

KEEN to raise the own-content level in its deliveries, the world's most prolific shipbuilder - Hyundai Heavy Industries - continues to invest in developing a range of HiMSEN medium-speed engines, mainly to serve the auxiliary power demands of diverse tonnage types built at its facilities and other South Korean yards.

The 210mm bore H21/32 design was introduced in 2001 and was followed in the same year by the 250mm bore H25/33 series, jointly developed with Rolls-Royce Bergen of Norway (which markets it as the C25:33). Hyundai says its H25/33 has since benefited from refinements introduced on the H21/32.

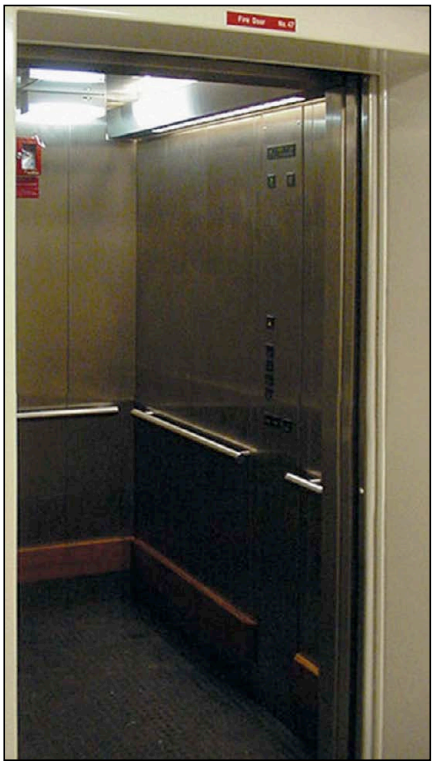
Joining the HiMSEN family will be a smaller Hyundai own-design brother, the H17/28 engine, now under development for market launching early next year. A wide power band

Lift contract for new Merwede ferries

DUTCH lift company Airborne Elevators has secured an order to supply lifts for the two new ro-pax ferries ordered from Merwede Shipyard by Danish operator Bornholmstrafikken (*The Naval Architect* July/August 2004, page 4). Each ship will have space for 1235lane metres of ro-ro cargo as well as 400 passengers; one vessel will be built at the Merwede yard at Hardinxveld-Giessendam, and the other at the Volharding yard in Harlingen. This decision was based on the very short delivery schedule.

The Airborne lifts will comprise a passenger unit with a capacity of 18 passengers or 1350kg, which is large enough to transport a hospital bed, and a dumbwaiter with a capacity of 100kg. Both will travel between the five decks of each hull. Due to safety measures, explosion-proof electronic/electric components will be used.

The available space for the passenger lift is extremely tight. On an earlier version of a similar ship (the design was based on a standard design from the former Van der Giessen-de Noord yard), an elevator for 13 persons was used. On the new ferries the capacity had to be raised to 18 persons, but using the same space for the trunk as on the earlier ferry. Airborne Elevators overcame this engineering challenge by, amongst others, using its certified A60 insulation material of less than 20mm thickness.



Lifts similar to this one pictured will be supplied by Airborne Elevators to Merwede Shipyard for two new ro-pax ferries.

MAN B&W engines for Hawaii ferry

HAWAII Superferry has announced an agreement with Austal to commence construction of the first of two new ro-ro ferries. The vessels will form the basis of the first high-speed vehicle ferry service for Hawaii and will use Austal's 105m catamaran technology.

When completed at Austal's Mobile Alabama facility, it is claimed they will be the largest aluminium ships ever constructed in the USA. When the ship enters service in 2006 it will provide a daily non-stop service between the islands of Hawaii, Kauai, Maui, and Hawaii Superferry's hub in Honolulu on the island of Oahu.

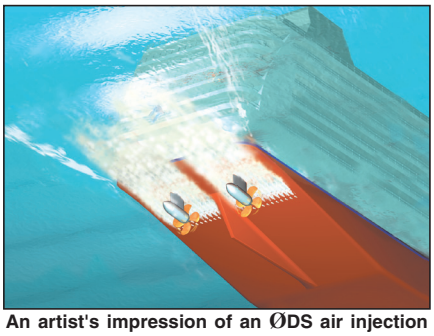
Four MAN B&W 20-cylinder RK280 engines have been chosen to power each vessel, providing a total installed capacity of almost 31,605kW. The engines will be built at MAN's Stockport plant in the UK and are scheduled for delivery during 2005.

The RK280 design satisfies requirements for low fuel consumption and a high power output without sacrificing accessibility for routine maintenance. The 20-cylinder RK280 is said to be the most powerful 1000rev/min engine ever built and is designed to meet new EPA 2007 and IMO emissions standards.

Solving noise problems by air injection above the propeller

REDUCTION of noise and vibration levels in the aft of a ship by introducing a layer of air bubbles above the propeller is a new technology in the cruise industry. Nevertheless, the technology has been known for decades; as an example, in the early 1980s the royal yacht *Abdul Aziz* was successfully fitted with an air injection system developed by the Danish noise consultancy Ødegaard & Danneskiold-Samsøe (ØDS). However, after successful noise reduction in a new liner in the autumn of 2003, the cruise industry's interest in use of this 'unknown' opportunity has increased significantly.

The hull geometry of modern cruise ships provides excellent opportunities for applying air injection. The more flat the bottom of the hull is, the easier it will be to control the position of the bubbles. The most valuable knowledge for an owner is that air injection can be retrofitted on existing vessels. Consequently, when propeller redesign or the addition of more deck materials having higher weight/losses are considered, air injection results in a superior cost-benefit ratio.



An artist's impression of an ØDS air injection system at work on the flat bottom of a cruise liner. The geometry of modern cruise vessels is ideal for the application of this technique.

Noise reduction at full speed is significant, and the system can be turned off during non-service hours. Such periods are - for example - closure of the aft restaurant or at times of lower speeds. Finally, the application of air injection is not limited to the cruise industry, as the system on *Abdul Aziz* has shown.

The advantages claimed for air injection include:

- cost-effectiveness
- reduction in propeller cavitation noise at the aft end of a hull
- it can also be retrofitted
- it functions additionally to other noise- and vibration-reducing measures
- may reduce the need for floating floors or visco-elastic deck coverings
- can be turned off when not needed
- it requires no modifications of accommodation spaces.

The only potential side effects are increased vibration level at very low frequencies and noise emission from the blower.

Leading the field in tank-washing and gas-freeing

THE Essex-based marine engineering design company Victor Pyrate Ltd was one of the original pioneers in the development of single- and twin-nozzle tank washing machines for use in crude oil, product and chemical tankers. As part of the Samuel Hodge Group, Victor Pyrate was able to capitalise on its early development of fixed programmable in-tank machines installed in early VLCCs during the tanker boom of the 1970s. Some 30 years later, there are still a number of these early machines in use, giving trouble-free and reliable service.

The tank washing machines designed today are built to minimise both cleaning time and cleaning media consumption, thus helping to optimise total vessel turnaround and productivity. Other issues require more and more attention in the development of tank washing machines to meet the demanding environmental requirements that will certainly affect the tanker industry in its future development.

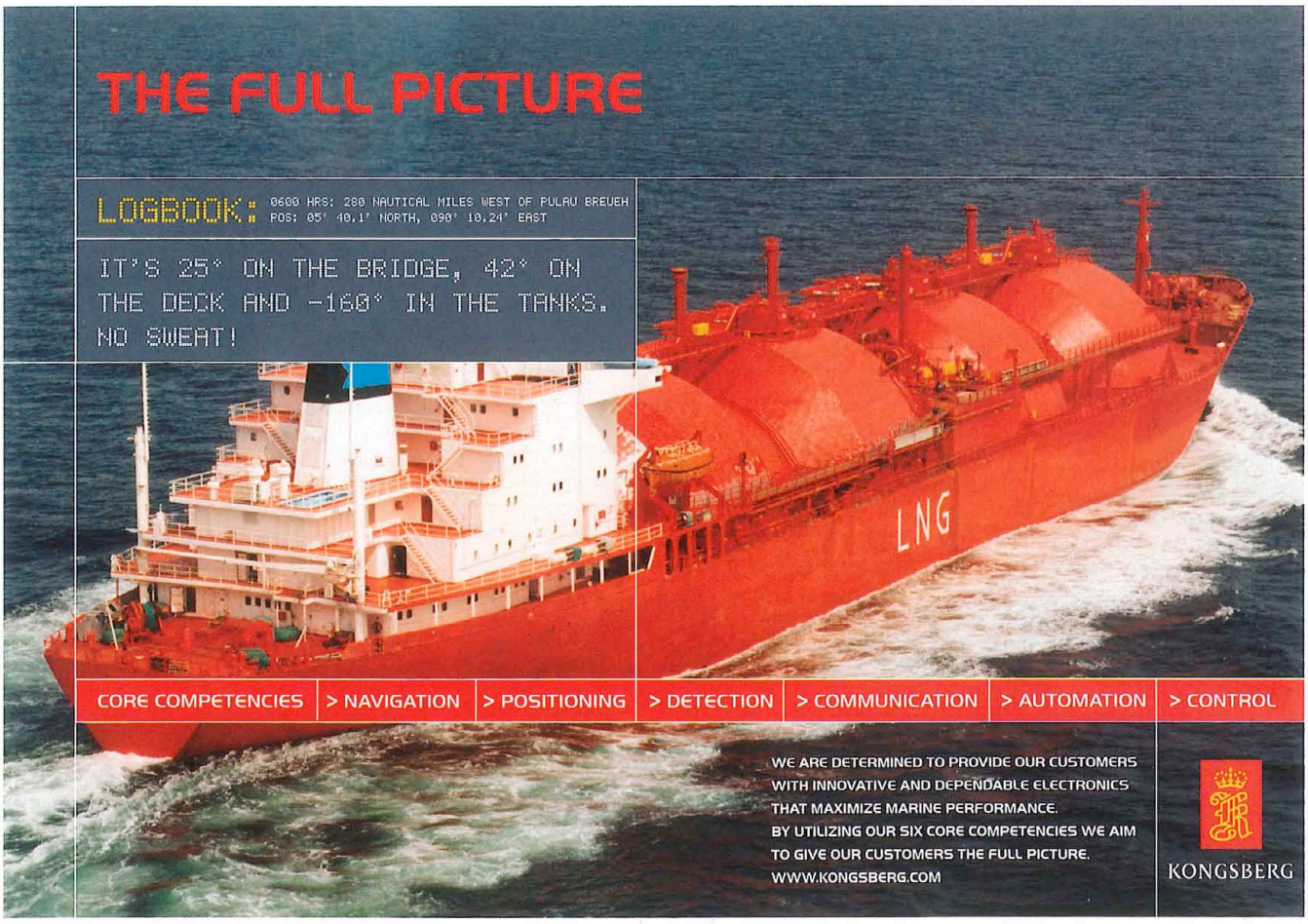
Almost all modern tankers have a fixed installation on-board supplemented by a small number of portable machines. With more than 1100 tankers currently on order, there is no doubt that this is another boom time for the industry.

New gas-freeing fans

In the same sector and as market leader in the design and manufacture of gas-freeing fans, Victor Pyrate can design and supply quality, cost-effective, high-performance and environmentally safe products. To be seen for the first time at the SMM exhibition in Hamburg, will be the new VP1500 WS, 1000 WS, and VP750 WS water-driven and VP950 AS air-driven gas-freeing fans.

This brand-new stainless steel range of fans should provide an effective alternative to current gas-freeing methods; all models are offered with full class society approval. Designed initially for the chemical and product tanker market, these new fans have excellent technical specifications and very good performance data, ranging from 14,770m^3/h down to 7580m^3/h air displacements requiring only 54m^3/h to a very low 6m^3/h water supply in the VP750 WS model. The VP950AS air-driven fan has equally good performance, with a maximum air displacement of 9220m^3/h.

Although the market is busy and cheaper competition is challenging, Victor Pyrate has maintained its original core values for producing high-quality marine products and is successfully winning important orders for FPSOs, product and chemical tankers, also supply vessels in all of the major shipyards around the world including China, Korea, Singapore, Turkey, and in Europe. In China in particular, efforts have resulted in a 288% increase in sales, and this shows signs of improving further as the number of orders the yards are contracting grows.



Meeting the challenge of next-generation LNG carriers in Spain

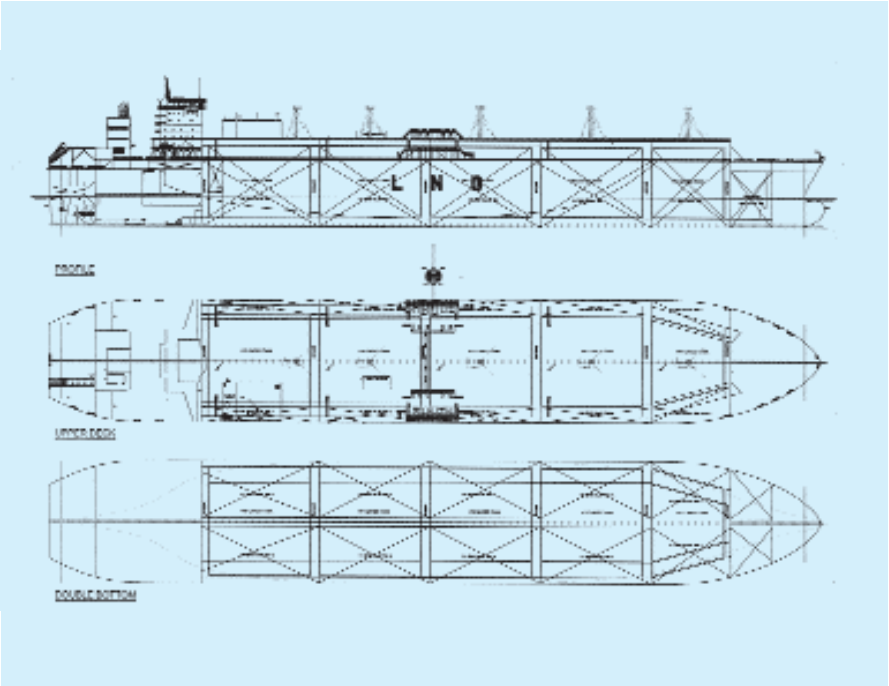
BUILDING on its successful contract for five 138,000m^3 LNG carriers to support Spain's new natural gas import policy (three have already been delivered), the Spanish shipbuilding group IZAR has been busy planning for much larger ships. *The Naval Architect* discussed this shipbuilder's new era in gas tankers in our March 2002 issue, page 3, and the ships are all of the membrane type, using the GTT NO 96 E2 containment system. The prototype, *Inigo Tapias*, was featured in *Significant Ships of 2003*, and the fourth ship, *Cadiz Knutsen*, is due for delivery soon from the Puerto Real yard to Knutsen OAS and Marpetrol. She will carry gas from Damieetta in Egypt to terminals at Ferrol and Sagunto.

Earlier this year, rumoured new contracts at IZAR for 145,000m^3 ships were reported, but these do not yet appear to have materialised. Today, the group has drawn up designs for vessels up to 250,000m^3, with in-depth R&D programs concentrating on propulsion, hull forms - both single and twin screw, hull structures, and sloshing. A very extensive series of CFD calculations has been carried out at MARIN, in The Netherlands, in order to reduce hull resistance, and a complete range of model tests, including an intensive seakeeping series, is currently under way at the same centre.

From the propulsion point of view, all possibilities are being compared for each ship size, taking into account criteria such as fuel consumption, maintenance and acquisition costs, impact on a ship's weight and dimensions, availability and reliability, also noise and pollution from emissions. Hull structures are being examined in close cooperation with Lloyd's Register and ABS.

As a result of all this, IZAR believes that both slow-speed diesel engines (typically twin MAN B&W 7S70ME-C designs of 21,770kW each driving FP propellers of 8.10m diameter at 91rev/min, plus a reliquefaction plant) and medium-speed dual-fuel diesel engines (four MAN B&W8L32/40 models) driving alternators to supply current to electric motors could be prime candidates for the future. In addition, IZAR has been studying alternative cargo possibilities based on higher temperatures and increased pressures (between 15bar and 250bar) - somewhat similar to various compressed or pressurised proposals elsewhere.

From a range of new ship designs being examined by IZAR, the accompanying table gives outline details of a 200,000m^3 proposal. It shows the various propulsion options that would be possible.

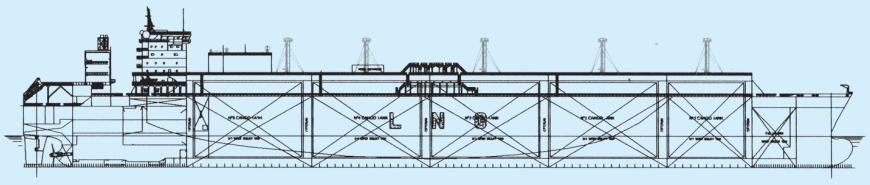


General arrangement plans of a proposed 200,000m^3 LNG carrier, drawn up by IZAR; various propulsion options are available. This Spanish shipbuilder also has new-generation designs ready for other sizes, ranging from 145,000m^3 up to 250,000m^3.

	Steam turbine	Slow-speed diesel	Dual-fuel diesel-electric
Length, oa	313m	313m	313m
Length, bp	300m	300m	300m
Breadth, moulded	50m	50m	50m
Depth, moulded	27m	27m	27m
Draught, design	12m	12m	12m
Speed, service	19.50knots	19.50knots	19.50knots
Cargo capacity	206,500m^3	207,000m^3	208,650m^3
Daily boil-off rate	0.13%	0.13%	0.13%
Propellers	1	2	1

Outline details of a proposed IZAR 200,000m^3 LNG carrier, with various propulsion options.

IZAR is also prepared for the largest size of LNG carrier currently being proposed - 250,000m^3. Various propulsion options are again possible: low-speed diesel engines plus reliquefaction plant (two propellers), gas turbo-electric (one propeller), and dual-fuel diesel-electric (one propeller).



More information on many technical aspects of the currently buoyant gas carrier sector can be found in the special supplement *Design and Operation of Gas Carriers*, which is published with this edition of *The Naval Architect*.

Promoting high standards at the Russian Maritime Register

TIMES are changing. For the shipbuilding industry of the former Soviet Union, the 1970s were prosperous. Many technically interesting vessels of different types were built to Russian Maritime Register (RS) class, among them such unique designs as nuclear icebreakers, research ships, manned submersibles and diving systems, and space-exploration support vessels. The result of the USSR dissolution was dramatic for the Soviet shipbuilding industry: the national fleet was divided among new states and privatised.

In lieu of 150 very large shipping companies existing in the USSR, around 2500 small owners came into being. The strategy of some was to derive profits immediately, and as a result funds allocated for maritime safety were diminished - in times of the USSR, most RS-class vessels were flying the well-recognised red national flag.

During the 1990s, RS started active cooperation with maritime administrations who paid much attention to ensuring the safety of vessels flying their flags. Thus, today RS has classed vessels flying the flags of more than 40 states, statutory surveys are performed on behalf of the maritime administrations of 42 countries, and the network of RS representatives has been considerably extended all over the world.

Now, the emphasis of RS activities is focused on eliminating substandard tonnage and implementing tighter requirements for vessels in service as part of a joint effort by international institutions such as IMO and the EC Transport Committee, maritime administrations, as well as owners, classification societies, underwriters, and shipbuilders to ensure high technical standards and safe navigation. RS has initiated a series of seminars entitled 'Substandard Shipping: Solution through Partnership', where all members of the industry can discuss ways to eliminating sub-standard shipping. The seventh seminar will be held on October 7-8, 2004 in St Petersburg, where the new goal-based standard concept will be discussed, so that the society can help support Russian designers, shipbuilders, and owners in achieving these high standards.

In recent years, RS has developed requirements for mobile offshore drilling units and fixed offshore platforms to support the industry's needs, as discussed in our May 2004 issue, page 50. So when intensive development of the Russian shelf fields commenced (such as Piltun-Astokhskoye, Lunskoye, Shtokmanovskoye, Prirazlomnoye, and others), the society was ready to deal with the whole range of subjects for oil and gas field development. RS has now been assigned by the Russian Federal government as the chief organisation for approval of design, conducting survey of the construction and operation of fixed offshore platforms, as well as of the manufacture of materials and products used for their construction.

New monitors for platforms operating in ice

Requirements for the classification of marine cargo terminals and marine floating oil storage units have already been developed. Bearing in mind that some gas and oil recovery units will be of the tension-leg platform (TLP) design, calculations have been made for this concept, and the hull shapes of TLPs to operate in wave and ice conditions have been developed. For the purpose of continuous control of ice-resistant platforms under the combined effect of ice, waves, wind, and seismic factors, it is planned to develop RS requirements for the structure of and basic parameters of a monitoring system. The society has worked out the requirements for classification and construction of the necessary mooring lines.

Being conscious of its duty to promote the highest standards of safety at sea, RS carries out intensive scientific research intended to further improvement of its technical and other bases. The results of this work are reflected in a reduced number of class-related port state detentions of RS-classed vessels and the society's removal from the penalty system of the US Coast Guard scoring matrix. RS has also developed a programme to help flag states improve their performance, one result of which has been the removal of the Russian Federation from the 'black list' of the Paris MOU port state control regime.

RS supported the IACS Council decision to develop IACS common rules, which are first being developed for tankers and bulk carrier hulls; the society is a member of the Joint Bulk Carrier Project. Members of the tanker and bulker groups shared chapters which they were to draft - RS was charged with ensuring interrelation of chapters developed by the JBP group members. Despite satisfactory completion of this, Nikolay A Reshetov, director-general of the Russian Maritime Register, says 'RS should first of all place more stringent requirements upon its own work'. In pursuit of this, in 2003 RS invited Stockholm Schools of Economics to carry out an independent customer satisfaction survey. This concluded that the 'satisfaction index' was 79 out of 100 points, and loyalty index, 82.

New contracts for ship communication system

OVER the past three years Ulstein Elektro's system and service department has sold more than 20 complete systems and a few component systems of Ulstein COM, a communications concept developed for ships; despite the fact that this system has barely been marketed.

A fully-integrated communications system, Ulstein COM receives signals from data, telecommunications, TV, and radio which reach the ship, gathers them in one central system and distributes the signals to the cabins and other areas on the ships via a cable.

Layouts are tailored to each ship and customers can choose between various options depending on how much needs to be included. A great many of the units include satellite TV as an integral part of the system. The advantage of collating all the signals is that they are all in one unit, and all the cabling between the equipment is already installed. Only one start-up is needed for all these subsystems. Ulstein COM is oriented towards the future with communication carriers which are always connected via IP-based VSAT satellite systems.

Ulstein Elektro believes that this unit integrates various systems in a way that no other supplier has on ships before. This solution allows, for example, a chief engineer to sit in his cabin and receive pictures from the engineroom monitors on his PC screen, coordinate them in a report and send it via e-mail to the owner on land. The total concept reduces the number of cables onboard a ship, which simplifies the installation phase. One also has data outlets in all cabins and offices on the ship in a very flexible solution. Should the ship owner later on wish to expand the system with, for example, a wireless data network or a wireless alarm system, it will be easy to arrange.

Complete Ulstein COM systems were first delivered in 2001 and installed in *Normand Cutter* and *Normand Clipper*. The units have been in operation on these vessels for three years without any kind of problems. The systems have now also been installed in new builds at Ulstein Verft and Havyard, and are under installation in several other yards such as Aker Langsten. More than 20 ships now now have Ulstein COM from Ulstein Elektro installed.

In May a contract was signed with the coastal express line OVDS regarding the replacement of the internal communications systems on three coastal express ships and substituting them with technology from some of the subsystems that form part of Ulstein COM. Recently the first export contract was entered into, and will be delivered to an offshore ship which is under construction in Brazil.

Bulk carrier safety at MSC 78

A NUMBER of safety measures for bulk carriers were finally decided upon at the 78th session of the International Maritime Organisation's (IMO) Maritime Safety Committee (MSC 78) held from May 12-21 in London. Most of these issues were an outcome of the Formal Safety Assessment (FSA) studies, which had been presented to MSC 76 in December 2002.

At that time many new measures had been agreed upon in principle, and a number of sub-committees had been tasked to develop new, or amended, regulation texts to encompass these measures. The most contentious of these new issues was the mandate of double side-skins (DSS) for new bulk carriers over 150m in length.

Prior to MSC 78, Greece had submitted a paper containing a critical review of these FSA studies, on which the decision to mandate DSS had been based. The Greek study highlighted, amongst other things, the different statistics and other data used in the various studies leading to very different results. According to the Greek review, the DSS was far from being cost efficient, as indicated by the FSA studies.

BIMCO's Marine Committee discussed the issue intensely at a meeting on 16 April and recommended to the Executive Committee not to support the mandating of DSS at this point in time. The main arguments for this stance were the unresolved differences between the various FSA studies and the Greek critical review and the fact that while the existing single side-skin (SSS) bulk carrier is a very well regulated ship today, there are literally no unified rules for DSS designs, scantlings or inspections, hence a mandate against a set of unknown rules is like writing a blank cheque. The decision of the Marine Committee was unanimously endorsed by both the Executive Committee and later by the Board of Directors.

A paper on the BIMCO position, and the rationale for it, was sent to a large number of IMO delegates expected to attend MSC 78. The discussion in IMO took place in plenary where a number of papers were presented after which a large number of delegations, including the BIMCO one, made interventions. As the plenary was almost equally divided, with a slight majority towards not mandating, the chairman felt obliged to call for a vote. The vote was 22 for the mandate, 32 against the mandate, and 15 abstentions. According to the rules of IMO, a simple majority of the votes would be decisive, hence the mandate was revoked.

The UK, which was leading one of the FSA studies showing the DSS to be cost efficient, later announced that it would reserve its position on the issue, but in reality this will have no real effect. It was merely a way of indicating dissatisfaction with the decision.

It was also proposed that the issue of DSS vs SSS is taken up under the agenda item 'Goal Based Standards' which will be allocated a working group at MSC 79 in December. Some delegations, however, felt that it would be a bad idea to use such a sensitive issue as a test case for this new concept. Whether a delegation will bring the issue up again once the various DSS rules are in place so that the DSS rules can be tested against the SSS rules, remains to be seen.

Other business

Other amendments to SOLAS Chapter XII, including design requirements for DSS bulk carriers, a ban on alternate hold loading for older bulk carriers, and mandating stability loading computers for bulk carriers under 150m in length, were agreed and will be subject to final adoption by MSC 79 in December 2004. These proposed measures had also been endorsed by BIMCO's Marine Committee.

Finally, a number of MSC/Circulars were agreed, amongst others on 'Standards and Criteria for Side Structures' for SSS bulk carriers, 'Inspection and Maintenance of Hatch Covers', and 'Longitudinal Strength of Bulk Carriers During Loading/Unloading'. The International Association of Classification Societies (IACS) and the industry were encouraged to develop draft performance standards for protective coatings in DSS spaces. This work has commenced. The work on common rules for DSS bulk carriers has also commenced within IACS. BIMCO and other industry associations have been invited to participate in this work, which is planned to be completed by the end of 2004. The dates of the first meeting have yet to be settled.

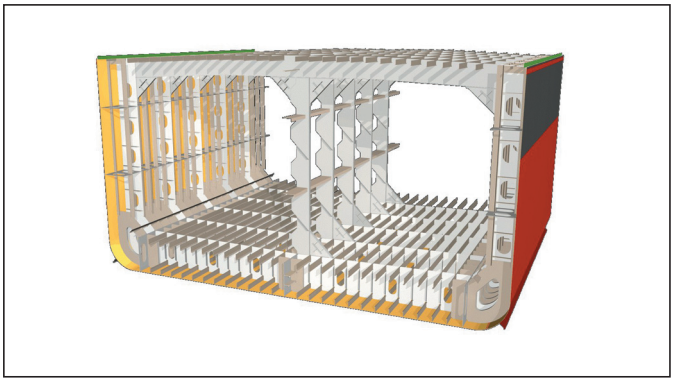
This report is compiled in association with BIMCO (the Baltic and International Maritime Council). See also the report on the IACS joint bulk carrier project on page 156.

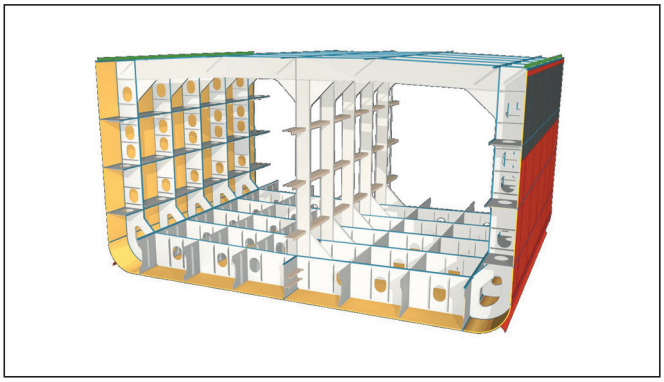
Guidance for ballast-tank inert-gas systems

AN important step forward in tanker operation safety has been taken by the classification society ABS with the publication of technical guidance for inert-gas systems for ballast tanks. ABS is believed to be the first society to set such standards - which, if used, will lead to the class notation IGS-Ballast - and to offer a notation for complying with design criteria and procedures for inerting ballast tanks on double-hull tankers.

The timely introduction of the *Guide For inert Gas System for Ballast Tanks* addresses industry concerns regarding the potential leakage of volatile gases from oil cargo tanks into ballast or void spaces - readers may recall a number of spectacular explosions in the early 1970s on large tankers resulting from gas in empty cargo tanks prior to the introduction of the inerting concept. Concern over explosions has been further heightened as double-hull tanker configurations become the standard with mandated phase-in by 2010. Leakage of oil into the double-hull ballast space for tankers, even from minor cracking or corrosion pitting, can lead to volatile gas build-up in these spaces. Installation of an appropriate inert-gas system reduces oxygen levels, thus reducing the atmospheric conditions that could lead to risk of explosion.

In our July/August edition (page 9), the incorrect illustration of a tanker cross-section was published to show the possibilities of Intelligent Engineering's composite Sandwich Plate System (SPS) in new ship construction. The benefits of this novel technology are re-illustrated here to reveal the much simplified structural arrangement that is possible when designing a tanker using the SPS system. On the left is seen a traditional steel cross-section, while to the right is the layout when using an SPS elastomer core sandwiched between two steel plates. Additional benefits include increased fatigue resistance, reduced in-service corrosion, and lower through-life costs.





Setting new standards in minimising air resistance

GREAT efforts are being made by design offices of major shipbuilders, both in the Far East and in Europe, to minimise air resistance of new hulls with large superstructures - typically car carriers and similar vessels. This follows on from efforts to design bow forms with more efficient (less pronounced) flare to improve seakeeping, as exhorted by Markku Kanerva, from the Finnish consultant Deltamarin, and others.

Today, much more effort is being put into the aerodynamics of ships, particularly car and vehicle carriers - a sector of the market that is currently enjoying a mini-boom; these vessels can generate a considerable amount of wind resistance. Typical examples of improved designs can be seen in car carriers designed and built in Japan, also by the Gdynia Shipyard in Poland, in the special combined forest products carrier *Jaeger Arrow*, from Hyundai Mipo Dockyard (*Significant Ships of 2001*), and some of the small vessels in the E H Harms fleet.

A good example is Mitsui OSK Lines' *Courageous Ace*, presented in *Significant Ships of 2003*, which featured a specially rounded and bevelled bow form. Unique 'wind channels' were introduced along the sides of the superstructure at the top of the garage deck to help maintain a straight course. The builder, Minami-Nippon, claims a 20% reduction in aerodynamic pressure in winds of 15m/sec, which can be translated in a 4% improvement in fuel efficiency and a 6% benefit in minimising leeway. As a result of all this, a speed increase of 1knot is claimed. *Courageous Ace's* design was created in association with Universal Shipbuilding (the new union of Hitachi and NKK).

With figures such as these, it is not surprising that yards such as Gdynia Shipyard have put much effort into refining superstructures on two recent series of car carriers delivered to Ray Shipping in 2002 and 2003.

Gdynia is continuing to work further to refine its special features for such vessels and to make other alterations and additions; some of the already realised features include the transfer of weather deck ventilation fans to inside the superstructure.

Gdynia claims that due to improved sea-keeping, better course stability and decreased air resistance, the sustained sea speed of its ships has been substantially improved. On the other hand, Gdynia designers and their CTO scientific advisers attribute to air resistance improvement less contribution than Minami-Nippon. Whatever the truth, it could perhaps be said that new standards are being set for the design of both the bow and upper works for car/vehicle carriers.

These views, captured by FotoFlite in the English Channel, of two recent Gdynia Shipyard-built vehicle carriers for Ray Shipping - the 6600-car-capacity *Hual Africa* and the 5000-car capacity *Global Leader* - illustrate the much improved bow waves from more efficient designs, also the carefully refined superstructures at the forward end to minimise air resistance. In addition, course-keeping on *Global Leader* has been enhanced on the short length/breadth ratio hull by an elongated and symmetrical transom and by fitting special Gdynia-designed fins at the stern, as illustrated in T*he Naval Architect*, July/August 2003, page 54.

New engine meets environmental legislation

SINCE October 2001 Daihatsu has manufactured a medium-speed compact DC-17 engine with one of the smallest output ranges - with a cylinder diameter of 170mm - among marine engines using heavy fuel oil. Now the company has also developed a large DC series, the DC-32. All engines in the DK series meet stringent environmental regulations.

Developed as a large DC series model and built only with eight cylinders in-line, the DC-32 incorporates experiences gained in developing the DK engine. The compression ratio is claimed to be the highest of any engine in this class, and the piston combustion chamber is shaped optimally for heavy fuel oil combustion, using a highly efficient supercharger. These features ensure stable low-load combustion of heavy fuel oil. The main market is seen as auxiliary use, to drive alternators.

By incorporating an optimal intake port shape, a fuel injection pump with high injection pressure, and a non-cooled fuel nozzle, Daihatsu has achieved low fuel consumption, matching these features to the most suitable conditions. The DC-32 meets increasingly strict environmental regulations by using a shape enabling clean combustion based on an analysis of the combustion chamber. Taking into account operability in projected maintenance, this engine enables the power unit - cylinder head, cylinder liner, piston, and connecting rod - to be opened up in one operation.

To make engine handling easier and reduce exhaust emission performance, control devices such as electronic monitoring in the engine, an electronic governor, and an electronic fuel oil injection device have also been introduced.

ENGINE MODEL	8DC-32
Number of cylinders	8
Cylinder bore x piston stoke (mm)	320 x 400
Stroke/bore ratio	1.25
Engine speed (min-1)	720 | 750
Piston speed (m/sec)	9.6 | 10.0
Engine output (kWm)	3600
Break mean effective pressure (MPa)	2.33 | 2.24
Fuel oil 50°C	Up to 700mm^2/sec @
	(CIMAC H55)
Engine dry mass (kg)	40,000
Air cooler	2-stage (air heating

Using two fresh-water cooling systems, a cooler and a jacket for engine cooling, jacket cooling water remains at a constant high temperature. For the air cooler, there is a two-stage cooling in which high-temperature jacket-cooling fresh water and low-temperature fresh water flow through a cooler system. Air is heated automatically to ensure stable heavy oil combustion at low load.

A review has also taken place of the channel configuration and engine lubrication, and Daihatsu has now arranged the pump, cooler, and other auxiliary machinery in the front of the engine to guard against component malfunction.

There is also a reduction in the amount of piping and components. Advanced structural analysis has been introduced via new software for major operating sections and components. The company plans to confirm quality through continuous engine endurance tests.

The first of these engines are being installed in a 8100TEU containership building at IHI Kure Shipyard for K-Line. A total of 16 engines will be installed in four ships in the latter half of next year to drive alternators. At present Daihatsu has no other orders for these engines, but has received numerous enquiries from shipyards about them.

First tankers equipped with oil recovery system

A PRE-INSTALLED fast oil recovery system for use in the event of a shipwreck is available from the JLMD Ecologic Group, (*The Naval Architect* September 2003, page 128). This system dramatically reduces the pollution resulting from damage to oil and chemical tankers, as well as large fuel tankers. On September 15, 2004, in Daewoo Shipbuilding & Marine Engineering (DSME) Shipyard, on Koje Island (Geoje), South Korea, the Italian shipowner Navigazione Montanari (TAMOIL) held an official christening ceremony for *Valtamed*, the first oil tanker equipped with the JLMD system.

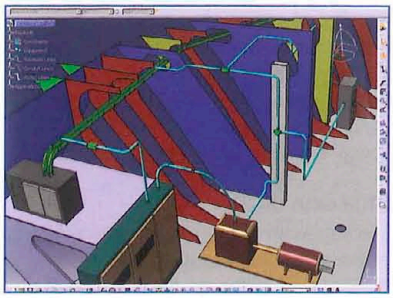
A second christening will be held in mid-October in Tahiti, by the French shipowner Socatra, and two additional tankers are currently under construction. By the end of 2004, four ships equipped with the JLMD system will be sailing international waters. In addition, another 30 ships are awaiting the installation of their JLMD systems. Some 50 ships, primarily operated by Asian shipping agents, currently have orders pending.

The Royal Institution of Naval Architects

EUROPEAN SHIPBUILDING, REPAIR AND CONVERSION - THE FUTURE

2-3 November 2004, London, UK

Second Notice



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Over the past 30 years, the European shipbuilding, and repair conversion industry has seen substantial rationalisations, mergers and consolidation. While there has been a reduction in market share, the industry has enjoyed relatively greater success in the high added value specialist vessel, shiprepair and the marine equipment sector.

Against a background of increasing shipbuilding capacity in China and South Korea continuing arguments on shipbuilding subsidies, how can the European maritime manufacturing sector maintain and increase its market share? Through the "LeaderSHIP 2015" initiative, the European shipbuilding and shiprepair industry has defined a long term strategy to develop appropriate policies to strengthen the competitiveness and ensure sustainable growth of the industry. This strategy envisages a knowledge-based industry for both product and production process, concentrating on more complex vessels. Research, Design and Innovation (RDI) is a key factor in this strategy.

In order for the European shipbuilding, repair and conversion industry to maintain and improve its competitiveness, it is essential that it develops and employs the latest technologies in design, engineering and production. The *European Shipbuilding, Repair and Conversion - The Future* conference will provide an opportunity to examine the future needs for RDI, and to present current work in that and related sectors.

This conference will cover such areas as:
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Developing the next generation of class rules for oil tankers

In 2002, the American Bureau of Shipping (ABS), Det Norske Veritas (DNV) and Lloyd's Register (LR) agreed to initiate a major project to jointly develop a single set of classification rules for the hull structure of oil tankers. The objective of the project to develop common rules is to avoid possible competition on the minimum safety standards.
Since that decision, the three classification societies have been working to combine their expertise and experience in order to produce a common set of rules for oil tankers with a length greater than or equal to 150m. This article* outlines the philosophy adopted by the project, the project schedule and key technical aspects that are ready for reporting to industry. The article also outlines the relationship with IACS unified requirements and other initiatives within IACS and IMO.

ALTHOUGH the principal forum for cooperation between classification societies is the International Association of Classification Societies (IACS), a number of informal groupings have existed for many years where senior staff members meet to exchange views and to develop a common position. Informal discussion has been taking place between ABS, DNV and LR for over twenty years. More formal discussions were initiated with the issue of a joint statement in March 2001 by the chief executives of the three societies, which identified ten points where a unified response would be developed and implemented. The emphasis was on greater transparency, consistency of approach and improving the overall quality of the world fleet. The central theme was that classification societies should not compete on standards.

A number of joint task groups were established to work on the development of common basic design criteria, which included consideration of loads and structural analysis. Preliminary work was carried out in joint task groups, which established good working relationships between the three organisations. The progress was limited and it became very clear that to achieve the goal of the chief executives, which was that competition between the classification societies on structural standards would be eliminated, it would be necessary to develop and implement a single set of common rules for the design and construction of the hull structure. At this point of time, early in 2002, there was discussion within the maritime community on the need for increased robustness in ship design and construction, with the aim of reducing the problems for ship owners during the service life. It was, therefore, decided that in developing a new common set of rules for oil tankers there would be a deliberate effort to enhance robustness by design.

The rules will cover the hull structure for oil tankers with a length greater than or equal to 150m. The development process, whilst nearing completion, has not yet ended and it is not, therefore, possible to describe the final content of the new rules or the consequences of the implementation of the new rules.

Project organisation

The project was launched following a meeting between the three societies in January 2002. A Steering Group was established which early this year comprised the three authors of this paper. Although there have been some inevitable changes at this level, the current members of the Steering Group have been involved with the project throughout its existence. The Steering Group is fully responsible for the project, both in terms of technical direction and resource management.

This project represented a quantum step forward in terms of collaborative working between traditional competitors. It was also a major project involving, at various times, more than 50 technical specialists across three organisations. An early decision was taken that co-location of a project team was not feasible, and would in any case involve large costs of relocation. The project needed access to the best people available, some full time and others as the need for particular skills arose. A very flexible method of working has been established with the main centres of operation being, not surprisingly, Houston, Høvik, and London. Great use has also been made of the expertise that rests with the Plan Approval Centres in the Far East where most tankers are dealt with.

The project management arrangements have evolved as the project has progressed, to best suit the current position and needs. Initially, as the societies were learning to work together with a common aim, management rested with the Steering Group and the leaders of the major tasks. Later, a Project Management Group was set up, with considerable authority delegated from the Steering Group to make decisions and to manage resource issues in the interest of achieving the project goals.

To support the project a single electronic project library, with shared secure Internet access, was set up at the outset and this has proved indispensable. Furthermore, the task of preparing the final form of the published documents, the Rules and the background documentation has been centralised in a single location, in the interests of efficiency and control.

A key element within the project organisation has been the establishment of an External Review Group (ERG). Although the output, the draft set of Rules, will receive the usual scrutiny from the Technical Committees of ABS, DNV and LR, at the appropriate time, it was decided that it would be very beneficial to have a sounding board to advise the project and to comment on the proposed course of action at various stages during the development. This has, indeed, been extremely useful and further reference to the ERG is made later. The individual members of the ERG act in their individual capacity, relying on their own experience and expertise.

It is unlikely that a project of this nature, carried out by three competitors on this scale, has been attempted before. The organisational issues have been predictably challenging and the management of a large group of highly motivated technical experts has required both sensitivity and focus. The success of the project in terms of its achievements so far indicate that the project organisation, and the changes made based on experience and periodical review by the Steering Group, has been effective.

Relationship with IACS

The relationship with the other members of IACS has been an important consideration throughout the project. Although the project was conceived by ABS, DNV and LR independently from any discussions within IACS, the existence of the project has encouraged debate. Along with other initiatives, such as the debate within the Council and Maritime Safety Committee of IMO on the development of Goal Based Standards, the IACS position is now that the members of IACS will develop common rules for ship structures.

The initial intent of the project was that it would be completed independently of IACS but all current and forthcoming Unified Requirements, relevant to the structural design of oil tankers, would be incorporated into the new rules. The option of making the final rule set available to IACS, for possible wider adoption, was a likely outcome. The current IACS position has meant that the project has been offered to IACS, and accepted, as a pilot project in the development of IACS Common Structural Rules, which has found widespread endorsement across the industry.

ABS, DNV and LR have continued to support the development of IACS Unified Requirements within the Working Party structure, notably for double hull bulk carriers, following the decision taken by IMO MSC77 to mandate this form of construction.

IACS currently has two principal pilot projects - the Joint Tanker Project described in this paper and a Joint Bulker Project. Cooperation between the two projects is an absolute necessity if coherence across ship types is to be maintained at the outset, and ABS, DNV and LR are working actively with colleagues from other IACS societies to support the IACS initiative. At

* This article is extracted from the paper 'Developing the next generation of classification rules for oil tankers', by Jim Card, senior vice-president, technology, American Bureau of Shipping, Houston; Bjorn K Haugland, manager, maritime development centre, Det Norske Veritas, Oslo; and Vaughan Pomeroy, manager, research and development, Lloyd's Register, London, presented at The Royal Institution of Naval Architects conference on the Design and Operation of Double-Hull Tankers, held in London on February 25-26, 2004.

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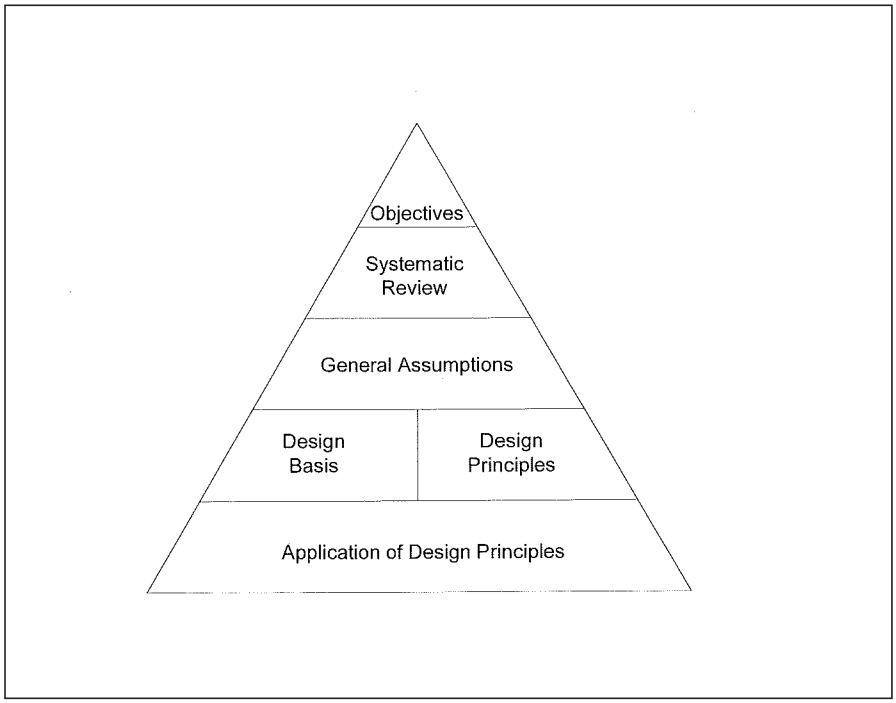


Fig 1. Framework for development.

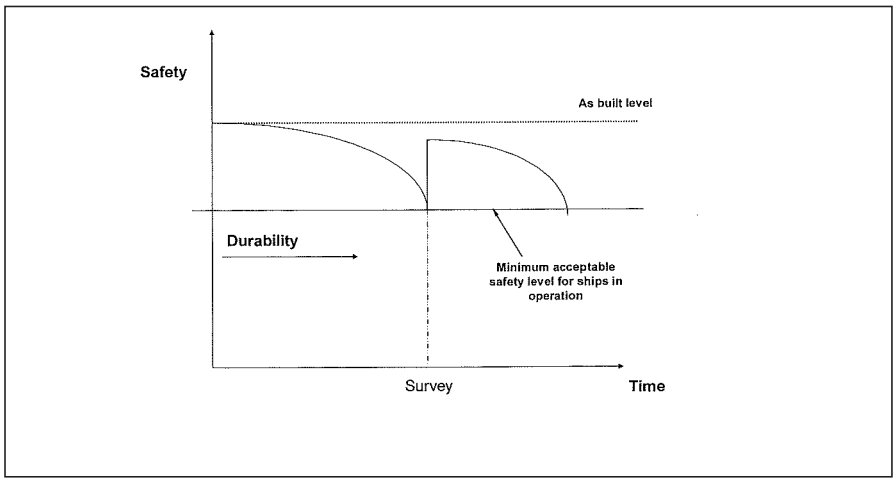


Fig 2. Durability through life.

the same time, progress on the project to develop common Rules for oil tankers in the time frame laid down at the start of the project has to be maintained.

Principles for development

Current classification society rules have evolved over many years and have been mainly developed on an empirical basis. As a consequence, the basis of the rules is not always transparent to the user. There have been many calls from the maritime industry for classification societies to adopt an approach which would lead to the development of rules that are more easily understood and based on clearly identifiable scientific principles.

Since the existing rules do not clearly state fundamental principles on which they are based, it is often not possible to relate all aspects of the structural requirements explicitly to the load and capacity models that are used in most modern structural design codes. Despite this, the service history and statistical records have demonstrated that ships constructed to the existing Rules are of a satisfactory standard. To meet the expectations of the maritime industry and to make use of best standards practice, it was decided by the project to develop a new set of rules that would provide, through transparency, a better understanding of the design principles underpinning them. This will benefit the shipping community, whilst ensuring through calibration that the experience gained over many years of successful ship design and operation was taken into account.

A very significant part of the total project has been invested in developing a documented statement of the principles, including design and operational assumptions, that were selected as the basis and used in the development of the rules. This work is quite fundamental to the entire project, and it has taken a great deal of effort involving most members of the project team from all three societies.

In setting out to define the project, a framework was established that sets out the relationship between the various elements within the development hierarchy, as illustrated in Fig 1. The objectives are set at the highest level. A systematic review determines the elements that should be considered, followed by setting out the general assumptions and then the design principles. This structure has been adhered to throughout the project and this ensures that the logical consistency and structure will be maintained. The concept follows closely the principles set down in the Formal Safety Assessment methodology that has been adopted by IMO for the development of regulations.

The primary benefits of developing and presenting the design principles in this way are:

- it gives a common platform for development of the specific requirements in the rules
- it ensures consistency throughout the Standard.
- It provides transparency in terms of scope and method for development
- it simplifies the process of extending the structural requirements to cover other ship types or to provide the basis for consideration of ships with non-standard structural configurations (novel designs)
- it provides the baseline from which to develop and refine the rules in a consistent and logical manner and hence leads to simplified Rule maintenance
- it permits identification of any gaps in the rules.

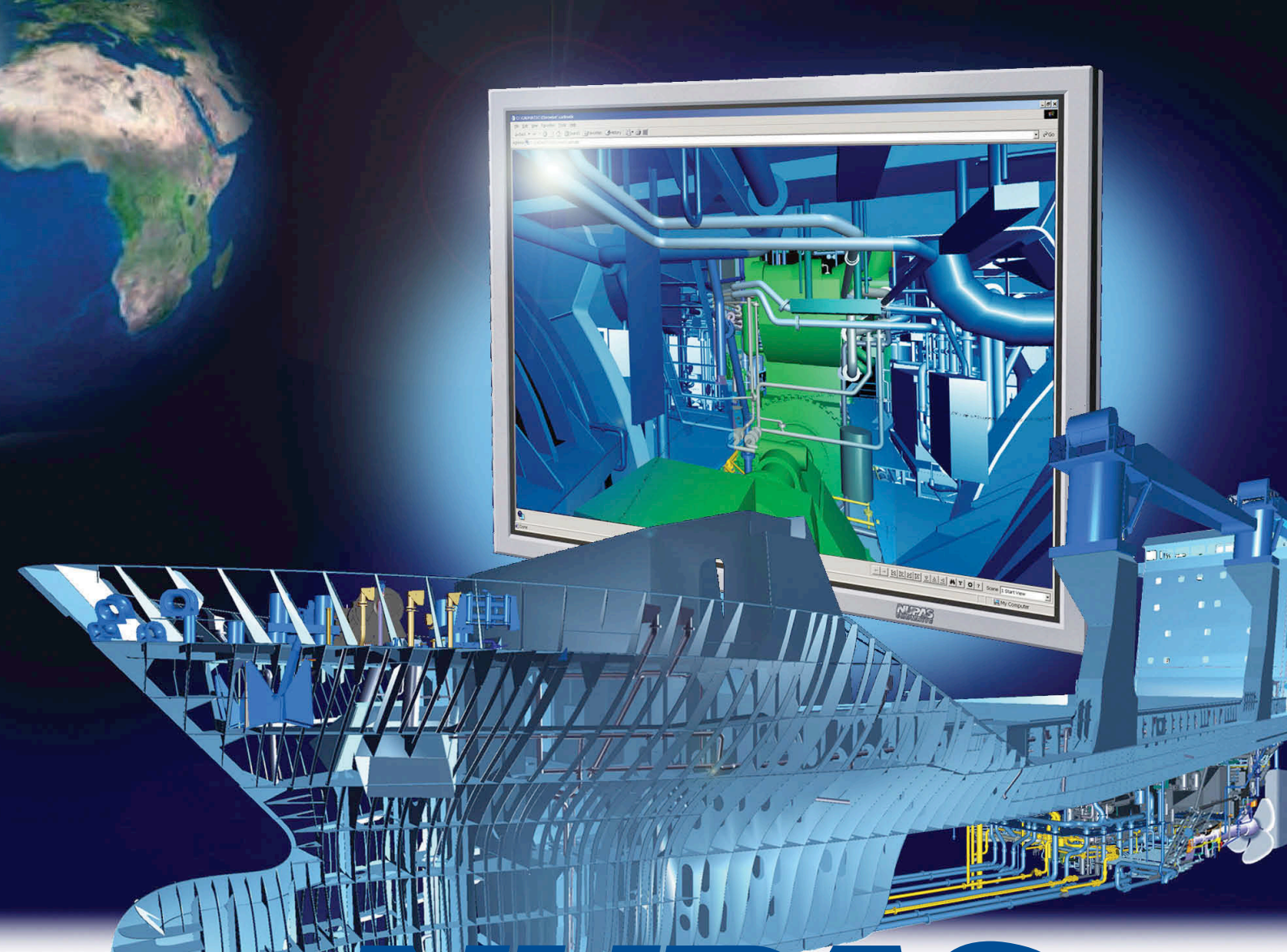
In the future, the clear statement and record of the underlying design principles will provide the basis for incorporating more rigorous reliability based techniques when these are developed to a suitable stage of maturity and fully calibrated. The development framework will also allow the incorporation of new knowledge in the future without a risk of losing the internal consistency and coherence of the rule set.

The intention of the new rules is to establish a consistent approach to the assessment of the ship structural system and its components. The approach presented is in a format in line with current structural design codes used in other industries. In particular, reference is made to ISO 2394 and EN 1990:2002. This approach enables a much more transparent design process to be adopted in that the failure modes can be more explicitly matched to the applied loads.

The intent of the 'Principles for Development' is to establish the basic principles used during the development of the rules. Although this is principally for use within the development project and subsequently in the continued development and maintenance of the rules some elements will be included, where appropriate, and other parts will form the basis of the published supporting background documents which will provide the user of the rules with an understanding of where the requirements come from and why they are there.

This high degree of structure within the development project has proved to be extremely challenging but the outcome is a solid basis for the development activity and an effective means of communication within the project teams that ensures consistency.

A very significant element of the project has been the stated aim of satisfying the call from industry for greater robustness in ship design. The project team has discussed the meaning of this call and concluded that the concerns



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principally refer to the issues of safety and longevity. Safety is associated with traditional classification strength requirements, whilst longevity refers to the period over which a ship retains the necessary minimum strength without significant repair or renewal of steel. The typical life pattern is shown in Fig 2 which shows the overall level of safety reducing with time as the effects of wastage and fatigue, the principal time dependent factors, take place. Life is then extended by repair and renewal as necessary at periodical survey intervals.

The aim of the project has been to develop, within the new rules, requirements that will satisfy safety issues and improve the longevity of ships by enhancing the requirements for fatigue life and wastage. Within the project this has been described as 'increased durability' or 'robustness.

Systematic review

The systematic review forms an essential part of the project in establishing the design principles within the development framework. The aim of the systematic review is to identify and evaluate the hazards to the ship structure and the corresponding consequences through a formalised process.

The development framework is then followed to ensure that appropriate risk control measures are included in the rules.

The systematic review is carried out in two principal stages. The hazards are identified by considering the 'ship in a system' for all phases of operation but limited to those affecting structural integrity, in its widest interpretation. The consequences are evaluated by considering the 'ship as a (structural) system' in terms of the impact on life, property and the environment should a failure occur, and as a result criticality ratings are assigned to each structural element.

The hazard management strategy is then determined, identifying those hazards that are to be controlled by the rule requirements and those that have to be managed by operating procedures.

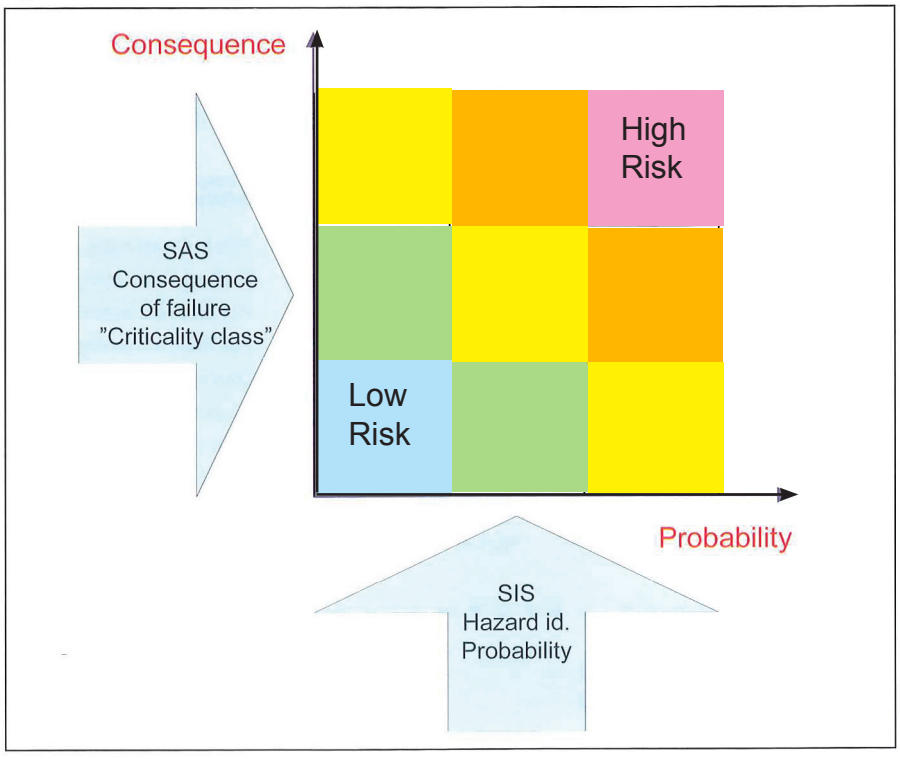
The hazards were identified during facilitated workshops with experts from a variety of backgrounds. The input from the ERG members was particularly valuable. Input was also provided by staff members, outside the project, from ABS, DNV and LR. Results from the workshops are recorded in a database. At this stage, it is not necessary to identify the root cause of each hazard or the sequence of events that could lead to the hazard, only that there could be structural consequences. Hazards are considered as single events and, consequently, event tree analyses are not considered explicitly.

The next stage is to consider the hazards and to evaluate the consequences of failure for each structural element of the ship. In each case, the basis for possible control through acceptance criteria and capacity models is determined. The structural hierarchy of a typical double-hull tanker is utilised. For each structural element the possible consequences of structural failure are identified and a criticality class is assigned relating to the consequences with respect to life, property and environment. A method was developed to derive a combined criticality class. The approach adopted by the project is shown in Fig 3. Based on the assessment of criticality determined by the systematic review the means for controlling hazards is determined and documented in the design principles reference for later use in the rule development process.

Loads

In order to make a significant improvement in the transparency and internal consistency of the new rules, the definition of loads will be

Fig 3. Critical hazard management matrix.



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included in a general section . The other areas within the rules and associated procedures will refer to this section and define how the loads are applied in the particular application. By adopting this approach, the user of the new rules should be in no doubt about the origin of the loads or what the loads represent.

The dynamic loads cover normal service loads, at 10-8 probability level, and more extreme hull girder loads for ultimate strength in the intact condition. Extreme loads on localised structure and accidental conditions, such as flooding, are not included although the modular approach that has been adopted lends itself to including other load cases, or introducing new information, at a later stage relatively easily.

Rule design wave loads are based on the existing IACS Unified Requirements where possible or derived using the wave statistics of the North Atlantic sea area specified in IACS Recommendation 34. First principles hydrodynamic calculation methods were used to derive the design loads and an equal probability was assumed for all headings.

The new rules contain formulations for ship motions accelerations, external and internal pressures and global vertical and horizontal wave bending moments and shear forces. The load formulations have been validated by comparison of the formulae with the results from direct calculations.

In determining the dynamic load cases for both the prescriptive rule requirements and for finite element analysis the conditions for obtaining the most onerous structural response are established based on maximising primary load components for a 25-year return period. The simultaneously occurring secondary loads are accounted for by using load combination factors, which have been determined using the equivalent design wave approach. The loads are applied to a number of fully loaded and partially loaded conditions in addition to the ballast condition.

For fatigue assessment the loads are used to calculate the expected stress range history based on a suitable distribution function. A number of assumptions are made, such as a forward speed of 75% of the declared service speed. The reference load value used is at the 10^{-4} probability level of the Weibull long-term probability distribution.

The loads associated with sloshing and bow impact are determined using existing approaches used by the three societies. Following evaluation of the various methods in use and experience gained in their application the project selected the best solution for adoption.

Net thickness approach and wastage allowance

A net thickness philosophy has been adopted for the new rules, which provides a direct link between the thickness that is used for strength calculations during the design stage and the minimum steel thickness accepted during the operational life of the ship. The strength calculations performed during the design stage are based on net scantlings. Newbuilding gross scantling requirements are calculated by the addition of an allowance for the expected wastage during the design life of vessel to the required net scantlings determined in accordance with the rule requirements.

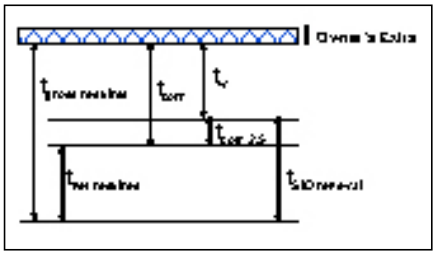


Fig 4. Net thickness methodology.

The relationship between the various thicknesses is shown in Fig 4 and is summarised as follows:

- the minimum required net thickness is the $t_{net\ required}$ value.
- the new building thickness $t_{gr\ required}$ is given by adding the required corrosion addition (t_{corr}) to the net thickness ($t_{net\ required}$), i.e. $t_{gr\ required} = t_{net\ required} + t_{corr}$
- the permissible wastage allowance (t_{waste}) is obtained by subtracting a small thickness ($t_{corr\_2.5}$), which is the corrosion anticipated/predicted to occur in the 2½ years between surveys, from the corrosion addition, i.e. $t_{waste} = t_{corr} - t_{corr\_2.5}$

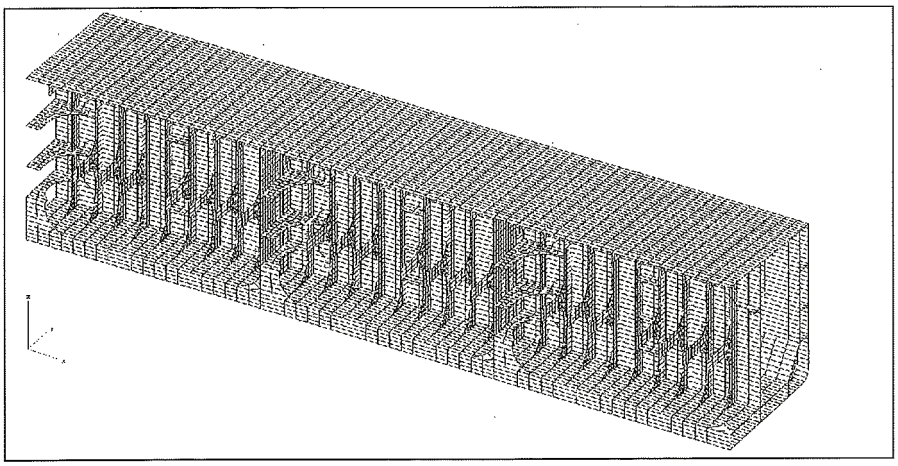


Fig 5. Typical FE model of the cargo tank region.

- thickness at which renewal is required is given by subtracting the wastage allowance from the gross as built thickness to obtain the $t_{renewal}$ value, i.e. $t_{renewal} = t_{gr\ required} - t_{waste}$

The approach adopted in the new rules is based on calculating a minimum allowable thickness that satisfies the requirement for strength, t_{net} required, and then adding a corrosion addition, $t_{corr.}$ to obtain the minimum allowable gross thickness, t_{gr} required. The proposed thickness, t_{gr} offered must then be greater than or equal to the rule required gross thickness, t_{gr} required. Owners may specify an extra addition and this should be deducted prior to comparison of offered thickness with the calculated required value. The actual values for t_{cor} and t_{waste} are based on data collected from thickness measurements on ships in service and represent a reflection of service experience into the new rules. The data source used in determining these values is that considered by IACS when investigating a net thickness approach, which consists of comprehensive thickness measurements from all IACS member societies.

The net thickness philosophy distinguishes between local and global corrosion/wastage. As the hull girder cross section does not corrode/waste uniformly, the reduction of the hull girder sectional properties will at any given time be less than the sum of the allowable local wastage allowance for members contributing to the longitudinal strength. The philosophy adopted by the project takes this into account by using different thickness deductions for calculation of the global hull girder section properties and for local elements. Both the global and local criteria will then need to be monitored during the ship in operation phase. During the ship life. local wastage should not exceed the value of the permissible wastage allowance, t_{waste}, and reduction in hull girder section modulus and shear area should not exceed the permissible global values.

The permissible average corrosion for larger structural areas will be less than the maximum corrosion permitted for local structural elements. When conducting finite element analysis and other assessments the effect of corrosion allowances is taken into account by appropriate scantling margins.

Finite-element analysis

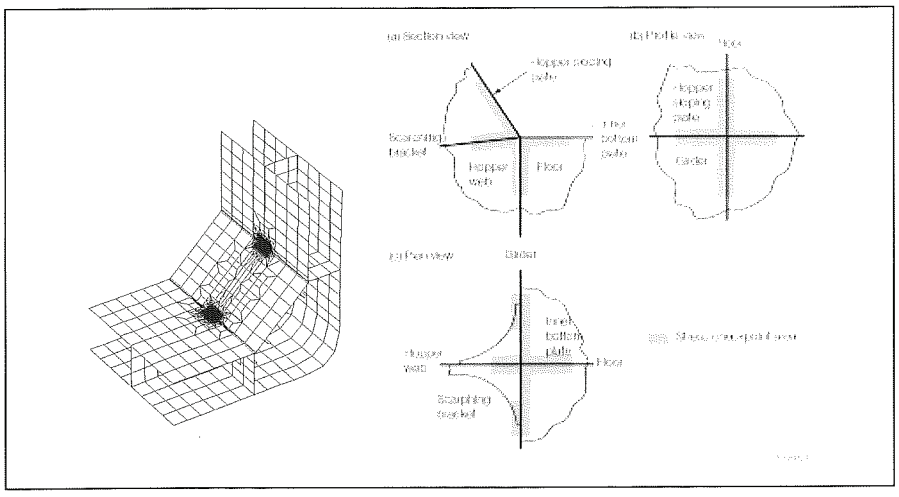
An assessment of the hull structure within the cargo region using finite element analysis is mandatory. The objective of the structural assessment is to verify that the stress level, deflection and buckling capability of the main supporting hull structures are within the acceptable limits under the applied static and quasi-dynamic loads.

The structural assessment is to be based on a three-dimensional finite-element analysis modelled in accordance with the procedure laid down in the rules. The analysis is to cover at least the hull structure of the midship cargo tank region. The minimum extent of the finite-element model is to cover three cargo tanks. If the cargo tank structure in the after and forward tank(s) is significantly different from the tanks under consideration, then additional analysis using an extended or additional FE model is to be carried out. A typical cargo tank finite-element model is shown in Fig 5. A full breadth model is required to capture non-symmetrical structure and loading.

In general, any recognized finite-element computation program may be employed provided that the combined effects of bending, shear, axial and torsional deformations are adequately considered. If the computer programs employed are not recognized by ABS, DNV or LR as appropriate, full particulars of the computer program, including calculation output, will require to be submitted for approval.

The use of finite-element analysis in connection with the evaluation of the design fatigue life of selected structural details is outlined in the next section.

Fig 6. Finite-element analysis of hopper knuckle.



Fatigue assessment

In recent years classification societies, including ABS, DNV and LR, have introduced fatigue assessment requirements in order to improve the fatigue life of critical details by providing attention to construction details at the design stage. Additionally, improvements in the fatigue life have been gained by limiting the use of higher tensile steel. Although the individual classification society approaches may differ the overall aim and the basic theoretical methodology have been the same. The new rules include a mandatory set of requirements for fatigue assessment that will replace the various approaches developed by ABS, DNV and LR that deal with similar issues. Of course, there will remain a number of areas where additional assessment may be required by owners or charterers beyond the rule requirements. The scope of the new rules includes all construction details currently covered within the classification requirements of ABS, DNV and LR.

The procedure set out in the rules provides a simplified approach to fatigue strength assessment, which may be used for certain structural details. The term 'simplified approach' is used here to distinguish this approach from the more elaborate analysis, such as spectral fatigue analysis, rather than a less rigorous methodology.

The fatigue assessment procedure within the rules is based on the following principal assumptions:

- S-N curve approach
- a linear cumulative damage model, based on the Palmgren-Miner summation method
- the use of cyclic stresses derived from the application of the specified loads

- the effects of mean stress are included
- the design fatigue life of the vessel is taken to be 25 years
- the long-term stress ranges of a structural detail are represented using a modified Weibull probability distribution
- long-term environmental data for the North Atlantic Ocean (based on the IACS Wave Data models) is used

There is a fundamental assumption that the quality of workmanship is in accordance with commercial marine construction standards that are acceptable to and verified by the attending surveyor. The rules will include requirements for detail configurations.

The procedure is specifically developed to evaluate the design fatigue life of tanker structural details that are known from experience to be potentially vulnerable to fatigue damage. The simplified fatigue assessment procedure is applicable to the evaluation of the design fatigue life of:

- all longitudinal stiffener end connections in the cargo tanks and associated ballast spaces using a nominal stress approach.
- for other critical details, such as the hopper knuckle joint, using finite element-based hot spot stress approach, as shown in Fig 6.

A structural detail classification based on the construction detail, joint geometry and consideration of the applied loading, such as illustrated in Fig 7, will be given in an appendix within the new rules. Where the loading or geometry is too complex for a simple classification, a finite-element analysis of the detail is to be carried out to determine the hot-spot stress at that detail. Guidance on the finite-element analysis required to determine the hot-spot stress at the weld is included in the new Rules.

Fig 7. Typical structural detail classification.

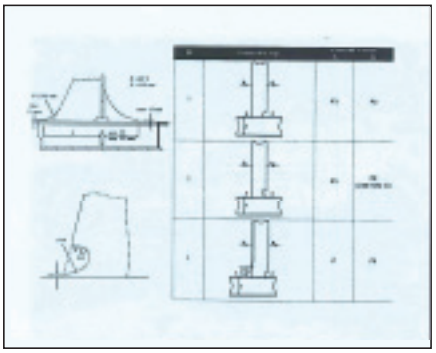
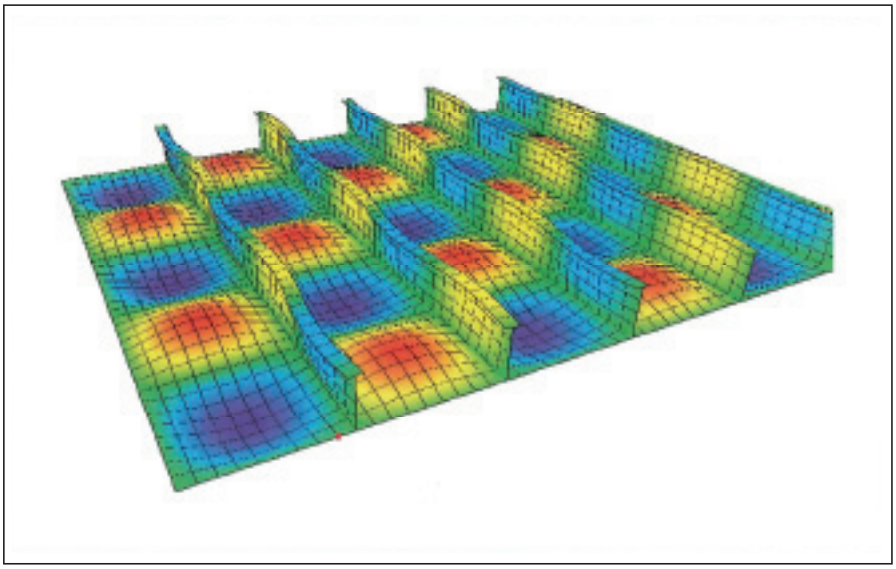


Fig 8. Typical buckling assessment using PULS.



Buckling

The new rules will contain simplified formulae to check buckling capacity of panels and main supporting members as a screening tool. If further buckling assessment is required, a general and local panel ultimate buckling strength evaluation assessment procedure, Panel Ultimate Limit Strength (PULS), is used to assess the capacity of panels and main supporting members. Practical guidance on the application of PULS in order to assess the structure is included, covering modelling of structural elements, application of loads, and boundary conditions for the different structural elements so that applications are kept within the limits of the theory upon which PULS is based.

While the application of PULS will in most cases be carried out using specific software tools, the basic theory behind the method will be presented so that users may understand the full background and development of the method. Alternative methods for buckling assessment are addressed and may be accepted as evidence of satisfactory buckling strength.

Hull girder strength and ultimate limit state

The prescriptive requirements include Rules for determining the longitudinal strength, based on the well established IACS Unified Requirements. Since these are based on gross scantlings some changes are inevitable because of the use of a net scantling approach within the new rules. For instance, the rule value of the hull girder moment of inertia is equal to 90% of the requirement set out in IACS URS11.

The new rules will also include a simplified Hull Girder Ultimate Limit State (H-ULS) assessment procedure in order to ensure that the hull girder has sufficient strength. The H-ULS procedure, currently under review by ABS, DNV and LR, is the same as the procedure currently under review by the IACS Working Party/Strength. This simplified assessment is not intended to replicate a complete extensive Hull Girder ULS assessment where the full load and capacity curves for the hull girder are developed, typically using non-linear approaches.

The simplified assessment procedure will only consider the sagging condition, which is the limiting case for oil tankers. Hull girder shear loads are neglected. The Rule requirement will take the form of a partial safety factor equation as follows:

$$\gamma S \cdot MS + \gamma W \cdot MW \leq MU / \gamma m$$

which is supported by details of characteristicvalues and defined partial safety factors.

The simplified assessment procedure for assessing the hull girder capacity in sagging uses a two-step approach with loading applied until failure of the deck and then until failure in tension of the bottom structure. The procedure is not dependent on any particular modelling method.

Prescriptive rules

The major portion of the rules will cover the prescriptive requirements, and include requirements for global longitudinal strength as well as local requirements for the hull envelope, transverse and longitudinal bulkheads and other primary supporting members. The prescriptive requirements will cover the entire ship, including the fore and aft ends of the vessel, to ensure consistency throughout the structure. The general rule format will provide greater transparency and ease of use than in typical class rules of today. The prescriptive requirements will incorporate all applicable IACS Unified Requirements, although these will be redrafted to reflect the net thickness approach.

The basic premise is that modern oil tanker design generally results in acceptable in-service experience. In other words, the required scantlings obtained through application of current rules are not deficient. The new requirements will provide a ship structure that will be recognized by the marine industry as being at least as robust as would have been required by any of the current rules of ABS, DNV and LR, although in some aspects the scantlings may be lighter than those required by one or more of the current Rules, due to a redistribution of steel that will achieve a more effective structure.

The assessment of design loads and capacity models are generally to be based on 'first principles' with corresponding acceptance criteria. The criteria will take into consideration the criticality class of each structural component as well as the uncertainties in the physical models for load and response. Other evidence, such as service experience and industry best practice, is also considered during the rule development process.

The new prescriptive rules are being formulated on the basis of net scantlings, which link to the Ship in Operation minimum scantling requirements and the corrosion values for rule scantling determination.

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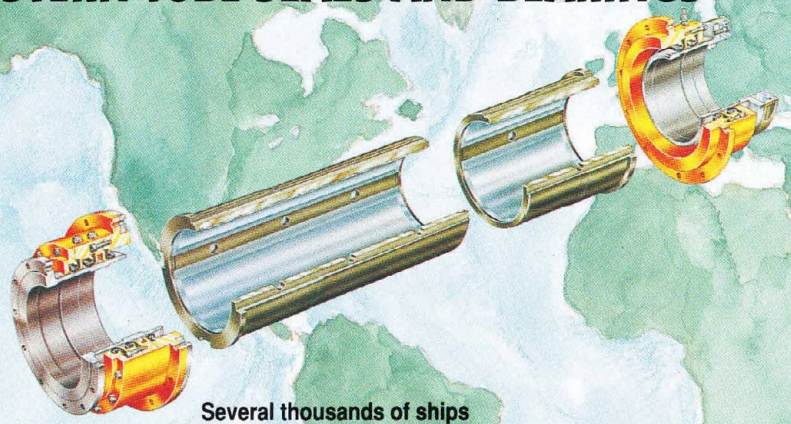

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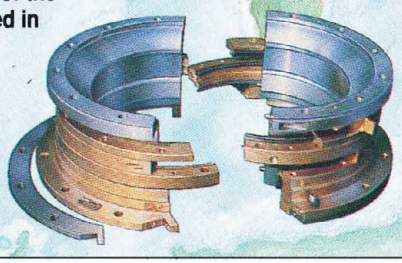

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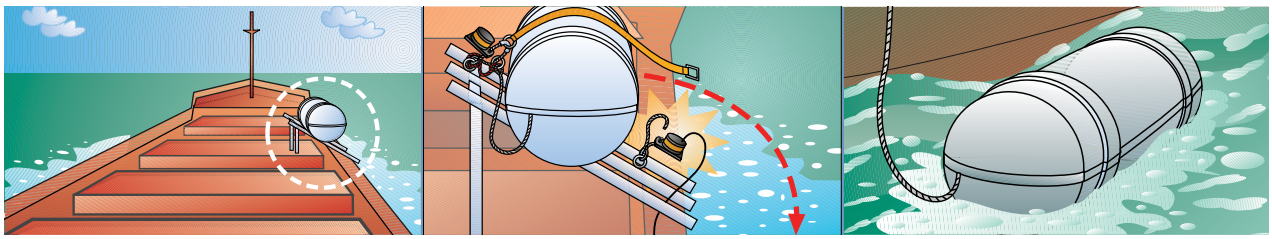

The Hammar remote release systems are designed to release heavy loads, such as liferafts or other objects, with little effort on all kinds of vessels. Two remote release systems are available:

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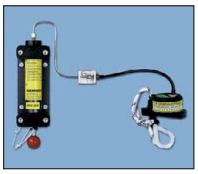
The Hammar manual remote release system (MRRS) is operated manually by means of a vacuum pump. The vacuum is conveyed via stainless steel tubing to a Hammar H20 remote release unit. When the unit is activated a sharp stainless steel knife cuts the rope sling holding the liferaft to be released.

The system is suitable for installation up to 50 meters in length.



ERRS – Effective management for evacuation of passengers

The Hammar electronic remote release system (ERRS) is operated via an electronic control panel that activates one or several electrical Hammar H20 remote release units. The ERRS system is easy to operate and install, saves space and is very flexible thus giving an effective management for fast evacuation of a large number of passengers. This system has no limitation in installation length.

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In addition to the scantling requirements mentioned above, general requirements such as welding, materials, closing appliances and superstructure, will be included in the new rules to ensure consistency in application.

Current status

The current status in the project is that the principal decisions have been taken and the project team is finalising the rules and preparing the background documentation that will support the rules. A major effort is in progress to test and calibrate the new rules, using a number of 'test ships' of various sizes. The outcome of the work of testing and calibration will determine the final rule requirements, but it is not expected that this programme will demand substantial changes either in detail or at a general level.

The new rules, and indeed many of the project working documents, will be provided to other members of IACS, as some major documents have been made available since October 2003, for their consideration in terms of possible adoption as Common Structural Rules by IACS.

Preparation of the rules and the background documentation to create the published form is progressing. A complete draft set was expected to be available to industry, through the Technical Committees of ABS, DNV and LR in June 2004.

After the usual process of consultation on new proposals, which includes the response to comments and suggestions from industry the new rules will be finalised and published within the Rules of ABS, DNV and LR in January 2005. Since the new rules will inevitably bring about changes that are greater than the usual incremental rule development process it has been decided that the current Rules of ABS, DNV and LR will remain effective in parallel for a six month period up to July 1 2005 to allow industry to make the necessary adjustments.

Although published within the rules of ABS, DNV and LR, in accordance with the constitutions of the individual classification societies the new rules will be treated differently to the incorporation of IACS Unified Requirements. Whereas the latter are often reworded and the text changed to suit the format of each society the new rules will be published with identical text and nomenclature, even where the format differs, which represents a fundamental shift towards a genuinely common standard that is very evidently just that.

The new rules will be introduced to industry in a number of high level seminars, presented jointly by ABS, DNV and LR in key locations. Each society will also be working with its industry partners to provide assistance and advice on the changes, the impact of those changes and the implementation of the new rules.

Conclusion

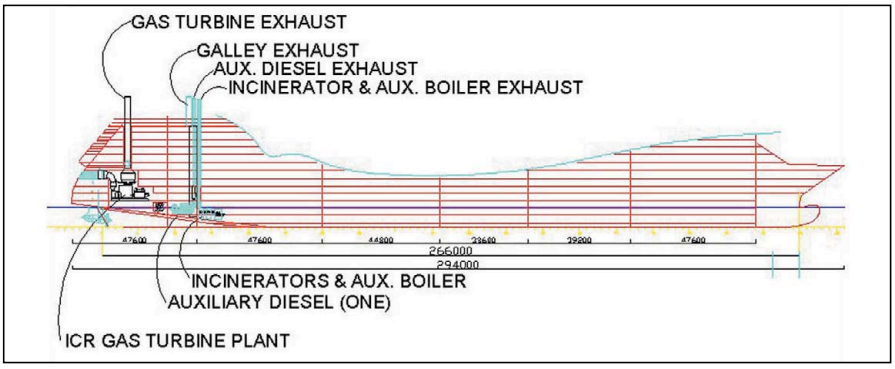
The project has presented huge challenges to the three participating organisations. It has been a very extensive and expensive project to complete and far more difficult than was apparent at the outset. The opportunity has been taken to take a significant step forward by including some new elements. The development process has also identified additional new elements which will be further studied and possibly included in future rule enhancements. It was also clear that the whole ship had to be covered to avoid transition problems with the interface to current rules. Whilst the project began to consider the main scantlings only, it became evident very early in the project that the scope had to expand to cover the entire hull structure including the local elements, if the end result was to satisfy the declared aim of developing a common set of scantling requirements for oil tankers that would put an end to competition, real or perceived, on steel weight between classification societies.

The outcome will achieve the project aims set down by the chief executives of ABS, DNV and LR. It will also provide a sound baseline for the initiative from IACS to develop common rules, initially for structures. The calls from industry and IMO for greater robustness have also been addressed.This represents a major change of direction for classification and will provide considerable benefit for the maritime industry.

Designing the environmentally sustainable ship

maintenance, installation, and environmental issues. The total configuration should be reconsidered, starting from general arrangement through powering, structure, building procedure and the schedule.

The power generating machinery can be positioned optimally to benefit cargo capacity. Several studies show that the optimum arrangement is to locate machinery vertically, with the propulsion motor on the double bottom; systems and electrical equipment at the intermediate level; and generating sets, boilers and other large machinery on the upper deck level. The most important feature is that the engineroom can be compact, releasing 3%-6.5% extra cargo tank volume within the same main dimensions and displacement. That offers 1300m^3 of space for a 40,000m^3 chemical tanker and 200m^3-350m^3 for a 5200m^3 chemical type. Other benefits of importance with diesel-electric machinery include less weight, a better hull form, less installed power, and lower fuel consumption.



An all-aft machinery installation based on gas turbines and electric motors separates the machinery function from crew/passenger accommodation and services.

Functional approach

Fuel efficiency is the most important system efficiency on a vessel, both from the economical and environmental view points. The design of an efficient hull form needs to take account of a great number of different conditions and parameters. It is worth paying particular attention to hull line development in a new design, and it is advisable to seek a third-party opinion since the development of hull form characteristics has been tremendous during the last 15 years.

Such developments include the bulbous bow, the ducktail, and trim wedge. These allow performance improvement of an existing vessel with a reasonably short payback time, reducing fuel costs and/or increasing the available speed, as well as softening the environmental impact.

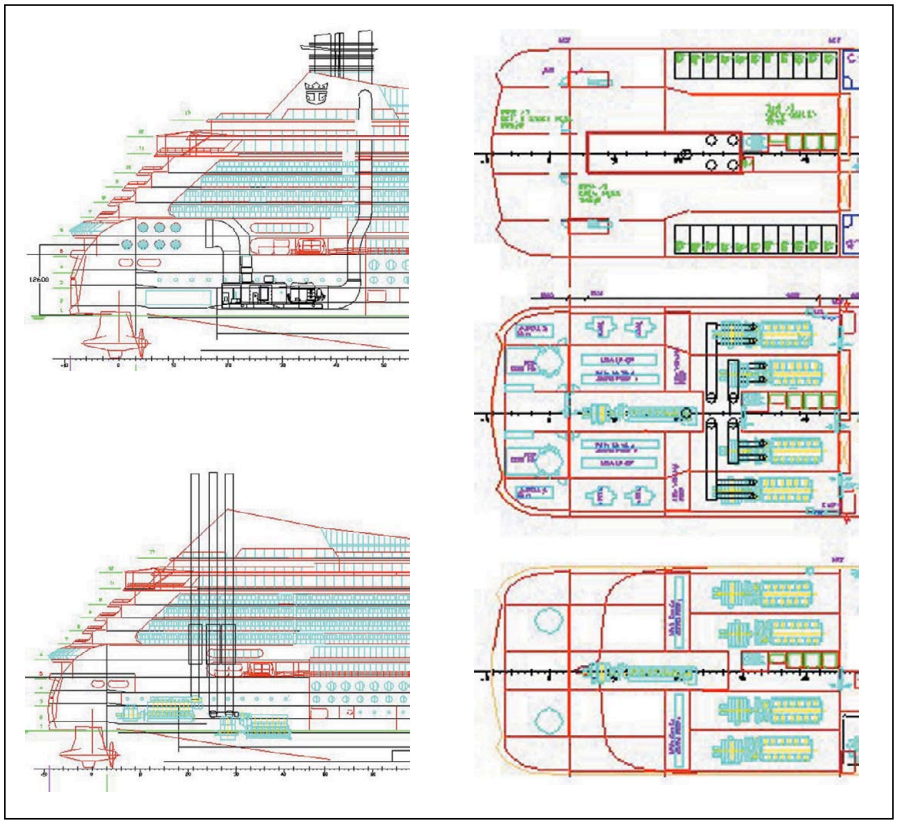
In principle, a bulbous bow fits any kind of ship. The effect of such a bow on the required propulsion power is typically from -8% to -15% in ships with modern main characteristics and hull forms. A typical bulbous bow today is a so-called 'goose-neck' bulb with an upside-down drop form. The bulb length is 4%-4.5% of waterline length, but surprisingly good results have been reached with lengths of 5% and above, especially for Froude numbers above 0.30, as well down to 0.20 and below.

A bulbous bow is extremely suitable for retrofits where the larger upper part can be placed on top of the existing bulb with a gain of between 3%-5% in propulsion power. Deltamarin recently tested cases for ro-ro passenger ferries and cruise ships with power gains between 8% and 13% for a ship built 10 years ago with operational speeds of 20knots-23knots. The payback time then becomes less than two years for a new bulbous bow. A typical example is a 10-year-old ferry with a bulbous bow design of the 1990s. The new design is a more pronounced bulb with a longer stem above the bulb, giving a gain of 11%.

The most recent development for aft ship hull forms is the application of a trim wedge combined with a ducktail. A trim wedge is located under the aft part of the vertical section, typically starting just aft of the propeller plane/rudder plane and extending 3m-5m aft and inclining the verticals downwards. A typical reference is a full-displacement fast ferry with a design speed of 27knots. The trim wedge has already proven successful at Froude numbers 0.23-0.25 for ro-ro passenger ferries leading to a propulsion power cut of 3%-5%. A ducktail/trim wedge combination is also suitable for retrofits, where a power gain of between 5% and 8% is typically measured in model tests.

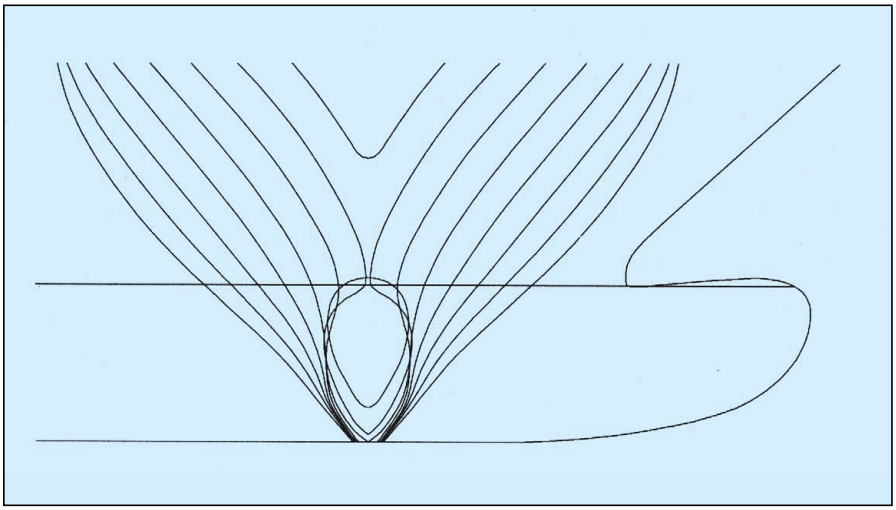
One simple way of improving fuel efficiency is to operate at optimum trim. An even keel is not necessarily the optimum, especially for modern hull forms. For new vessels, it is easy to include propulsion model tests at different trims with the final selected hull form, and to make sure the trim can be easily varied without ballast under normal operational conditions.

An existing vessel requires a different approach. Studies for several vessels show fuel saving

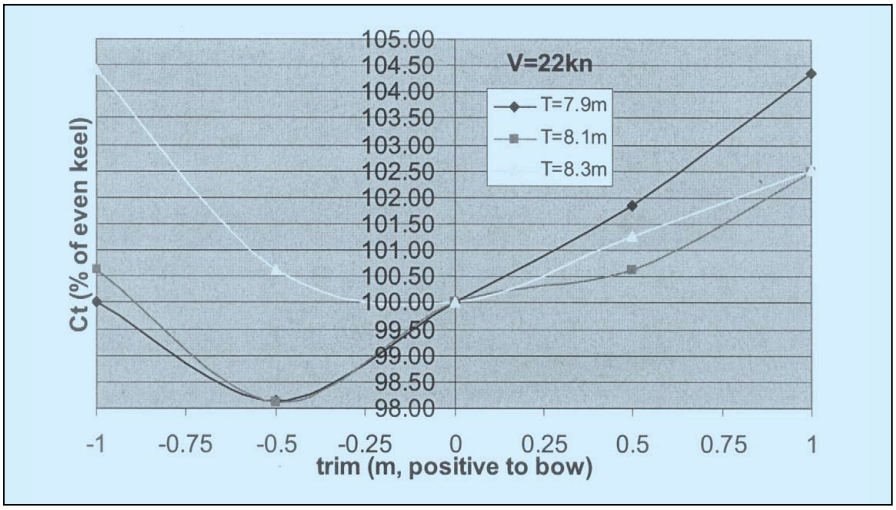


Details of an all-aft electric machinery layout, with a COGES plant (top) and alternatively, with a medium-speed diesel plant (bottom).

Extracts from a paper presented at the Green Ship Technology Conference, held in London, April 28-29, 2004.



Profile of a modern bulbous bow for a passenger/vehicle ferry, with the upper contour above the design waterline.



Results of CFD trim study for a Panamax-class cruise liner at a service speed of 22knots.

potential lies between 1% and 4%, levels that can only be achieved if trim variations are at the same displacement without pumping additional ballast.

The first approach can be made with simple CFD calculations which show the potential. A CFD study was carried out for a cruise ship at a speed of 22knots. With the study result, the actual trimming capabilities onboard were checked, and a recommendation was made to the owner to carry out an in-service verification test. In this case, the test proved the CFD results correct, and a procedure was set for the masters to use stern trim up to even keel, avoiding forward trim as far as practicable.

It should also that substantial fuel cost savings can also be made by operating heating, ventilation and air conditioning machinery at an optimum level.

Cruise-ship waste-water management

Since 1990, the number of cruise ship passengers visiting Alaska has increased by almost three-and-a-half times, according to a recent Alaska Department of Environmental Conservation study. In 1990, 235,000 passengers travelled to south east Alaska while by 2003, the number of visitors rose to around 800,000, with tens of thousands of crew. As the state's waters are very sensitive to all pollutants, emissions and effluent, pressure is growing for regulation and control of all discharges.

Traditionally, waste water treated aboard a passenger vessel consists of only black water. However, recent changes in waste-water treatment have broadened this to include galley and grey water. Recent regulations and public scrutiny have attracted attention to waste-water discharges, which has prompted moves towards better treatment.

The most common sewage system is the biological plant where sewage is treated by a biological process by micro-organism (bacteria) colonies. Another solution is the physical/chemical process where sewage is treated with chemicals and by separating solid particles. This system requires regular dumping of solids. In the electrolytic system, sewage is oxidised and treated in an electrolytic cell. All these systems can be connected to various screening processes by mechanical and membrane-type micro-filtering.

In the last couple of years, several new marine sector firms have emerged to provide advanced new treatment plants, especially membrane bio-reactor systems (as reported in various issues of *The Naval Architect*). References in larger scale are not yet available, however, to show the long-term performance of these plants functioning in marine conditions. Meanwhile, cruise ship owners are seeking to replace old sewage treatment plants with advanced versions.

In addition to the actual volume of waste water generated, the density of contaminants in the flow also determines the treatment plant capacity. The density of contaminants is measured by parameters including BOD and TSS, but uniform standards have not yet been established for shipboard applications.

Estimates of waste water generation aboard a cruise ship can vary significantly, based on the assumption of passenger and crew activities. To estimate tank volumes and plant capacities, Deltamarin uses waste-water generation values listed in Tables 2 and 3.

For ro-pax vessels, the quantity of waste water generated depends heavily on the sailing route taken. Routes with little cabin occupation see low grey-water generation, while some vessels travelling other routes where cabins are heavily occupied, yield grey-water generation rates similar to cruise ships. In the case of an undefined route, Deltamarin assumes the ro-pax values for limited use of cabins, showers and restaurants shown in Table 3.

Integrated approach

System selection should be based on a long-term decision of what to do with treated waste and the remaining sludge after treatment. The economical impact of the choice should be considered, not only installation costs, but also considering maintenance required and annual chemical consumption. With some systems, a dedicated waste water engineer may be needed as well as the environmental officer, to handle operation and necessary sampling. In addition, the footprint and energy consumption of the sewage treatment plant itself should fit within the concept. When all these questions are resolved, the technical integration of the plant is possible.

Technical integration depends on whether a new or an existing ship is involved. The conversion of an existing ship is more complex and merits an in-depth examination. Several phases are recommended at least for replacement of old sewage treatment plant with new models. These include:

Logistics - if a shipyard carries out a conversion, then it is responsible for everything including the logistics. But if a sewage treatment plant vendor does the conversion, assisted by installation companies, logistics can be vulnerable, so this would need an owner's detailed schedule, followed in the master schedule by waypoints. Minimum steps for the logistics phase include overseas and continental logistics, port installation logistics, and installation logistics onboard.

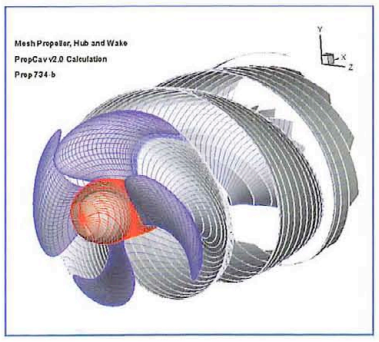
Footprint and volume required for a plant - the power and space required by waste water treatment units differ to a great degree with the manufacturer. These differences are related to the type of treatment processes used.

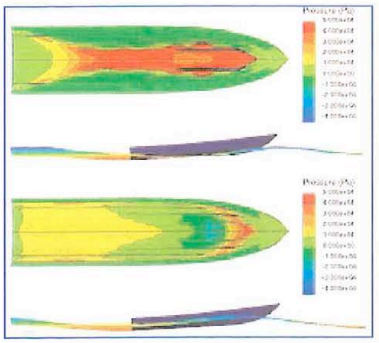
continued on page 148

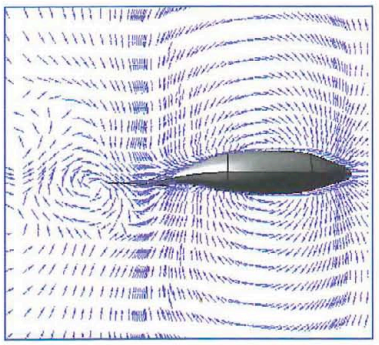
The Royal Institution of Naval Architects

Marine CFD 2005

The Fourth International Conference on Marine Computational Fluid Dynamics







A Riviera Maritime Media Ltd event organised by the Royal Institution of Naval Architects

30 - 31 March 2005, Southampton, UK

First Notice & Call for Papers

The International Conference on Marine Computational Fluid Dynamics and associated workshops offer delegates the opportunity to meet and hear from the leading industry and research experts in this field from around the world.

Computational fluid dynamics is a powerful tool for solving complex hydrodynamic problems. CFD offers the designer cost and flexibility advantages compared with model testing. However, many still see their use as more of an 'art' than a science, and the province of specialists. A lot of work is going into making CFD a universal design
tool.

Marine CFD 2005 will focus on the application of CFD techniques to hull hydrodynamics, marine propulsors (propellers, pods, waterjets, etc), hull/propulsor interaction, and ship aerodynamics for conventional and unconventional ship design. The programme includes software workshops which will give the delegates a chance to participate in and discuss demonstrations of the latest CFD software. The Institution invites papers on:

- Practical applications of CFD techniques to marine design
- Experimental and computational validation and benchmarking
- Improvements in automatic mesh generation
- Developments in adaptation grid generation
- Coupling of CAD and CFD software
- Development of quality standards and best practise

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The Royal Institution of Naval Architects

HUMAN FACTORS IN SHIP DESIGN, SAFETY AND OPERATION

23-24 February 2005, RINA Headquarters, London, UK

Call for Papers & First Notice

Naval architects and marine engineers have a direct influence over designs and as such have an influence over how their designs are used by seafarers. In recent years, they have made increasing efforts to gain an awareness of human element issues and to improve their understanding of how and why their designs influence human behaviour.

The traditional view that human error is the major cause of all accidents is being challenged by some who consider human error to be a symptom of deeper problems with the system. Errors can be induced through bad design, poor training or poor/inadequate management systems. Indeed, some argue that modern technology has reached a point where improved safety can only be achieved through a better understanding of human element within the system.

This conference aims to bring together international specialists and professionals including designers, ship operators, mariners, equipment manufactures and regulators to highlight how the sensible application of ergonomics and human factors can provides an opportunity to both reduce costs and improve safety.
The Institution invites papers in such areas as:

- Integration of human factors into the design process
- Practical applications of human factors engineering
- Survivability, escape and evacuation systems
- Design of navigation & control systems
- Onboard working environment
- Feedback from the users into the design loop
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	COGES ship	Diesel-electric ship
Passenger cabins	50 more	Reference
Crew cabins	20 more	Reference
Fuel consumption	2% less	Reference
Annual fuel and lubricating oil costs	US$2.7 million more	Reference
NOx and SOx emissions	Less	Reference
Particulate emissions	Less	Reference
CO_2 emissions	Less	Reference

Table 1. Summary of the main results (gains) from a COGES versus a diesel machinery study prepared by Deltamarin for RCI.

Source	Generated waste water
Toilet flush (gravity)	6-8
Toilet flush (vacuum)	1.4
Shower (5 min)	60-70
Laundry load	30-40

Table 2. Waste water generated by typical water consumption activities (litres).

Sewage	Cruise ship	Ro-pax ferry
Black water	15	10
Hotel grey water	200	175
Laundry grey water	35	-
Galley grey water	60	-

Table 3. Typical values for waste-water generation on a cruise liner and ro-pax ferry, for initial calculatons (litres for each person each day).

Environmental pressures around the globe are prompting greater efforts to address green issues in ship design. Markku Kanerva and Harri Salama, from Deltamarin Ltd, of Raisio, Finland, consider how such issues can be realised as the industry targets the environmentally sustainable vessel.

AN environmentally sustainable ship can be described as one requiring the minimum fuel to keep its emissions and effluent at the lowest possible level, and one that is built of materials with the least impact on natural resources and capable of 'end-of-life' recycling or direct re-use. It should also minimise cargo spillage.

A vessel fulfilling all these requirements is yet to be built. However, during the 1990s, especially during the latter half, much progress was made in all areas. The political system and the IMO have taken their time, but local pressure has led to specific legislation in limited areas. Meanwhile, environmental issues have become part of the development and decision-making process in new ship projects. This article presents some ideas and references on how environmental issues can be taken into account in developing a new construction project, as well as how to improve performance in operation.

Environmental ship design

Environmental issues and risks can be approached at an early design stage of a new ship project, very much in the same way as are functional and safety issues. Propulsion is one example: power and fuel consumption improve a project's feasibility, but they also reduce emissions and environmental impact as well as other effects such as shore erosion. The functional efficiency of all ship energy-producing and consuming systems improves the feasibility and environmental friendliness of a project.

The safety approach is aimed at reducing the risk of incidents/accidents and any consequences in case something does happen (this can be achieved through system arrangement or configuration design). Improving safety automatically enhances environment-friendliness and reduces ecological risk. Action can be taken in areas ranging from system functioning, propulsion and steering, to fire and damage safety. The use of double hulls in any format and similar measures reduce the risk either of a ship sinking or of cargo or fuel spillage in case of collision.

The design approach can be divided into four different steps: concept, configuration, function, and protection. Vessel concept development usually has a great impact on environmental issues. The concept stage involves the selection of the main ship dimensions and basic layout of tanks, machinery, and cargo space. Main dimension selection has a major impact on resistance and thus, on propulsion power, while the arrangement of spaces has a direct and indirect impact on environmental risks.

Configuration development deals with the selection of main and auxiliary machinery and other ship systems, as well as their location, arrangement, and protection. The functional stage includes development of systems, the most important from an environmental viewpoint being the hull form and propulsion system. Protection involves the development of the final detailed arrangement and location of tanks, pipelines, fire subdivision, and others, taking account of environmental risks.

Concept and configuration

The best way to describe the concept approach is through a few examples. Firstly, a Panamax-class cruise liner. Today, an electric power plant with pod propulsion is almost a standard solution. Typically, however, diesel-electric vessels are still not radically different from those that are mechanically driven.

By locating the power plant aft, close to the largest power consumers - the pod propulsion motors - the whole midship area is released for other purposes. The idea is to have all machinery functions aft, all service functions near the tanktop, the freeboard deck forward for passengers, and the decks in between for the crew. In that way, functions are separated, the volume of the hull is better utilised, capacity is increased, and safety and environment-friendliness improve.

The engine casing is divided, gas turbine plants (if chosen) having separate engine casings with air intakes in the aft corners of the ship, and one casing provided for incinerators, oil-fired boilers, and galley exhaust. The incinerator and its exhaust is naturally located near the main galley and provision service flows. Under this arrangement, the galley is located aft with dining rooms forward of the galley.

When the main source of electrical power is moved aft, the remaining machinery such as fresh water generators, air conditioning cooling compressors, and the sewage treatment plant are left on the double bottom. The aft machinery section can be separated with a watertight bulkhead from other sections on the freeboard deck, and the margin line may be defined to follow one deck higher up at the aft end, thus improving stability. An aft machinery position does not disturb the passenger, crew, and service flows.

What is gained with this arrangement? Primarily, greater passenger capacity - between 100 and 140 more cabins compared with a

continued on page 151

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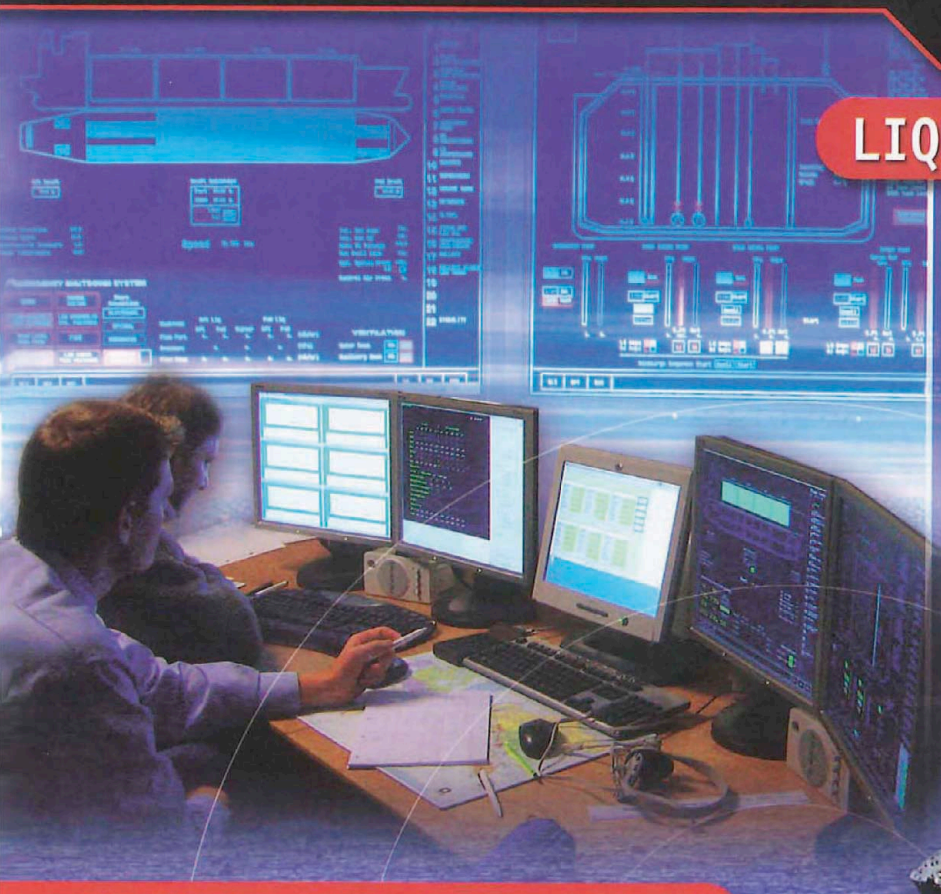

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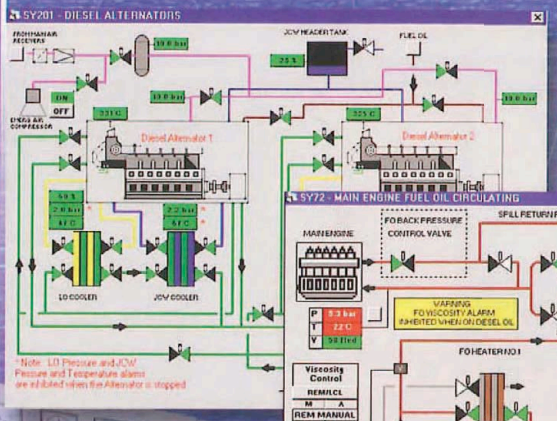

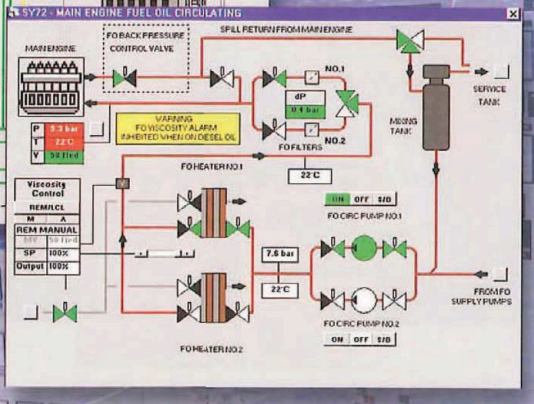

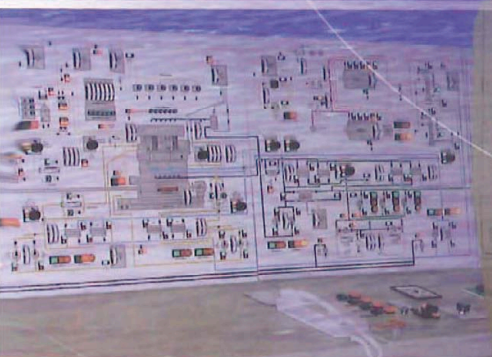

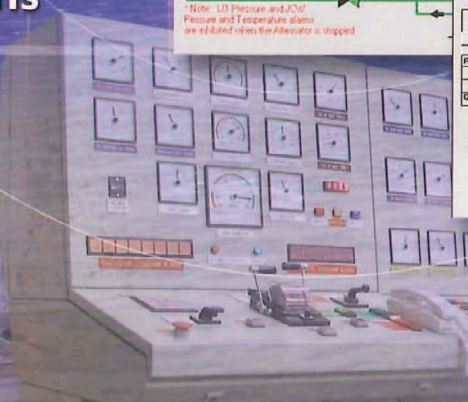

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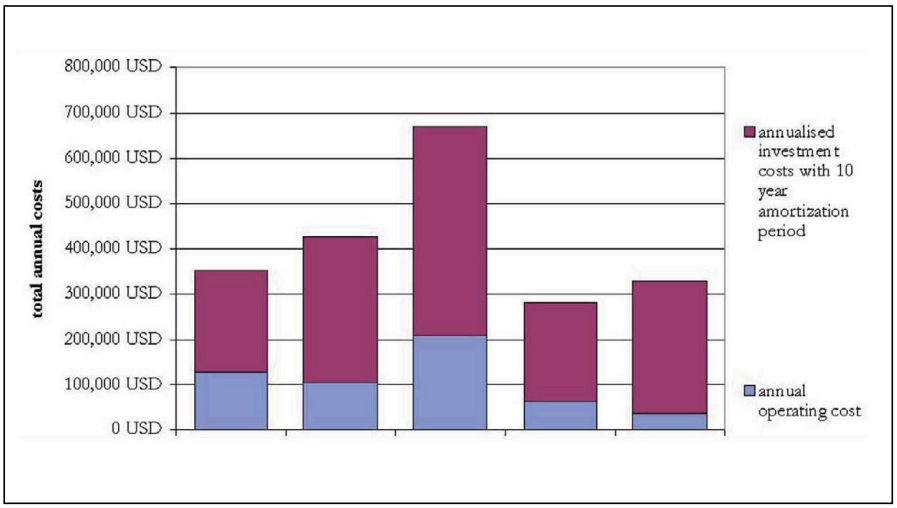
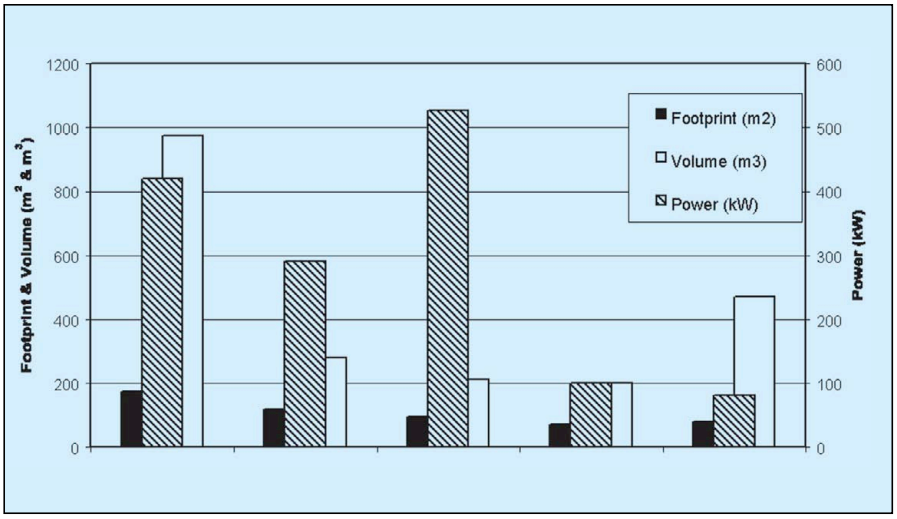


Investment and operating costs for five different waste-water management systems.



Footprint required by the five waste-water management systems. The differences relate, in part, to the type of treatment process involved.

typical Panamax-size vessel of today. In addition, better service flows and better space utilisation result, and the machinery is located aft, thus minimising risk of collision in machinery and tank spaces.

Benefits of a gas turbine choice

The configuration approach includes selection of the main machinery. Again, in the case of a Panamax-size cruise ship, Table 1 presents the results of a comparative study between a combined gas and steam turbine (COGES) plant and a diesel plant, both driving electric generators. This study was the basis for Royal Caribbean International in its choice of a COGES plant for the *Millennium* and *Radiance*-class ships.

It is interesting to note that even CO_2 emissions are lower than with the diesel configuration. This is due to the operational profile of the ship and use of steam in fresh water production. Capacity, operational economy, and environment-friendliness were driving forces for the COGES plant configuration.

Concept thoughts for a diesel-electric tanker

The development of diesel-electric tankers is another good example of concept and configuration thinking. Deltamarin claims that, despite much brainstorming and conceptual development work, it always came to the same conclusion: the complete configuration of the vessel must be considered. Simply to replace conventional machinery with diesel-electric is certainly not sufficient, the company believes.

Points to be considered include machinery location, machinery modularisation, cargo tank location, cargo volume capacity, loading capabilities, hull form, power requirements, operations under special service conditions (such as ice or restricted waterways),

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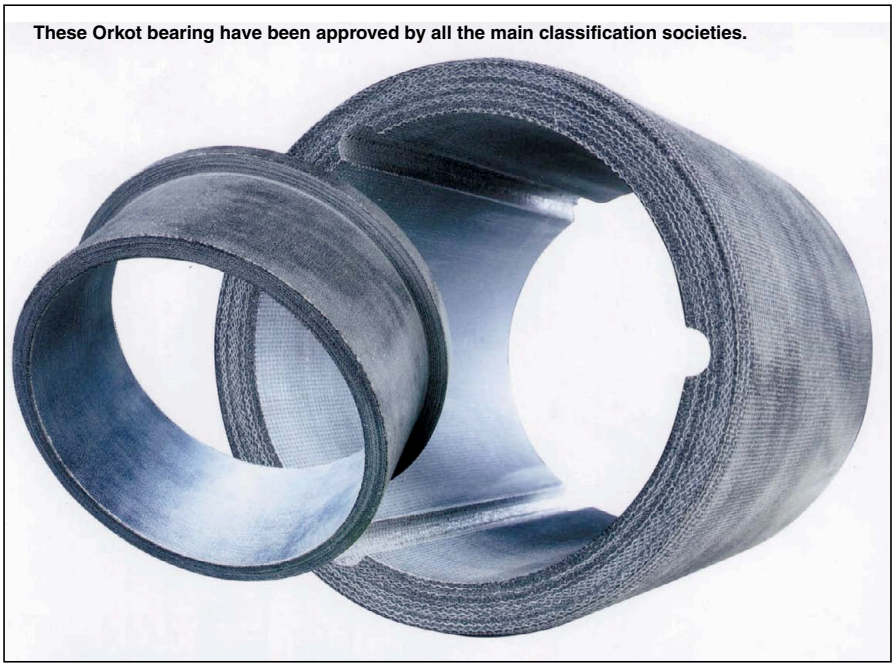
ORKOT Marine Bearings' range of composite bearings features the TLM series which have approvals from all the main classification societies for use as rudder bearings and water-lubricated sterntube bearings. The latest options for greaseless operation, such as for rudder carrier bearings, are included in the approvals.

Allowing for the big increase in allowable bearing pressure for rudder applications in recent years, Orkot bearings are typically now approved for 10N/mm^2 or even 15N/mm^2, which is three times the pressure for traditional bearing materials.

Orkot bearings up to 1200mm diameter can easily be freeze-fitted using liquid nitrogen. The material is not brittle even at cryogenic temperatures, providing a simple method of obtaining an interference fit.

Availability within 24 hours for shipowners and repair yards is ensured by extensive stocks and a global network of agents and distributors. This Germany-based company's bearings have been fitted to over 1000 vessels worldwide over the past 25 years.

These Orkot bearing have been approved by all the main classification societies.



Goal-based rules for more pro-active classification

THE Polish Register of Shipping (PRS) believes that goal-based standards for ship construction will allow a more pro-active, not reactive, attitude to rule making. A representative of PRS recently took part in IMO discussions on the future form of these standards at meeting MSC78 of the Maritime Safety Committee (MSC), and this small class society now aims to contribute further to their formation.

In developing the concept of goal-based standards, PRS believes that the first step should be to define the goal itself. This is to ensure the structural safety of a ship for its entire lifespan. Subsequently, this lifespan needs to be established to determine the components of the safety standard. For example, wave-generated stresses which can occur in a structure and the resulting fatigue are determined by the period of time that a ship spends at sea.

The standard defining the safety level of a ship's structure should determine what such a structure should be expected to withstand in terms of operational loads and actions of the environment, and the criteria for ensuring that the strength of that structure is sufficient to withstand these loads. The concept of the standard proposed by this Polish society refers to:

- a ship's environment: North Atlantic wave conditions and the probability of exceeding the value of ship response to waves, affecting ship safety, equal to 10^{-8}
- a ship's structural strength: stresses in a structural members caused by any combination of loads shall be less than stresses that cause the structure material to yield, while compressive stresses shall be less than critical stresses, and the number of cycles that cause cracking shall be greater than the number of stress cycles occurring during a 25-year period at sea.

Compliance of a ship's structure with the set standards should ensure that the goal is achieved. The PRS proposal further assumes that the development of instruments (such as detailed rules, prescriptive requirements, design formulae, procedures, and computer programmes) that enable implementation of the standard and verify compliance of the ship's structure with that standard can be left to recognised organisations, such as classification societies. To ensure the completeness of the safety system, PRS believes that these organisations should be recognised by IMO.

Existing ship structure safety standards are developed by classification societies and are, in general, a mixture of different criteria and prescriptive requirements with a tendency to recommend ready solutions. In response to the sinking of bulk carriers, for example, classification societies developed and adopted new regulations stipulating that a ship must withstand significantly increased wave pressure values, retro-active measures were taken to reinforce the forepart of bulk carrier hulls, evaluation of scantlings of transverse corrugated bulkheads were undertaken, new criteria for the renewal of the side shell frames in single side-skin bulk carriers are to be observed, and more stringent securing requirements for cargo hatch covers must be met.

This, according to PRS, means that the present safety system is generally built on a reactive approach. However, developments in shipbuilding, and the use of IT, for example, have resulted in new ship structures and materials that are not always embraced by these reactive class rules, and therefore require a pro-active approach to rule development. This classification society does not see the fact that many of its competitors use different instruments for calculations as a problem, since it believes that as long as the final calculation is the same, it does not matter how it is achieved.

To remedy the situation, PRS believes the safety standard itself should be separated from the instruments for verifying a ship's structural compliance with that standard. The standard determining safety is longstanding, whereas the instruments, approached separately, are continually developed. This prerequisite was a key element in the proposal worked out by PRS.

PRS firmly believes that the development of such a system - based on longstanding ship structure safety standards and continually developed instruments for verifying their implementation - will result in pro-active rather than reactive policies - without doubt, says the society, a revolution in the industry's approach to safety assurance at sea.

ECDIS package for new Brodosplit tankers

The Russian company Transas has delivered a comprehensive bridge equipment outfit to the first of two P-960 tankers for Primorsk Shipping to be built at the Brodosplit Shipyard, Croatia. The equipment contract for the two 108,000dwt tanker newbuildings was signed in November 2002. The installation on the second tanker will be completed by the end of this year.

Sakhalin Island has been supplied with a complete Transas Navi-Sailor 3000 ECDIS, designed in compliance with the latest IMO regulations for UAIS interface, and is enhanced with navigational consoles, ARPA/radar and Navi-Conning display. The delivery set also contains radio equipment, including GMDSS units, satellite communications, and intercoms.

The significance of this contract is said to be that for the first time Transas has supplied a tanker with a Track-Control system. This, in conjunction with positioning sources, heading, and speed information, is intended to keep a ship automatically on a pre-planned track under various conditions and within the limits of the ship's manoeuvrability and with minimal participation from the navigator. The route plan for the system is generated in the Navi-Sailor 3000 ECDIS-I system, while the system itself is connected to the automatic helm. The Transas Track-Control system meets all the requirements of IEC 62065 standard, Category C for full track control on both straight courses and turns. All equipment has been certified by Det Norske Veritas.

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The 108,000dwt Primorsk Shipping tanker *Sakhalin Island*, built at Brodosplit Shipyard, has been installed with a complete Transas Navi-Sailor 3000 ECDIS package.

Water ingress alarm system

According to SOLAS regulation chapter XII/12, IMO Resolution MSC 145(77), and IACS Unified Interpretation SC 180, all bulk carriers should be fitted with a water ingress detection and alarm system (WIDAS) after July 1, 2004.

The regulations state that two alarm points should be available in each cargo hold. Unlike monitoring in other void spaces, direct monitoring in cargo holds usually implies contact or exposure of the sensors to the cargo.

Diversity of bulk cargoes and cargo handling machines, tools and equipment puts serious demands on the robustness of the sensor. Many systems offered in the market can be classified as indirect systems, ie, the water detector is separated from the cargo by means of a filter. These systems depend on proper working of the filter for all types of cargoes but filter-based systems risk being clogged by certain cargoes. Such systems also require thorough cleaning and maintenance at regular intervals.

To overcome the restrictions of such indirect systems, Tanksystem, of Norway, has developed a direct system. In a system of this type, the special sensor (based on the advanced microwave technology) is in direct contact with the cargo ie, no filter system is required.

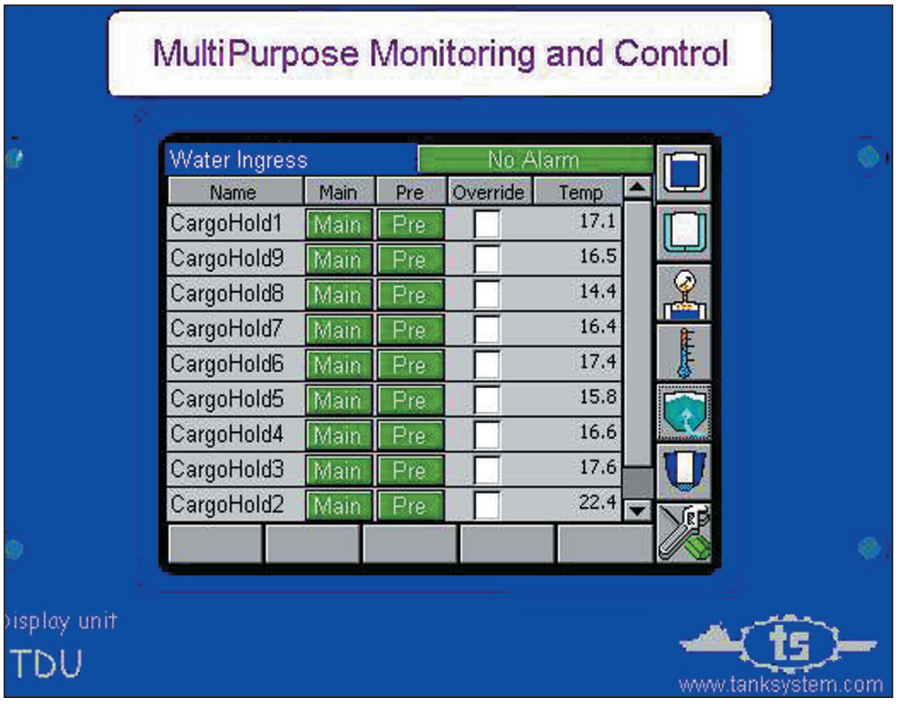
The working principle is based on the reflection of microwaves by the presence of a certain concentration of water molecules. The sensor constantly checks the dielectric constant of the space 0cm-10cm from the microwave antenna. Reflection is processed based on a medium's dielectric properties. Water ingress in the cargo hold leads to a substantial change of the reflection coefficient, which is detected by the microwave sensor.

The Tanksystem WIDAS features:

- high reliability
- simple installation
- user-friendly interface for the display unit
- protected (mechanically and chemically) sensors to ensure long periods of operation and correct functioning
- continuously self-checking system
- no maintenance required
- no filter, no moving parts, no restrictions in cargo list.

Selecting the type of WIDAS demands very careful consideration by an owner not only for the initial cost, but also for the cost of daily

The display panel for Tanksystem's new water ingress monitor.



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Wiper systems for new chemical tankers

Wynn Marine, now part of Hepworth Marine International following a company merger in June, has been contracted to supply the wiper systems for four chemical tanker newbuilds at the Rousse Shipyard in Bulgaria. The vessels, on order for UK company Crescent Tankships will use Wynn Marine's best-selling Type C wipers.

The Type C is an internal motor straight line wiper suitable for all heavy-duty applications. It is ideal for large ocean going vessels such as LNG carriers, container ships and chemical/oil tankers.

Wynn Marine's own high powered AC induction motors provide the Type C with efficient and quiet operation with the added benefit of very little to no maintenance. The wipers are also made from high quality, non-corrosive metals.

Tony Parker, Wynstruments, Wynn House, Lansdown Estate, Cheltenham GL51 8PL, UK. Tel: 01242 232266. Fax: 01242 231131. E-mail: tony.parker@wynn.co.uk

Generator sets delivered to Russian tankers

Palmali Shipping is increasing its fleet with a total of 10 new tankers for transport of crude oil, petrochemical products, and originally chemicals. The ships are being built at the Tersan Tersanecilik shipyard in Istanbul.

To date, three vessels in the Armada series have been launched and originally Palmali Shipping chose generator sets from three different engine manufacturers for these ships. Volvo Penta's installation was used aboard the 6200dwt *Armada Trader*. The vessel has a length of 138.70m, a beam of 16.50m, and a maximum speed of 10.5knots. Palmali Shipping has since decided to equip the remaining seven vessels in the series with Volvo Penta's solution.

The engineroom on *Armada Trader* is unmanned, which places high demands on the engine's reliability and the flexibility of the monitoring system. The installation is based on three Volvo Penta D-12-AUX engines at 294kW each which combined provide the vessel's main power supply. An emergency unit at 133kW was also installed.

In other news, Volvo Penta has received an order for two more installations during 2004 and signed a contract with Palmali Shipping for delivery of complete generator sets to the remaining five vessels in the series.

AB Volvo Penta Corporate Communication, SE-405 08 Göteborg, Sweden. Tel: +46 31 66 84 18. E-mail: ann-charlotte.emegard@volvo.com www.volvopenta.com

IACS joint bulker project seeks new-rules industry input

COMMON rules for bulk carriers have taken some key steps forward with the International Association of Classification Societies (IACS) joint bulker project (JBP) team making a series of presentations to shipowners, seeking industry input to the rules, and the publication of the proposed rules in early July. The JBP is made up of Bureau Veritas (BV), China Classification Society (CCS), ClassNK, Germanischer Lloyd (GL), Korean Register (KR), Registro Italiano Navale (RINa), and the Russian Maritime Register (RS).

The aim of the Joint Bulker Project is to develop a set of common IACS rules and procedures to determine the scantlings of structural members of single- or double-hull bulk carriers of more than 90m length (LR, ABS, and DNV are involved in the concurrent joint tanker project - JTP). The first draft of the bulker rules has now been presented to industry in Shanghai, Tokyo, Pusan, New York, Rome, and London, and a review of the draft will be complete by October this year. The new rules should enter into force with all IACS members on July 1, 2005.

Jean-François Segretain, regional marine manager at Bureau Veritas and a member of the steering committee of the JBP, says, 'We have had excellent feedback from owners at all our consultation meetings, and are well placed to complete work on the rules. The shipping industry and IMO want to see class deliver a common high standard. These new rules are the first concrete evidence of the hard work and cooperation which IACS members have put into meeting those demands'.

Drawbacks of the current framework are that there are not always transparent goals, a clear acceptable degree of risk, or the evaluation of alternative designs, and that with different sets of class rules there is competition on scantlings and different shipbuilding standards may apply.

The expected benefits of the new rules are:

- to offer to the industry a classification standard valid for both single-hull and double-hull vessels allowing fair comparison between these competing designs
- to eliminate competition between class societies with regard to structural requirements, and design and construction standards
- to embrace the intentions of the anticipated IMO requirements for goal-based standards for newbuildings
- to ensure that a ship meeting these new standards will be recognised by the industry as being safe, robust, and fit for the purpose.

A number of innovative requirements will be included in the new rules:

- for single-hull vessels, more accurate formulae for the scantlings of the lower and upper frame brackets, explicit consideration for fatigue, and new requirements for scantlings of connecting brackets and hatch end beams
- adoption of net scantlings and values of corrosion additions based on a 25-year conventional service life for all designs
- new sea loads formulae based on hydrodynamic computations and test model basin results
- closed-form formulae for buckling, allowing complete and accurate determination of the scantlings of the secondary structure of the ship (plates and ordinary stiffeners) at an early stage of the approval process
- explicit computation of the ultimate strength of the hull girder, allowing a better assessment of deck and bottom structures in order to avoid breakage of the ship into two parts at sea or in port
- a new fatigue procedure based on the combined previous experience of all members of the project.

Mixed industry response

The first reaction from industry has been positive with a welcoming of the rationalisation of rules between the societies. It is felt that the move will make yards better able to withstand pressure to trim structure to the minimum, and it has been suggested that the new rules will result in a small increase in steel weight for a vessel compared with the situation today.

However some concern has been expressed by the Greek Shipping Cooperation Committee, which represents some 150 Greek owners. In particular, there is focus on the corrosion allowances, which have been changed from a percentage addition to the specified plate thickness to a fixed addition to the thickness. In addition, it is felt in some quarters that a longer period should be allowed for discussion on the details of the new rules.

As regards the corrosion allowance, this is now based on the concept that corrosion occurs on the surface of a plate or section at a constant rate, no matter how much material lies behind the surface. That is, if the plate is 10mm or 100mm thick, corrosion will take place at the same rate, not at a faster rate in the thicker plate.

With the bulk carrier and tanker joint rules now in place and coordinated together, subject to detailed discussions and amendments, attention will now turn to the container ship sector.

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To reserve tickets or for further information, contact Sophie Armitage at Tel: +44 (0)20 72012401 or Email: sarmitage@rina.org.uk.

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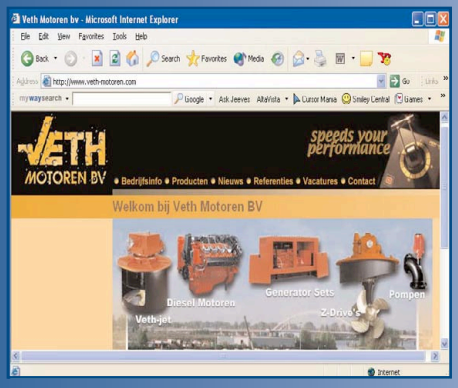

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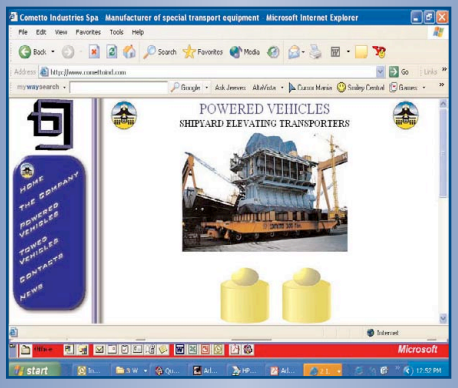

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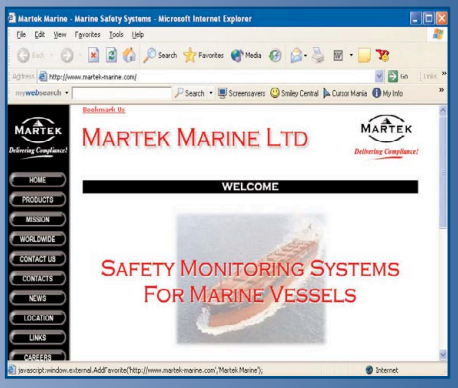

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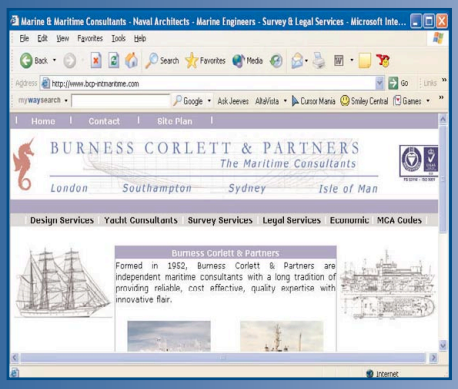

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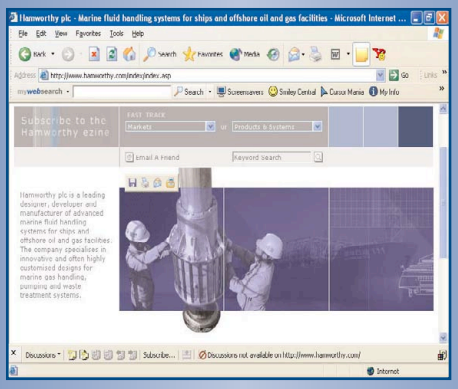

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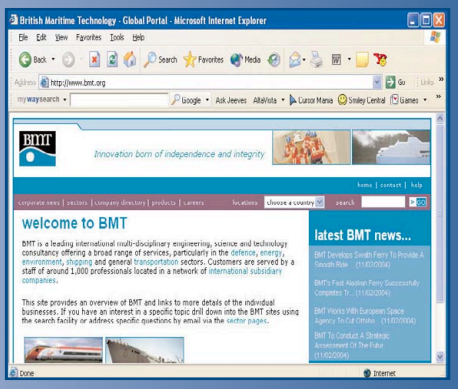

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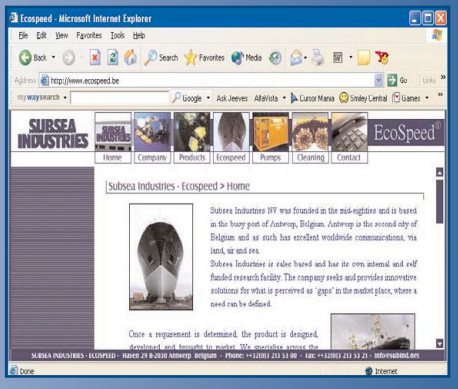

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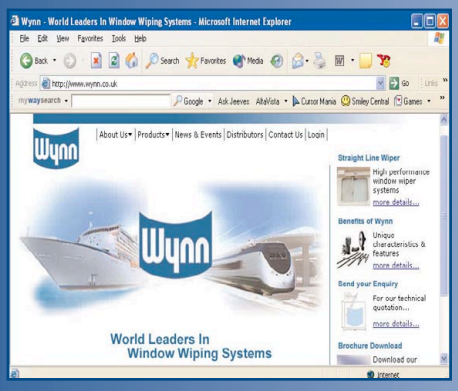

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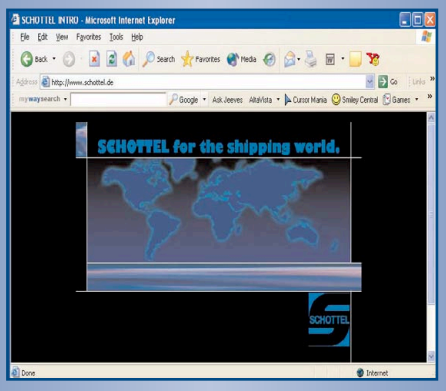

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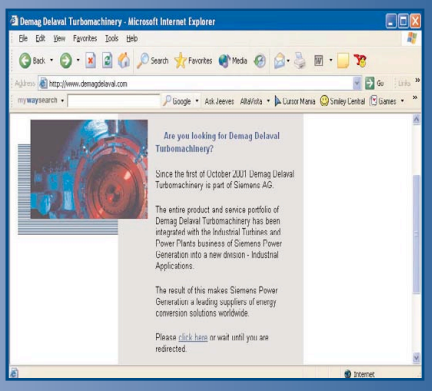

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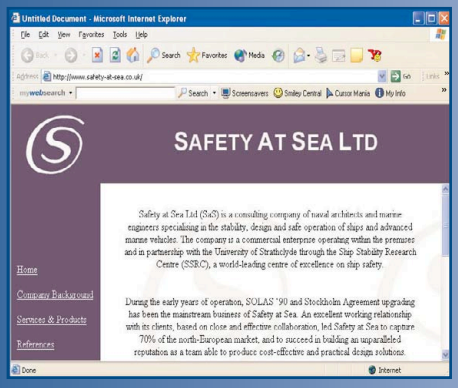

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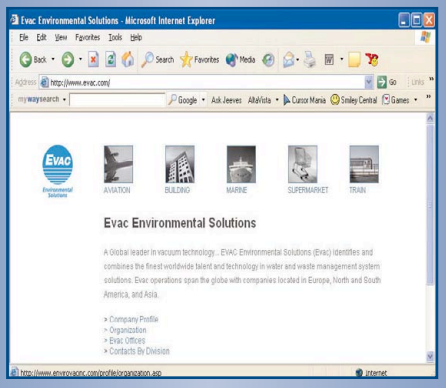

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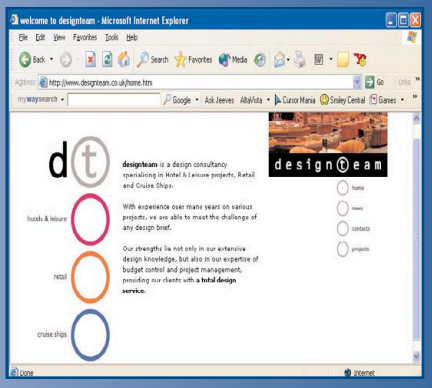

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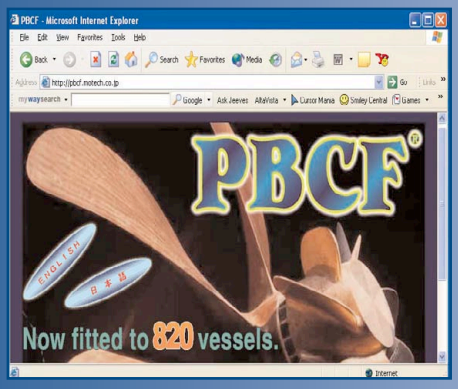

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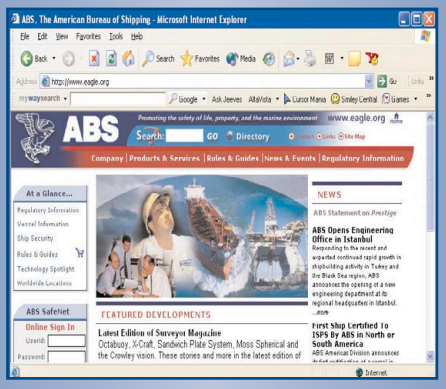

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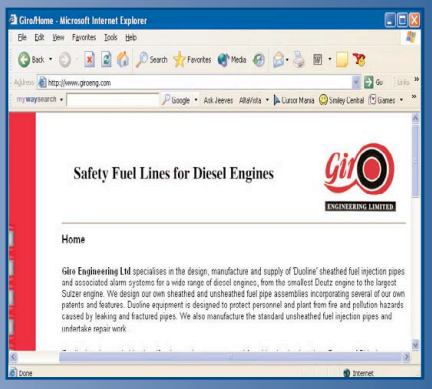

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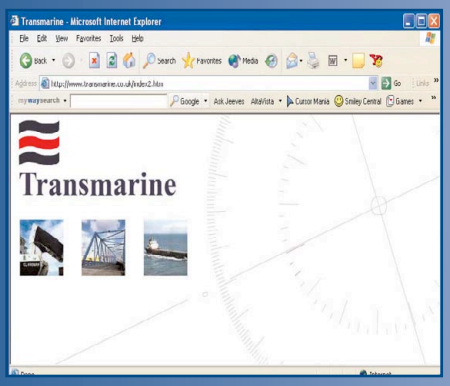

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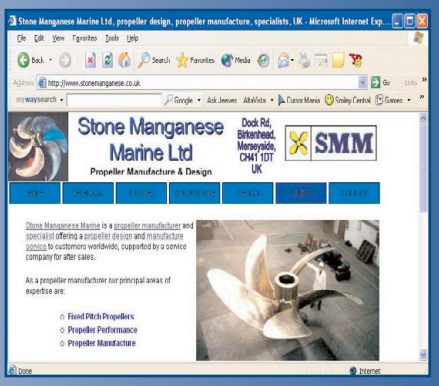

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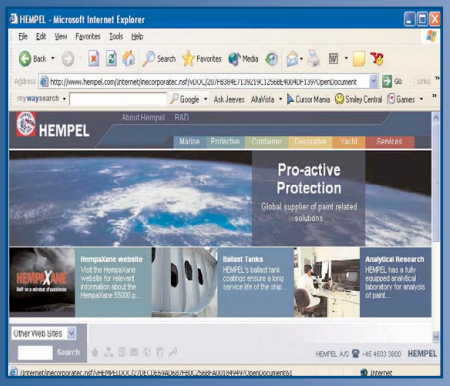

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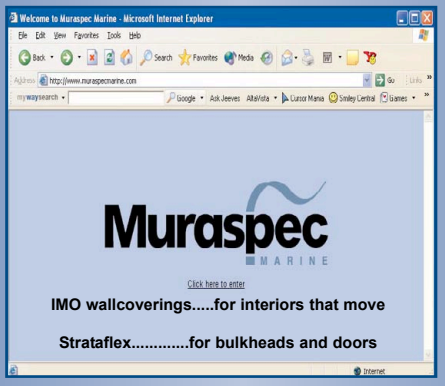

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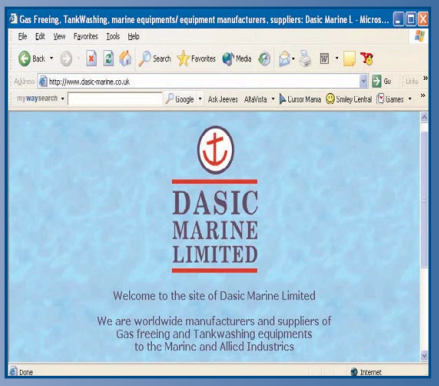

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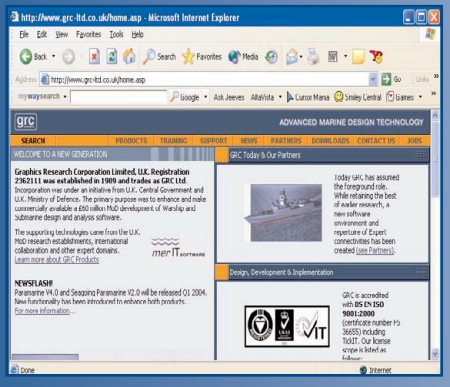

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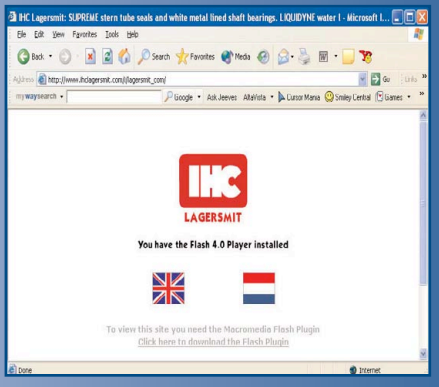

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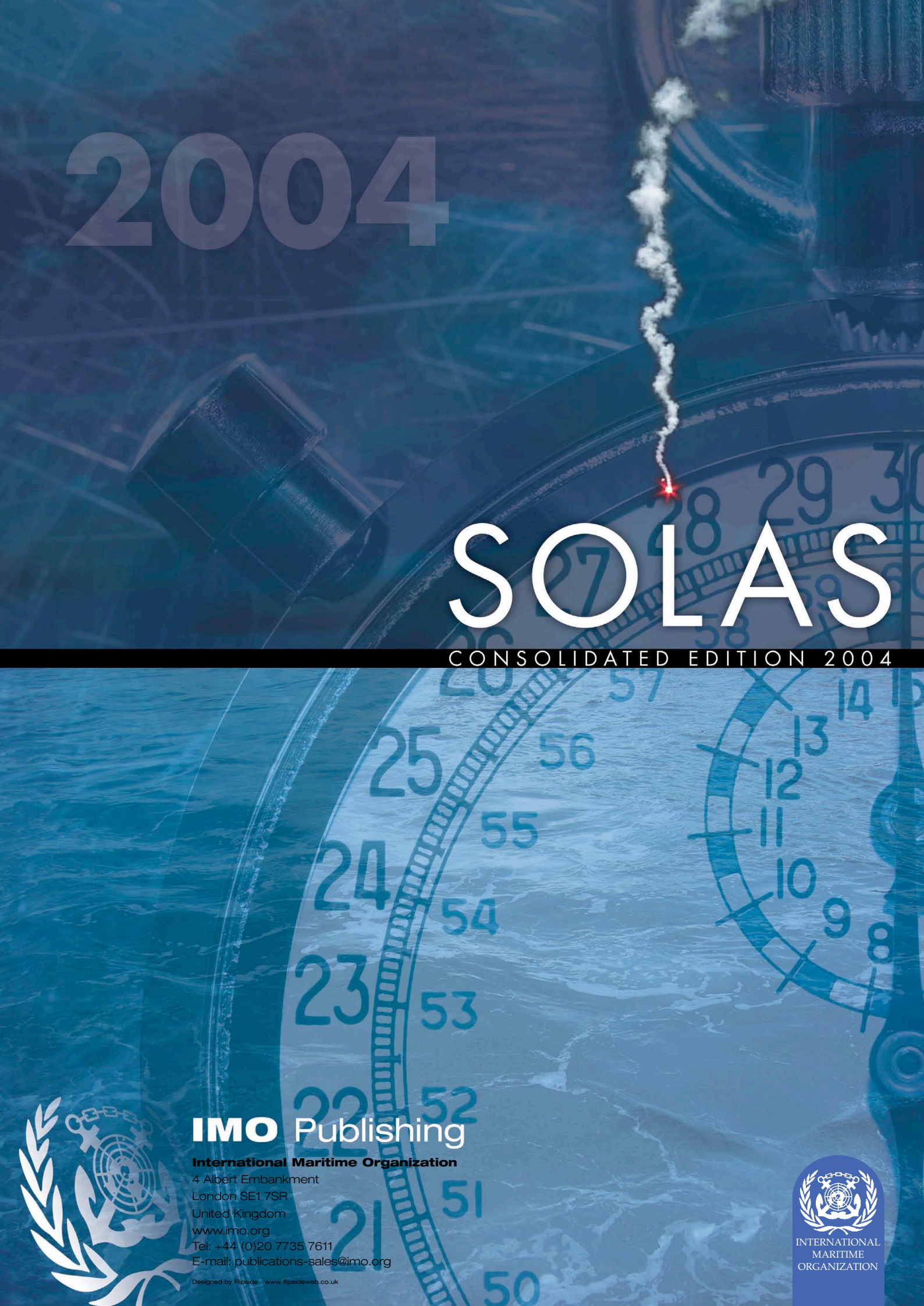

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