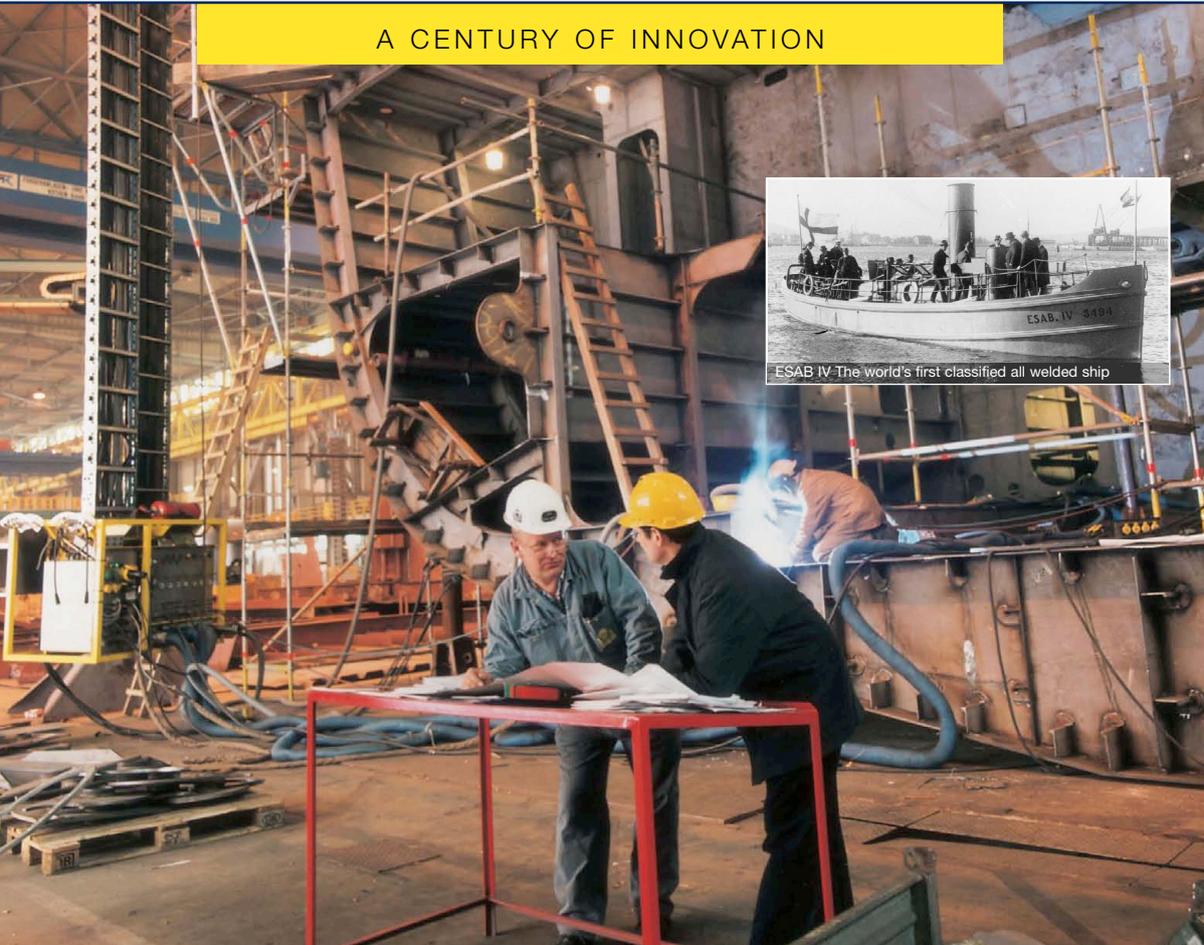


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THE NAVAL ARCHITECT



Safety redundancy for ro-ro ramps and linkspans: this interesting piece of equipment is a prototype RoSafe independent safety brake on test in the Bosch Rexroth factory at Lohr, Germany. In the event of a failed hydraulic cylinder or wire rope/ winch, it will activate within one-tenth of a second and, typically, arrest a ramp fall within 350mm of travel. Although originally planned by ports consultancy Royal Haskoning for shore-based systems, a RoSafe unit could also be installed on ships. More details appear as part of our Ro-Ro 2004 exhibition and conference report, which begins on page 34.

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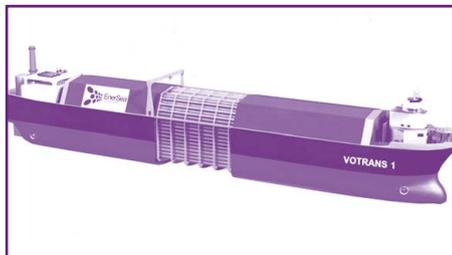
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Second Notice



There is currently considerable optimism about the future growth of the natural gas market and while not all the proposed LNG schemes may materialise, many still expect a significant increase in the number of vessels in the world LNG fleet. Recently, there has been both an increase in orders and an increased programme of scrapping of older vessels. The market is also moving away from the traditional long term 20-year time charter and greater use is being made of spot market vessel charters.



While some companies are looking at the possible economies of scale of larger vessels (in the range of 175,000- 250,000 cu.m.) others are looking to develop options for developing small vessels to exploit shortsea and coastal trades in LNG.

New alternatives including compressed/pressurised natural gas (CNG/PNG), where the gas is stored under pressure at ambient or semi-refrigeration temperatures, are also being developed. There is also a growing interest in LNG Floating production, storage and offloading systems for offshore oil & gas developments and re-gasification tankers and plants designed to avoid the need to construct huge land-based processing and distribution centres.



Steam turbines have traditionally been the preferred power plant for LNG carriers; however, other options such as medium speed diesel electric or slow-speed diesel engines, with reliquefaction plants to reclaim boil-off gas, are being developed.



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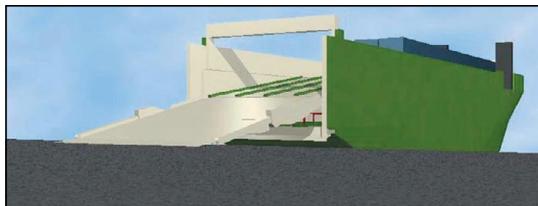
Shortsea highways: which way forward?

SHIFTING freight off the ever-more congested motorways of Europe and elsewhere and onto the sea is currently occupying the minds of many people. The controversial issues that are raised by this subject were thrown into focus again at the RoRo 2004 conference held at the end of May in Gothenburg, Sweden, and organised by Lloyd's List Events. Even in the USA, people are becoming concerned, as Mr Robert Kunkel, chairman of the US Short Sea Shipping Cooperative Program and vice president, operations of Apex Marine Ship Management Co, explained in his paper.

Nevertheless, this shift first came to prominence at the very beginning of the 1990s with the excellent Italian proposal to build a fleet of new ships to run a so-called Viamare (sea road) service between such ports as Genoa and Naples. Seven ships (headed by *Via Ligure*, which was presented in *Significant Ships of 1992*) were completed by Van der Giessen-de Noord, Tille Shipyards, and Fincantieri, but regrettably the fine ideas eventually collapsed, due, it is believed, to political problems. Certainly in the UK, the road freight lobby exercises a powerful influence.

Today, several new ventures are being examined in detail; in our April 2004 edition, page 20, we reported on the optimism of Mr Nigel Gee on prospects for his 247m-long pentamarian stabilised monohull ferry, refined in association with the Spanish shipbuilding group IZAR and awaiting a first contract. This could carry 150 lorries at 31knots, and

Squeezing quarts into pint pots: a computer-generated impression of the prototype proposed ro-ro INTERMODESHIP, planned to shift freight off motorways onto the sea between Sweden and Germany. Up to 48 trailers can be loaded, but space is at a severe premium; as shown here, the stern ramp can be raised to link with the upper deck, and the internal ramp to the lower hold is a two-level structure.



the first example, postulated Mr Gee, could possibly run on a route between Italy and Spain - two countries already linked by a new Grimaldi ro-pax service.

Speed is seen by many - but not all - as being essential if a sea highway is to compete with a land motorway. In northern Europe, the latest proposals of the Rolls-Royce naval architectural consultancy Nordvestconsult were presented at the RoRo conference. Per-Edil Vedlog outlined details of his company's 151m x 22.4m P2500 monohull ro-pax design for 42knots; this had been evolved with CFD and the test tank help of Marintek, at Trondheim, and could accommodate 1500 passengers, 38 loaded trucks, and 245 cars. It is planned for simple construction with maximum use of flat panels, a wave-piercing bulbous bow, demi-hull stern with a wedge, and fabricated mainly from high-tensile steel. Nordvestconsult is also examining other ro-pax designs including a 171.00m x 20.80m, 2800dwt cargo version featuring Rolls-Royce MT30 gas turbines and Kamewa waterjets - perhaps one that could travel between Southampton and Vigo (Spain) at 38knots in 18 hours, or another that could transport fresh fish from Norway to continental Europe at 27knots.

Of course, critics will point out that a high-speed hull will probably cost something near twice that of a conventional form, which is perhaps why Kockums Engineering, RWS Line, and TTS Ships Equipment are considering a totally different concept to take advantage of IPSI and INTEGRATION cargo-handling features. In Gothenburg, this trio outlined details of a pilot proposal, under the

INTERMODESHIP program (yet another part-taxpayer-funded industrial R&D project), for an 88.00m x 13.40m ro-ro freight ship intended to sail between Lake Vänern in Sweden and Duisburg on the river Rhine.

The challenges on this particular route are immense, due to lock restrictions at Trollhättan and variable water levels on the Rhine, but the team is also proposing larger (and possibly more realistic) ships up to 130m length for other routes, notably from Southampton or Portsmouth to Paris (up the river Seine) or from UK East Coast ports to Duisburg. To maximise deadweight, much effort has been expended at the University of Newcastle, Helsinki University of Technology, Chalmers University, and the Italian R&D organisation Cetena to limit lightweight. Despite investigations into aluminium, composite, and steel sandwich alternatives, the conclusion was that conventional high-tensile steel was best - possibly a predictable result.

The very modest number of trailers to be carried on the Swedish route - 48 - was considered almost derisory by one delegate at RoRo 2004, while the high cost of the proposed diesel-electric propulsion plant (almost mandatory because of no available machinery room at the stern) with its 10% efficiency loss was criticised by another. We might also add that the highly innovative cargo-handling plant, although admirably and imaginatively conceived to fit 48 trailers on to three decks in a hull of such compact dimensions, would almost certainly contribute to high construction costs compared with the volume of freight being carried at the proposed mean sea speed of 14knots.

Space has been at a premium everywhere on this ship, hence the aft mooring winches are placed in the steering gear flat. Maybe the design team should consider a QuaySailor automated vacuum mooring solution, as featured in this issue of *The Naval Architect*? The authors also noted that for one month in a year it might not be possible to reach Duisburg due to Rhine water levels!

Historically, many really revolutionary - and at first highly optimistic - technical ideas for cargo ships, particularly those relating to high speed, have not resulted in owners flocking to build vessels. Once again, this journal considers that perhaps, for economics and financial impregnability, owners seeking to help the world reduce the number of motorway lorries and limit emissions, should stick with well-proven concepts, ie, the traditional ro-ro ferry (in either pure freight, ro-pax, or passenger versions) - but taking on board the newest cargo-handling techniques, eg, AGVs, and retaining their equally traditional diesel engines. Thus, apparently successful European concepts, using large ships running from large terminals, such as those run by Cobelfret and DFDS Tor Line with state-of-the art tonnage, could continue to be a sound base for profitable shipping - today and in the future.

As a tailpiece, one factor to add in could be a revival in Europe of train ferries: after a newbuilding boom around 20 years ago and notwithstanding the recent construction of various tunnels and bridges in Europe, international rail freight can still offer a competitive service, according to Antje Falk, from Baltic Rail Gate GmbH. At RoRo 2004, she claimed that dedicated block freight trains could reach Stockholm or Oslo from Basel (Switzerland) in 36hours, travelling on well-established ferry routes from Travemünde to Malmö or Trelleborg. Clearly, in the battle to remove freight from motorways, the optimum path for sea ro-ro freight is still opaque! 

A further report on the RoRo 2004 exhibition and conference appears in this issue.

Flurry of activity in European ro-ro sector

RECENT weeks have been characterised by an unprecedented volume of news relating to new orders for ro-ro ships. Following on from the new contracts at **Flensburger Schiffbau**, which were reported last month, this German yard has scored yet another coup, with an order for two so-called ConRo freight vessels from the Belgian operator **Cobelfret**. These twin-screw designs will be built to a totally new hull form capable of accommodating 848TEU, 258 trailers, or 656 cars. Their length will be 200.00m, with a breadth of 31.00m, and a draught of 7.40m, and the cargo space will total 3900 trailer lane metres spread over the large number of five decks – a figure believed to be unprecedented for this ship type.

Propulsion power for a service speed of 21.70knots will be provided by a pair of MaK 12VM43 medium-speed engines, each developing 10,800kW, and twin asymmetric rudders of the shipyard's own design, with a Costa bulb included, will be employed. The first ship should be delivered in the first quarter of 2006 and the second in the second quarter of 2007. They are expected to operate on routes from Zeebrugge and Rotterdam to the new Cobelfret terminal at Killingholme on the Humber estuary in the UK.

Rumours that the **Merwede Shipyard** in The Netherlands had secured a ferry order from Denmark have finally been confirmed. Two 400-passenger/1235lane metre ro-pax vessels will be constructed for **Bornholmstrafikken**, the operator serving the Baltic Danish island of Bornholm from Copenhagen, and from Ystad in Sweden. Crucial features of the order included a very short delivery time, which appears to have partly been possible by basing the ferries on the 1998 *Ben-My-Chree* design of recently closed IHC Caland group member Van der Giessen-de Noord. The latter hull itself was based on that yard's most successful concept which was used for a large number of variations. Work already started in February at Merwede in anticipation of a formal contract.

The new pair will, however, be longer at 115.10m length bp, with a greater moulded breadth of 23.40m, with a 5.30m design draught. Deadweight at design draught will be much larger at 3000dwt, and the trial speed will be 18.50knots. A total of 60 passenger cabins will be included, and the space for trailers will total 1235lane metres. Construction will be to



An impression of the new ConRo ferries ordered by Cobelfret from Flensburger Schiffbau. They will have space for up to 3900lane metres of freight spread over the remarkable number of five ro-ro decks.

Lloyd's Register standards. The total contract value is €76 million, and both vessels will be delivered in April next year.

In Spain, the **Barreras** yard has successfully concluded a contract to build a pair of new ships for **TransManche Ferries**, which operates the English Channel service between Dieppe and Newhaven. Details of these appear in our RoRo 2004 report in this issue.

The Italian shipbuilder, **Rodriguez Cantieri Navali**, famous for its hydrofoils and fast monohulls, has made a surprise move into larger hulls, with an announcement that it will enter the market for ro-pax and ro-ro ships. The reasoning for this is based on current European activity in finding solutions to shift freight off motorways onto the sea (as updated in our report on the RoRo 2004 conference in this issue).

Last year, Rodriguez won an order for four 82m-long ro-pax ferries but now, following collaboration with an Italian design consultancy in Genoa, Ruggiero, a complete range of ferries has been launched; these will have lengths of 104m, 165m, and 180m. The largest will be able to load up to 150 lorries and be offered in two configurations - ro-pax with 1000 passengers, or freight only. Apart from its base yard at Messina, the company also today controls the former Pietra Ligure yard near Genoa which is capable of building such vessels as are being proposed.

RESIDENCE SHIP ORDER FOR KVAERNER MASA - Good news for Kvaerner Masa-Yards is a conditional contract to build a 200m-long, 42,500gt luxury residential cruise ship, which will be branded, managed, and operated by a company named Four Seasons Hotels and Resorts. Approximately 100 spacious residences will be on board, varying in size from 125m² to 320m². Construction of the ship, to be named *Four Seasons*, will commence when sales targets for the apartments have been reached, which is expected to be before July 2005. Construction is then expected to take two years, and there is an option for a second hull. The prototype ship of this type was *The World*, built by Fosen Mek Verksted in Norway and presented in *Significant Ships of 2002*.

NEW CABIN CONCEPT - A UK government grant has been given to Space (formerly McNeece) to develop a new cabin system for cruise liners and ferries, based on a new material invented by British chemists and a ballistics expert and originally planned for naval ships. This material can be made into panels which, it is claimed, are 20% lighter than anything else on the market; it is non-combustible, non-carcinogenic, has a high acoustic performance, and can be worked like a solid material. R&D work is expected to take six months.

PLC FOR HAMWORTHY - The leading UK marine equipment manufacturer Hamworthy KSE, based at Poole, has sought admission of its shares to trading on the Alternative Investment Market (AIM), of the London Stock Exchange. Dealings were expected to begin in July this year. The name of the company will be changed to Hamworthy Plc. 

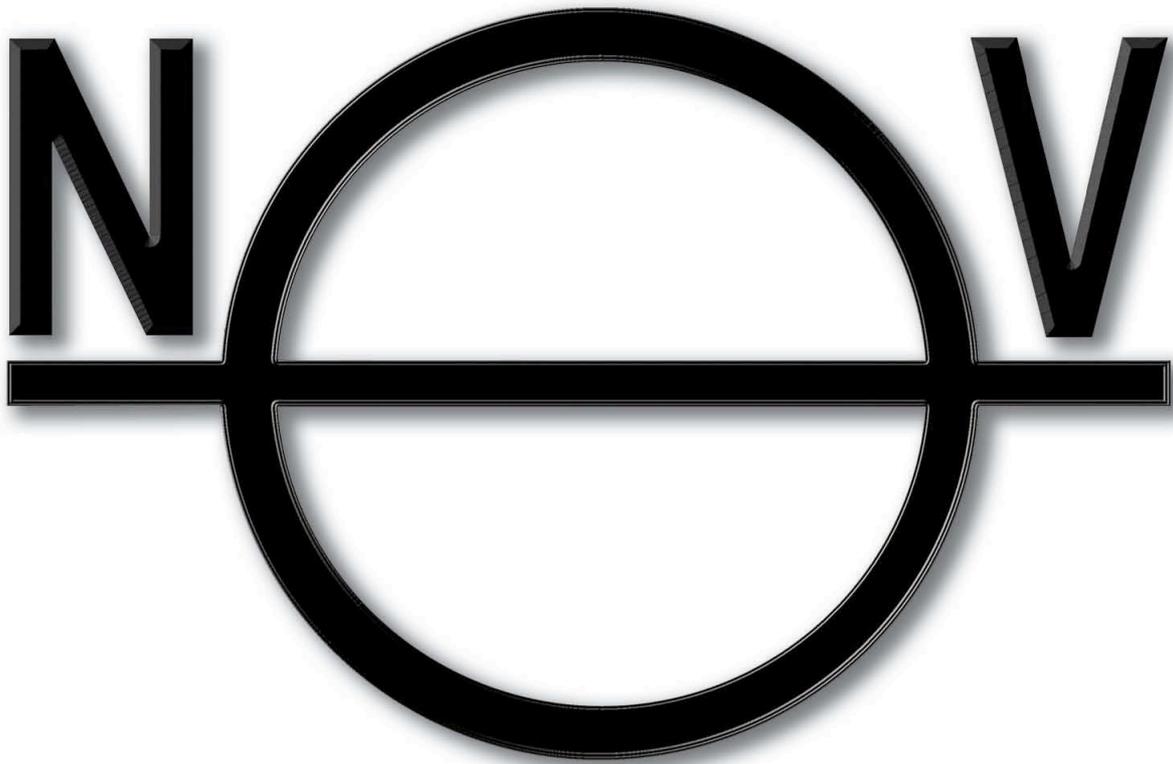
Profile of the new 42,500gt residence ship for Four Seasons Hotels and Resorts, that is expected to be built by Kvaerner Masa-Yards when sufficient apartments have been sold.



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New trailer ferry proposal to relieve US road congestion

ELSEWHERE in this issue, we report on the RoRo 2004 conference, where delegates were updated on moves in Europe to try and switch freight off motorways onto 'sea highways'. Some people may have been surprised to learn that similar problems of congestion also exist in the USA, and Mr Robert Kunkel, chairman of the new Short Sea Shipping Cooperative Program, outlined plans (in his interesting paper 'The North American short-sea initiative') for a new class of open-water ferry to assist solve these difficulties.

The design for a new family of such ferries - which particularly aims at accommodating domestic 53ft trailers - has been drawn up by the Vancouver (Canada) naval architectural consultancy Robert Allan Ltd, well-known for its advanced tug and other designs. These Ulysses-class concepts come in various formats, depending on individual operators' requirements, with one or two trailer decks. Most are for sheltered waters but Mr Kunkel also requested a more robust version with stern-only access to sail on exposed East Coast routes. The designer additionally says that the ships are appropriate for certain European operations.

All are based on successful prototypes developed in the 1960s by Robert Allan for ferry companies in the British Columbia area running services to Vancouver Island. Today, many of these are due for replacement, and this was one of the catalysts for the new generation of Ulysses ships.

The essential character of the hull form has been well proven on other comparable vessels, such as the Kootenay Lake ferry design Osprey 2000, and performance characteristics were confirmed recently through a comprehensive model test program. A fully developable double-chine hull should ensure easy and low-cost construction, with resistance as good as most typical round-bilge forms. A 1.80m-deep double bottom extends throughout the hull length to provide easy access for maintenance, and this extends outwards to cover the chines - areas vulnerable to impact damage. Subdivision is to a two-compartment flooding standard. All fuel tanks are located inboard and above the double bottom.

Ballast tanks are located at the extreme hull ends and at the extreme sides to provide maximum trim and heel correction moments with the minimum amount of ballast transfer. This should reduce the cost of coated tanks and time for trimming. Additional ballast space could be provided in the double bottom if required for light load conditions.

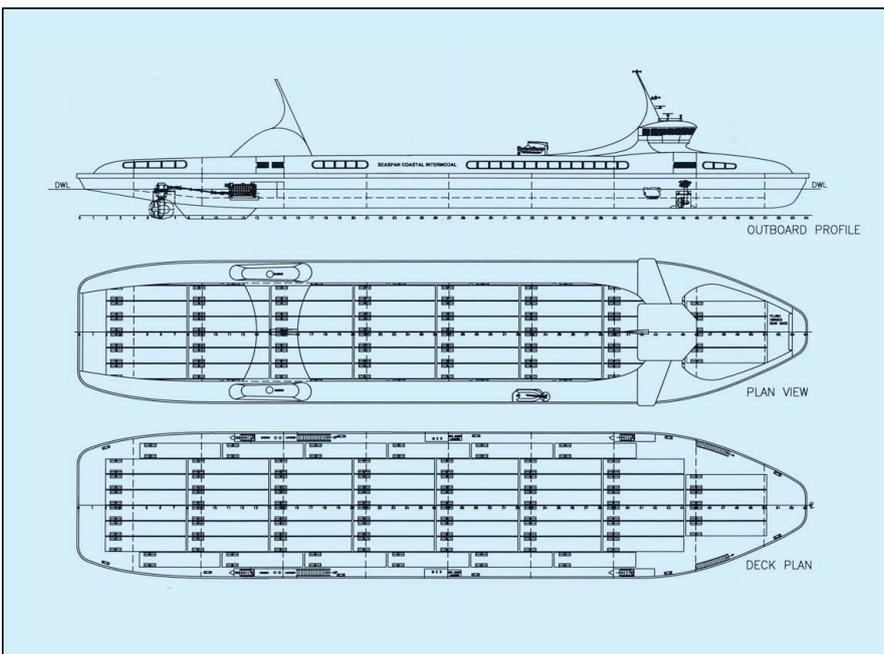
A main deck layout has been carefully planned to maximise the ease and speed of trailer handling, with eight lanes running almost the full hull length, minimal use of casings and on-deck structures, and designated parking areas at the bow for tractor units. The entire level is enclosed by a 3.8m high so-called stanchion 'fence'.

All crew facilities are above the main deck and all stores spaces are either below decks or in the superstructure, to avoid wide casings. Various passenger and crew layouts can be provided, depending on an owner's request.

Although the accompanying illustrations and general arrangement plan show a Z-drive



An impression of a typical Ulysses-class ro-ro trailer ferry for protected waters, designed by Robert Allan to help relieve road congestion in the USA. This version has two trailer levels but a single-deck variant has also been conceived; for more exposed routes, the bow access would be enclosed and cargo only loaded over the stern.



General arrangement plans of a proposed Ulysses-class 1250S single-deck ferry for protected waters, with bow-door access for 58 x 50ft unaccompanied trailers. Drive-through versions for trailers with their tractors are also possible. Although a Z-drive propulsion configuration is shown, Robert Allan can provide a conventional geared diesel-mechanical or diesel-electric plant if required.

propulsion layout, a Ulysses-class ship can be powered by a conventional geared diesel arrangement, or an electric propulsion layout; Robert Allan will evaluate a system to suit an individual project.

A typical example of a Ulysses ferry is the 1250T twin-deck version for 88 unaccompanied trailers. This has a length oa of 127m, a breadth over the fenders of 25.80m, a depth of 6.1m, and a draught of 3.2m. Two diesel engines (such as Caterpillar

3608 types, 2 x 6600bhp or 2 x 4800kW) would drive two azimuthing Z-drives (such as Rolls-Royce US305 designs fitted in Nautican high-speed nozzles).

A retractable 1600bhp Z-drive or tunnel bow thruster could be fitted. With this arrangement, the service speed would be around 18knots. Bow and stern access would normally be provided for all models, except on the open-water version, which would feature stern-only access. ⚓

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Recent developments in production technology

George Bruce reports on some of the newest techniques being employed in today's competitive shipbuilding environment, beginning with a round-up of some new alternatives to conventional welded structures and associated shipbuilding systems. A more detailed examination of some of these and other systems appears in following articles.

ONE of the critical issues facing shipbuilders today is the need to produce ships quickly and efficiently. Maintaining dimensional accuracy is a fundamental problem, especially where thin plate is used, for example in ship superstructures. Some recent developments in available technologies may offer yards worldwide significant actual and potential improvements.

Various alternatives to conventional welded steel structures have been successfully created, particularly to provide efficient, lightweight panels. Sandwich panels as an alternative to traditional, stiffened plate structures have been available for many years. They have been incorporated, initially into warship structures where weight is critically important, but subsequently into passenger ship superstructures in particular.

Resistance welded panels have also been obtainable for many years. In these, a steel core in the form of a honeycomb or pyramid truss is used to separate two relatively thin steel plates. Resistance welding allows the three components to be joined without access to the interior, so there are no practical limits on the thickness of panel which can be made available. However, this process does not offer a structure suitable for many structural, load-bearing applications.

In the USA, several such products are available, two examples being Navtruss and Navsteel. These are truss-core and honeycomb sandwich panels, produced by Astech Technology. They are described by the maker as lightweight, strong, and versatile, and have been used for turbine-exhaust uptakes, deck-edge lift doors, antenna platforms, workshops, and deckhouses.

Other applications include helicopter hangars and hangar doors, platform decks on naval fighting ships, as well as hotel spaces and landing decks for offshore drilling platforms. Both Navtruss and Navsteel are all-resistance-welded sandwich panels which can be manufactured in any reasonable length, up to 1219mm width in a variety of core geometries, face sheet, and core thickness. Navtruss uses a corrugated core system. As a typical example, exhaust uptakes for US Navy Aegis-class guided missile cruisers cut weight by 32 long tons over previous designs.

Marine structures incorporating Navtruss and Navsteel are claimed to have provided very useful weight savings of 25% to 45% over stiffened plate structures for equivalent strength and stiffness. This structural efficiency is more important as ships become top-heavy with added electronics or weapons systems but would also be of great interest to shipyards building cruise liners and ferries.

All panels can be manufactured from stainless steel, which is very corrosion-resistant and maintenance-free. They are also said to be resistant to corrosion and toxicity problems and to be fire-resistant in accordance with test specification ASTM-E-119.

According to Astech, the company is the world's largest producer of resistance-welded honeycomb sandwich structures. The honeycomb consists of flanged ribbons that are resistance-spot-welded to face sheets, creating a unique, high-strength panel material claiming superior performance characteristics.

Other products from the US company are Stresskin and Soundwich honeycomb panels, which can also be manufactured from any resistance-weldable material, including stainless steel, nickel-based and titanium-based alloys, and can be produced in any reasonable length. The all-welded or diffusion-bonded construction eliminates foreign bonding agents, thereby reducing weight, and eliminating the potential for galvanic corrosion.

These structures are said to have exhibited more damage tolerance than competitive designs and to be repairable in the field using standard sheet-metal techniques. The panels are also claimed to be very resistant to sonic fatigue and thermal shock.

There is also a variant on the honeycomb panel, which was developed for structures requiring thicker face sheets and greater core depths. They use the same resistance welding techniques developed for honeycomb construction.

Moving from the highly specialised applications used to date by these US designs to more mainstream ones will require some changes, notably the development of cost-effective manufacturing and production processes for the sandwich panels and a development of new design principles. The ability to exploit novel structures will need competitive prices for the products, based on economies of scale in manufacturing.

Alternative panels using laser welding

The relatively new laser welding process, offering stake welding possibilities, has allowed more robust structures to be created. In stake welding, the internal stiffening for a plate is welded from the plate side, with the laser penetrating through to the stiffener. Full penetration welds can be achieved, providing considerable scope for application of panels produced using this process.

Introducing composites with the Sandwich Plate System

The Canadian-based company Intelligent Engineering has successfully developed the Sandwich Plate System (SPS) for marine applications, and this journal and its associate *Shiprepair and Conversion Technology* have reported on several projects involving this interesting new solution. This is part of a different category where the internal structure is a homogeneous material rather than a honeycomb or corrugated structure. It claims to give a number of advantages.

The steel manufacturer Corus has developed a product which uses twin steel panels joined by stud-welded supports, with a matrix in between the sheets of concrete. This provides a suitable panel for application such as blast walls on offshore structures.

Alternative materials for ships

Other materials are available for use in shipbuilding, and although some may be regarded as mainstream, novel applications continue to be developed. Copper-nickel alloys are widely used for marine applications due to their excellent resistance to seawater corrosion and biofouling. In addition to decades of providing reliable service in such applications, they offer effective solutions to many of today's technological challenges, especially those involving cleaner waters and decreased chlorination levels. Applications include condensers and heat exchangers, pipes, pumps, valves, water boxes, offshore oil and gas process facilities, and desalination operations.

A new resource, providing on-line information on the marine applications of copper and its alloys can be found at www.coppernickel.org. This website is the result of collaboration between US and European copper centres, including Copper Development Association UK, and is presented as a worldwide resource. The site discusses the composition, physical and mechanical properties of each alloy, and their suitability to particular applications.

Applicable standards (EN, ASTM and ISO) are identified for all product forms, along with thorough information on welding and fabrication. The site features an interactive ship with layers depicting each system and linking to relevant information.

Further uses of copper include an antifouling solution, developed by Ecossea, a technology-based company founded in 2001, using the patented Cupro FF antifouling system. In future, this product and its associated variants will be marketed as Cuproguard.

Utilising copper-nickel alloys in a patented, combination of several bonded layers (including an impermeable membrane) on an adhesive backing sheet, Cuproguard is currently supplied in 300mm x 360mm panels suitable for cladding hulls of a variety of ship types and offshore structures. Ecossea claims that the 'tiles' are flexible, facilitating ready attachment and accommodation to the curved surfaces of most underwater sections. The typical life of the cladding is stated by Ecossea to be 20 years, and the company states that it will provide a five-year written guarantee.

The association of copper-nickel alloys, particularly the 90/10 CuNi, with the marine environment is well established, and extensive use of its well known anti-fouling and anti-corrosion properties benefits such applications as seawater condenser tubes and tube boxes, seawater-carrying pipework, and special valves and components for critical operation on naval vessels, commercial shipping, and offshore platforms.

Over the years, various tests and experiments have demonstrated that the marine organisms associated with the progressive fouling-up of hulls simply do not stick to copper-nickel. The complex oxide film formed over a short period of initial seawater contact acts as the perfect prophylactic. Hulls for experimental vessels, where the underwater sections were made entirely of copper-nickel, have admirably demonstrated the performance of this alloy and are still in use today.

It is claimed that the long potential life of a cupro-nickel protection system will contrast dramatically with conventional paint systems, which require periodic renewal. Cuproguard is said to offer a proven and elegant, eco-friendly and maintenance-free solution to antifouling paints.

Laser scanning

Photogrammetry has been used for many years, but the arrival of the digital camera has revolutionised the process. The process was originally based on the use of two photographic images of the same structure, taken by cameras a

short distance apart. Superimposing the two images allowed a stereoscopic effect. The two images could be analysed to provide an accurate, three-dimensional picture of the structure.

The process was time-consuming, but provided a useful means of assessing large structures, which needed to be joined. One example was in the joining of two halves of VLCCs built at Scott Lithgow in the early 1970s.

With current technology, the ability to produce a digital image has moved the processing of images from a matter of days to more or less instantaneous availability of results. A single digital camera is used to take images of the structure from different locations. Provided a small number of points appear on different images, the software used for processing can create a 3D model of the structure, which is accurate. A project in The Netherlands to reconstruct existing hulls using photogrammetry was discussed in *The Naval Architect* July/August 2003, page 34.

Various uses of photogrammetry are possible. It is used, for example, to measure circularity of submarine pressure hulls. Other applications

include the measurement of existing structures such as ships to be lengthened, and the assessment of one ship block so that the next one to be assembled can be adjusted to provide a precise fit. The process can also be built into panel lines and other production systems to check accuracy during production and make adjustments as necessary before the interim products are completed.

An alternative is the use of laser scanning. In this case, the equipment, developed from laser range finding, rapidly scans the structure and creates a 'point cloud' of precisely located points on the structure. From these, the software can again create an accurate 3D model of the structure to be assessed. The process has been used in conversion, for example, lengthening, and has potential application in ship construction. It would appear that the challenge to produce effective ship structures, both quickly and accurately, is increasingly being met not only by the application of novel materials and structures, but also by an increasing ability to measure the results. ↓

Sandwich Plate System (SPS) for new ships - a technical update

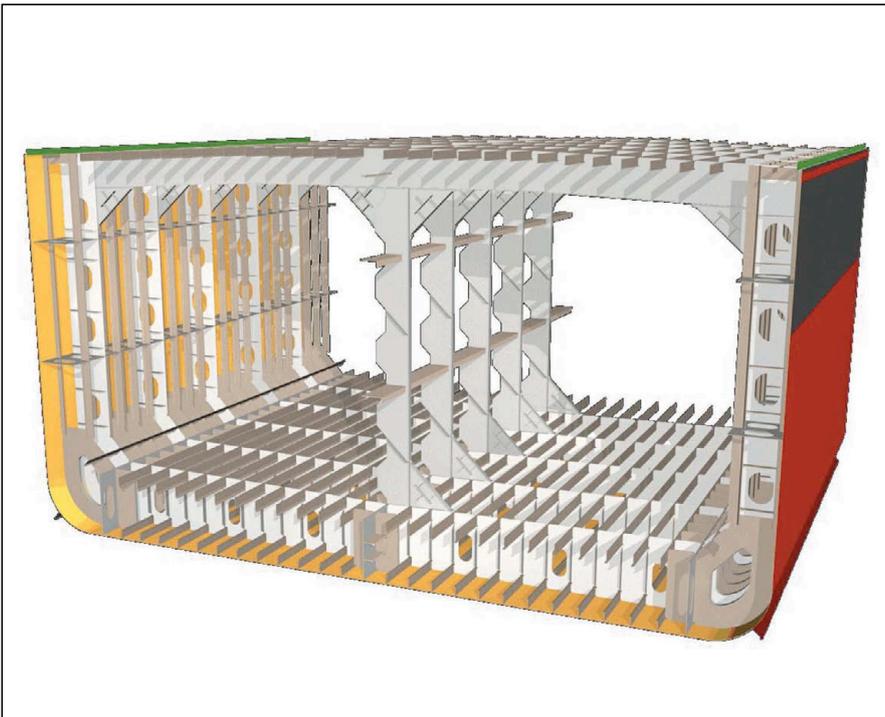
A NEWCOMER to the industry, although one which has had a 10-year development programme, is the Sandwich Plate System (SPS) from Intelligent Engineering Ltd. Originally developed to provide impact-resistant structures for the Canadian Arctic offshore oil industry, SPS has found uses in civil engineering, more recently

in shiprepair, and currently in new ship construction applications. This innovative solution was first discussed in *The Naval Architect* November 2000, page 10.

SPS structures incorporate the sandwich - a continuous elastomer core bonded between two metal plates - with more conventional primary stiffening. Closely spaced stiffeners

Conventional ships are largely designed using traditional materials and design methods. Production requirements are not always considered in great detail, nor is there usually a creative search for alternatives to the conventional. However, a number of new developments in materials, novel applications, and new production technologies have been made in recent years, and one of these is reviewed here. Overall, there is potential for ship designers and builders to place greater emphasis on materials and the production process to reduce overall costs and create novel solutions to demanding ship operational requirements.

Section through a 14,000dwt product tanker, designed to be constructed using SPS technology.



which resist buckling and local deformations are replaced by the elastomer core. This results in a structure that is claimed to be much stiffer and stronger than a single plate, and therefore lighter for an equivalent strength.

Other advantages claimed for SPS include a simpler structure, increased fatigue resistance, reduced in-service corrosion, and lower through-life costs. In specific applications, further benefits attributed to SPS by the designer are fire resistance, blast and impact resistance, and reduced transmission of noise and vibration.

Intelligent Engineering has developed SPS in collaboration with Elastogram GmbH, part of the BASF Group in Germany, over a 10-

year period. Classification approvals have been obtained and some 25,000m² of the product are in service.

Many of the applications have been carried out on ships in service, for example in strengthening vehicle decks on ro-ro ferries and repairing impact-damaged cargo spaces in bulk carriers. More recently some newbuilding applications have been made. In 2003, Flensburger Schiffbau-Gesellschaft experimented with the use of SPS structures in the funnel casings of a series of ro-ro ferries for DFDS Tor Line (*The Naval Architect* July/August 2003, page 49).

The choice of SPS was made to reduce weight and to increase the space available for the installation of equipment. Space saving is achieved by elimination of the secondary stiffening of the panel structures also because the panels are approved to A60 standard with no additional insulation beyond the SPS core. It is the view of Intelligent Engineering that both fire resistance and the reduced space, thanks to the elimination of stiffeners, provide potential benefits in application of the product to accommodation spaces.

Hatch covers for bulk carriers?

Other current developments applicable to new construction are designs for UR S21- compliant hatch covers. These are for Panamax and Capesize bulk carriers, taking into account resistance to high pressures and impact loads anticipated by the newest regulations. Further work in hand includes lightweight vehicle decks, and two new inland waterways barge projects are at various stages of progress. In Japan, Mitsubishi Heavy Industries is also looking into the attractions.

A study by Intelligent Engineering is claimed to demonstrate potential construction savings for shipyards in the region of 50% over conventional structures. The company believes that the technology that it has developed will provide lower costs both for production and through-life. Enhanced safety is also a benefit which is claimed; however, it is recognised that the

application of SPS on a larger scale will require a fresh approach to structural design. Longitudinal strength is assessed in a similar manner to a conventional structure, with the two plates contributing to section properties; the core is not taken into consideration. Local strength can be managed by tailoring the material thicknesses to specific requirements.

Rules for the use of SPS are under development, and a draft is anticipated from Lloyd's Register in 2005. Material properties may be varied to suit strength requirements based on direct calculation of structural loads. This may be similar to the use of reinforced composites, which require a different approach to the design process. Significant development will be required to take the panels to their full potential, but Intelligent Engineering is convinced that benefits will make the effort worthwhile.

Concerns about the long-term effects of corrosion and fatigue in double-hulled tankers have also been raised as a potential reason for the use of the SPS concept. Benefits are claimed to include:

- a simpler structure with fewer stiffener connections as potential sources of problems
- reduced production costs
- better distribution of stresses and less opportunity for coating breakdown
- reduced area for coating and improved access
- easier inspection of structures in service.

Use of dissimilar metals

An interesting potential application would allow construction using two dissimilar metals for the panel faces. As an example, Intelligent Engineering proposes that a panel with one stainless and one mild steel face could be a solution for chemical tankers. The company suggests this approach would eliminate problems of joining the dissimilar metals (although, of course, an alternative could be the tri-metal bonded approach).

A design study for a 14,000dwt products tanker has been carried out. This was based on Lloyd's Register rules and that classification society's ShipRight direct calculation procedures. A description of the work carried out was presented by M A Brooking and S J Kennedy, from Intelligent Engineering, in an interesting paper at the Royal Institution of Naval Architects' Double-Hull Tanker conference, held in London on February 25-26, 2004.

Integration into shipyard steelwork lines

In addition to novel design considerations, the use of sandwich panels will require novel production technologies. The need to integrate the SPS panels into the current, conventional production technology is well recognised. Two options have been proposed.

The first would make use of prefabricated SPS panels delivered to shipyard assembly workshops. The second would integrate SPS panel fabrication into routine yard assembly lines. In the first case, the use of a dedicated SPS facility with economies of scale would, according to IE, provide low-cost panels for design specifications. In the second case, a conventional shipyard panel line would be partially replaced by the SPS requirements.

The production process proposed by Intelligent Engineering for panels is as follows. Steel plates, blasted to the appropriate standard and surface profile (SA 2.5) are brought together and welded to form panels of correct size. The primary stiffeners (such as floors, webs, and girders) are located and welded to the inner panel sides of the sandwich. The major saving claimed at this point is elimination of the secondary stiffening (conventional frames and longitudinals), which make up the bulk of panel line welding requirements.

The outer plate panel has the required spacers and perimeter bars located and welded. It is necessary to maintain precise separation of the two panels. The inner panel, carrying the stiffening, is then located and welded over the outer panel. It is essential to provide a seal around the perimeter to ensure none of the elastomer can escape during the injection process.

The complete panel is then moved to an 'injection bay' where the elastomer is injected and allowed to cure. During the curing time, a specific temperature must be maintained and the panel restrained to ensure dimensional accuracy is maintained.

Time savings are claimed for the panel process over conventional structures and fabrication, based on elimination of the considerable fairing and welding needed for stiffeners. While there are no current examples of large-scale SPS panel production, smaller panels have been produced and the process is a known quantity.

Although there is clearly a lot of development work still to do to bring SPS into the mainstream of ship design and production, what has been seen to date shows considerable promise. If the claimed benefits can be realised, and in particular if the production processes can be developed to provide the necessary economies of scale, then SPS seems to have a considerable part to play in the future of shipbuilding. It will be interesting to follow future developments and *The Naval Architect* looks forward to reporting wider application of SPS in the future.

An SPS sandwich panel for a funnel structure on one of the series of DFDS Tor Line ro-ro ships on order at Flensburger Schiffbau.



Exploiting friction-stir welding of aluminium

ALUMINIUM is commonly used for smaller, high-speed craft, but has dropped out of favour as a material for larger, especially passenger, ships. Although recognised as providing lower weight than an equivalent, conventional steel structure, difficulties in welding and some problems in performance have made the material less attractive to many yards.

In recent years, friction-stir welding (FSW) has moved from a laboratory demonstrator to production process (*The Naval Architect* July/August 2003, page 47). New developments are now claimed to offer the ability to expand the scope of application of aluminium in the shipbuilding industry. The key, according to ESAB, the leading Swedish manufacturer of friction-stir and many other mainstream welding systems, is the provision of accurate welded components that require minimal fit-up work. Crucially, FSW allows the use of high-strength aluminium grades that were formerly regarded as un-weldable.

A new development from ESAB is the Legio modular friction-stir welding machine, which, the company told *The Naval Architect*, will bring this new welding process within the reach of shipbuilders with only moderate investment costs. FSW provides a joining technique with very low heat input. As a result, there are minimum residual stresses, the welded components are accurate, and the fit-up during subsequent assembly into larger units and then welding is reduced. ESAB claims that the resulting savings in both time and money will create competitive advantage to the users of FSW prefabricated parts.

The benefits available include:

- industrial production with a high degree of completion
- repeatable components which ensures uniform performance, quality and narrow tolerances



Friction-stir welded, straight panels being inspected at ESAB's centre of excellence in Sweden.

- enough flexibility in production equipment and capacity to permit customised solutions with reliable delivery
- completed panel units are inspected and approved, as at present, by classification authorities
- a high level of panel straightness ensures easy assembly at a yard, which should mean less manual welding
- supplementary work, such as floor levelling and preparation for floor coverings, is reduced.

Another feature which ESAB promotes is that there is no need for time-consuming post-weld treatment such as grinding, polishing, or

straightening. However, the company does point out that panel components must be designed for the process - a panel design which would normally be welded using a MIG or TIG process may not necessarily be suitable for friction-stir welding.

A common limiting factor is the need for a relatively high down-force needed to restrain components when friction-stir welding. Support in a form of a backing bar or design change may be needed to ensure levels of repeatability not previously experienced in welding.

According to ESAB, one reason often quoted for not using aluminium has been 'that it is not as strong as steel'. This is actually dependent on the alloy to be used, and surprisingly enough, there are aluminium alloys which are as strong as or even stronger than steels. For example, the so-called Alustar has yield and tensile strengths comparable with alloy steel S235. AlCu4SiMg (AA2014) - an alloy typically used in aerospace applications - has significantly higher strength than alloys in the 5xxx and 6xxx series which are typically used in shipbuilding.

Another reason for not previously considering the use of these alloys in shipbuilding has been their poor weldability, but with friction-stir welding, some of these barriers can be overcome. As an example, a strong alloy such as AA7021 might be used to produce thin aluminium floor panels to reduce weight significantly.

The accompanying illustration shows the use, in a smaller shipyard, of ESAB's new Legio machines for the fabrication of small batches of friction-stir welded panels. This is at Estaleiros Navais do Mondego SA in Portugal.

ESAB believes that friction-stir welding is simpler to introduce than most other welding processes. This is primarily because the welding operator does not need any special skills, since the parameters are repeatable and high quality is easily achieved time after time.

An ESAB Legio 3UT friction-stir welding machine being demonstrated adjacent to the shipbuilding production line at the Portuguese yard of Estaleiros Navais do Mondego.



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Special steels for specific applications

ANOTHER example of tailoring a material to the particular needs of a project or operating situation can be found in the special steel developed for the pioneering windfarm installation ship *Mayflower Resolution*, featured in *The Naval Architect* April 2004, page 28, and May 2004, page 7. The need for a stable lifting platform for tower installation dictated a relatively large vessel (the main dimensions of *Mayflower Resolution* are length 130.50m, beam 38m, and a draught permitting operation in water as shallow as 3.50m or as deep as 35.00m. With such a large structure supported on six jack-up legs and carrying a maximum 300tonne load on its main crane, the forces generated in critical parts of the structure are considerable.

These demands created a need for a steel material with high-strength, fine-grain, toughness at low temperatures and workability. A solution was found by AG der Dillinger Hüttenwerke, a steelmaker based in Dillingen, Germany. This company claims that use of 'conventional' steels in these circumstances would have resulted in considerable thicknesses of materials, with a consequent reduction in vessel payload in a weight-sensitive design.

Weldability was also a consideration, since very thick materials pose problems. Since the ship is required to operate in cold, northern waters, low-temperature steel toughness is important. As thickness increases, the demands on toughness to resist brittle fracture are also greater.

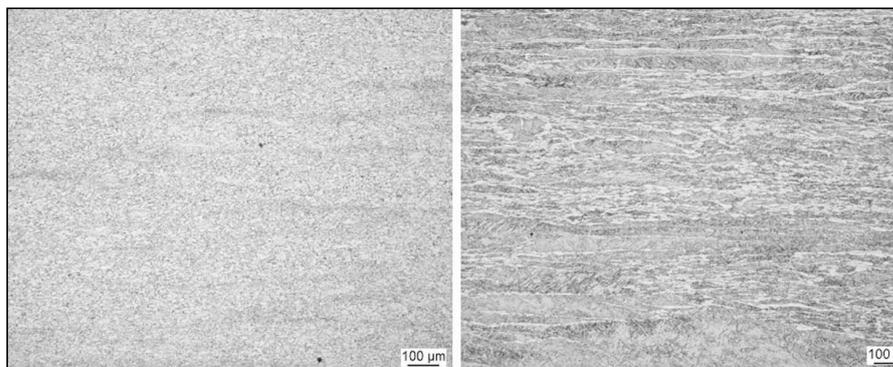
The project required some 5400tonnes of high-strength steel plate. This conformed to Det Norske Veritas specifications NV-E/F36 and NV-A/D/E/F500, that is a minimum yield strength of 355MPa and 500MPa respectively, and capabilities down to -60°C. The thickest material delivered was 150mm.

Such steels are used in other taxing situations, including mobile cranes, bridges, water-hydraulic engineering, and some offshore applications. Previous experience was used to assist in the optimisation of steel for *Mayflower Resolution*.

The production process for this material was a thermo-mechanical rolling method to achieve the high grade and quality required. This is a combination of thermal and mechanical

	R _{eh} [MPa]	R _m [MPa]	A _V [J] at T [°C], long	SD	Max. Thick. [mm]	Tonnage [t]	
NV E36	355	490-620	34 (t ≤ 50 mm)	-40	TM	-	
			41 (>50, ≤ 70 mm)		Q	110	17
NV F36			50 (> 70 mm)	-60	TM	100	255
				Q	150	265	
NV A500	500	610-770	50	0	TM	42	394
NV D500				-20	TM	42	3000
NV E500				-40	TM	75	988
					Q+T	150	14
NV F500				-60	TM	75	246
				Q+T	150	213	
For comparison:							
NV A	235	400-520	27 (t ≤ 50 mm)	0			

Technical details of the high-strength plates rolled by Dillinger Hüttenwerke for *Mayflower Resolution*.



Grain structure (near surface, left, and mid-thickness, right) for a thermo-mechanically rolled NV-F500TM plate.

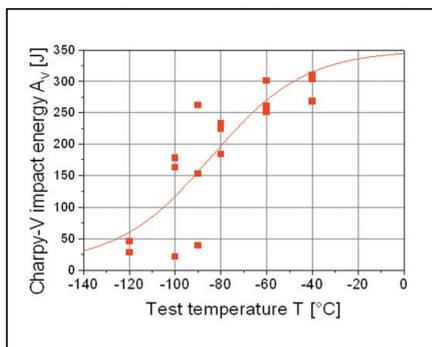
treatment of the steel, which achieves a grain structure not attainable by the use of thermal treatment alone. The process can use a wide variety of rolling and heating combinations to achieve a fine grain structure. This provides the required toughness and strength without high alloy content.

Other considerations are the need for very low percentages of elements such as sulphur and phosphorous. Dillinger Hüttenwerke claims that its integrated iron and steel plant is a key to producing the high-grade materials to demanding specifications. Phosphorous contents below 0.015% and sulphur below 0.013% were achieved.

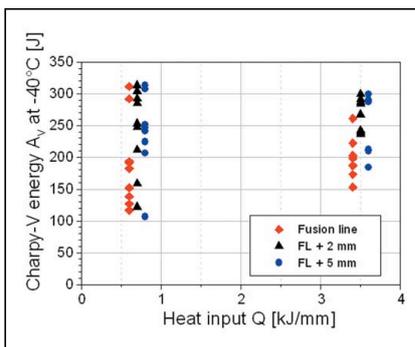
Plates up to 75mm thick were produced in grade NV-F500 using the thermo-mechanical process employed at Dillinger Hüttenwerke. The company claims that this process, possibly combined with hardening and tempering, can produce the high-grade steels for special applications in a reliable and repeatable way.

The steels are reported to have good working properties and very good weldability. This is partly due to favourable alloying properties of the materials. Dillinger Hüttenwerke firmly believes that specially tailored steels for given applications can provide a cost-effective solution to the requirements generated by harsh and demanding operating conditions on special ships.

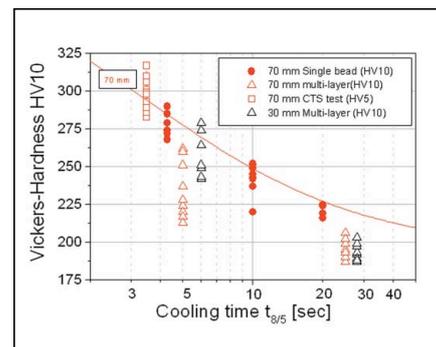
Charpy V temperature-transition curve for a NV-F500TM steel, 75mm thick (longitudinal values).



Charpy V values in the HAZ after welding, as a function of heat input (NV-E500TM, 75mm).



HV10 hardness values in the HAZ after welding (NV-E500TM, 75mm).



New advances in efficient stiffener production from Dutch specialist

AN ability to produce large numbers of plate and profile (stiffener) components is fundamental to efficient shipbuilding. Much effort has been focussed on plate cutting, to ensure that panels are produced to tight tolerances but there is also a need for profiles to be equally accurate. Accuracy and speed of production are the critical requirements, set by major shipbuilders, including the world's largest, Hyundai Heavy Industries, of South Korea, as discussed in *The Naval Architect* March 2004, page 53.

Satisfying these demands is a major task, but it is one that HGG Profiling, from Middenmeer in The Netherlands, believes it can carry out. This company has recently completed two profile preparation lines for the Korean giant, to supplement two which were installed at Ulsan in 2003. In addition to Hyundai, HGG has secured an order from Damen, for that Dutch builder's associate yard at Galatz in Romania. The chief executive of Hyundai is quoted as saying 'the PCL 600 is a revolutionary product and is an answer to the ever-increasing demand in the shipbuilding industry for efficiency and accuracy'.

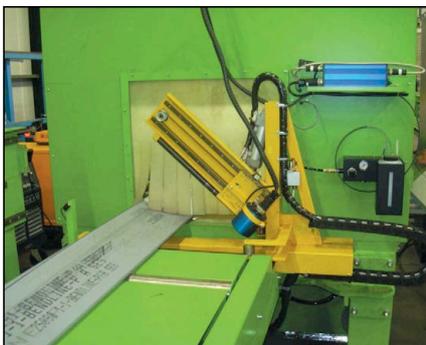
The Naval Architect was recently invited to view the new equipment in The Netherlands during testing, prior to shipment to Korea. Opportunity was taken to inspect other aspects of HGG operations, including pipe-profile cutting equipment and the subcontract production of specialised fabrications.

Profile lines made by HGG include a number of features which the company claims to be special and which give a competitive edge. Of these, the measurement system is one of the most important. As a profile is moved onto the infeed conveyor, the end is sensed and then gripped by the device which will push it through the processing cell. As the profile is pushed into the cell, a light beam detects its other end, which fixes its position for the robot cutting system.

Prior to cutting, the profile can be moved through a marking cell, where an ink jet system can add text - to provide part identification, bending lines - for inverse curve frame bending, and other production information as required. The software associated with the profile line includes part preparation data and nesting capability.

The test pieces that were seen during our visit had a high quality of cut edge. Grinding would be required for sharp edges requiring subsequent coating, but otherwise the parts are said by HGG to be ready for welding with no further processing required. The system inspected used a plasma cutting process, but cutting using oxygen and a fuel gas is also available.

As a profile is moved through the cell, not only does the robot move to make the necessary cuts, but also the profile itself is indexed. This allows HGG to provide a smaller than usual processing cell, and a more compact robot to be used. The cell includes a



Details of HGG's advanced new PCL 600 profile production line, seen here on test at the company's factory in The Netherlands prior to shipment to Hyundai Heavy Industries in Korea.

totally enclosed working area with integral fume extraction; fumes are discharged via a filter. As a result, there are no fumes to limit observation of the cutting process or affect the workforce.

Overall processing speed, using plasma cutting, is claimed to be up to 30% faster than for comparable systems, with equivalent accuracy. Accuracy is said to be within 1mm. Cutting speed is varied automatically to suit material thickness and cutting angle. A typical speed, according to HGG, is around 1500mm/min. Apart from the speed of cutting, logistical support provided by the conveyor system ensures a steady flow of materials for maximum utilisation.

Recognising that profiles, as delivered to shipyards, may not be entirely straight, although still suitable for production, HGG has developed its profile lines to manage relatively curved products. The precise location of the profile as it passes through the production cell is sensed by two rollers. If the profile is bent, or the height varies, the rollers move with it and this movement adjusts the robot location.

As a result, the need for the robot to check the workpiece position is eliminated, contributing to the speed of processing. One important result is that no force is required to constrain the stiffener during processing, which lightens the system.

Specific requirements can be built into a profile line, based on shipyard operating parameters. If necessary, lines can be general-purpose, capable of a wide variety of production of a range of stiffeners (or pipes). This gives flexibility, but does not optimise production for any specific type of profile. Alternatively, as was the case at Hyundai Heavy Industries, the line can be tailored to a small range, focussed on high throughput. Hyundai required a system specifically developed and optimised for processing of angle bars, to give maximum production rates.

HGG began as a pipe profiling company and this remains an important product. In addition to hardware, the company has developed its own software, stated to be compatible with major CAD systems, including AutoCAD and Tribon. A wire frame model of a tubular structure was seen, from which using tube diameters and wall thicknesses, complete production data can be extracted.

HGG is an integrated company, which not only makes profiling equipment but also uses it in a subcontracting arm of the group. This provides direct operating experience of the equipment which is fed back into designs.

Founded in 1984, as a company to cut pipes for the offshore oil industry, HGG rapidly moved into development of equipment to cut pipe profiles accurately. Specialist, and sometimes portable, equipment was produced

to give the pipe cutting capability that was required. Since then HGG has developed a range of pipe profile cutting equipment for sale and also uses its own machines to supply pipes to customers.

The latter include shipyards, offshore, and increasingly, civil construction companies (HGG has produced components for the roof of the new Wembley stadium in the UK). HGG produced its first robot profile cutter in 2000, for a variety of tubes, and has since

moved into shipyard profile cutting. Selection of HGG by Hyundai was partly on the basis of a contract to produce pipes for a Hyundai subsidiary in Kuwait. As a result, HGG told *The Naval Architect*, Hyundai was prepared to place its first order on the basis of the design drawings. Most shipyards prefer to see a prototype or a system in operation before placing an order, which indicates a large degree of confidence in HGG's ability to deliver.

HGG has its base in Middenmeer, and a subsidiary subcontract company in Germany. In July 2004, the company will open an office in China, recognising the extraordinary expansion of shipbuilding in that country, as profiled most recently in *The Naval Architect* February 2004, page 49. Although the basic configuration of profile processing lines has been established for many years, HGG has demonstrated that positive advances are still possible. ⚓

VOC software for NASSCO steel line

THE US shipyard, NASSCO, in San Diego, builder of both naval and merchant ships, has installed a suite of software to handle its solvents emissions reporting and to enable it to comply with environmental regulations. This is VOC Manager, developed by the UK consultancy Safinah Ltd, based at Morpeth, Northumberland; VOC is an acronym well known in the tanker field, standing for 'volatile organic compounds'.

The software has been installed in NASSCO's blast and primer shop upstream of the steelwork line, and is initially being used to monitor paint consumption and VOC emissions from the two treatment lines; these are critical areas for the

yard because of very strict local and federal record-keeping requirements. Regulations call for daily consumption of primer, volume of VOC emissions, and volume of VOCs abated. The new software was developed in conjunction with the EU-funded ECOPAINT project (*The Naval Architect* January 2003, page 34).

The Safinah system employs bar-code technology to capture data about a particular product as the can is being opened. Once this data is captured, a scanner will download the information, and the system will record when and where the paint was used. Other shipyards have been using VOC Manager for more than two years. ⚓

Fatigue and fracture course

FOR the first time, BMT Fleet Technology Ltd, based in Canada, is to offer a special short course in the UK on the key subject of Fatigue and Fracture Analysis of Ship Structures. In particular, the three-day course considers the materials, structural configuration, fabrication, and environmental issues that contribute to the failure of ship hulls - all factors that concern naval architects from design through to maintenance.

The UK course will be held on October 20-22, 2004 at Kingsway Hall, Great Queen Street, London WC2. Further information can be obtained from Mr Shannon Nicholson, BMT Fleet Technology Ltd. E-mail: snicholson@fleetech.com ⚓

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Geislinger couplings for new catamaran

A LARGE new diesel-powered catamaran ferry, *Spirit of Ontario*, is equipped with several innovative products from the Austrian manufacturer Geislinger. These include four of the company's torsional elastic steel couplings between the MTU 20V8000 main engines and their ZF gearboxes, but in addition, the new ferry features Gesilco fibre-reinforced couplings and shaftlines. These BF100/40/2H/1 designs each transmit a nominal torque of 75kNm and have a

length of 1m but the mass is only 134kg. Including bearings and bulkhead seals, Geislinger delivered 32 components for this vessel.

Besides products for high-speed engines, Geislinger also builds couplings for medium- and low-speed diesel engines. Of particular note was the delivery last year of a torsional elastic coupling, believed to be the world's largest, for installation in a new Japanese VLCC featuring a

contra-rotating propeller. This was built at IHI Marine United's Kure shipyard. The coupling is a BE280/60/140U model, which transmits half of the main Sulzer 7RTA84T-B engine's 27,160kW output and protects the special gearbox which changes the rotational direction of the forward of the two propellers. Further information can be found in *The Naval Architect* September 2003, page 62 and October 2003, page 38. ⚓

New management software version launched

THE latest version of Kronodoc's software has recently been released. The most important development areas for the release are document management features and hours reporting with resource management. New features in the document creation process include creating new documents using a file template and inheriting document properties from folder properties. Both of these features make the document creation process faster and should help to ensure more efficient documentation.

The document mass operation is a new function which boosts efficiency when working with large volume of documents. In version 3.2, users can change status and access control of multiple documents with one single operation. Future releases from this Finnish consultancy will include more mass operation functions.

The advanced search now includes an option to use several custom document property fields as a search term, in addition to all standard document properties. This is a useful feature with which to refine a search with additional search terms, if the customer has a lot of documents with several custom property fields. A small, but very important feature for both data validity and system usability is the small calendar screen with date validation for all date fields.

Hours reporting with resource management functions have been developed in close relationship with CRF Inc, especially for distributed project teams. At CRF Inc, project tasks are created in Kronodoc software by the project manager. During task allocation Kronodoc shows resource availability; the project manager can then see who has been assigned to the task, what its status is, when it will be completed and how much time has been spent. ⚓

German gearboxes for new Japanese ferry

TWO horizontally offset reduction gearboxes for a new 16,000gt ferry being assembled at Mitsubishi's Shimonoseki shipyard for Taiheiyo Ferry are currently being installed in the ship, following completion at the Reintjes factory in Hameln, Germany and approval by the Japanese Government as classification authority. The SVA1120 horizontally-offset designs will reduce the output from two MAN B&W L58/64 medium-speed engines, each of 11,840kW at 428rev/min, to a propeller speed of 141rev/min.

The new ship has a length of 199.90m and a breadth of 27.00m, and will be able to accommodate 800 passengers, plus 186 lorries and 115 cars on 1368 lane metres of ro-ro deck space. Service speed will be 23.00knots when the ship is completed next January. ⚓

BOOK REVIEW

Fully Refrigerated LPG Carriers

By Syd Harris. Published by Witherby & Co Ltd, 32-36 Aylesbury Street, London EC1R 0ET, UK. £75.00 (book can be ordered on website: www.witherbys.com). Also available from the RINA bookshop: £75.00 (non-members), £70.00 (RINA members); RINA post and packing: free in the UK, £7.00 (Europe), £14.00 (Rest of the World). ISBN 1 85609 266 6

This new publication, claimed by the author, gas shipping consultant Syd Harris, as unique, provides the first comprehensive study of the design and development of fully refrigerated LPG carriers. It spans a period from the challenging and exciting refrigeration breakthroughs in the late 1950s to the present day, having been written from a naval architect's point of view and by a man who has spent his whole working life in the gas tanker sector.

The chapters are loosely arranged around a number of shipbuilders who entered this

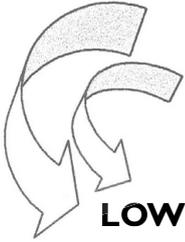
specialist field, as each made a significant contribution towards the safe sea transport of liquefied gases in bulk the success it is today. During the 1960s, the author worked at the Hawthorn Leslie yard as a naval architect on the team for the 11,750m³ *Clerk-Maxwell*, believed to be the first purpose-built fully refrigerated design from a UK shipbuilder.

Gas tanker progress was generally made independently by yards and, as such, each has a story in its own right. Much work was done in France and later in Japan. Many shipbuilders had distinctive characteristics which were built into designs and were often repeated and improved, on later ships, as experience was gained and capacities increased. This book records many notable milestones, together with the names of shipyards regrettably no longer with us but whose technical legacy lives on, such as Chantiers Naval de la Ciotat, AG Weser, and Kockums. Today, modern-generation LPG tankers are being built regularly in Japan and Korea, by yards such as Mitsubishi,

Kawasaki, and Hyundai with large capacities around 80,000m³ (eg, *Crystal Marine*, presented in *Significant Ships of 2003*), although a 101,000m³ design, *Esso Westernport*, had been built much earlier.

Approximately 100 general arrangement plans and drawings, plus more than 150 photographs and paintings are included, together with technical details of all fully refrigerated LPG carriers built or converted. In conclusion, the author presents a new fully refrigerated design concept that he has named Ptarmigan; this will be featured in *The Naval Architect's* special Gas Tanker supplement to be published with the September issue.

There are 25 chapters, also eight extensive appendices which include a delivery chronology, dimensions, capacities, shipbuilders' reference lists, and name changes of all fully refrigerated LPG carriers featured. This will be an indispensable reference book for all involved in the gas shipping business. ⚓



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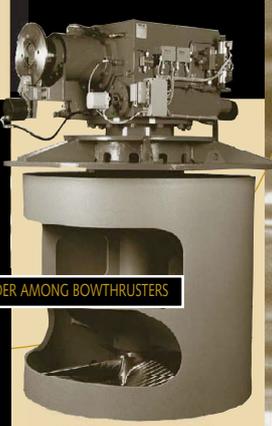
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Successful solutions to technical problems at CTO

Wojciech Górski and Leszek Wilczynski, from the ship hydromechanics division of the Polish model tank and research organisation CTO SA, report on some recent projects.

THE beginning of 2004 turned out to be very promising for Ship Hydromechanics Division of Ship Design and Research Centre (CTO), based at Gdansk, Poland. Positive trends in the shipping market brought in a number of interesting commercial and research projects, which enabled the organisation to implement both the latest developments in experimental techniques and computational fluid dynamics (CFD).

A contract with Peter Döhle Schiffahrts KG, of Hamburg for the design of a new propeller for its container ship *DAL East London* (formerly *Ajama*) is of a special interest not only because propeller design is a key activity at CTO but more important, because the guidelines elaborated in the EU project EROCAV* could be harnessed. This vessel was delivered in 1994 and during service suffered severe erosion problems. After some years of operation, serious damage to the propeller was observed. Although countermeasures were taken (eg, repair by welding and reduction of the propeller diameter), the problem persisted.

The vessel was even taken as a full-scale case in the EROCAV project, where CTO was one of the partners. For this purpose, observation windows were fitted to the stern of the hull. Within the framework of EROCAV, observations and video registrations were performed, which gave insight to the cavitation phenomena responsible for erosion problems.

Finally, the owner of the vessel decided to opt for a new propeller. The design was ordered from CTO's Ship Hydromechanics Division. This was an ambitious task, not only due to the fact that the propeller suffered from heavy erosion but also because the organisation wanted to implement the measurement technique validated within the EROCAV project. Therefore it was decided to carry on its own R&D project in parallel to the standard design procedure.

Within the framework of the research, a number of soft paint tests, the technique used in EROCAV, were performed. The soft paint test consists of time-limited tests in a cavitation tunnel under conditions corresponding to full-scale propeller operation. The propeller model is painted with a

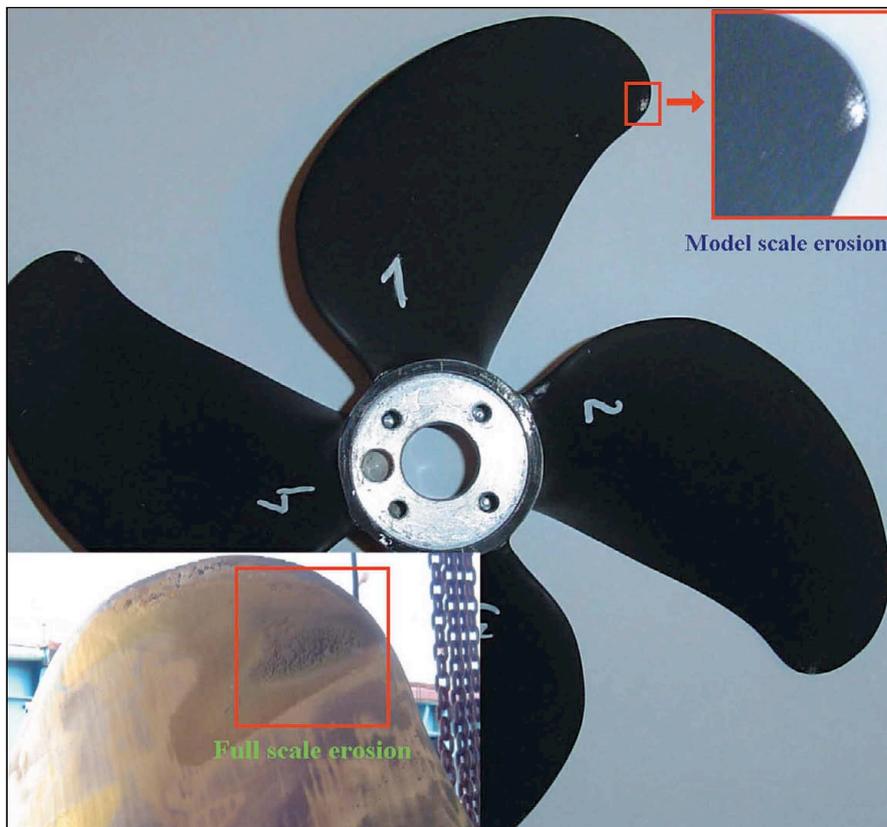


Fig 1. A propeller model after a soft-paint test at CTO, compared with full-scale erosion.

specially selected ink, which when exposed to erosive cavitation, is removed from the propeller surface giving an indication of full-scale erosion.

First, CTO decided to investigate the correlation between model tests and full-scale erosion. For this purpose, a model of the existing propeller was manufactured and used in cavitation and soft paint tests. Correspondence to the full-scale cavitation pattern recorded during the ship's operation was very good. Encouraged by these results, CTO also investigated the correlation between erosion occurrence on the model and ship propeller. To engineers' satisfaction, the correlation was also very precise, proving the suitability of the soft-paint test technique for erosion problems.

At this point, CTO was confident that its new design could be checked against erosion in a more reliable way. Finally, the new propeller was designed and proved with calculations and tests. Results were very promising, indicating only slight, unstable cavitation sporadically occurring at the blade tip at its top position. Sheet cavitation was not observed and the margin for the pressure side cavitation exceeded 30% of the advance coefficient (referring to the point of operation). Also, pressure pulses measured on the hull above the propeller were within an acceptable range.

Based on these results, CTO considered its design to be safe from erosion, which was also

confirmed by additional soft paint tests. The propeller was manufactured by ABB Marine and installed on the vessel at the end of May this year. So far, limited information has been received about performance from the sea trials.

According to measurements, the ship meets its required speed without exhibiting any unwanted behaviour which may suggest cavitation noises or excitations. Unfortunately, during these sea trials it was not possible to carry out propeller observations or pressure-pulse measurements in order to further validate the design, but, thanks to the kind assistance of the owner, additional on-board measurements and observations are being performed during service.

With the recent, rapid development of numerical methods and computer resources, CFD provides equally important information, as do model tests. In many cases, the obtained results are more complete and give better understanding of the physics of flow phenomena. There is a growing tendency to supplement or even substitute model tests by CFD calculations. Very often, it is more convenient and much faster to evaluate different variants by means of CFD and to test only one or a few.

Research projects can provide the example. Within limited time and budget resources, it is often necessary to recognise the influence of many

* Project partners: Hamburgische Schiffbau-Versuchsanstalt (HSVA), Germany - coordinator, Centrum Techniki Okretowej (CTO SA), Poland, Delegation Générale pour l'Armement (BEC), France, Chalmers University of Technology AB, Sweden, Germanischer Lloyd, Germany, Wärtsilä Propulsion, The Netherlands, Lloyd's Register, UK, Maritime Research Institute Netherlands (MARIN), Mecklenburger Metallguss GmbH, Germany, SSPA Maritime Consulting AB, Sweden, and Wallenius Lines AB, Sweden.

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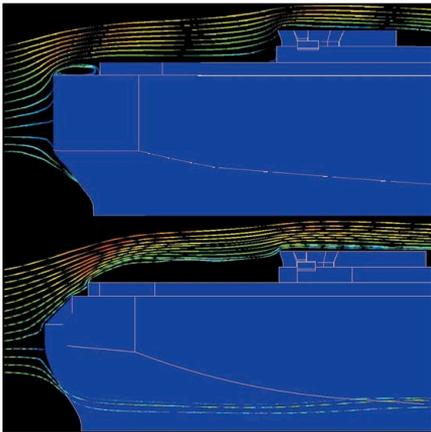


Fig 2. Air flow around two superstructure versions of a car carrier, calculated by CTO with the help of CFD.

A good example is an initial evaluation of hull lines and their modifications. Using the computational tools, a designer is free to experiment with different options and quickly assess their quality.

To assist with this work, a special software package has been developed and validated by CTO. This offers fast and reliable calculations of free-surface flows around a ship hull with a working propeller, enabling the quality evaluation of hull lines and providing the input data for propeller design at early stage.

In many research projects, especially those sponsored by the EC, the widely known CFD codes, such as Comet and Fluent, are utilised. With these new tools, work is not limited to the

parameters forming the wide research domain. In such circumstances, CFD can be the only reasonable solution. A quite similar approach can be also implemented in commercial projects.

underwater flow. In recent months, an interesting research project has been run which focuses on air flow around the superstructure of vessels, for which air resistance is significant (eg, car carriers).

First calculations were done using the Fenics code available to the students of Gdansk Technical University; this mainly concerned air flow disturbance in the bridge region where the wind speed is measured during the sea trials. These calculations, although valuable for positioning of wind speed meters during onboard measurements, could not be used for calculations of air resistance. Therefore the subject of air flow has come into focus again when recently CTO obtained an academic version of the Fluent CFD package.

This time, research was concentrated on the air resistance comparison of two superstructure versions for car carriers designed and successfully built by Gdynia Shipyard. The geometry for the calculations was provided by the shipyard's design office, based on its long experience with this type of vessels. Although R&D is still ongoing, some conclusions have been already derived.

First of all, the Fluent package seems to be capable of recognition of air flow phenomena around a ship superstructure. It provides not only the qualitative output (eg, with respect to exhaust gas propagation behind the funnel) but can be also used in order to calculate the air resistance of different superstructure versions. Research also proved large discrepancies between calculated air resistance and the value obtained using the standard ITTC method based on the air resistance coefficient CAA.

Despite the fact that calculations do not reveal the expected significant reduction of air resistance, the actual service reports from aerodynamically shaped vessels indicate their better performance. This might be due to a combination of both above-water and below-water improvements. Nevertheless, it should be emphasised that the experience obtained so far indicates that CFD calculations serve as a convenient tool for superstructure optimisation, aiming at the reduction of air resistance. Published information from leading operators of ocean-going car carriers shows growing interest in that sector of ship design research. ⚓

Cooperation for new intelligent bridge system

THE electro and electric systems division of Hyundai Heavy Industries Co has chosen Transas as a cooperation partner for the joint development of the new Hyundai-Transas intelligent bridge system (HTIBS). According to this agreement, the advanced HTIBS will incorporate hardware and software from both manufacturers.

This includes Hyundai's advanced control and integration system, intelligent voyage data recorder, and the company's intelligent conning system. Transas will supply its new-generation navigation and information system (Navi-Sailor 3000 ECDIS-1) and its digital radar system with advanced chart and AIS functionality. ⚓

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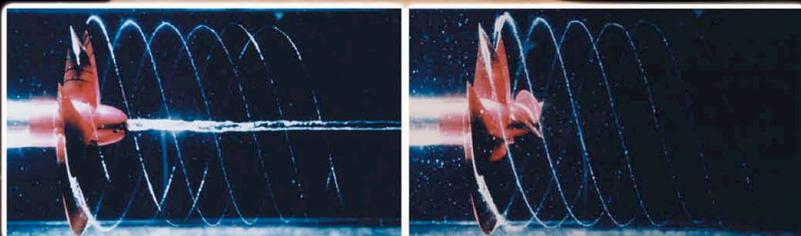
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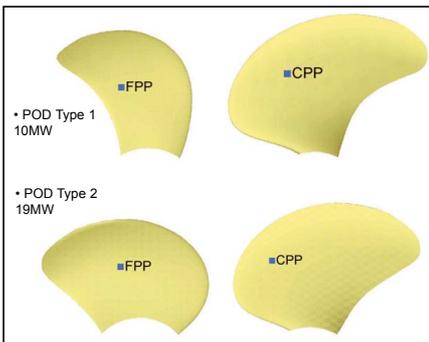
First CRP Azipod installation goes to sea

ALTHOUGH initially conceived as a propulsion solution for very large container liners and avoiding the need for two shaftlines, the CRP Azipod concept from ABB, in Finland, will first go to sea on a large high-speed Japanese ferry. The concept, which was developed in association with Samsung Heavy Industries, was outlined in *The Naval Architect* October 2001, page 6, and the Japanese ferry project in June 2003, page 6. This pioneering new 17,000gt ship, named *Hamanasu* - which would probably have been fitted with twin screws as a traditional design - was expected to sail on trials in July from the Nagasaki yard of Mitsubishi Heavy Industries and to enter service soon with her owner Shin-Nihonkai Ferry. A maximum speed of 31.50knots is anticipated.

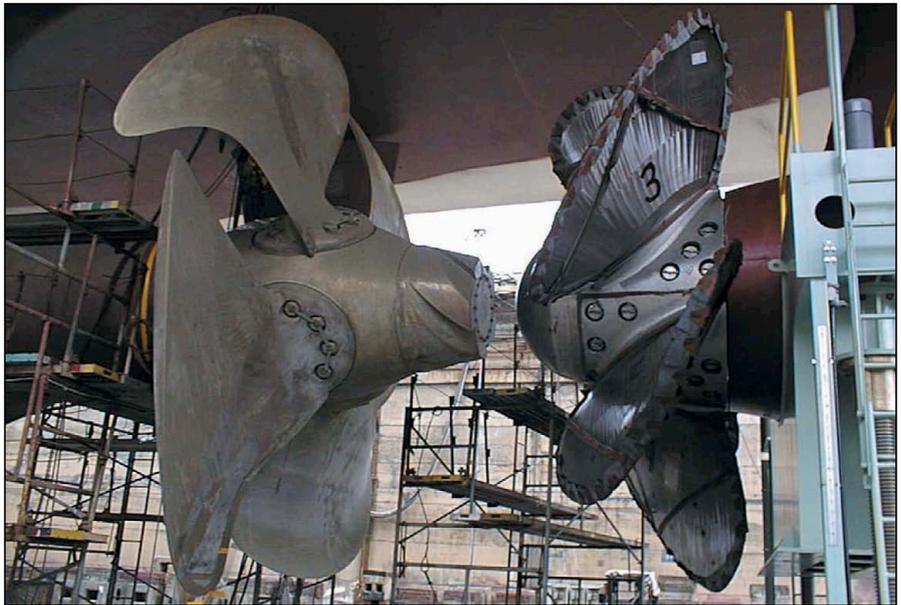
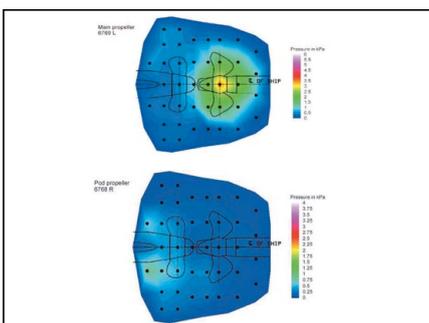
A CRP Azipod enables a single propeller shaft to be retained while dividing the load over two propellers - a mechanically driven CP propeller and electrically driven FP Azipod behind and rotating in the opposite direction. All the benefits of the Azipod azimuthing concept are harnessed, and in this case remaining energy from the forward propeller is recovered by the Azipod. Cavitation characteristics are said to be improved due to reduced blade loading and excitation forces are lower due to the smaller propeller diameter. Very good manoeuvring possibilities will, of course, be provided.

Useful power savings are also claimed by ABB, with best figures achieved in a single shaftline arrangement. The concept also helps with reduced diameter blades where restricted draught is a problem, and performance in ice is said to be excellent, with extraction from difficulties

Propeller blade profiles for two CRP Azipod installations on a proposed Enviropax ferry.



Pressure pulse measurements for the main and pod propellers on a proposed Enviropax ferry. The patent mini-fins on the hub cap for the mechanical propeller (right) can be seen.



A fine illustration of the first CRP Azipod installation on *Hamanasu* at Mitsubishi's Nagasaki shipyard. This is on the first of two 17,000gt single-shaftline ferries ordered by Shin-Nihonkai and planned to sail at 31.5knots maximum speed. The mechanically driven main CP propeller with four blades can be seen to the left, with the CRP Azipod unit (FP) with five blades, on the right.

achieved satisfactorily. Tests in 2000 by KMY Technology (a Kvaerner Masa-Yards subsidiary) showed that US\$1 million could be shaved off the fuel bill annually, for the Rostock-Helsinki route and compared with a mechanical option. Weight was said to be 120tonnes less, and propulsion efficiency improvements between 8% and 15% could be obtained. These figures were confirmed in 2001 by further tests at Marintek, in Norway*.

Samsung investigations at its own model tank showed that for a 10,000TEU container liner travelling at 26.00knots, the propulsion power with a CRP Azipod installation would be 61.6MW, compared with 64.7MW for a single-screw conventional layout, and 67.2MW with a twin-skeg design. Further examination of the concept has also been completed by the Krylov Ship Research Institute in St Petersburg and by VTT, in Helsinki.

For Shin-Nihonkai's new ferry, which will be the first of two ordered, Mitsubishi carried out extensive model tests at its own tank in Nagasaki, with focus on performance and cavitation. Several

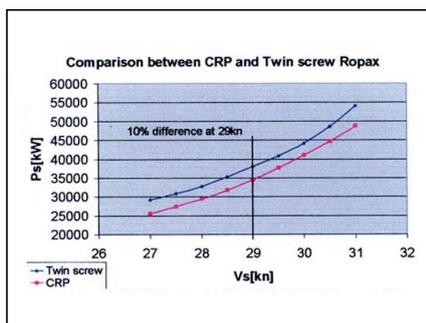
propeller designs were tested and evaluated to achieve best possible efficiency, and manoeuvring tests were also performed. The new ferries will each have a length oa of 224.50m and a breadth moulded of 26.00m. Diameter of the main propeller will be 5.6m and that of the Azipod, 4.8m. The mechanical propeller (driven by two 12,600kW Wärtsilä 12V46 medium-speed engines) will run at 145rev/min, and the Azipod at 175rev/min.

Current for the Azipod will be supplied by two gensets driven by a further two 12V46 engines. The main propeller will have four blades, with five on the Azipod. Total power will be 24.40MW on the main propeller, and 17.60MW on the Azipod. ABB is additionally supplying 6.6kV power generation and distribution equipment, also the propulsion control system. Voltage to the Azipod's electric motor will be transformed to 3.1kV.

The CRP Azipod concept is also a main theme of the 34,000gt Enviropax ferry proposal, developed jointly by Kvaerner Masa-Yards, ABB, and Wärtsilä, and discussed in our February 2004 issue, page 6. This offers various machinery alternatives, using large or small pods, to achieve a service speed of 28.00knots with a single shaftline.

A special feature is a new patent hub cap on the mechanical propeller, using mini fins; a large fin will be fitted below the pod. Various tests for this have been made by MARIN, in The Netherlands, at its cavitation tank in Ede. Tests here and at VTT, in Helsinki, showed that an Enviropax ferry travelling at 29knots could save 4890kW in propulsion by using a CRP Azipod layout (33,140kW instead of 38,030kW for a conventional twin-screw arrangement). ⚓

A comparison - power plotted against speed - between CRP Azipod and twin-screw installations on a proposed Enviropax ferry, and showing a 10% power reduction at the 29knot service speed.



* Most figures in this article are taken from the paper 'CRP Azipod: R&D development report', by Risto Pakaste, of ABB, and presented at RoRo 2004, Gothenburg, Sweden, May 25-27, 2004. Organised by Lloyd's List Events.

Five-bladed thrusters for the Techno-Superliner

AN innovative design of tunnel thruster has been developed by Nakashima Propeller Co especially for installation on Japan's new Techno-Superliner, which is currently being built at Mitsui's Tamano shipyard. This model TCT-105 has been specially designed for the hybrid air-cushion/waterjet long-distance ferry, which was discussed in our October 2003 issue, page 44. It will be operated between Tokyo and the Ogasawara Islands (1000km) by Ogasawara Kaiun Co and should enter service in spring next year; maximum speed will be around 39knots.

The vessel accommodates around 725 passengers and 350 cars or equivalent vehicles, and has a length overall of 140.00m, an overall breadth of 29.80m, and a gross tonnage of approximately 14,500gt. She will be equipped with two bow thrusters on the port side and two on the starboard side of the catamaran-type hull.

Since the Techno-Superliner has an air cushion, the vessel is lifted over the seawater surface with pneumatic air between the double hulls. This feature means that air loss through the thruster tunnels must be prevented. Thus, it will be necessary for the propeller blade area ratio to be increased, which, however, will deteriorate thruster efficiency due to blades without camber.

Against such difficult operating conditions, Nakashima has successfully developed a thruster with five blades instead of the normal four, as a measure to avoid air ventilation while still maintaining efficiency.

TECHNICAL PARTICULARS NAKASHIMA TCT-105 THRUSTER	
Input power.....	335kW (electric motor) (4 x 335kW on the Techno-Superliner)
Nominal thrust.....	50.0kN
Number of blades.....	5
Propeller diameter.....	1050mm

With this technique, the thrust equivalent to that of a conventional thruster can be generated with the same propeller diameter and the same input power as for a conventional thruster, without deterioration. At the same time, the volume of air lost when the hull is hydroplaning is reduced as much as possible, with the clearance at each blade minimised to the absolute limit.

On the other hand, since the Techno-Superliner hull is made of aluminum to save weight, it will also be necessary for insulation of the hull and the thruster to be taken into careful consideration. With this new TCT-105 thruster, which is provided with a perfect insulation measure, it has been possible to reduce the mass by around 40%, compared with that of a standard Nakashima standard thruster, due to maximum use of aluminium.

Normally, it is usual practice on such vessels that the thruster tunnels are equipped with opening/closing covers, which, of course, calls for



An impression of the new Nakashima TCT-105 side thruster, specially developed for the Techno-Superliner with its hybrid air-cushion/waterjet hull.

operating/controlling equipment at an extra cost. However, on the Techno-Superliner, the thrusters will have no such an appendages, due to the successfully developed technology which is being used. Nakashima says that the design can be adapted for other ships.

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Efficient Z-Drive and Compact-Jet units for numerous applications

THE Veth-Z-Drive rudder propeller concept is one of a number of products developed and manufactured by the Dutch company Veth Motoren BV. Characteristics of the Z-Drives are high thrust and maximum manoeuvrability in ships ranging from passenger vessels, ferries, and hopper dredgers to tankers and dry cargo ships.

The Z-Drive is also available as a contra-rotating system, which has even more advantages. Here, two propellers are mounted either end of the hub, each turning in opposite direction. The high velocity of the water, generated by the forward propeller, gives extra thrust to the aft unit - the second propeller causes the water flow to straighten. The combination of these two factors improves performance considerably - up to 15% compared with a single propeller is claimed. It is also possible to increase power input to the unit by using smaller propeller diameters than would be with a single propeller system.

Another advantage is that the system is very quiet. Input power is divided between two propellers and therefore the blade load is much lower; the optimum rotational speed is also much lower than with a single propeller. This, in combination with the larger number of blades, ensures a lower sound level. For these reasons, passenger vessels, where a low sound level is very important, are often provided with this machinery.

However, other kinds of vessels are more and more being specified with contra-rotating rudder propellers, because of the high thrust and small propeller diameters. Typical recent examples of installations are two contra-rotating rudder propellers of 783kW each on the inland cruise ship *Rousse Prestige* (*The Naval Architect* May 2004, page 27), built by the Merwede Shipyard, and two Z-Drives of 955kW each on the Dutch cargo vessel *No Limit*. The latter Z-Drives are provided with a height adjustment of 70cm, so that the propellers will always be under the waterline, even when the ship is in ballast, and maximum thrust is assured.

Other recent deliveries by Veth Motoren are two contra-rotating Z-Drives of 160kW each to Myti Mussels (UK) new mussel dredger *LöliPop*, and two contra-rotating rudder propellers of 1000kW each to the Greek ferry *Ano Hora II*. In addition, two contra-rotating rudder propellers of 1250kW each are fitted on the 135m long inland tanker *Jade*.

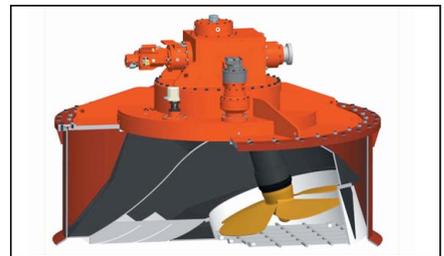
Veth Motoren has always invested in developing new products. The Veth-Jet bow thruster is probably the most notable example. The drum-channel system was invented by Veth almost 35 years ago; its principle is that with the help of a horizontal propeller, water is sucked up from beneath a hull. Manoeuvring is by means of a 360deg rotating deflector, which turns the water through 90deg and forces it through a tunnel.

Shallow-draught thruster

More recently, Veth Motoren also developed a shallow-draught thruster, the Veth Compact-Jet. This consists of a circular unit, which can rotate



An example of a typical Veth contra-rotating Z-Drive propulsion unit, showing the fore and aft FP propellers.



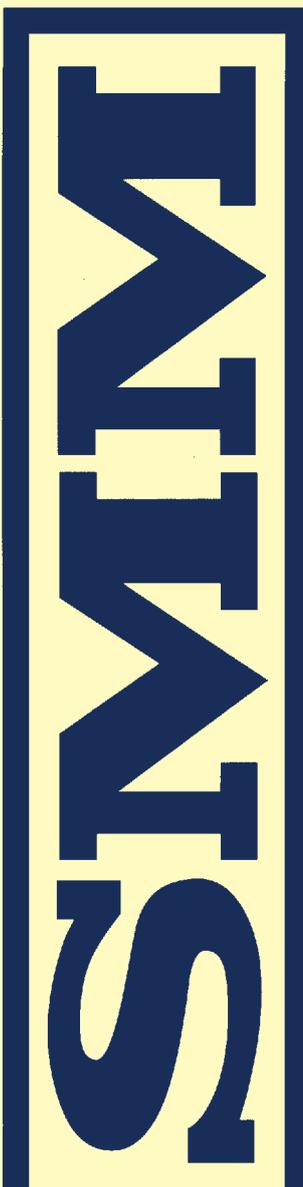
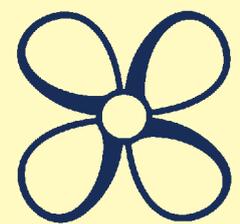
The Veth Compact-Jet is specially designed for shallow-draught operations and can be used as either a propulsion unit or as a bow thruster. It is normally mounted at an angle of 17deg.

for steering. A streamlined and optimised channel, which contains both the propeller suction part and the stream exit side, rotates together with the whole fabrication. Thus, thrust is the same over the whole 360deg.

The propeller is not mounted horizontally, but at a 17deg angle in the streamlined channel. This unique design is said to show high efficiency, even when the vessel has a certain speed. The Compact-Jet has various applications. There are no protruding parts under the hull and therefore the Compact-Jet can make flat-bottom craft such as barges self-propelled. The Compact-Jet can also be used as a bow thruster. In cases where a very low sound level is required, eg, in passenger vessels, the Compact-Jet is a useful solution.

The Compact-Jet is already installed on several barges in The Netherlands, such as the pusher barge *Lourina* (*The Naval Architect* May 2003, page 44) and several barges of Danser Container Lines. In addition, the 135m x 20m inland tanker *Jade* has been specified with a Compact-Jet. The combination of two 1250kW contra-rotating rudder propellers (as explained earlier) and the Compact-Jet (which will be used as a bow thruster) ensures high manoeuvrability.

Another example where the Compact-Jet will be used as a bow thruster is in a new ship for Viking River Cruises. In this case, the Compact-Jet will be provided with a vertically mounted electric motor, which saves a lot of space. This new passenger vessel will also be provided with two contra-rotating Veth Z-Drives of 783kW each. ⚓

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New joint CLT propeller projects for Sistemar

IN 1997, co-operation among Astilleros Españoles (today IZAR), CEHIPAR (the El Pardo model tank in Madrid), and the Spanish propeller design company Sistemar first started with an R&D project entitled 'Optimisation of ship propulsion by means of innovative solutions, including tip-plated propellers'. The conclusions were very positive for all three partners, and the main goal secured was development of a procedure to extrapolate, at full-scale, model test results with Sistemar CLT propellers (a tipped design that has been discussed in detail on several occasions in past issues of this journal).

The necessary empirical know-how was deduced in such a way that today CEHIPAR can extrapolate CLT propeller full-scale model test results with approximately the same degree of security and accuracy that the organisation can extrapolate at full-scale with conventional propellers - an important achievement.

Another important goal of this R&D programme has been to realise the scale effect existing in the epsilon coefficient, which defines the balance between over-pressure and under-pressure forces acting on the blades of a CLT propeller. As a consequence of this, it has also been concluded that these facts must be taken into account when conducting cavitation tests with CLT propeller/models.

These conclusions prompted IZAR to undertake further research, in order to clarify the results. Following this, a new R&D project entitled 'Research on the cavitation performance of CLT propellers, on the influence of new types of blade annular sections, mean lines, and the potential application to pods', was carried out between 2001 and 2003 by the three parties.

The objectives of this project were as follows:

- to develop a new procedure for conducting cavitation tests with CLT propellers, in order to ensure that inside a cavitation tunnel, a phenomenon similar to the one corresponding to full scale could be developed
- to study the advantages that may be derived from the use of a CLT propeller, of a new type of mean line developed by Sistemar, seeking a maximum increase of the momentum that the cascade of the propeller blade annular section gives to the water.
- to compare the pressure pulses induced on the hull by a conventional propeller with those induced by a standard CLT propeller and a new CLT propeller designed using the new mean line.

New procedure for CLT propeller cavitation tests

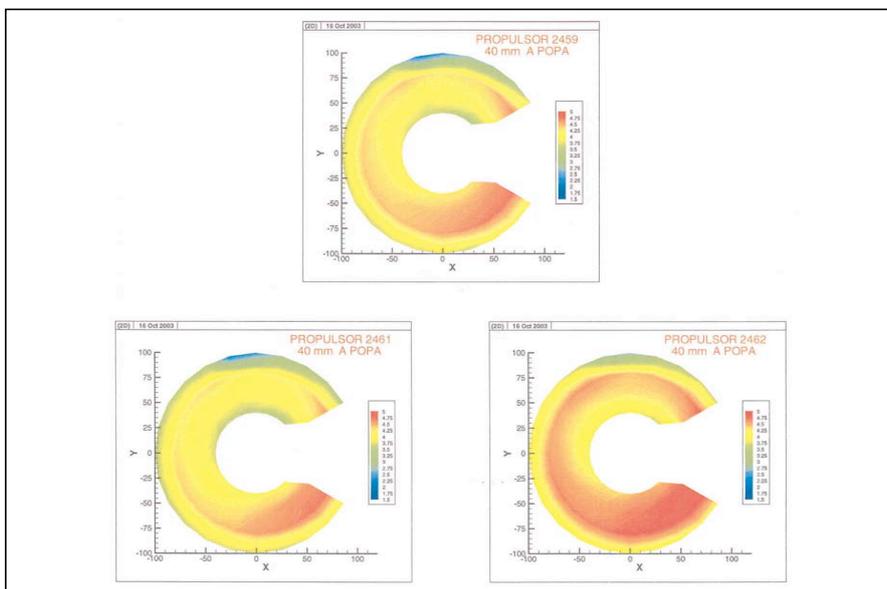
Sistemar proposed a procedure to take into account the scale effect on the epsilon coefficient on cavitation tests carried out with a CLT propeller model. As a consequence of the research, a new procedure to conduct cavitation

New financing arrangements for owners fitting CLT propellers

IN March 2003, BBVA Trade (a subsidiary of the major Spanish Bank, BBVA) and Sistemar signed a collaboration agreement to market CLT propellers. From now on, BBVA Trade and Sistemar will offer to clients very attractive financing conditions, by virtue of which, expenses derived from the design and manufacturing of the CLT propeller/blades could be paid through a scheme defined in accordance with the savings to be achieved in fuel costs due to the higher efficiency of the CLT propeller.

BBVA Trade is a foreign trade company, founded in 1985, and belongs 100% to BBVA. It has offices in Cuba, Indonesia, China, Mexico and Vietnam, but it also takes advantage of the wide presence of BBVA Group in 35 countries and has an extensive network of commercial agents and representatives worldwide.

The main advantage for the client from this scheme is that BBVA Trade participates directly in the operation, acting as principal, providing the financing and guarantee conditions requested, and managing the charge/payment flow. Supply of a propeller is structured on a turnkey basis. Several offers of CLT propellers have been presented under this framework, including one for a military vessel with a European Navy.



The results of measurements of the axial components of velocities downstream of the propeller disc for three Sistemar CLT propellers. Propeller 2459 is a standard CLT design (mean line 0.8). Propeller 2461 is a CLT design with a new mean line of moderated character, and Propeller 2462 is a CLT design with a mean line of extreme character.

tests with CLT propellers has been developed and proved. Several CLT propeller models on different types of ships have been tested both with the traditional and the new procedure.

IZAR has carried out detailed modelling by means of finite-element analysis of the stern structure of one of the vessels, for which the full-scale vibration performance was known. Pressure pulses measured in the cavitation tunnel with both the traditional and new procedures have been used as input in the calculations to evaluate the dynamic response of the stern.

It has been clearly deduced that the pressure pulses measured through the new procedure lead to a much more accurate estimation of ship response, if compared with the results of full-

scale vibration measurements. On the other hand, from the tests carried out with the new type of mean line, the following improvements have been detected:

- a reduction of under-pressure existing on the suction side of the CLT propellers/blades, also a reduction in the volume of sheet cavitation, with a consequent reduction of hull-pressure pulse levels.
- an increase in over-pressure existing on the pressure side of the CLT propeller/blades. This leads to an increase in propeller open-water efficiency of the actual CLT propellers.

New orders for CLT propellers

A NUMBER of new contracts have been secured by Sistemar for its CLT tipped propeller. In particular, the Spanish shipping company Distribuidora Maritima Petrogas recently ordered three product tankers at RMK MARINE in Turkey - two of 4300dwt and one of 6750dwt. All three vessels are being equipped with CLT blades fitted on CP hubs supplied by Berg Propulsion AB.

The 6750dwt design has been already delivered. Results obtained during sea trials with the CLT propeller were very satisfactory, the ship obtaining an extra speed of 0.35knots - higher than expected, and vibration levels well below the maximum allowable. At the time of writing, the first 4300dwt tanker was expected to be delivered in few weeks.

Meanwhile, a monobloc CLT propeller has been recently manufactured for the 6000dwt Petrogas product tanker *Faycan* and will be retrofitted at the next drydocking. Petrogas has satisfactory experience with the performance of CLT propellers installed on other vessels of its fleet. These are the 4000dwt tanker *Mencey*, retrofitted in 1988 with a monobloc CLT propeller, and the 9425dwt product tanker *Hespérides*, delivered by Union Naval Valencia in 1997 and fitted with CLT blades on a Kamewa CP hub.

Following successful results obtained with the 2900m³ capacity tuna purse seiner *Txori-Toki*, delivered in 2000 by Astilleros Murueta to INPESCA and fitted with CLT blades on a CP Wärtsilä hub, the sister ship *Txori-Argi*, also owned by INPESCA, has been recently delivered. Another new ship from the same yard for ATUNSA, to be delivered in a few months, is likewise to be equipped with CLT blades.

Recently, Sistemar has secured an order from the Spanish shipbuilding group IZAR to design a five-bladed, 5.7m diameter CLT CP propeller for a double-hull replenishment tanker for the Spanish Navy.

CLT blades will be fitted on a fast ferry actually in service (currently fitted with high-skew conventional propellers), and a very extensive experimental program both at model and full scale is going to be carried out, with the ship alternatively fitted with conventional and CLT blades. The project includes full-scale observation of cavitation and pressure-pulse measurements.

Agreement with IZAR for pod units

During coming months, a wide program of model tests is also going to be conducted at CEHIPAR, and a CLT propeller has been manufactured for a 1850kW pod unit developed by IZAR, which will be tested in full scale. Sistemar and IZAR have reached an exclusive agreement by which pod units designed by IZAR will be equipped with CLT propellers designed by Sistemar.

3D measurements of water speed with a laser-doppler velocimeter in four axial positions (plans) with regard to each propeller tested have been carried out. One axial position was defined upstream of the propeller disc and the three remaining ones downstream of the disc, and hence the fluid vein contraction for each propeller has been determined. The test condition corresponding to each propeller was selected to Kt identity with the value of this coefficient corresponding to the cavitation test.

From these measurements it is deduced that the induced velocities by the CLT propeller downstream of the propeller disc are noticeably higher than those corresponding to a conventional propeller.

CLT propellers with the new type of mean line were also checked, and induced velocities downstream were noticeably higher than these corresponding to the basic CLT propellers with a NACA 0.8 mean line.

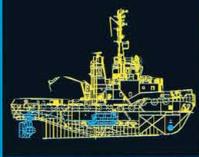
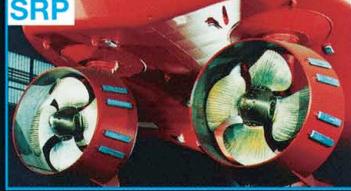
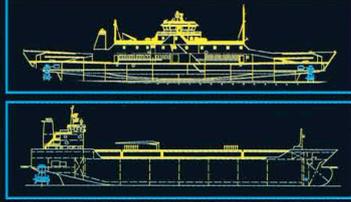
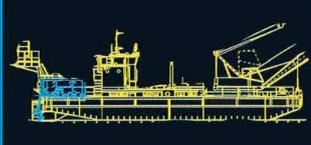
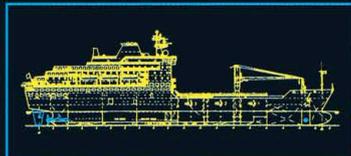
The illustration on the previous page shows the result of measurements of the axial components of the velocities downstream of the propeller disc corresponding to three CLT propellers. Propeller 2459 is the standard CLT propeller (mean line 0.8); propeller 2461 is a CLT propeller with a new mean line of moderated character; and propeller 2462 is a CLT design with a mean line of extreme character.

These results are, in principle, coherent with the assumptions of reaching a higher efficiency using a CLT propeller in comparison with the one corresponding to a conventional propeller. The new types of mean lines used in the design of alternative CLT propellers produce higher induced velocities downstream of the propeller disc than those corresponding to other traditional CLT propellers.

Another new R&D project entitled 'Research on the performance of highly loaded propellers on fast conventional ferries' was initiated during the last quarter of 2003 and should be complete by mid-2005. IZAR, CEHIPAR and Sistemar are once again co-operating in this project, together with other partners, including a leading ferry operator.

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Azipull - a 21st century propulsion concept

THE new Azipull mechanical thruster propulsion concept, developed in Norway by Rolls-Royce Ulstein, opens the way for new thinking in ship design. It has recently secured mainstream credentials following a contract for four 14,500dwt tankers ordered with this equipment by the Swedish owner Broströms. This interesting order will be featured in more detail in our September issue. Prior to this order, the prototype installation with four units was installed on Norway's first FerryCat from the Fjellstrand yard, an innovative double-ended ship creation designed to revolutionise that country's commuter ferry system; since then, similar ships have been ordered for Turkish operators. Other contracts have been placed for offshore support ships and another tanker, and today the total number of units in service or on order totals 40.

We have discussed the Azipull design in several articles but notably in January 2001, page 47. This is a mechanical thruster equipped with a pulling propeller, developed to take the gear-driven azimuthing thruster principle into higher speed ranges, while combining low drag with high efficiency. Units can be used to propel a wide variety of vessel types, as the first orders have already shown.

The lower bevel gear and pitch-setting mechanism is based on experience drawn from designing and manufacturing thousands of thrusters of many types at both the Ulstein and Aquamaster works. These mechanical elements are enclosed in a hydrodynamically-optimised leg with a wide chord to provide rudder effect and improve course stability. The leg incorporates a skeg extending below the gear housing; together, the streamlined leg and skeg recover swirl energy from the slipstream of the pulling propeller, raising overall propulsive efficiency, because this otherwise wasted energy is converted to a forward force on the thruster leg. Within a hull is the upper gear housing with an associated input shaft and steering motors; these components are derived from the standardised Ulstein Aquamaster azimuthing thruster range to maximise commonality of spare parts and minimise technical risk.

Azipull can offer owners and designers several advantages, including:



Two of four Azipull azimuthing propulsion units on one of the new Norwegian FerryCat double-ended shuttle ferries built by Fjellstrand.

- high efficiency due to improved hydrodynamic design
- low noise and vibration emission due to clean propeller inflow conditions
- continuous ship speeds up to 24knots
- flexible with respect to prime movers such as diesel-electric systems both with fixed and frequency-controlled revolutions, diesel mechanical, and direct-drive gas turbine. Both FP and CP blades can be supplied
- low steering torque due to counterbalanced hydrodynamic forces between upper leg and the lower fin, combined with vertical pinion shaft torque (patent applied for).

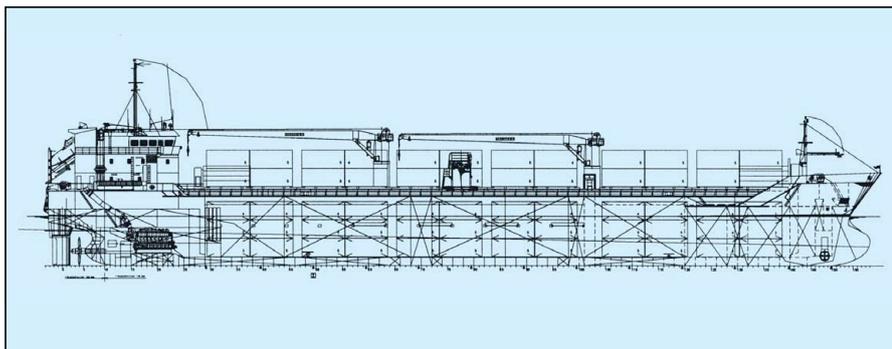
Initially, production is being concentrated on the AZP085, AZP100, and AZP120 frame sizes, covering an output range from around 800kW up to approximately 3500kW, but power can be extended considerably.

The first units to go into commercial operation were four AZP085 models installed in the innovative Fjellstrand FerryCat *Stavanger*. Apparently, they have fulfilled expectations and have now accumulated 6500 running hours each. The design has radically improved the operating economics of shuttle ferries, while the freedom from propulsor-induced noise and vibration improves passenger comfort. Similar units are fitted to two more FerryCat double-ended passenger vehicles about to enter service in

Turkish waters. To control the four Azipull units in each vessel, a new joystick system has been developed; this is designed with full attention to human factors and is now available as a product in its own right for application to other types of vessel.

A Rolls-Royce designed UT745E diesel-electric offshore supply vessel was retrofitted with the first two Azipull AZP120 units to be manufactured. These replaced conventional azimuthing thrusters. Fully instrumented sea trials showed that the maximum speed increased by 0.6knots, or alternatively the original speed was achieved with 900kW less power. Six months of operation in the North Sea, to date, are said to have demonstrated considerable fuel savings, while noise and vibration levels are substantially reduced.

Finally, a 4250dwt tanker ordered at the RMK Shipyard in Turkey by Bergen Tankers and planned for charter to Statoil and designed by NVC (Nordvestconsult), will be propelled by two Azipull units, direct-coupled to two main engines that also drive generators and supply power for cargo pumps. This solution provides enhanced manoeuvrability, a high level of propulsion system redundancy for safer operation, and a compact machinery layout which increases the cargo tank volume by 5%-7% within the given hull envelope. This design was discussed in our January 2004 issue, page 18, and the ship is planned for delivery in September 2005. ⚓



Profile of a pair of new 4128dwt container ships now entering service with Columbia Shipping (Hermann Buss). These ships have been designed by Conoship International and built by Bodewes Shipyards at Hoogezand, in The Netherlands; each features a CP propeller, shafting, and control system from the Swedish propeller manufacturer Berg Propulsion. Each propeller is of the 1140HX/4 type employing nickel-aluminium-bronze blades and with a diameter of 3900mm. Propulsion power is provided by a MaK M32 medium-speed engine developing 3840kW at 600rev/min; speed is reduced to 158.6rev/min in a Renk HSU-800 gearbox. Ship service speed is 14.5knots, and both ships are classed with Bureau Veritas. ⚓

Designing an efficient propeller system for modern fast full-displacement ships

IN recent years, the speed of ships has increased quite noticeably. This applies particularly to large container liners, large dredgers, and large ro-pax ferries. Concurrent with this trend has been more stringent requirements for propeller design. When designing propellers, it is a general rule, notes Wärtsilä Propulsion Netherlands*, to aim for the highest possible level of efficiency while keeping vibration and noise, and hence cavitation, at the lowest possible level. This leads to conflicting boundary conditions. Less cavitation, for example, results in a large blade area ratio, whereas trying to obtain high propeller efficiency requires the reverse.

Each ship has its own dedicated design propulsion system which guarantees the best operational performance. Its propeller, therefore, keeps a subtle balance between several extremes, resulting in a compromise that depends on the experience of the propeller designer and the correct use of design tools at his disposal.

To reduce boundary limitations as much as possible, Wärtsilä has developed blade sections that combine large cavitation-free operation with good structural characteristics and low drag properties. The result is an optimised design with higher efficiency. In addition, the propeller design system used and developed by the company consists of interactive design and analysis modules.

Selecting the criteria

A propeller design can only be initiated after the criteria have been selected; these consist of the ship type, mission profile, and possible limitations regarding propeller diameter, efficiency, ship speed, cavitation behaviour, and propeller-generated pressure pulses on the hull. Such criteria normally have their greatest impact constraints on the balance between the design and off-design properties of the propeller.

Shaft speed and propeller diameter are closely related. For a given diameter, a low shaft speed is beneficial from the efficiency point of view but this also leads to a relatively high shaft torque and subsequently to large shafts, hubs, and gearboxes. A balance must therefore be found between hydrodynamic performance and the total cost of the propeller system.

The accompanying graphs (Fig 1 and Fig 2) show the relation between propeller power and ship speed, alternatively the power density (the power divided by the propeller disc) versus ship speed. They show a clear trend, typical for most vessels. When ship speed rises, so does power density on the propeller, and therefore the difficulties of designing an installation increase.

Many vessels today are equipped with CP propellers, especially those with an installed power less than 10,000kW, but FP models are often chosen when a ship mainly operates on the open sea - simplicity counts. Nevertheless, there

* Extracts for the article 'Technology guidelines for efficient design and operation of ship propulsors', by Teus van Beek, Propulsor Technology, Wärtsilä Propulsion Netherlands BV, and published in *Marine News*, No 1, 2004.

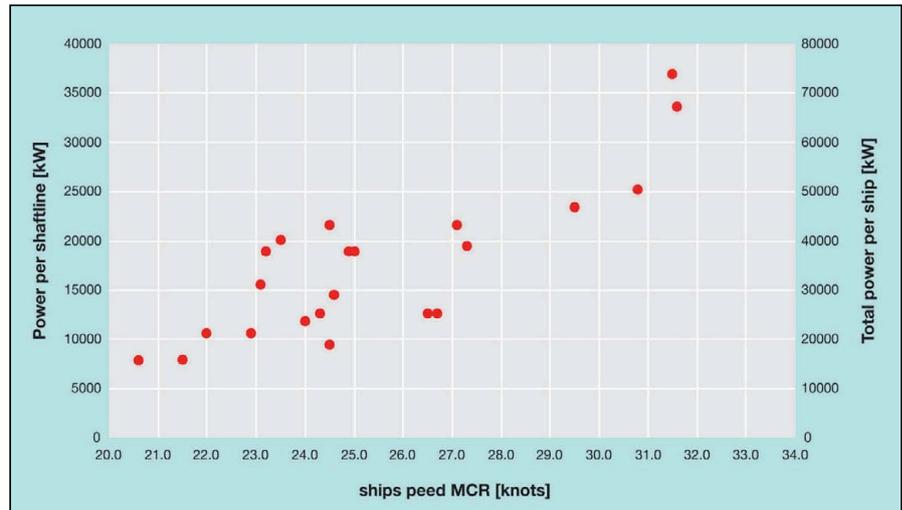


Fig 1. Shaftline power plotted against ship speed for ro-pax ferries.

are limits to the operation of FP designs. For instance, most two-stroke diesel engines cannot operate below a certain number of revolutions, which restricts slow-speed sailing. CP propellers also make it possible for diesel engines to absorb the full power in both bollard and free-running conditions.

At the pre-design stage, the main parameters are determined in close cooperation with the yard and owner. Important inputs from model tests are: self-propulsion tests with a stock propeller (and nozzle, if applicable), open-water tests with stock propeller (and nozzle), and wake-field measurements. Geometry is based in four key parameters: chord length, pitch and camber, skew and rake, and profile thickness.

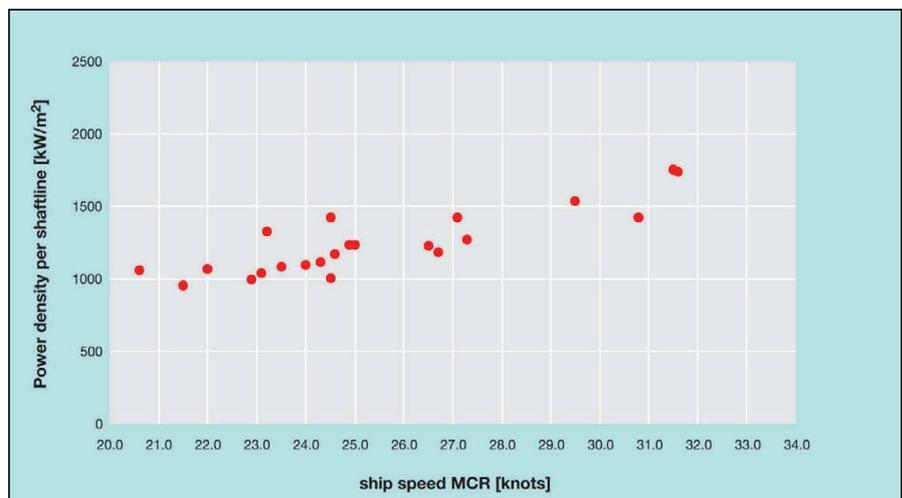
A basic propeller design has an unloaded tip, which is accomplished by the pitch and chord length distribution. The larger the power density, the more tip unloading is required to reduce noise and vibration hindrance; unloading in free-sailing conditions has

evolved from a loaded tip to an unloaded one by around 50%, following a specially developed circulation distribution in the tip area.

Fine tuning of cavitation patterns is carried out by means of the camber distribution, with camber selection based on minimising the cavitation extent in free-sailing modes, while face cavitation has to be avoided for part-load conditions such as operation on one engine. Skew distribution has an effect on several items - the higher the skew, the smoother a propeller blade will enter the wake peak, and thus will generate less variation in thrust. In addition, tip skew has a beneficial effect on tip unloading.

Unfortunately, skew increase will not always improve a propeller design. Excessive skew can result in leading edge vortices, which can be erosive or generate noise. The aim should be a good balance and combination with loading at the tip; obtaining an optimum

Fig 2. Power density plotted against ship speed.



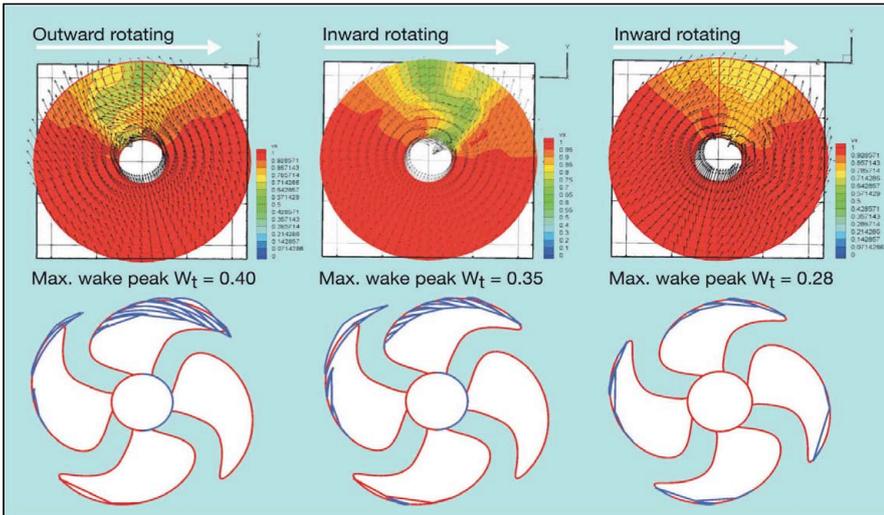


Fig 3. The effect of wake fields on the direction of propeller rotation and calculated cavitation extent for a fast ro-pax ferry.

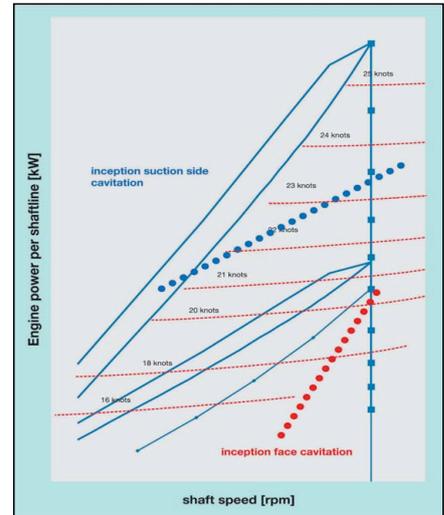


Fig 4. Engine load limit curves and propeller cavitation limits.

solution requires considerable skill. A high skew at the tip can also lead to high blade stresses. Finally, skew is one of the determining parameters for the hub actuating forces.

Blade thickness is the result of a fatigue and static strength assessment, using the finite-element method. Each propeller design is analysed regarding fatigue and peak loading. The mean and maximum stresses in the free-sailing conditions are determined.

Those figures are compared by Wärtsilä with corrosion fatigue data of the material used. Peak stresses, exceeding a certain maximum, can cause cracks or micro-cracks in the blade; such cracks can grow rapidly due to fatigue and can cause blade failure. An example of a peak load is the crash stop. The internal criterion for peak stresses adopted for Lips (Wärtsilä) propellers is more stringent than the rules from classification societies, but thanks to well-balanced design, this does not result in greater blade thickness than class rules require.

It should be noted that behaviour is different for FP and CP designs. For FP versions, the direction of rotation is reversed. This leads to increased loading on the area of the blade tip, which restricts the amount of skew that can be applied for FP designs. For CP models, since the direction of rotation is not changed, stresses are not critical.

Pressure pulses and vibration limitation

Using the calculated cavitation pattern, pressure pulses on a hull can be calculated. Such pulses are related to vibration by means of the so-called 'integrated force'. When the propeller rotates, the force on the hull varies with rotation; the variation in time versus the variation in size of the force generates noticeable vibration inside the ship. Depending on the hull strength and the occurrence of resonance (this is to be avoided), the vibration limits in the ship are either met or not. Tip clearance is clearly an important aspect in preventing vibration onboard. Doubling the tip clearance reduces pressure pulses and the integrated force by a factor of two.

Achieving optimum control of propeller and engine

A CP propeller can generate a given thrust or power with infinite combinations of pitch and shaft speed. Various control strategies can achieve the required

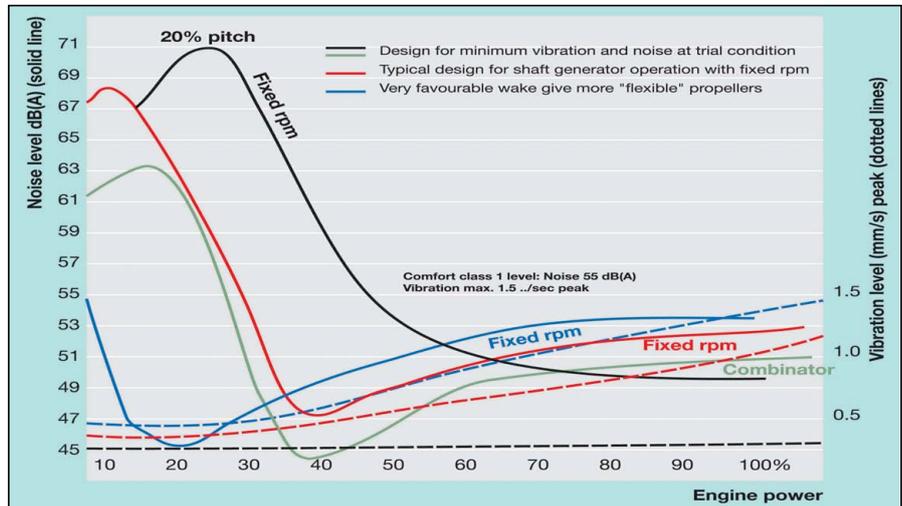


Fig 5. The effect of using a combinator for quiet operation on a ro-pax ferry.

propeller thrust. The classical approach is to programme a pre-set combination between pitch and shaft speed, making it possible to control the generated power easily by a lever on the bridge.

This so-called combinator control is ideal for stationary ship conditions and in a propulsion system without propeller-shaft power-take-off alternators, but to avoid overloading the main engines, a load control system is normally needed, in addition to the combinator. Load control keeps the engine load within its operating envelope.

A combinator curve is designed, taking into account engine requirements, cavitation patterns of the propeller in various conditions, and the ship's mission profile. Load control reduces the pitch as required by the combinator in case of acceleration of the ship during manoeuvring and when power-take-off current is being used.

The accompanying diagram (Fig 4) shows a power absorption diagram for a ro-pax ferry, with the operational limits of the engine for two- and one-engine conditions. Lines are plotted for a given ship speed but at different propeller pitch. An increase in pitch indicates a lower revolution rate and reveals lower power absorption, closer to the engine load limits. This is the result of greater propulsive efficiency. Also plotted in the diagram are dotted lines indicating the limits in cavitation for various pitch settings.

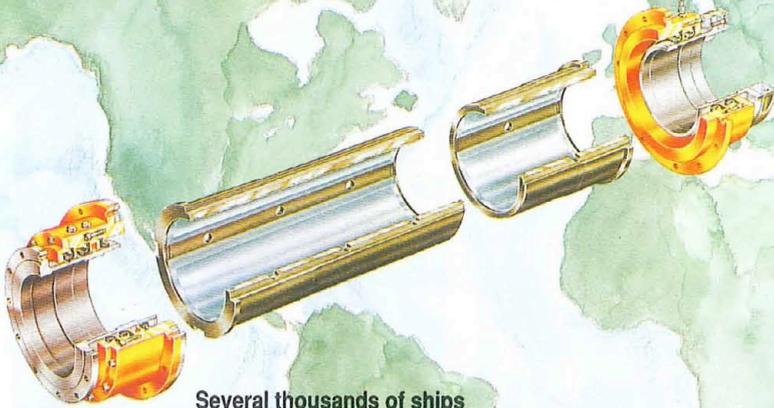
Given a number of revolutions at increased pitch, more cavitation will appear on the suction side of the propeller, and pressure pulses will increase. These pulses and the amount of suction-side cavitation will be highest at the maximum power point with the highest revolutions.

This same diagram also indicates the limit against pressure-side cavitation. This appears when pitch is reduced at a given number of revolutions. The propeller starts to cavitate on the pressure side and, if the pitch is further reduced, propeller thrust in the tip area will become negative. The propeller will then generate an unsteady type of cavitation, and this will be observed inside the ship as increased noise.

This is also demonstrated in Fig 5, which shows the measured noise levels for various control options. At constant revolutions, reducing the pitch from full power to a lower level first reduces propeller excitation and thus the noise. Reducing pitch further will pass the point of pressure-side inception. At the point where thrust at the tip becomes negative, noise will increase again and will be more extensive than when operating at full power. The use of a combinator will then reduce noise levels significantly. The level can be further increased when wake distribution at the propeller is improved.

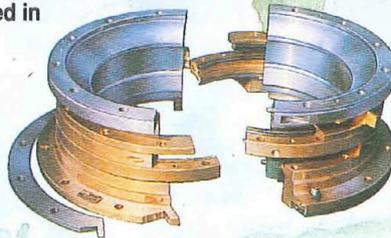
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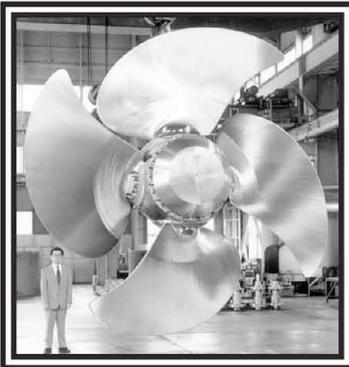
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More than 800 ships benefiting from PBCF

TODAY, a remarkable total of 870 ships are fitted (both new installations and retrofits) with the simple hub cap device known as the propeller boss cap fin (PBCF), which was developed in Japan and is today marketed by Mitsui OSK Techno-Trade Ltd. A PBCF can cut fuel consumption and exhaust gases by up to 5%, and incurs no additional maintenance costs once installed. As a propeller-enhancing device, the PBCF rectifies the propeller hub vortex and recovers rotational energy otherwise lost in the propeller slipstream.

By increasing propeller thrust by more than 1% and reducing propeller torque by more than 3%, the PBCF results in fuel savings of up to 5% or, compared with vessels operating at equivalent speeds but without the PBCF fitted, a 1.5%-2% increase in speed at the same engine output. By eliminating propeller hub vortex, the design offers reduced stern vibrations, propeller noise, and noise contamination on ships fitted with acoustic equipment. It also resolves a number of rudder erosion problems.

The PBCF is a boss cap with fins made from the same material used in conventional boss caps and installed in the same way. This means the PBCF, like conventional boss caps, does not require additional maintenance once fitted, and can be easily replaced. A number of vessels, such as oil tankers and container ships, have been retrofitted with a PBCF whilst at sea. When replacing conventional boss caps with the PBCF, no shaft design reviews are required by the major classification societies. Approximately 40% of

A typical PBCF installation, seen here on a large container liner with a 53,000kW main engine.

PBCFs sold to date have been retrofitted to existing ships, and the remainder have been fitted to new vessels.

Since the first PBCF was installed on an 8973kW car carrier in 1987, and despite the downward trend in oil prices since this date, sales have steadily increased, and have now reached 870 units. Of this total, MOL companies have directly dealt with the sale of around 550 units, the remainder having been handled by agents. The abundance of performance data now available from vessels using the PBCF confirms a consistent 5% fuel saving on any type of vessel using screw propellers.

In February this year, Mitsui OSK Techno-Trade published the results of a new study of self-propulsion tests for a PBCF operating in waves, carried out at the Akishima laboratories. A broad, full-form ship type of 226m length and a block coefficient of 0.82 was selected, since the considered wave effect was relatively large. The model propeller had a pitch ratio of 0.636, a boss ratio of 0.155, and an area ratio of 0.46, with a Dp of 0.25m.

A propeller open test (in still water under five advance coefficients and three Reynolds numbers) showed good correlation with results obtained from two other tests, and the volume of measured data of the PBCF effect in still water



showed good repeatability. The PBCF effect varied under different conditions, although on average, 93% of the effect found in still water was maintained even under 4m regular wave conditions. Therefore, overall, the effect of a PBCF on a wide full-form hull can be said to maintain almost the same effect in 4m high wave conditions, as in still water. ⚓

Workshop on squat

Dr C B Barrass, FRINA, reports on an interesting workshop held recently in Germany.

ON March 3 and 4, the 2nd International Workshop on Squat took place at Fachhochschule, University of Applied Sciences, Elsfleth, Oldenburg, in Germany. The title was 'Aspects of Underkeel Clearance in Analysis and Application'. A total of 13 papers were presented, and 75 delegates attended. Many had travelled from afar.

There were four sessions, which included papers on:

- squat as a part of underkeel clearance
- determination of underkeel clearance
- measurement and quantifying squat
- the ship and the waterway
- squat and dredging requirements
- economic aspects of squat.

Dr C B Barrass, from Southport, UK, delivered a paper on '32 years of research into ship squat.' In it, he outlined the phenomena of ship squat and the performance of ships in shallow-water conditions. He listed 14 vessels that, because of excessive squat and high speed, have gone aground in recent years.

Professor Dr M Vantorre, of Ghent University in Belgium, gave a lecture on 'Model test-based requirements for under-keel clearance in the access channels to Flemish harbours.' Professor J Moes, of CSIR, South Africa presented a paper on 'Squat and wave response measurements of bulk carriers in the entrance channel to the port of Richards Bay'.

A presentation on 'Measuring and quantifying ship squat in shallow and confined channels - the Canadian experience using GPS technology', was given by Professor B Morse, of University Laval, Quebec, while Dr T W O'Brien, of OMC International, Melbourne gave a résumé on 'Under-keel clearance management through DUKC' (DUKC stands for dynamic under-keel clearance, ie, the remaining clearance when a ship is travelling, say, at a forward dynamic speed of 10knots). He has been working with seven port authorities across Australia, advising them on the problems associated with ship squat.

In discussions following the papers, it quickly became apparent that today, with much larger ships (such as VLCCs) and faster types (such as container ships and passenger liners), squats have become much larger. Consequently, the subject is much more important when considering and preparing a passage plan.

In some situations, squat has now moved from being measurable only in centimetres to sometimes being as dangerously high as 1.75m. Therefore, risk of grounding has increased.

The workshop also confirmed the links between squat, increased loading of a vessel, ship safety, oil pollution, compensation claims, loss of ship daily earnings, repair costs, and even loss of life. This is especially so when ships are sailing in confined channels.

At this second workshop, a very useful set of papers was presented, and good post-lecture discussions took place, with an excellent interchange of viewpoints, and many new contacts made through this fascinating topic.

Such was the success of this conference that a third workshop is already being planned for the future. Perhaps some other members of The Royal Institution of Naval Architects, and readers of this journal, would be interested in attending.

Those wishing to have hard copies of the papers or a copy of the workshop CD should contact Professor Dr A Harting or Professor Dr K Windeck, at the Nautical Department of Fachhochschule Oldenburg/Ostfriesland/Wilhelmshaven, Weserstrasse 2, D-26931 Elsfleth, Germany. ⚓

INTERMODESHIP: a new shortsea ro-ro proposal

ONE of the latest part-European Commission-funded projects to develop ways of relieving congestion on Europe's motorways and to shift transport onto the sea is INTERMODESHIP, which aims to develop suitable ro-ro vessels to sail on various shortsea routes and which would also be capable of navigating up important inland waterways. Work is being carried out by companies that include TTS Ships Equipment, Kockums Engineering, and RWS-Line, and some of this was detailed at the Ro-Ro conference by speakers from these companies*.

Various routes have been identified as suitable, including Paris (France) to Southampton or Portsmouth (England), UK East Coast to Duisburg (Germany), and Lake Vänern (Sweden) to Duisburg. Ships of up to 130m long are being considered, but a prototype study has centred on the difficult Lake Vänern route, where hull dimensions are limited to 88.00m length and 13.40m breadth by the Trollhättan lock flight; at the other end, on the river Rhine, air draught is limited to 9.30m and occasionally, water levels mean that ship draught must be limited to approximately 3.70m.

Into such a hull, the design team are proposing to load a very modest 48 trailers, with a high proportion of automation and 'green' features on board. It is hoped to use straight-line cargo handling for maximum efficiency, as proposed by the IPSI and INTEGRATION projects (updated in *The Naval Architect* April 2003, page 19), and the access arrangements for three cargo levels have been developed by TTS; these will use straightline kerbs and trestles, both developed under the IPSI programme.

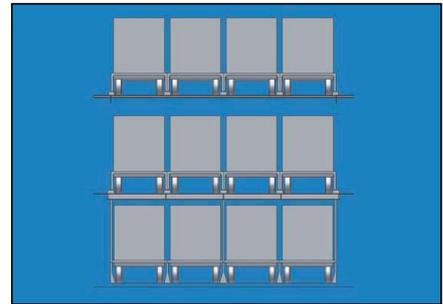
Access gear includes a novel folding stern ramp that can be hoisted to connect with part of the upper deck that can be lowered to provide access

* 'A European project for the development of ro-ro solutions on inland waterways and shortsea', by Stig Åke Svensson, RWS Line AB and co-ordinator EU-Intermodeship; 'Ro-ro vessel for inland-sea traffic - a technical challenge', by Jan Grönstrand, Kockums Engineering AB; and 'Cargo handling with straight lanes and automatic lashing concepts for the Intermodeship', by Lennart Svensson, TTS Ships Equipment. All presented at Ro-Ro 2004, held on May 25-27, in Gothenburg, Sweden. Organised by Lloyd's List Events, 67-69 Paul Street, London EC2A 4LQ, UK.

The Ro-Ro 2004 exhibition and conference was held from May 25-27 in Gothenburg, Sweden, and was attended by *The Naval Architect*. Some of the highlights are reported here.

to that level, also an enterprising box-shaped hoistable ramp to the lower hold. Trucks can be stowed on this to maximise loading, while the top of the 'box' forms the main-deck ramp cover. Although trailers are the primary envisaged cargo, cassettes and swap-bodies could be loaded in future, using the automatically guided vehicles (AGVs) discussed in our April 2003 article.

Notwithstanding many challenges that were thrown up during development, Kockums Engineering has drawn up outline plans of a diesel-electric ship, whose hull form was evolved from test-tank work at MARIN, in The Netherlands, and by Der Versuchsanstalt für Binnenschiffbau (VBD), at Duisburg, in Germany. A typical problem was loss of stability, discovered after perfection of what was thought to be an ideal hull:

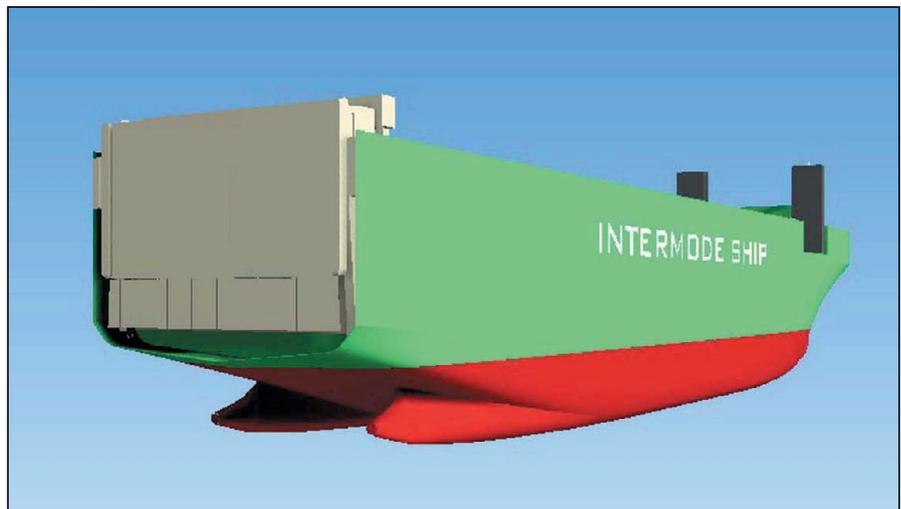


By using defined IPSI kerbs, it will be possible to stow tightly four lanes of trailers on all three deck levels.

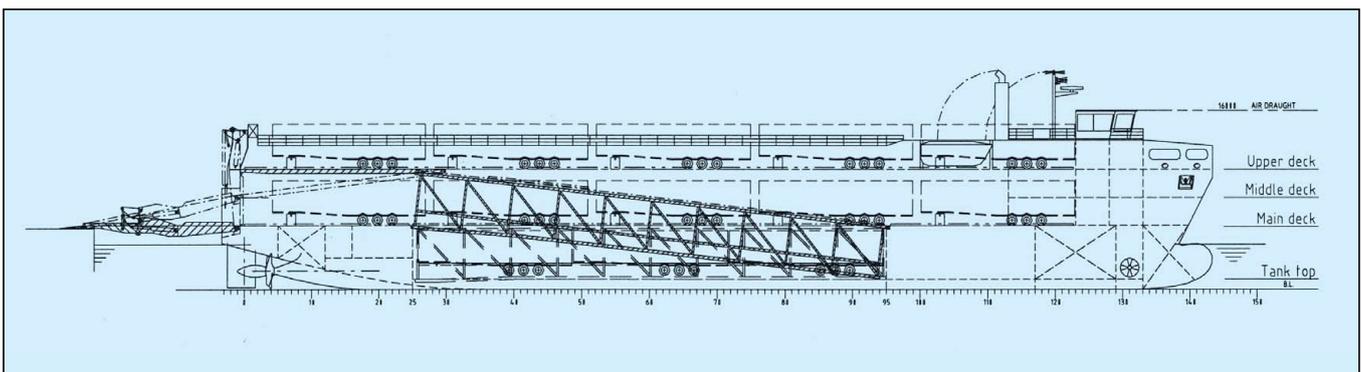
the waterline area had been so much reduced that around 150mm had been lost on GM - a figure unacceptable for river conditions. The target at 4.00m draught was a power of around 1400kW at 15knots, but resistance tests so far have revealed a power of slightly less than 1500kW. At the time of writing, propulsion test results were still awaited.

Due to the very short stern section, a conventional machinery arrangement was

A computer-generated impression of the prototype INTERMODESHIP, showing the folding ramp and twin-skeg stern.



Profile of the proposed pilot INTERMODESHIP vessel, engineered to meet the considerable restrictions of the Trollhättan locks in Sweden and navigation on the river Rhine. Although this version has a length of only 88.00m, larger ships of up to 130m length are planned for other routes. A total of 48 trailers can be squeezed into the hull using various innovative techniques, including those developed under the IPSI project.





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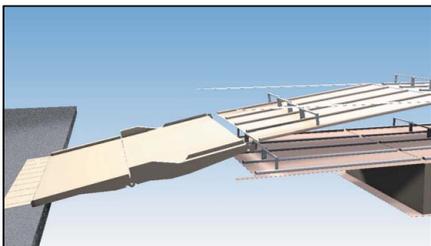
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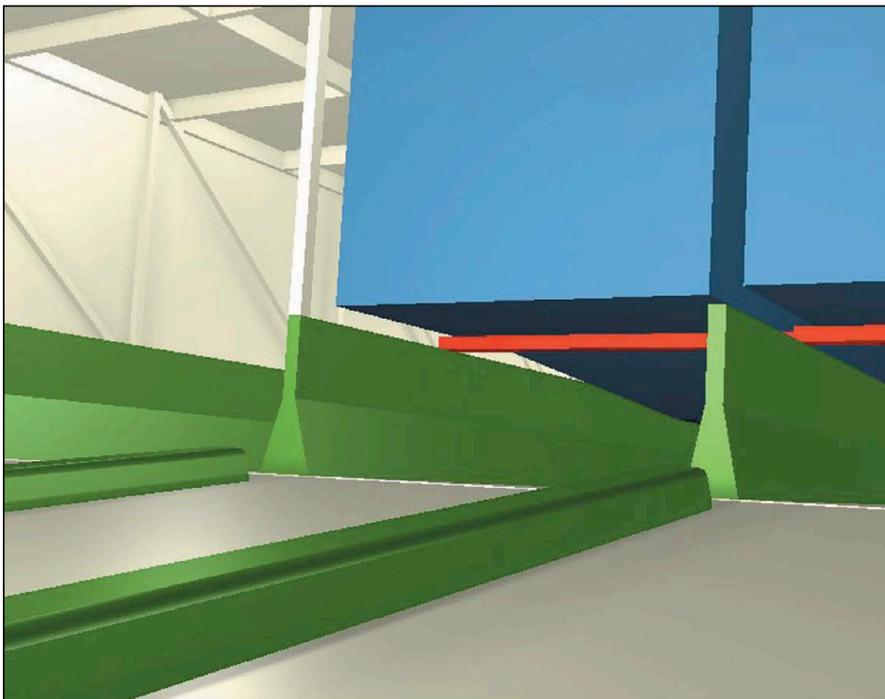
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A diagram showing how the stern ramp can be hoisted to link with a lowered upper-deck ramp to provide access to the upper level.

impossible. Therefore, a diesel-electric solution is being proposed, featuring high-speed diesel engines (to save weight) totalling 3600kW output and positioned forward. These would supply power to twin electric motors delivering 2 x 1600kW, possibly in an arrangement featuring a Costa bulb on each rudder or a Wärtsilä efficiency rudder. Diesel oil will be burned in the engines to limit emissions but SCR catalytic converters would also be installed to boost the 'green' credentials. The design team is convinced that it is possible to build such a ship but the project raised some controversial discussion at the conference, as reported in our Editorial Comment in this issue on page 3. ⚓



The IPSI kerbs proposed by TTS Ships Equipment to be used in the lower hold of the INTERMODESHIP would be different to those on the main and upper decks. On the tanktop, a higher kerb would be needed and a different trailer trestle - an IPSI beam without legs. This is because of the limited height available and the impossibility of lifting trailers over the kerbs.

New ro-ro freight design from Damen

THE cargo ships division of the energetic Damen group in The Netherlands is promoting a brand-new design: a freight ro-ro ship developed in association with the UK consultancy Sea Highway. This is a 22knot vessel suitable for loading between 1500lane

metres and 2000lane metres of freight and is planned as a 'basic, reliable workhorse' with one fixed ramp to the upper deck and another to the lower hold. It will have twin propellers and the hull could be built at any of the three group yards overseas, in Romania, Ukraine,

or China. CFD work has been carried out but no model tests have been made at the time of writing; however, *The Naval Architect* was told that the hull would be conceived so that it could be lengthened if required in the future. ⚓

Automatic mooring arrives at Dover

THE port of Dover, the English Channel's premier ferry port, is soon to have a trial automated mooring system in position at the new Nos 8 and 9 piers. This is based on the

revolutionary Ironsailor vacuum design of Mooring Systems Ltd, of New Zealand (formerly Mooring International), and first fitted to the new ferry *Aratere*, built in 1998 by

Barreras for TranzRail (*The Naval Architect* April 1999, page 8). Four units were fitted on that ship, in addition to traditional mooring winches, and the system is still believed to be operating efficiently.

Since then, the accent has been on shore-based equipment, known as the QuaySailor, which is already in operation at Melbourne and Devonport (Australia) for Patrick Shipping's Bass Strait services, although ship-based designs are still being developed and promoted (Series I for new ships, Series E for retrofits, and Series T for inland waterways). The Dover outfit, which is being handled in association with Cavotec UK, will comprise two QuaySailor 80 units at the seaward end of the berth and one at the shore end, on one berth.

The vacuum pads used have been tested and rated by Lloyd's Register and Det Norske



Automated mooring for ferries: an impression of part of the QuaySailor 80 vacuum arrangements to be installed at Dover; there will be two units at the seaward end of the berth and one at the shore end. Such technology was developed in New Zealand by Mooring Systems Ltd and is being installed in association with Cavotec UK. Ship-based solutions are also being promoted.

Veritas, and the whole unit can emulate the range of movement, resilience, and elasticity of a traditional line mooring system. Using state-of-the-art software, full control mechanisms and

load measurements are inbuilt and can be read out in real-time on the bridge of the ship at the quay, including on wing consoles, by a wireless communication system. Tidal ranges are

accommodated since the equipment is a combination of fixed and floating units. If this prototype equipment proves a success, more systems could be installed at Dover. ⚓

Sea highways could put more pressure on emissions

THE European Union proposal to transfer more ro-ro freight off congested motorways onto the sea - so-called sea highways - could perhaps put a further spotlight on emissions from diesel engines, according to Mr Don Gregory, director for environmental sustainability at BP Marine, the fuels supplier, who was one of the speakers at the Ro-Ro conference, in his paper 'Low-sulphur fuels and their impact on EU ro-ro and ferry trades'. In late 2005 or early 2006, the so-called Emission Control Area is likely to

extend to the North Sea and English Channel; this will limit sulphur content in fuel to 1.5%, while the European Union is pressing for 0.5% by 2013. By 2010, the European Council of Ministers hopes to limit sulphur burnt in port to 0.1%. Some of the figures may change later this year as a result of the June elections for a new European parliament.

Various options are open to owners seeking to comply, the most important of which include burning diesel oil instead of heavy fuel, but this can be more expensive;

installing blending equipment on board; or fitting exhaust-gas scrubbing equipment - often of the selective catalytic reduction (SCR) type. Exhaust scrubbing techniques are already employed by quite a number of environment-conscious operators; a new example just entering service is the Tallink cruise-ferry *Victoria* from Aker Finnyards, which is fitted with the German Sinox SCR system from Argillon (formerly sold by Siemens) on its four Wärtsilä propulsion engines. ⚓

MacGregor access package for Finnlines ro-pax ferries

THREE 42,000gt ro-pax ferries, plus two options, ordered in Italy at Fincantieri by the Finnish operator Finnlines (*The Naval Architect* April 2004, page 15) and claimed as the largest of their breed, are to be

equipped with a MacGregor package of access equipment for the extensive ro-ro decks, which total a massive 4200lane metres. A series of external and internal ramps and ramp covers will be designed,

together with bow doors, hoistable platform decks, and shell doors. The first ship is expected to be completed in November 2005 and will operate between Helsinki and Travemünde. ⚓

Danish consultancy working on Chinese ferry project

THE leading Danish consultancy Knud E Hansen is working on the concept of a new ferry project for China. Although designated the Bohai Straits ferry, the ship is planned for use either here or on coastal voyages. The company already has an

office set up in Dalian in association with the Swedish consultancy FKAB, and DF Marine.

It is anticipated that the new ship will have a length of 160m, with space for 800 passengers and 1400lane metres for cars and

freight. Service speed is expected to be around 22knots. Ferries to cross the 128km Bohai Straits from Yantai to Dalian have been on the drawing board for some years now; they could be designed to carry rail wagons, as we reported in February 2002, page 26. ⚓

New cross-Channel ships for TransManche

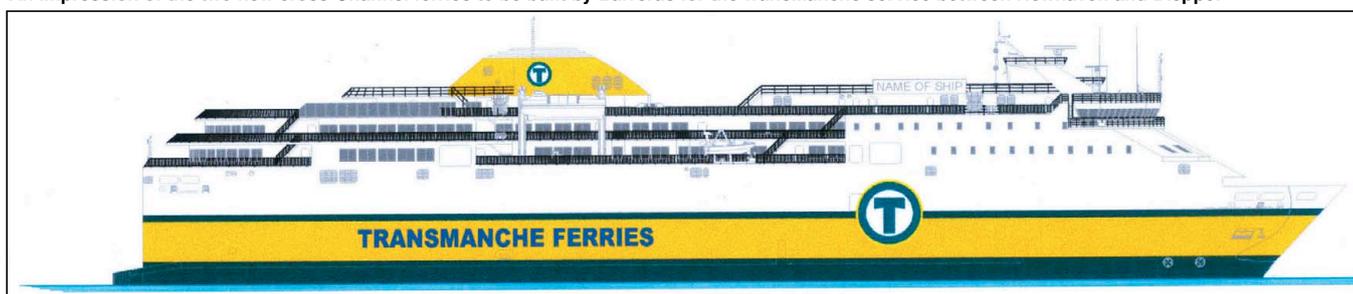
THE Spanish shipbuilder Barreras, at Vigo, has won an order to build two new 2850dwt ro-ro passenger/vehicle designs for TransManche Ferries, which runs the medium-distance cross-Channel service from Newhaven to Dieppe. The new pair will each have a length of 142.45m, a length bp of 125.00m, with a breadth moulded of 24.20m, and a moulded draught of 5.70m. A typical load will be 124 trailers and 51 cars, although actual capacities are 62 trailers and 224

cars. Amenities will be provided for a modest passenger complement of 606 (49 cabins will be provided for 196 passengers), with a crew of 44.

An unspecified power plant totalling 19,900kW will provide a service speed of 22knots, and three main auxiliary generators will supply a total electrical power of 3375kVA. Two 1300kW bow thrusters of 2m diameter will be installed, together with two independent conventional spade rudders at the stern.

Both bow and stern loading will be provided, and internal ramps will be fitted for interdeck connections. The new ships will be classed with Bureau Veritas to the standards 1 +HULL, +MACH, Ro-Ro Passenger Ship, Unrestricted Navigation, AUT-UMS, ALP, SDS, In-water Survey. The regulations of the Stockholm Agreement will be complied with, and sufficient stability will be included to withstand significant wave heights up to 4m. ⚓

An impression of the two new cross-Channel ferries to be built by Barreras for the TransManche service between Newhaven and Dieppe.



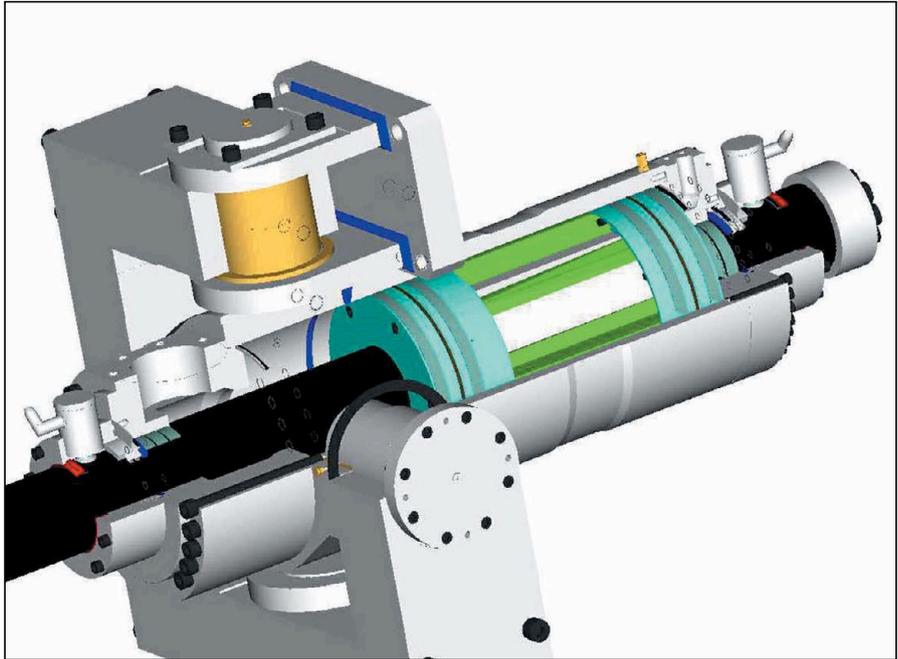
Improving ro-ro access safety

WITH the current emphasis on general safety and particularly redundancy of control and load paths, a new feature introduced by the leading ports consultant Royal Haskoning in conjunction with Bosch Rexroth, the hydraulics specialist, will be of interest. This is the RoSafe independent safety device for adjustable linkspans and ramps; although originally planned for shore-based systems, some marine specialists feel that the concept could usefully be applied not only to ship-based external ramps, too, but also those adjustable decks and ramps inside a ro-ro hull.

Catalysts for the introduction of such devices to provide a 100% redundancy feature have included the Ramsgate passenger walkway disaster, a new Canadian standard (CSA S826 Ferry Boarding Facilities) standard for lifting equipment, and new European Union safety legislation. Port adjustable lifted ramps can mainly be divided into two groups: those hoisted and lowered by winches and wires, and those using vertical hydraulic cylinders. The latter is considered by many to be superior, but whichever is fitted, the RoSafe can be applied. Royal Haskoning has examined a number of options to provide complete duplication but none achieves a system that may be readily integrated into a linkspan or passenger walkway lifting arrangement without compromising other design and operational criteria. The answer appears to lie in independent equipment employing different technology to that on the main hoist system, which can give a wide range of benefits, including fail-safe operation and ability to be retrofitted if necessary.

First introduced as a concept in 2002, the RoSafe has been further enhanced and today comprises the following:

- a collet/cone brake, with a spring applied with hydraulic fluid for lift-off (brake release and opening)
- a brake installed and floating within a hydraulic cylinder, which is pressurised with hydraulic fluid arranged to absorb dynamic forces
- a self-contained hydraulic system for pressuring fluid, as well as charging an accumulator and cylinder
- a self-contained electrical system



A computer-generated image of the heart of the RoSafe brake system. In the event of main system hydraulic or wire rope/winch failure, this equipment will be activated within one-tenth of a second and will, typically, arrest the fall of a ramp and vehicle totalling 300tonnes within 350mm of travel.

- a cylindrical rod, with articulated mounting to follow movement of the linkspan.

Should a catastrophic failure of the main lifting system occur, the rod and brake body follow the gravity movement, but a cushion of hydraulic fluid within the brake cylinder absorbs the energy derived from initiation of the braking. Oil is discharged to a reservoir through specially designed relief and control valves. The depth of the cushion, fluid pressure, and velocity of the discharge all combine to arrest movement of the brake body and hence the ramp, with a damper feature aiming to avoid structural damage to the linkspan or ramp.

A RoSafe brake would be installed within the support tower for the hydraulic cylinder or rope winch, with the braking rod attached to the linkspan roadway (or ramp if on a ship). This brake is normally in the 'off' position, but is activated on sensing abnormal movement: hydraulic fluid is released from the plunger section, and springs move the braking cone segments to the 'on' position. Remarkably, action within one-tenth of a second is achieved, gripping the rod and body of the brake, and arresting the fall of a ramp and vehicle load with a combined weight of 300tonnes within 350mm travel (different time periods and distances can be set to suit loadings). Technology is available to suit weights up to 1000tonnes. ⚓



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Advanced new modules added to Foran

THE latest release of the Spanish CAD/CAM integrated software suite Foran (V50R2.0) from Sener includes a great number of innovative technological solutions. New features include an advanced design and drafting module (FDESIGN), an integrated solution for collaborative engineering management (FTEAM), development environment (FDE), treatment of HVAC, and a build strategy solution (FBUILDS).

Advanced design and drafting module

Drawings are generated directly from the 3D product model. The 2D entities that represent the product model elements are linked to the 3D elements and are always updated with the latest version of the product model. A symbolic representation for modelled elements is possible, and different visualisation methods are available.

Additional information (labels, dimensions, material lists, and texts) can be added in either 3D or 2D. These entities are also linked to the product model elements, and dimensioning using ship references is allowed. The module fully supports Unicode characters. A complete API is available to open the program to users and thus allows complete user customisation.

FDESIGN includes a project browser for the management of documents integrated with the FTEAM module. FDESIGN can also be used as a stand-alone drafting tool, for the generation of drawings not linked with the 3D model. Printing and plotting is possible from this module, as well as previewing of the final result.

FDESIGN allows a user to:

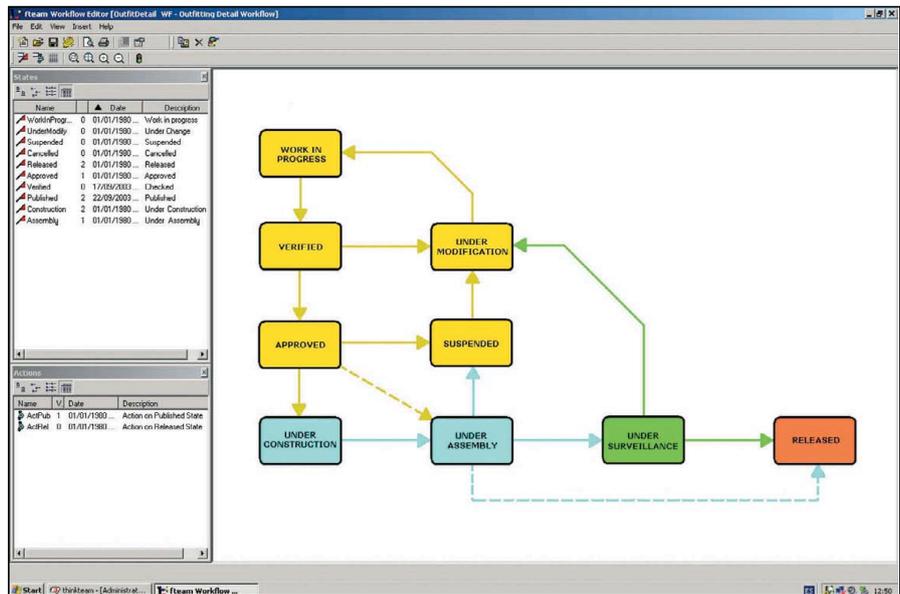
- create 'smart' dimensions linked to the entities
- insert labels and balloons using entity properties, also linked with entities
- build automatic parts lists from information inside drawings
- create standard symbols and symbols libraries
- create internal and external references to other drawings
- create user templates to customise drawings.

FDESIGN is a solid modeller that allows the creation of solids and surfaces using a set of powerful tools. It is parametric: the user can create solid models with dimensions related to each other which can be changed at any time. It is also dimension-driven, ie, a user can change the size of a part by selecting and editing its corresponding dimension values.

FDESIGN offers capabilities such as advanced solid modelling, smart objects for encapsulating and sharing design practices, modelling and development of sheet metal, large assembly management, interference analysis and collision detection, integrated surfacing, solid/surface interoperability, automated drawing creation, full 2D design capabilities, 2D and 3D standard parts library, 2D and 3D translators, engineering and collaboration tools, and product data management tools.

Collaborative engineering management

FTEAM has been conceived as a collaborative engineering management tool to facilitate both the control of the product data configuration and its



This screen display depicts the FTEAM module's work-flow editor function.

documentation. The solution helps to minimise implementation and customisation effort, allowing a shipyard to efficiently utilise the system in a short time.

FTEAM includes two work environments: documentation management and product data management. Both are linked, but the documentation management can be used stand-alone. Moreover, documentation management is commonly perceived to be the first step towards product data management.

Documentation management

FTEAM allows the control of all documents of a particular project and the corresponding files, independently of their format and from the software with which they were generated. This control is called documentation management.

Document lifecycle is controlled by the corresponding workflow, which consists of the assignment of different possible status to the documents, and the connection of status by means of transactions. These transactions are authorised to certain users or group of users of the organisation chart, depending on the role they have been assigned.

Customised workflows can be defined in a graphic environment for each type of document. The creation of new versions of documents is made automatically by the system, taking into account the corresponding workflow. Documents inside the document structure can be cross-referenced. With this, the user immediately knows which documents are affected by a change.

Product data management

FTEAM allows the control of the parts of the Foran 3D product model of a particular project;

this control is called product data management. Inside FTEAM is the logic entity that represents one element (either single or interim product) of the 3D product model.

The management of parts of the product structure is similar to the management of documents of the document structure. FTEAM allows the user to automatically update the status of any part which has been modified, due to a transaction attached to the workflow. Any modification of parts of the 3D product model after their release can be controlled and authorised from FTEAM.

FTEAM includes a search engine that allows the display of information required with customisable criteria. The query views allow a preview of the corresponding document, checking of its attributes, its references and the possibility of opening the attached file for viewing purposes directly from FTEAM.

Searching for information is also possible using a standard Internet connection with the help of a web browser. This allows a user to check the status of documents and to visualise them from remote located sites, facilitating the subcontracting of design works.

Development environment

The QSA-based integrated development environment of Foran is aimed at designers and system developers who want to extend the system functionalities to meet specific user requirements. Typical tasks that may be realised by designers are: macro recording and automation of repetitive tasks using existing application commands.

Typical tasks that may be realised by system developers are: extraction of data from the product model, tailor-made reports with additional graphics, implementation of customer-specific

tasks (rule based), implementation of interactive commands, and integration of Foran with other systems.

A system developer can add new functionalities to the application by creating new commands. An application command is implemented as a class, inheriting characteristics from a common base class, and typically consists of: user interactions (dialogues, selection), access to application objects for processing, calculations, modifications/ creation of application objects, and presentation of result (such as reports and file outputs). New commands have been added to the application custom menu.

New HVAC module

A new HVAC module has the most advanced Foran user interface, including navigation through the model in real time, so a designer can perform a first review of the elements defined, in a virtual reality mode. Once the technological and geometric characteristics of the intended duct are defined, the routing is performed by interactively defining the points of the polygonal that serves as the axis of the duct.

Alternatively, the HVAC duct can be defined by laying out user-configurable components and fittings (such as branches, reducers and offsets), or inserting them in an existing duct at the same time that clashes (soft and hard) can be detected on-line. The position of the fittings in the modified duct is automatically updated.

Once the 3D model of the HVAC ducts is defined, it is possible to obtain the corresponding information for workshops. With just one click of the mouse, the system automatically generates fabrication sketches and a complete bill of materials.

Product model configuration

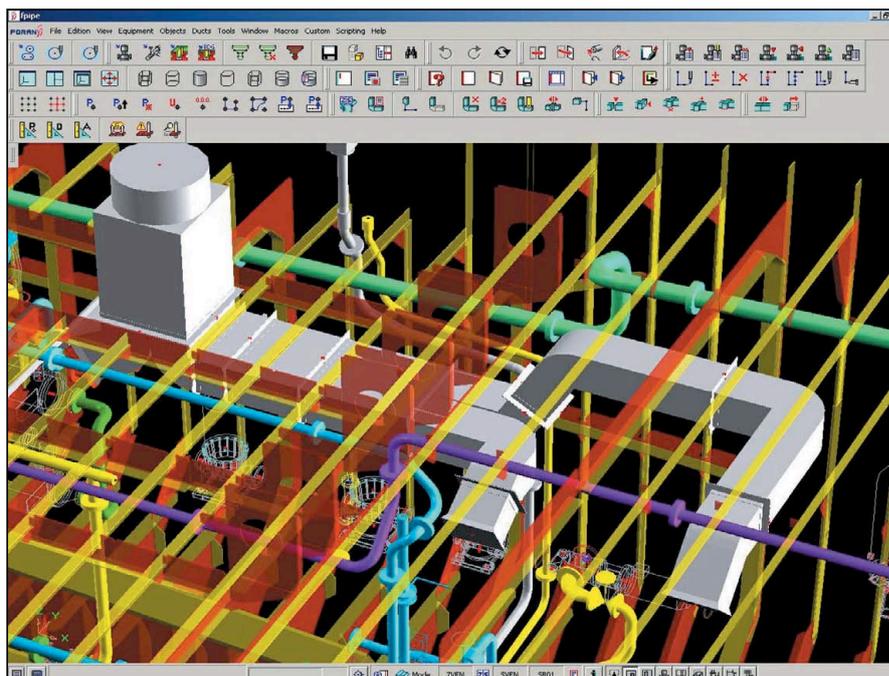
FBUILDS provides a powerful tool for configuring product model structures of a project carried out with Foran. In particular, it especially suits the breakdown of a project into interim products according to the building strategy needs.

FBUILDS is based on a dual user interface consisting of a tree-oriented project browser and a 3D graphic area that supports the advanced 3D modelling and visualisation environment of Foran V50. The project browser provides access to the read-only design product model, organised according to the Foran traditional design concepts (such as surfaces and systems), and also supports the functions to define and display the user-defined project organisation.

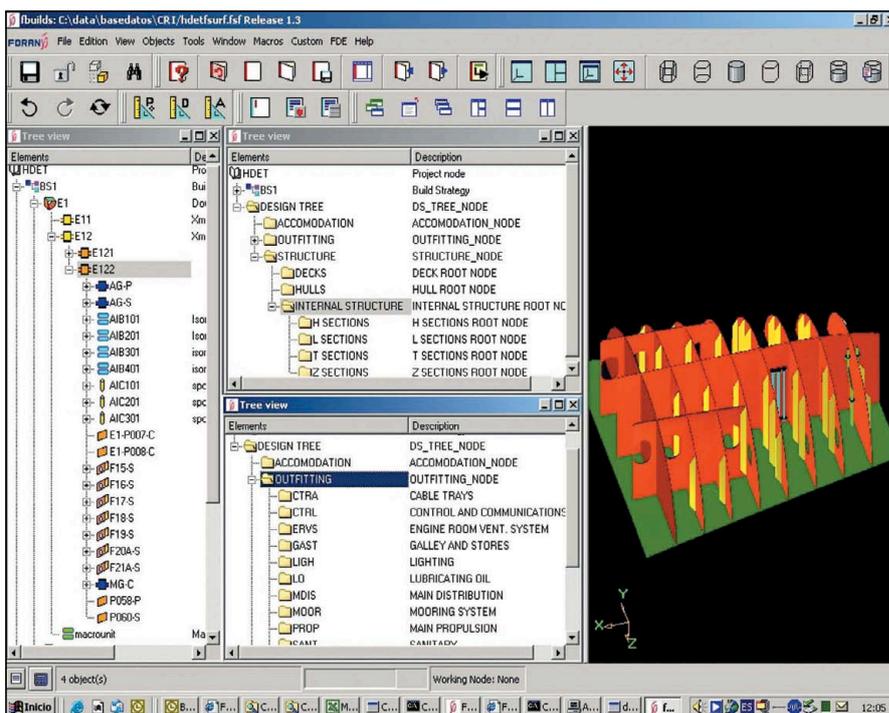
Items created with any Foran design application (structural parts, machinery equipment, piping components, HVAC, electrical, or accommodation) are accessible through the design browser, and all of them are available for creating new product structures.

The main features of FBUILDS are:

- flexibility as regards the product model configuration. The only restriction is that one part cannot appear twice in the same project structure
- more than one project model can be defined (such as different building alternatives)



Foran's new HVAC module allows users to navigate through a module in real time.



FBUILDS allows configuration of product model structures within a project.

- advanced interactive functions for defining product structures, such as: cut, copy and paste from one product model to another, or from the design tree to one product model; assign parts to a product structure either from the graphic area or from the design tree; perform typical downstream recursive operations with product structures, such as delete, cancel, and query items; and model parts into the graphic area just by drag-and drop from the project browser
- obtain recursive bills of materials of any product structure, including weights and centre of gravity
- multi-user definition of the product structures (each designer only locks one branch of one product model)
- classify the product structures in 'classes' (for instance, flat or curved panel, stiffened bracket subassembly, floor subassembly or outfitting module) and define as many attributes for each class as needed
- define user attributes and new identifications also for parts
- create programming scripts to automatically assign the value of the attributes of each product structure or part
- export the project structures as XML files.

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SMALL CRAFT REGULATIONS

20 - 21 October 2004, RINA HQ, London

Second Notice



This international conference on Small Craft Regulations will provide a forum for discussion on the various present or future national, European and international regulations applicable to small craft. Such regulations include, the MCA Harmonised Code for craft less than 24 m , MCA Large Yacht Code , presently applicable to charter yachts of and over 24 m length , ISO Standards for Small Craft for compliance with EC Directive on recreational craft , for craft less than 24 m in length , EC and UK regulations for inland waterway craft and safety standards for RIBs and rescue craft. These are examples only and papers on small craft regulations other than those mentioned will be equally welcome.



The regulations mentioned above vary in content. All are concerned with safety of life and protection of the environment. Most delegate structural strength to classification societies or refer to classification strength standards. Some such as the ISO Standards for Small Craft include structural strength standards. This conference will provide an update on present regulations as well as giving an introduction to new regulations. RINA invites papers on the following subjects as they might apply to aluminium, FRP, steel or wood vessels



- development of and experience in the use and application of the regulations in general or on specific topics such as;
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New CFD code for flow analysis

THE CD adapco Group, a provider of CAE solutions, has recently released STAR CCM+, a next-generation CFD code for flow analysis. Unlike other CFD codes currently on the market, this new software is said to have been developed by a group of experts from a clean sheet of paper.

The result is a code that is said to offer ease-of-use delivered through an object-based tree-structured graphic user interface (GUI), which, it claims, should guide even the most novice user through the set-up and analysis of a CFD problem. Utilising the latest numerical algorithms including an advanced pre-conditioned coupled and segregated solver plus state-of-the-art software coding, the new product claims to bring unheard levels of accuracy, reliability, and flexibility to CFD engineers.

STAR CCM+ has an object-based user interface so users need only populate the features that have been activated, and nothing additional appears in the interface. It is said to be almost impossible to set up a model and not obtain results. Unlike conventional GUIs' 'form-filling' approach, this GUI asks the user a sequence of relevant questions, and will not be satisfied until it receives each answer. When all questions have been answered, the solver is almost certain to run.

A unique polyhedral cell formulation accommodates any mesh type, and STAR CCM+ is able to import meshes from any leading grid-generation system, including those of STAR-CD, ICEM, GridGen, and Fluent/Gambit, with

generalised mesh interfaces such as CGNS available. The polyhedral cell approach offers faster solutions that require less memory than old-fashioned hexahedral or tetrahedral meshes, and advanced methods such as embedded refinement and arbitrary interfacing are achieved with effortless ease.

STAR CCM+ also allows for parallel operation, which requires no prior knowledge of set-up. The user simply opens STAR CCM+, states how many processors are required and from that point on, and they will be used in the simulation. There is nothing to learn and nothing to do, says CD adapco - the code looks to find what CPUs are available and automatically processes the job.

Visualisation is totally integrated with analysis, for the first time enabling dynamic 'steering' of the solution. For example, if the rate of convergence of a solution looks unsatisfactory to the engineer, he/she can intervene and change the relaxation parameters 'on the fly'. For example, if watching the flow field establish around a wing profile, the screen can be split and it is possible to watch several monitored quantities evolve with each iteration, and no user input is required.

'Add-In' for CATIA V5

This company has also recently become a Spatial CAA V5 adopter and will create two new CFD 'add-ins', STAR-CAT5 and Comet-CAT5, designed to bring the benefit of advanced CFD technology to users of CATIA V5. Tightly

integrated CFD 'add-ins' have been created that facilitate parametric design studies through enhanced automation and bi-directional association between CAD and CFD models.

Comet-CAT5 is intended for design engineers who need to carry out quick studies in their design process using CATIA V5. Simple flows can be easily modelled using the built-in Comet CFD solver. Modern and unique automatic polyhedral mesh generation means models can be set up very quickly and fast solutions achieved. Users can quickly assess different 'what-if' design scenarios.

STAR-CAT5 is intended for engineers needing to extend their flow analysis to include highly complex physics directly within the CATIA V5 environment. It offers complete compatibility with the leading CFD solution STAR-CD, allowing highly complex physics to be modelled directly. The same breadth of flow and heat and mass transfer regimes can be handled as Comet-CAT5, together with chemical reaction and combustion, multi-phase, and multi-physics capabilities.

These add-ins enable rapid high-quality meshing, model setup, solution and result evaluation to be completely integrated within the CATIA V5 environment. Engineers who are familiar with CAD will therefore find adding CFD to existing models easy and intuitive, since boundary conditions and fluid properties are simply entered within the familiar CATIA V5 GUI environment. ⚡

FORAN

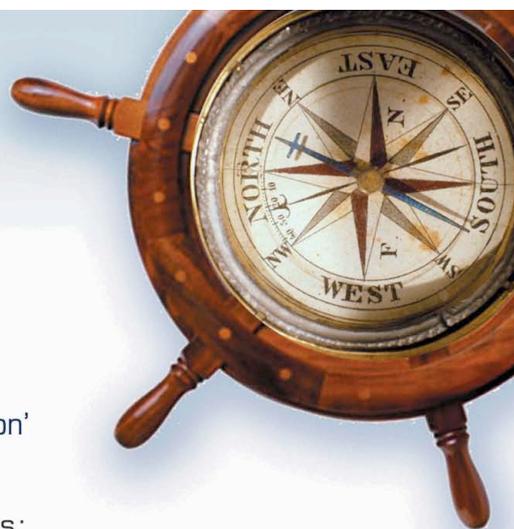
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New tools in Defcar system v2004

THE new company CintranaVal-Defcar SL is the result of a recent merger between CintranaVal - a leading Spanish design office - and Defcar Ingenieros - the CAD/CAM software programmer based in Madrid; thus, the programming skills of Defcar have been reinforced with the 40-year experience of CintranaVal's naval architects. Consequently, new tools have been added to the latest version of the Defcar system, with internal improvements made to all modules. Clients who are currently part of Defcar's maintenance service will receive the new version (v2004) free.

Naval architectural calculations

DFhydro includes the following new calculations, capabilities, and tools:

- submerged volume correction according to the mean thickness of the shell
- IMO criteria for supply vessels
- ability to define s/s of negative height (which is very useful to discount volumes)
- ability to obtain the real calculation of heeling moment corrections (instead of using the IMO formula)
- maximum admissible bending moments
- turning heel angle and passengers alongside stability criteria.

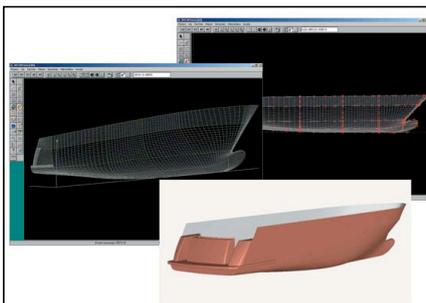
In addition to those, the following tools have also been refined:

- DXF files import
- generation of symmetric compartments
- generation of compartments with insulation
- permeability management in damaged stability calculations.

Special emphasis has been put on improvements in printing outputs of tank heeling moments, curves of flooding angles, KG limiting curves, and estimation of power.

Hull design and fairing

DFform is the result of the installation of Defcar in the Polish design office Naval Engineering & Design (NED), based in Gdansk. CintranaVal-Defcar programmed the export of Bezier surfaces from Defcar to NUPAS-Cadmatic's production bundle. This tool has been used successfully with several vessels developed by NED. The offsets table of knuckles and the spline routine have been also refined.



Hull design and fairing with the DFform.

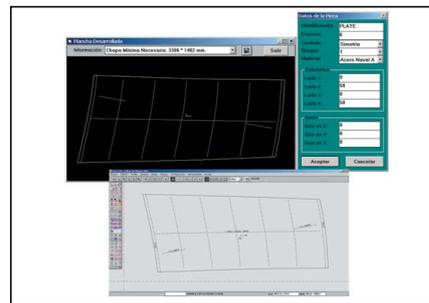
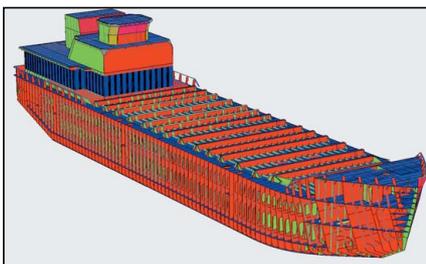
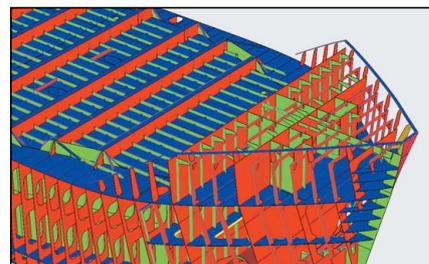


Plate development with DFshell.



Structures of a small oil tanker designed by CintranaVal-Defcar using the Defcar system. This vessel is currently under construction at the Zamakona Shipyard.



Shell plate development

In DFshell the following calculations and tools have been implemented:

- in the previous version, the developed plate was saved with the following information: code, thickness, side, block, and material. In the new one, the excess on the four sides and the rotation around the three axes can be saved as well. The excess is marked in the plate drawings
- capability of adding texts to the drawings of developed plates
- DXF import of detail lines
- listing of materials and densities
- parametric configuration of flat bars
- T-type cutouts
- filter to cutouts to fit in with the stiffeners.

The profile and plate development processes have been improved as well, with regard to the calculation of the cylinder axis.

Structural steelwork drawings

Another design office, NAVNAUTIK, based in Calcutta and Singapore, is using a useful tool to calculate the intersection between a part and a cylinder, named DFstruc. This allows users to easily obtain the structure near the propulsion system in Z-Peller tugs, or any

other kind of vessel with this type of propulsion. The following tools have also been implemented:

- refined process to generate reinforcements
- automatic generation of a drawing with all the parts of a section
- marking of parts
- association of texts to parts
- measurement of angles
- export to the nesting and NC cutting module LANTEK of the parameters 'material' and 'block'
- saving of the following parameters in the database: 'back marking', 'chamfer', 'forming' and 'fold' (as well as the geometrical parameters, codes, material, and type of part)

In addition to this, DXF files import/export have been refined, as have automatic management of brackets in intermediate sections, management of blocks and weight lists, norms insertion automatically checked against the tolerance, and generation of reinforcements for profiles.

Currently, the Defcar system is used by 86 companies in 25 countries. The most recent reference is the Brazilian company TWB Group, which has installed the whole software in its shipyard at Navegantes. 

3 MAJ implements the Tribon system

THE 3 MAJ Shipyard has recently purchased the Tribon shipbuilding system for design and production of ships at its yard in Rijeka, Croatia. To increase automatization and efficiency, 3 MAJ will, in the first phase, implement the Tribon system to achieve an efficient steel construction department,

but to ensure faster interaction between yard designers and suppliers in order to reduce man-hours and costs when searching for equipment, the shipyard is also linking to the Tribon.com database.

The main production programme of 3 MAJ comprises all types of ships up to 260m length and

50m breadth, mainly tankers up to 110,000dwt, container ships up to 4000TEU, and bulk carriers up to 130,000dwt. With 20 ships currently on order - for owners from Germany, Greece, Latvia, and Croatia - the order book is full up to the end of 2007. 

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SafeHull Express - design evaluation for a new century

IN our January issue, page 4, we reported briefly on ABS' new structural evaluation software SafeHull Express - a speedier and more efficient successor to the original SafeHull, launched in 1993. Following a June visit to ABS headquarters in Houston, Texas, we can now report more fully on this interesting evolutionary suite.

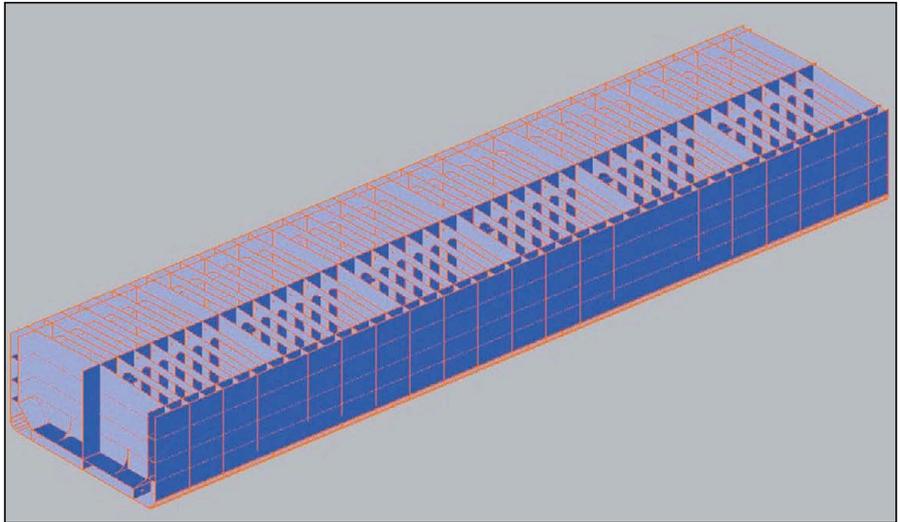
Up to now, some 500 ships from 40 yards (mainly in Asia) have had their structures analysed by SafeHull, which gives an excellent base on which to build the new package; it comes in nine versions, with interfaces to the associated software, SafeShip and SafeNet. Perhaps the most pivotal and far-reaching enhancements in the Express version are a change to 3D modelling - a practice being increasingly adopted by the shipbuilding industry; equally notable is that the whole package operates much faster than the previous version while significantly improving user-friendliness.

SafeHull Express is especially planned to take into account the International Association of Classification Societies' (IACS) Common Structural Rules for Tankers and Bulk Carriers, of which the tanker version is expected to enter force on January 1 next year. Indeed, at present, only a tanker module is ready for use but IACS' joint bulk carrier project is currently being progressed by the seven classification societies studying this ship type, and SafeHull Express will be aligned with these new common rules, too.

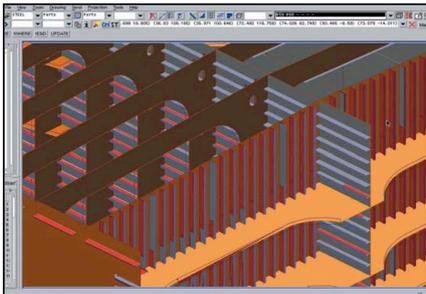
Several yards have been assisting ABS with its new software development, in particular to assure that the software work flow conforms with ship design practices.

The switch to 3D modelling has, naturally, required the most work, since much finely detailed data has had to be injected into the memory. For this reason, ABS sought a system to supply the base geometry, and thus the society turned to the respected Finnish company Napa Oy; a licence agreement has been concluded for the NAPA system of initial and basic design, also for the NAPA STEEL software for structural design; these have been customised to suit the Express software. NAPA suites already have interfaces to Tribon and other production software, and ABS software engineers are currently working on a link to steelworking lines for SafeHull Express, using the STEP process.

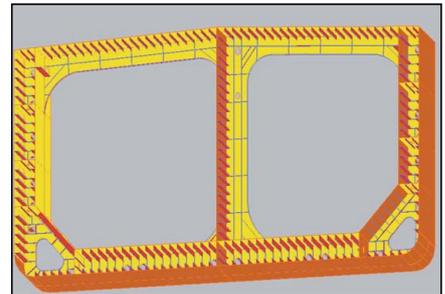
To create a finite-element model - often a lengthy and tedious process, ABS linked with the US consultancy MSC Software, well-known for its PATRAN and NASTRAN suites. Once again, software was customised to fit in to SafeHull Express. As class criteria continue to be improved, SafeHull Express will, of course, be upgraded accordingly, but it is interesting to record that some data successfully launched in the earlier versions of SafeHull (which started to enter the industry at a time when double hulls and a return to first principles were making themselves felt) have already been included in the new IACS joint tanker rules - a tribute to the good groundwork incorporated at the beginning. These have included a net scantlings base for



A typical double-hull tanker parallel mid-body created using SafeHull Express with its 3D modelling ability.



A 3D tank section, showing the details with helpful see-through effect.



Details of a typical web frame.

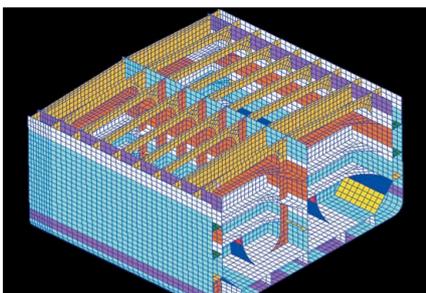
rules, the dynamic-load-approach (DLA) concept, and finite-element analysis. SafeHull Express can, of course, be used for both completely new ships, or for extrapolation from an existing design.

User-friendly features in the software include the employment of a standard stiffener library, since these are found in many yards, while frames and other components will be automatically trimmed, based on the topological relationship of structural members when designs are being adjusted - this will save users considerable time. Extremely detailed

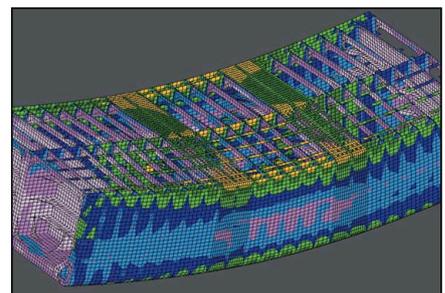
reports are a notable feature throughout, but especially of pressures generated during the finite-element analysis.

This new software package should be able to create or evaluate a rule-compliant basic ship design, plus a weight report, within one day, and a complete finite-element analysis within two weeks. Indeed, the goal of the SafeHull Express design team was to cut current design and analysis time in half, and it appears to have succeeded in achieving this, largely as a result of the huge advance in computing power that is today available to enable speedy analysis of 3D model-based designs. ⚓

A finite-element-analysis illustration of a hull section, showing the different steel thickness.



Stress and deflection of a 3D modelled hull section.

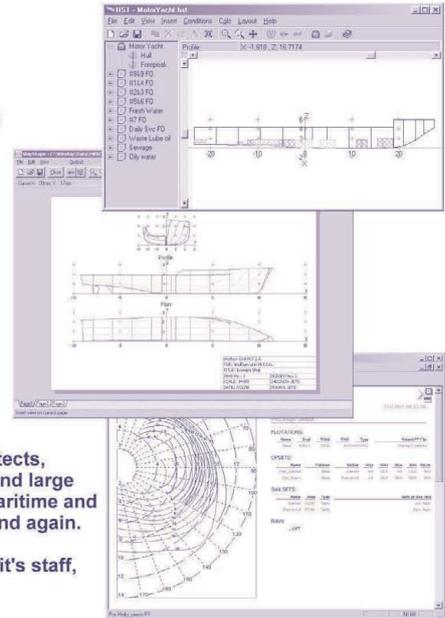


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Ship Control Systems

ShipConstructor2005 released

THE latest version of Albacore Research's (ARL) AutoCAD-based 3D product modelling software, ShipConstructor2005, has recently been released for the fabrication of complete ships and offshore structures. ShipConstructor2005 was developed under the AutoCAD2005 system with compatibility to AutoCAD2004; it provides many new functions that will improve productivity, not only while operating the software, but also downstream in production and through integration of ShipConstructor with other business processes.

New hull module

With the introduction of a new hull module, ARL brings much of the functionality of the proven but so far stand-alone ShipCAM solution into ShipConstructor, thus running inside of AutoCAD. Users will be able to open ShipCAM files, and import 3DM (Rhino) and IGES (most hull design programs) files.

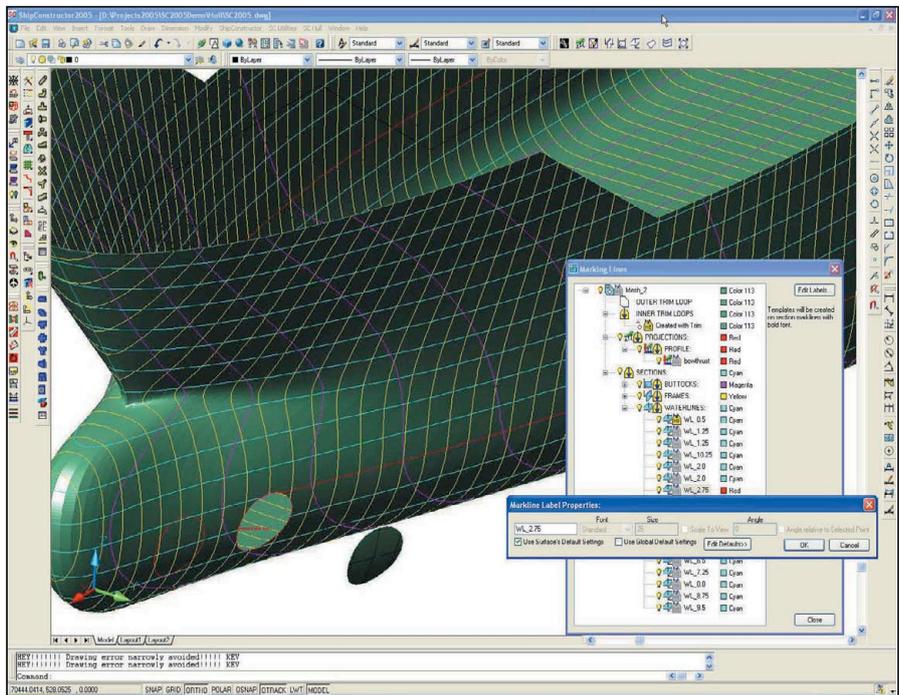
The hull module's functionality is greatly improved over ShipCAM, and provides trimable surfaces, stringer layouts, pin-jigs and inverse bending. Plate expansion, including forming templates, accuracy control data, and strain maps are also included.

More ShipCAM features will continue to be integrated into Hull, beginning with an autumn 2004 interim release of the Hull module. All ShipCAM users with current maintenance and support contracts will automatically receive the hull module, and Hull purchasers will automatically receive ShipCAM at no additional cost.

Enhancements and new features

Established ShipConstructor modules (manager, structure, pipe, penetrations, equipment, and HVAC) are boosted by numerous performance improvements to offer users more flexibility, fine-grain control, and quicker functionality. Notable features of ShipConstructor2005 include:

- 'Smart' bills of materials - ShipConstructor2005 will see the introduction of the 'smart' bill of materials (BOM). This new BOM is designed to further enhance the usability and integration of the software to enable users to improve on their project delivery times and overall product quality. The BOMs are dynamically linked to the backend SQL server database to make updating production drawings much easier. The entire BOM is a 'smart' object that the user can resize, while also changing colours, styles, and grid types to conform to individual company standards. Furthermore, a change in the BOM will automatically update any labels in place, retaining the often-significant efforts users have made. These smart BOMs will become part of the assembly drawings, pipe spool, and HVAC spool drawings, as well as arrangement drawings.
- Improved database integration - The Manager module now provides easier



In ShipConstructor2005, 'smart' hull module surfaces inside AutoCAD allow user creativity.

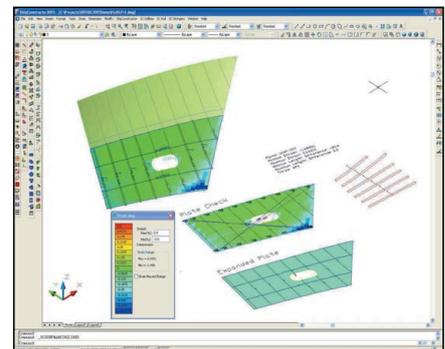
integration with the client's databases. UserID, ModelNo, and OrderID are new fields that allow easy linking of the ShipConstructor project database with a customer's purchasing and material handling databases. Manager's custom reports have also been enhanced. They now feature additional fields for better tailored production reports, saving valuable time once needed for production to request more information manually from engineering. Also, users can add spooled and/or no spool items to custom reports in order to monitor the engineering progress on the various pipe systems.

- Pipe module enhancements - The pipe module has undergone new development to save users time. Pipe display performance has been vastly improved in response to the ever-growing project sizes undertaken by ShipConstructor users, yielding a great performance improvement in operations such as panning, zooming, orbiting, and regeneration. The level of detail displayed on screen can be adjusted by the user as required for the task at hand.

Replacing pipe objects due to last-minute specification changes has become much easier. The find-and-replace function allows replacement of all pipe items. Still spec-driven, the function can easily swap out any number or type of objects while still retaining their original orientations.

New pricing options

With ShipConstructor2005, ARL now offers two new pricing options in addition to the proven perpetual licence option and the lease licence option. With the new annual renewable



Hull module plate expansion using smart surfaces with two-way links and updating.

licence, the user can distribute his payments over several years. A new month-to-month rent licence is advantageous when a user needs to supplement existing licences during peak demands or when consulting companies want to send their experts to their jobs with ShipConstructor in hand.

Future plans

With ShipConstructor2005 just released, ARL is already looking ahead to the release of ShipConstructor2006 in the spring of 2005, to accompany the likely release of AutoCAD 2006. Currently planned is a major extension of ShipConstructor's central SQL database, allowing for splitting and merging of the database to simplify outsourcing of project sub-areas and sharing the database with subcontractors.

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 manufacturers and regulators to highlight how the sensible application of ergonomics and human factors can provide 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
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- Feedback from the users into the design loop
- Safety performance and management
- Maritime operating organisations and teamwork



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Update to HST for hydrostatic calculations

THE Wolfson Unit for Marine Technology & Industrial Aerodynamics, based at the University of Southampton and well known for its software development work and a full range of consultancy and troubleshooting services, includes amongst its portfolio the HST module for calculating hydrostatics, stability, and tank capacities. This has now been updated considerably with an additional loading module. This calculates weights and centres, loading conditions, longitudinal strength, maximum KG and intact stability criteria, also inclining experiment data. The module can be plugged-in to the HST program and uses the same hull and tank definitions defined in HST.

Weights and loading

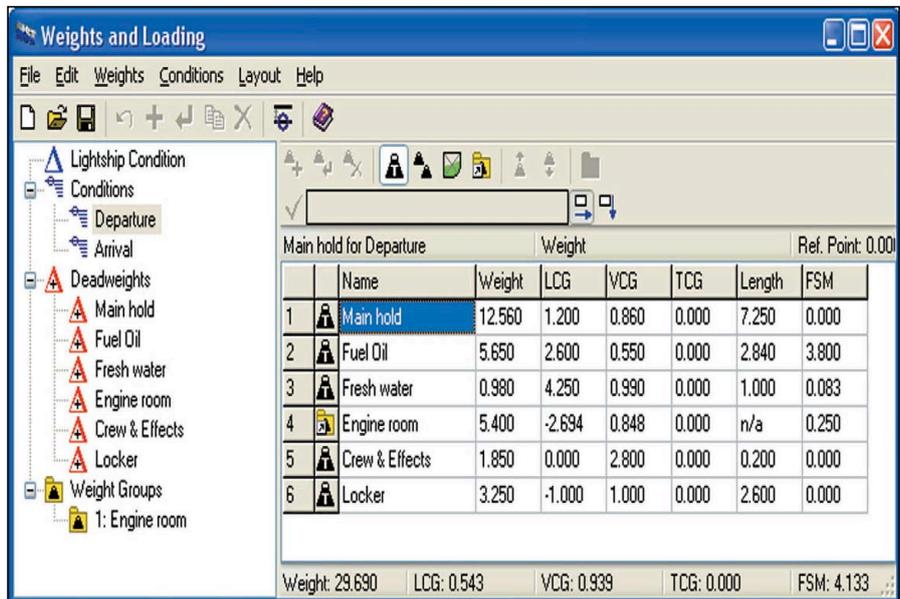
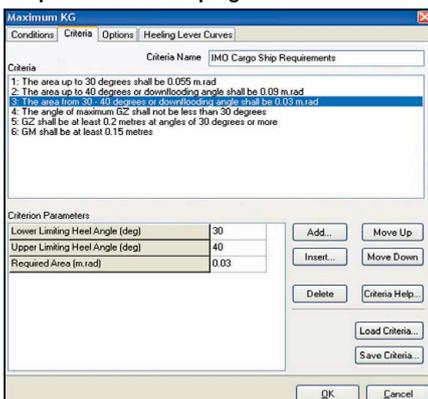
The weights and loading section creates databases of information for use in the loading conditions, longitudinal strength, and inclining experiment calculation methods. It can also be used as a general-purpose weights and centres calculator. Deadweights are used to define a vessel's various loadings for operation of both the loading conditions and longitudinal strength calculation methods. Weights may be referenced as single weight items or as groups of weights, allowing these groups to be collected together to form larger blocks. Tank definitions created in HST may also be used and weight items referenced to these either by weight, percentage full, sounding, or ullage.

The loading conditions section computes the displacement, sinkage, trim, and initial stability for vessels defined in HST for the conditions specified in weights and centres. It has been written specifically to assist in the compilation of stability information booklets, as the printed output is suitable for direct inclusion in the booklet. Loaded conditions are combined with the vessel's lightship condition in order to calculate the final displacement, draught, trim, and initial stability. The results may be used in the calculation of intact stability or maximum KG stability criteria.

Longitudinal strength

The longitudinal strength module combines the hull data from HST and loading conditions, in order to derive shear force and bending moment

A number of data files of IMO stability criteria are provided with the program.



The weights and loading module creates databases for use in the loading conditions.

data. A trochoidal wave profile can be defined, with its crest at a specified point along the hull, in order to calculate maximum hogging and sagging cases. Having determined the load curve, the program proceeds to balance the vessel, either in still water or on the wave profile specified. The resulting curve of buoyancy is added to the load curve in order to calculate the shear forces and bending moments. If required, the vessel's stiffness may also be input to create a table of deflections.

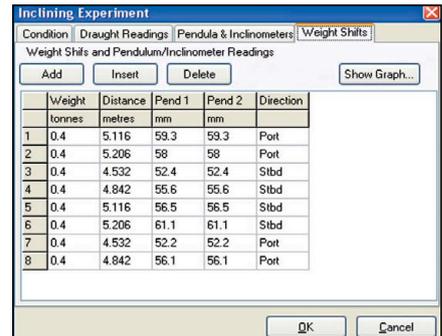
Maximum KG

The maximum KG section performs a number of tasks, primarily related to matching calculated stability curves with a variety of stability criteria. These are as follows: maximum allowable KG, wind heeling, turning moments, passenger crowding, general heeling limits, and GZ curve summaries.

A number of data files of IMO stability criteria are provided with the program, covering general cargo and passenger vessels, offshore supply vessels, cargo ships carrying timber loads, pontoons, and fishing craft. These criteria can be augmented by additional sets of criteria, or adapted to suit local requirements. The program can also present a summary of the GZ curve suitable for inclusion in stability information booklets, can calculate IMO wind heeling data, and perform passenger crowding simulations, and turning moment calculations.

Inclining experiment

The inclining experiment module works with the data gathered during an inclining experiment, the hull definition created in HST, and also with the weights and centres data, which define items to be added or removed for the lightship condition. The program calculates the as inclined condition GM, the displacement, and centre of gravity.



The inclining experiment section accepts deflections for pendula or inclinometers and for a number of weight shifts.

Weights are then removed or added, and the lightship displacement, centre of gravity, draught, trim, and GM are calculated. The program accepts deflections for up to four pendula or inclinometers, for a number of weight shifts. Draught readings may be entered at any number of locations port or starboard along the vessel. Both the pendulum/clinometer readings and draughts are fitted by linear regression to find the best fit to the data.

Help system

The program comes with a full manual and help system describing the module calculation processes and systems. The help system includes comprehensive definitions of the stability criteria and a comprehensive tutorial on the loading conditions definition. Included is a full glossary of terms showing the derivation of calculated data.

Enhanced features in latest upgrade

DUTCH CAD/CAM software and Engineering company MasterShip has launched the 2004 version of its CAD/CAM software. This suite is mainly used as a primary CAD/CAM system in medium-sized and small shipyards. For large shipyards, where the use of AutoCAD is widespread, MasterShip qualifies as a typical AutoCAD 'accelerator'. Alongside large shipbuilding applications such as Tribon, Foran, and Catia, MasterShip, the company claims, performs very well. A recent test by a Korean shipyard demonstrated that MasterShip outperforms Tribon in several areas.

MasterShip is currently expanding quickly worldwide, and centres are being set up in several shipbuilding regions of the world. Each MasterShip centre sells the software and offers a full set of MasterShip services such as training, software support, and engineering services. In the South East Asia region there are now centres in Bali, Singapore, Shanghai, and Zhenjiang.

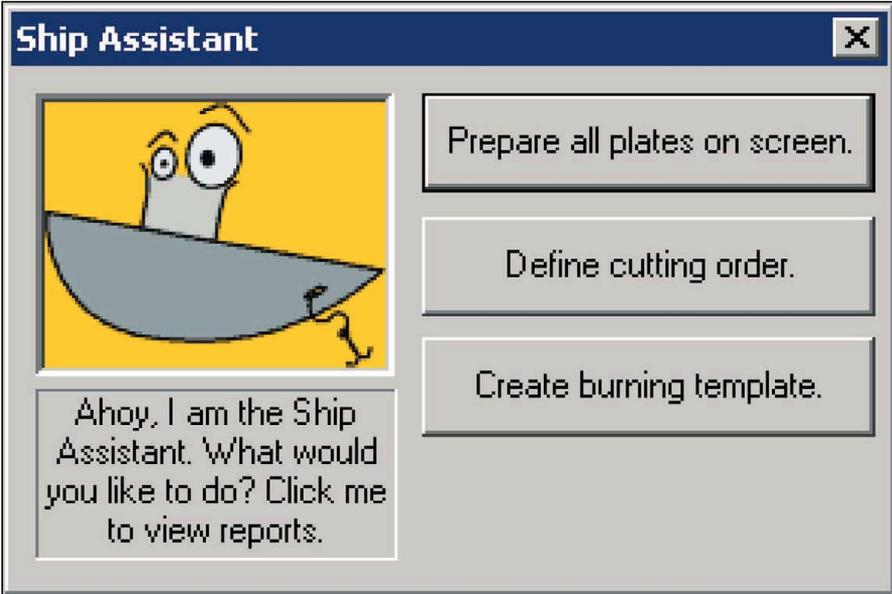
This CAD/CAM suite translates a concept design into production (lofting) information and is fully integrated with the latest AutoCAD versions. MasterShip consists of three generators and an organiser, plus an integrated SQL database. The shape generator creates a 1:1 faired production model of a hull and superstructure. The parts generator creates all parts for the hull and superstructure including internal construction, hull plates and stiffener material. An NC generator then translates all parts into production information. It nests the parts efficiently and should guarantee problem-free control of all types of cutting machines.

The new 2004 release is available in two versions: one based on AutoCAD 2002 and the other on AutoCAD 2004 and 2005. Numerous improvements, large and small, have been made to all generators. For example, the 3D function has been further improved to create a 3D assembly with all parts as solids at the touch of a button. This is useful for fast identification of parts that do not fit or obstruct each other.

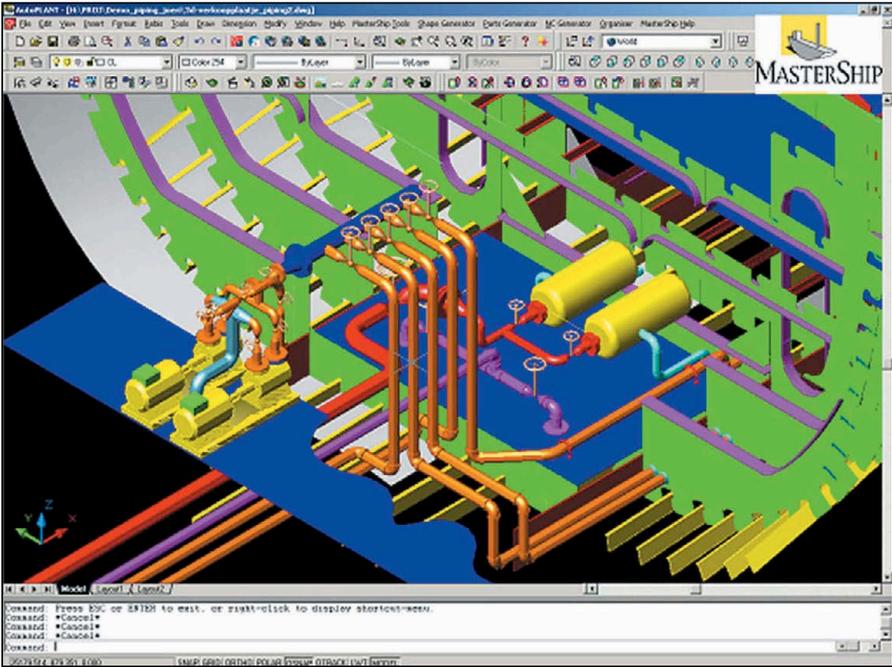
There is also a seamless link to Autodesk Inventor for interior design and to Bentley AutoPLANT for 3D piping. AutoPLANT is an object-based 3D plant design and modelling system using 'spec-driven' pipe routing and component placement. There is a seamless link between MasterShip and AutoPLANT, so that the same 3D AutoCAD ship model is used as the basis for the 3D engineering of a ship's installations with AutoPLANT.

MasterShip organiser, the SQL-based parts database, has now been fully integrated into the generators. The new Ship Assistant function in the NC generator handles routine tasks automatically and considerably simplifies nesting. An improved Nupas interface allows importing of Nupas parts, converting them automatically into MasterShip parts. A MasterShip tutorial is now available with improved drawings and step-by-step instructions. Based on the universal MasterShip tutorial vessel, this is said to be ideal for self-learning.

A 2004 training programme is now available worldwide, with a new course called advanced work preparation. The contents of the existing six



The Ship Assistant module, located in the NC generator, handles routine tasks automatically and simplifies nesting.



Improved 3D modelling in MasterShip now allows users to create a 3D assembly with all parts as solids.

courses have been renewed and adapted to the new 2004 versions of MasterShip, and AutoCAD courses are oriented towards practical implementation, resulting in fuller utilisation of

the MasterShip and AutoCAD software. MasterShip courses are held in the company's headquarters at Eindhoven, in centres, or at a customer location.

New features for finite-element analysis suite

RELEASE 2.3 of Strand7, the general-purpose finite-element analysis software suite, has recently been released by Imagineering UK. All new features are seamlessly integrated into the Strand7 Windows environment and are said to be straightforward to learn and use. In all, there are more than 40 new features and enhancements, many of them the result of feedback from Strand7 users.

New element type

Load patch is a plate element that has no physical properties and is used solely for transferring loads distributed over an area to beams on its perimeter. An example of this would be transferring wind loads to the side of a structure or live loads on a floor slab. The load patch converts the area load into an equivalent line load on the beam. This simplifies the application of loads to a complex array of beams; changing the load on a single plate automatically changes the load on the perimeter beams. Loads can be applied to load patch elements as normal pressure, global pressure, face shear, and non-structural mass. The first three are converted to beam distributed forces; the fourth is converted to beam non-structural mass.

There is also a 'create load patches' tool. This automatically defines load patches over a polygon of beam elements. Another new tool can convert patch loads to beam loads. This is useful for viewing the way a load is distributed onto beams from load patches.

Inertia relief

In addition to the normal freedom case, users can now select an inertia-relief freedom case. Inertia relief allows free-floating structures with static loads (such as vessels) to be solved using the linear static solver without applying any restraints. Global linear and angular accelerations are automatically applied to generate inertia forces that balance user-applied loads. Inertia relief can be applied to completely free bodies and symmetric free bodies (such as where a half or a quarter of the structure has been modelled).

Online help

The comprehensive Strand7 online help module now includes a global navigation pane to the left of the content pane, and in a pulley modelling system, connected truss elements can now be grouped together to form a string group. This group acts like a string passing through a series of frictionless pulleys. Each

node acts as a pulley and constant tension is maintained in all the elements in the group. A string group can be open-ended or closed loop.

Non-structural mass

As the name suggests, such a mass is not part of the structure. It is mainly used for modelling live and non-structural dead loads that may vary across a range of operating conditions. For example, furniture not fixed to a structure will generate gravity loads on a slab and therefore can be modelled as a non-structural mass. Previously, this had to be applied as a pressure, but this made no allowance for the inertia of the mass in dynamic analysis. The user can choose whether to include structural mass or non-structural mass for each load case; this ensures that the structural mass is included only in the self-weight load case.

Finally, a FFT (fast fourier transforms) module is used to convert transient results from the time domain into a frequency domain, allowing easy identification of the frequency content of the response. It is also now possible to convert an acceleration vs time table into an acceleration response spectrum. This allows a simpler spectral solution to be used instead of the longer transient one. 

New subsidiary strengthens software presence in Asia

FOUNDER and president of Albacore Research Ltd (ARL), Rolf G Oetter, and Dr Oskar Lee, director of ARL Asia Pte Ltd (ARL Asia) as a solutions provider and training and technical centre for ARL's ShipConstructor software in Asia. ShipConstructor is a well-established AutoCAD-based 3D product-modelling software package for the design and fabrication of ships and offshore structures, and for use by large and small yards.

Dr Lee will provide CAD/CAM system integration in the Asia Pacific region for all ShipConstructor clients, with the aim of coordinating sales and technical support. To aid this effort, ARL Asia has enhanced its website to provide full product, training and exhibit information for ShipConstructor's Asia-based clients.

To provide a localised service, ARL Asia has established a dealer network in the Asia region, which includes, to date, eHYS Inc (Korea), CAD&Soft Co Ltd (Korea), S&I Technologies Asia Pte Ltd (Singapore), Peripheral Solutions (S) Pte Ltd (Singapore), and Aries Marine & Engineering Services (UAE).

Seoul-based eHYS, nominated by Autodesk Korea as its sole business partner in Korean marine industries, is the key Autodesk agent for that country. Building on the company's extensive client network and comprehensive expertise, eHYS has worked closely with ARL Asia to develop the market for ShipConstructor in Korea.

CAD&Soft, in Busan, specialises in management technology consulting and software development for Enterprise Resource Planning (ERP) for the marine industries in Korea. Existing clients include large shipyards as well as small and medium industries.

S&I Technologies Asia (S&I), a Singapore-based database integration company, is a leading provider of server systems, enterprise solutions, and service integration that help customers maximise business value through the strategic use of information technology. S&I has a strong presence in Malaysia, China and Thailand, as well as partners in the Philippines, Thailand, Indonesia, Malaysia, Hong Kong, Taiwan, China, and Australia.

Peripheral Solutions (PSL), ARL's established dealer in Singapore, is now strategically aligned with ARL Asia. PSL has extensive experience in the supply and implementation of office and factory automation hardware and software. Both ARL Asia and PSL are registered agents for Autodesk products with particular strength in the support of AutoCAD 3D design tools.

Finally, Aries Marine & Engineering Services is based in the United Arab Emirates and provides naval architecture and marine engineering services. Existing clients are mainly in the marine and oil and gas industries located in Africa, India, and Azerbaijan. ARL Asia will also be working closely with Australia-based Formation Design Systems Pty Ltd and its Asian representatives. 

New PropExpert software ensures user efficiency

THE newest version of US-based HydroComp's propeller sizing software is PropExpert 2004. The interface is built upon the user-friendly PropExpert architecture and many new features have been added. These include a new data file system, which will allow a company to set up a common project directory for all users, and reports in HTML format to enable easy distribution of reports to clients and customers.

In addition, there is a host of new features to improve user efficiency - quick printout of data entry forms, immediate selection of recent projects, supplemental cupping definition, and easier design speed options. There are also features to insure full understanding of data and results, including immediate graphical plots, enhanced help information, and basic engine/propeller resonance checking. 

The Royal Yachting Association, based in Hamble, is the national governing body for the sports of sailing, windsurfing, motor boating and powerboat racing.

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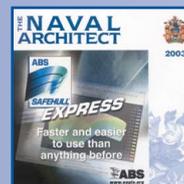
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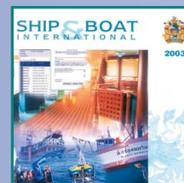
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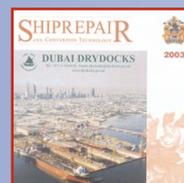
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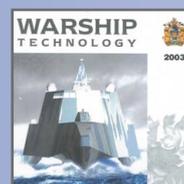
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SIGNIFICANT SHIPS OF 2003

A publication of
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of Naval Architects

The Royal Institution of Naval Architects has published the fourteenth edition of its annual *Significant Ships* series. Produced in our usual technically-orientated style, *Significant Ships of 2003* presents approximately 50 of the most innovative and important commercial designs delivered during the year by shipyards worldwide. Emphasis has been placed on newbuildings over 100m in length, although some significant smaller cargo ships, fast ferries and offshore vessels have been considered. We have included a cross-section of ship types, with each vessel being either representative of its type or singularly significant. Each ship presentation comprises of a concise technical description, extensive tabular principal particulars including major equipment suppliers, detailed general arrangement plans and a colour ship photograph.

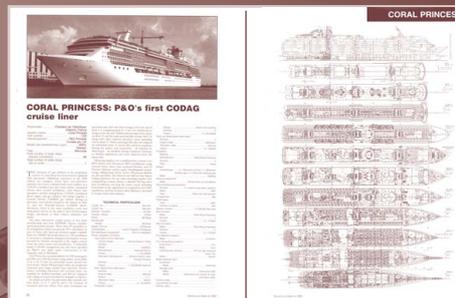
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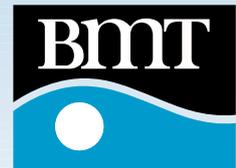
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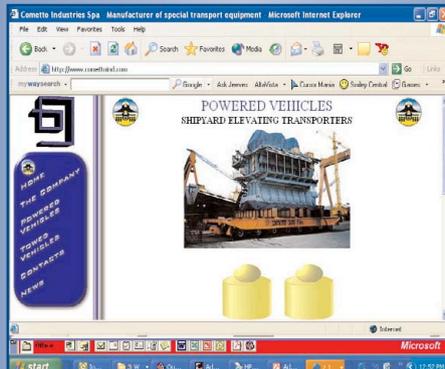
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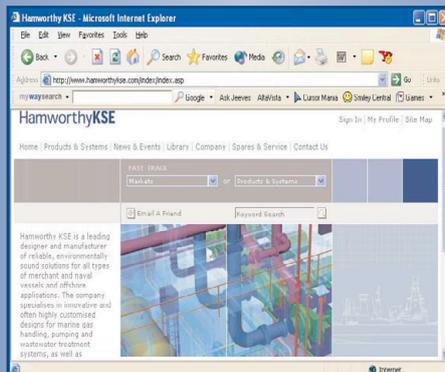
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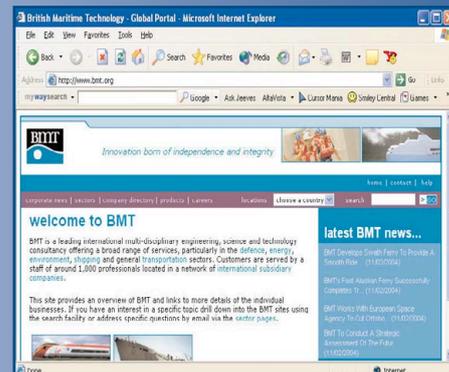
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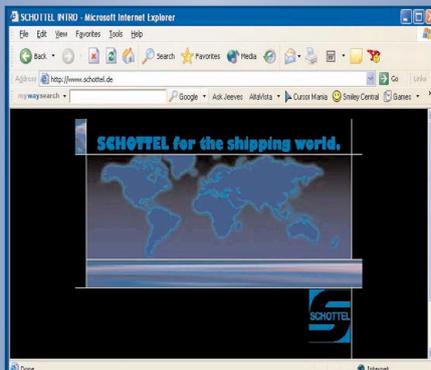


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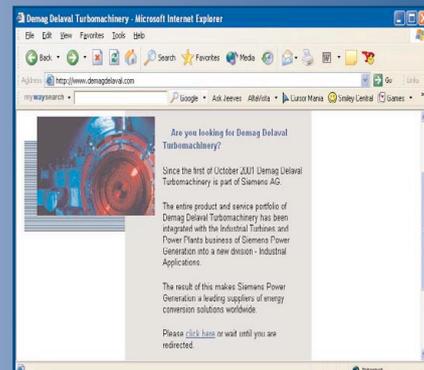
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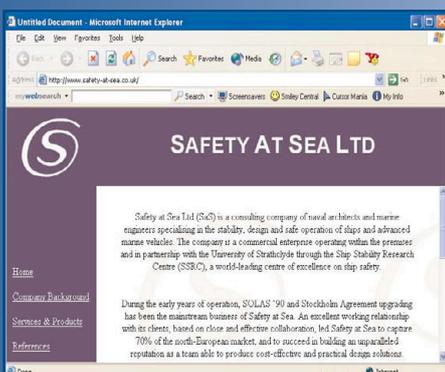
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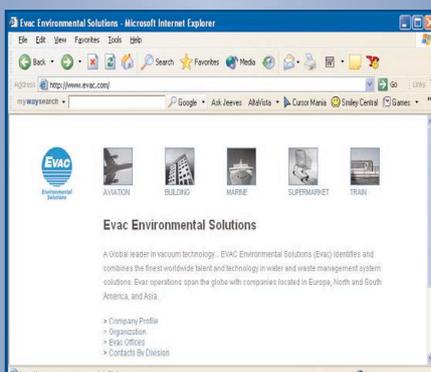
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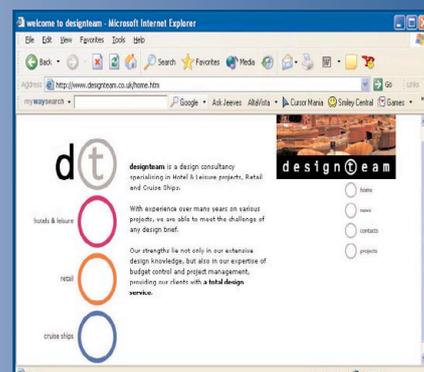
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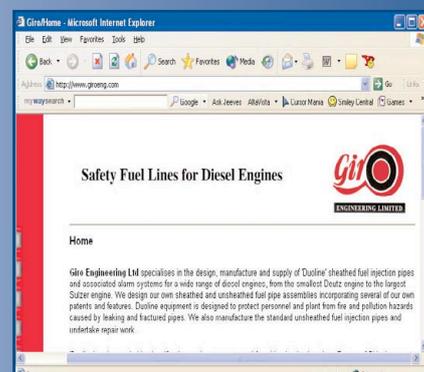
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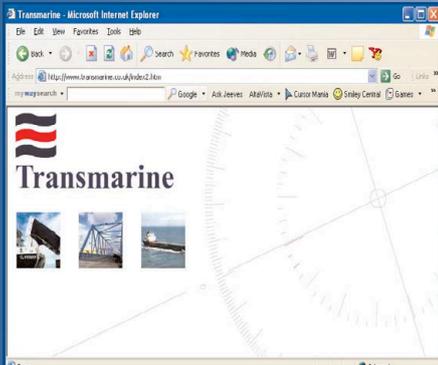
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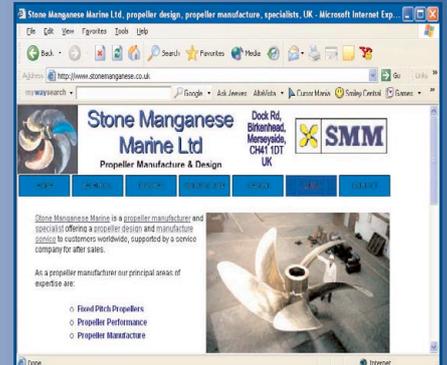
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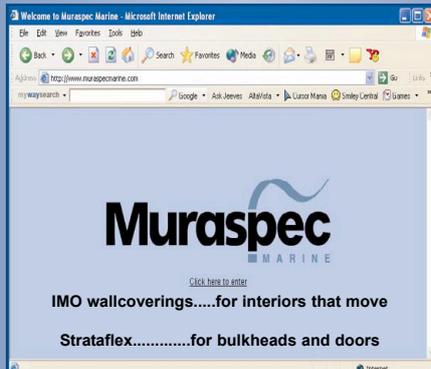
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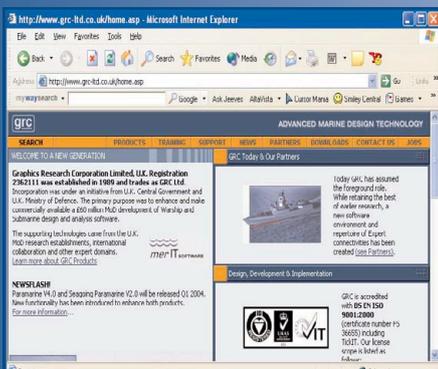
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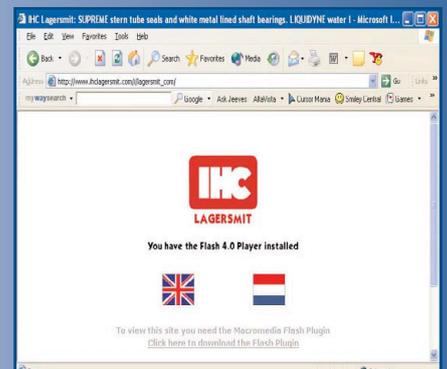
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October 7-8, 2004: Sub-Standard Shipping: Solution through Partnership. Goal-Based Standards: New Concept for Maritime Industry, St Petersburg, Russia. Contact: Russian Maritime Register of Shipping, 8 Dvortsovaya Nab, 191186 St Petersburg, Russia. Tel: +7 (812) 314 0743. Fax: +7 (812) 312 3569. E-mail: 004@rs-head.spb.ru

October 21-24, 2004: SHIPEC 2004, Hawaii Grand Hotel, Limassol, Cyprus. Tel: +44 1252 849707. Fax: +44 1252 849708. E-mail: annette.cox@mpigroup.co.uk www.mcleanevents.com/shipec

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November 2-3, 2004: European Shipbuilding, Repair and Conversion - The Future, international conference, London, UK.

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January 27-28, 2005: The Motor Ship Marine Propulsion Conference, Barakaldo, Spain. Contact: Donna Bushell, Highbury Business, Media House, Azalea Drive, Swanley, Kent BR8 8HY, UK. Tel: +44 1322 611306. Fax: +44 1322 616379. E-mail: d.bushell@highburybiz.com ☎

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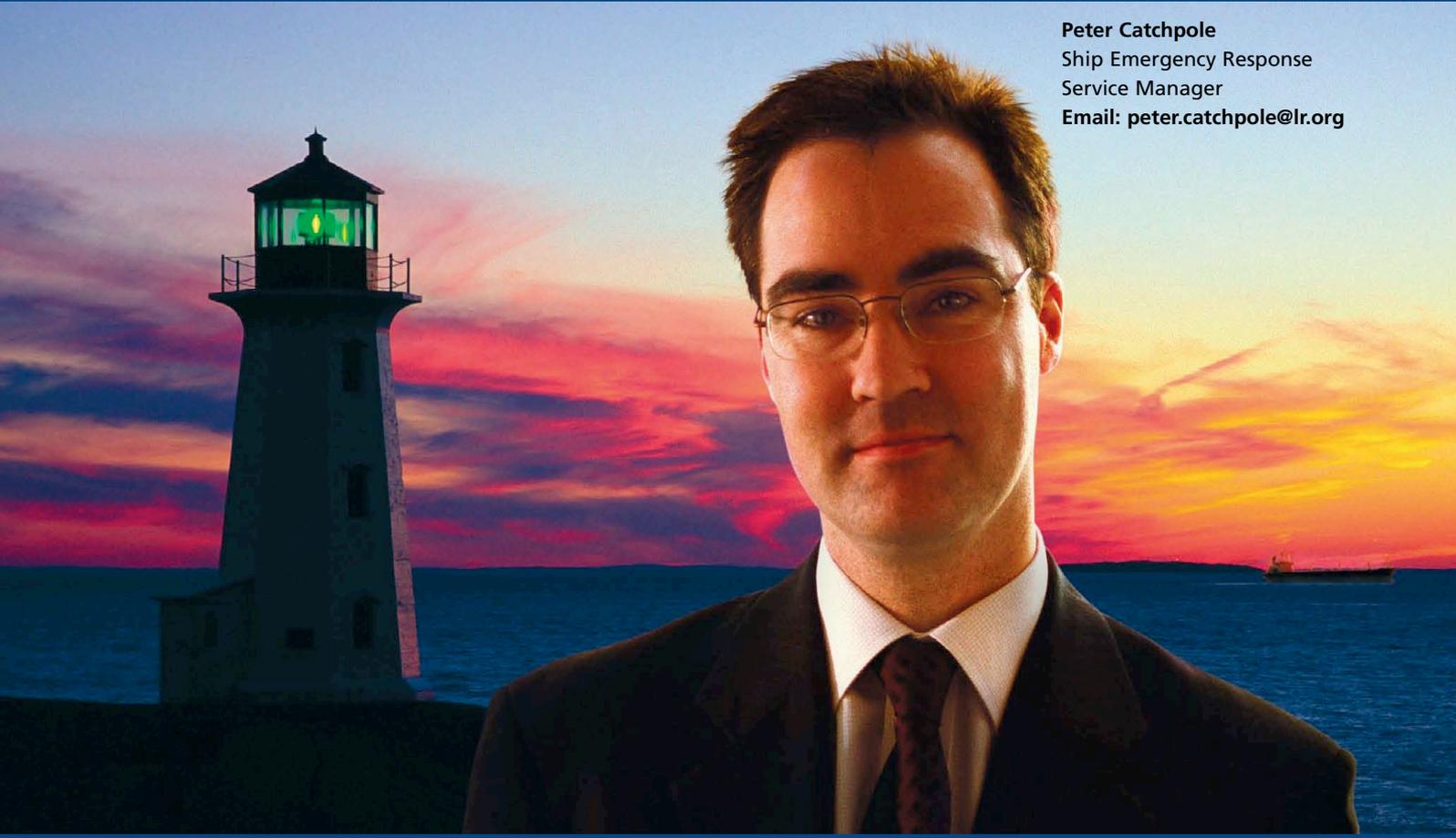


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