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More orders have been secured for the innovative German ship design from New Logistics, the Futura Carrier, despite shipyard problems with completion of the prototype. One of the new models is a tanker, the C-1100 - an impression is seen here - and contracts have been secured from Gerhardt & Deymann. More details appear in our article on page 36.

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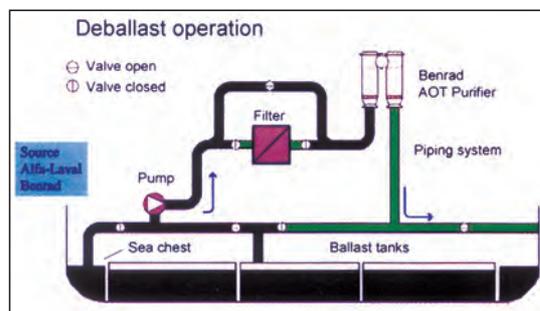
# Taking a lead in being green

A FULL set of green credentials are today a goal of forward-thinking shipowners worldwide but it must be unique for a company to make public and actively promote its efforts in this field. Credit must therefore be given to Wallenius Wilhelmsen, the joint Swedish/Norwegian ro-ro operator specialising in 'global ocean transportation and logistics management' - carrying export cars, lorries, and all types of heavy rolling cargoes, and which also carries on its payroll a vice president for the environment, Lena Blomqvist. For the year 2005, this enterprising consortium published a special report on its environmental activities.

Wallenius Wilhelmsen made its first public move with the futuristic concept ro-ro ship *Orcelle*, which was discussed in the April 2005 edition of this column but had been active in the 'green' field before this. That proposed design includes the complete elimination of any combustion technology - bad news for diesel engine manufacturers but good news for advocates of sail, fuel cell, solar, and wave-derived energy.

A ship such as *Orcelle* has yet to be built but Wallenius Wilhelmsen currently holds a highly impressive list of priorities in sectors where plans are afoot to ensure that it remains at the very top of the 'green' list. These particularly include trying to burn low-sulphur fuel throughout the year, to limit the volume of polluting exhaust emissions. This is a well-discussed topic today but in 2005, this company's fleet bunkers had an average sulphur content of 1.72% - a very highly commendable figure despite the extra cost of US\$12

Arrangement of the experimental ballast-line arrangement on the Wallenius car carrier *Don Quixote*, using a new Alfa Laval/Benrad filter and purifier to try and remove undesirable organisms from the water.



million. The international maximum is 4.5% but the Baltic limit is 1.5%, a figure which will be extended to the North Sea next year.

A low-sulphur fuel policy generally means larger tanks for those ships sailing on deepsea voyages, so that bunkers of suitable quality can be loaded in one port only - mainly a European one for Wallenius Wilhelmsen ships. These policies will additionally be assisted by the new technique of employing, on two-stroke machinery, fuel valves of the fully-emptying slide type; these can offer substantial improvements in NOx emissions. Further elaborations, such as scavenge air moisturation, are being studied by leading engine designers, and extra reductions seem likely in the future. Meanwhile, fuel cells wait in the wings.

Wallenius Wilhelmsen is additionally taking part in a Norwegian Shipowners Association project to develop bolt-on equipment, such as new-generation selective catalytic reduction gear, which can prevent the escape of sulphur oxides in exhaust fumes. Another environmentally-conscious owner, Taiwan-based Evergreen, has adopted the technique of cold-ironing in port - shutting down diesel-alternators and plugging into a shore supply, particularly on the environmentally sensitive US west coast, as we reported in our January 2006 edition. Wallenius Wilhelmsen is additionally making a conscious effort to ensure that all new ships use, as far as

possible, materials suitable for eventual recycling (the Green Passport initiative - a new topic but one which everyone in our industry will certainly know about in the years ahead).

Naval architects will be equally interested to know that Wallenius Wilhelmsen's newest class of large ro-ro ships from Mitsubishi, in Japan, are not only 'green' but also super-efficient. They feature a Mitsubishi stator fin on the rudder to utilise residual energy from the advanced-geometry propeller. This fin, in association with a Mitsubishi-developed new and refined hull form - another success for Mitsubishi's industrious hydrodynamicists, is claimed to save an amazing 10% in fuel consumption - at the same time as cargo capacity is increased! It might be well to remember that Wallenius Wilhelmsen also notes that optimum hull trim can help to save between 2% and 4% of energy.

The newest ship in this Mitsubishi-built series - fourth of 10 - was christened during August at Southampton. The 61,321gt *Topeka* can load up to 6500 cars. The joint Wallenius Wilhelmsen operation, which also includes EUKOR, will take delivery of 44 new ships between the current year and 2009, to meet an anticipated 4% growth over the next 10 years. This number of ships represents approximately 30% of the total order book for this class.

Environmental work by Wallenius Wilhelmsen continues to hone both existing and new ships to ensure that they are as 'green' as is possible. At the same time, the organisation is working in association with the World Wildlife Fund - one of few marine companies to do so. Under a three-year agreement, the goal is 'to preserve and promote the conservation of marine life on the high seas'.

Already, ships in the fleet are careful about that other topical operation - water ballast transfer, to avoid shifting undesirable organisms around the world. A special procedure has been adopted in company ships for transfer. This is not only for 'green' reasons but perhaps also to maintain correct stability when such operations are performed in the open sea; the unfortunate recent accident to the ro-ro vehicle carrier *Cougar Ace* revealed what can happen in such circumstances.

The admirable aim of Wallenius Wilhelmsen is not just to meet required standards but to push ahead to new frontiers. Already, one ship in Wallenius' fleet, *Don Quixote*, is experimenting with a new Alfa Laval/Benrad filter and purifier arrangement in its ballast lines to stop migration of organisms in their tracks.

Other goals for the current year include replacing older, more damaging refrigerants, with more environment-friendly products, improved oily water separators, maximum use of 'green' onboard chemicals, and issuing two ships with class society Green Passports.

For its part, Wallenius will soon take delivery from DSME, in Korea, of a new series of seven mega car carriers able to load 8000 cars. For these, DSME naval architects have also succeeded in introducing a more slender forebody, a wider aft body and better stability. Allied to these features is the introduction of a Becker flap rudder with a twisted leading edge (*The Naval Architect* September 2004, page 49), which Wallenius believes will save approximately 5% in fuel (3.5% for the flap and 1.5% for the twisted edge) as well as resulting in less cavitation erosion. The overall 'green' equation is believed to give a 15% reduction in fuel costs and emissions for each cargo unit, to which can be added the use of biodegradable oil in all hydraulic systems, an effective bilge water cleaning system able to achieve between zero and 5ppm (well below IMO's 15ppm), and a Lloyd's Register Green Passport.

The marine industry should be exceptionally grateful for the pioneering work and first-class public lead being taken both by Wallenius Wilhelmsen and Wallenius. Maybe their example will inspire others to make greater efforts in this direction. 

## First conversion for compressed gas liquid carrier

CLASSIFICATION society the American Bureau of Shipping (ABS) is set to class and certify the proposed conversion of several existing 150,000dwt Suezmax oil tankers to compressed gas liquid carriers (CGLCs) for Houston-based SeaOne Maritime Corp - a transporter of natural gas using its own technology. A somewhat similar concept was discussed in *The Naval Architect* June 2005, page 20; and more details about new technologies in gas carriers can be found in our Gas Carriers supplement which will be included with our October 2006 issue.

According to ABS, this is unique for industry as the gas processing system and the cargo containment system are both proprietary SeaOne Maritime Corp technologies that have never before been applied to a marine vessel. Natural gas processing and cargo containment are the two critical areas of review, and SeaOne is looking at liquefying the gas at other than cryogenic temperatures plus the containment system is different than any other configuration that ABS has ever seen for liquefied gas. The SeaOne concept calls for gas to be stored at a modestly elevated pressure with the temperature lower than atmospheric but much warmer than the cryogenic temperature for LNG.

Earlier this year ABS issued its approval in principle (AIP) on the SeaOne containment system using the ABS *Guidance Notes on Review and Approval of Novel Concepts*. The AIP process draws upon engineering, testing and risk assessments in order to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice. The methodology relies heavily on risk assessment techniques as a way to better understand and anticipate structural and operational issues related to a new or novel concept.

ABS evaluation of the overall system includes an assessment of the cargo containment system and process system to the requirements of ABS rules, an International Gas Code (IGC) structural strength feasibility study, and an analysis of the cargo tank support system.

SeaOne calls this a 'real alternative to LNG and CNG for those smaller and remote worldwide natural gas reserves'. The production or conditioned gas is to be transported in ocean-going gas carriers in a liquefied form, called compressed gas liquid or CGL. The liquefied gas is transported at a modest pressure and refrigerated temperature in a pipeline system mounted within the cargo area of the tanker. The carrier design is scalable and can deliver either pipeline quality gas as loaded and/or fractionated products.

Several CGL designs have been developed for conversions ranging from Aframax to ULCC-sized crude oil tankers as well as for newbuilds of up to 6.0 billion ft<sup>3</sup> capacity. The ABS-classed conversions will be the first for CGLCs.

The SeaOne CGLC will be designed for worldwide operation. Production gas loading and sales gas offloading will be handled via a flexible pipeline connected to a conventional single point mooring using a catenary anchor



A new container ship for Maersk has been officially named *Maersk Baltimore*. The ceremony took place at the Volkswerft Stralsund GmbH, Germany.

The vessel itself is the largest the yard has built, at 294m long and with a capacity of 4170TEU. The ship was named by Mrs Jacqueline Harris, the wife of Alba Plc Chairman, a company which has had a long relationship with Maersk, shipping televisions and radios with the company since 1972.

leg mooring (CALM) buoy. ABS will provide the class notation: A1-Compressed Gas Liquid Carrier, AMS, F (CGL) PLR. These notations currently exist, however, this will be the first time they will be configured in this fashion to identify a CGLC. ABS will certify the process and marine equipment onboard the vessel to the ABS requirements as well as the European Union's CE mark for quality and safety.

SeaOne Maritime is currently conducting extensive gas process and cargo containment prototype testing with ABS review. The tanker conversions are on a fast-track schedule of 24 months with the fabrication work expected to take place in Dubai. The conversion consists of new and existing technologies packaged in a unique way. Unlike compressed natural gas (CNG) carrier concepts and liquefied natural gas (LNG) carriers, the CGLC has onboard production gas conditioning and processing, liquefied gas storage, and sales gas fractionation.

**LIFEBOAT MANUFACTURER TO BE ACQUIRED** - TTS Marine ASA has entered into a letter of intent with Umoe Industri regarding the takeover of Umoe Schat-Harding, which supplies lifeboats and other life-saving equipment to the shipping and offshore markets. The agreed purchase price is around Nkr360 million.

The agreement is subject to final approval of the sale/purchase agreement by October 1 2006 by both companies' board of directors. TTS will conduct a 'due diligence review' of the company during September.

Umoe Schat-Harding's properties in Norway will at the same time be sold to Umoe for

Nkr20 million in a sale-leaseback agreement of 15 years to market conditions. The lifeboats and security equipment will be takeover of Umoe Schat-Harding be established as a new division in TTS.

The takeover of Umoe Schat-Harding is in accordance with TTS' strategy of expanding through organic growth and acquisitions, and to become a one-stop-shopping centre for deck equipment on a global basis. The potential for increasing the joint business, both with respect to new sales and especially after-sales and service activities are considerable. Umoe Schat-Harding has its strength in the cruise segment as well as in the offshore market, whereas TTS mainly delivers to the regular merchant fleet. Together, the companies should increase sales of new products in these markets, and strengthen the effort with respect to service and after sales.

The new TTS Group will comprise five divisions: dry cargo handling, marine cranes, port and material handling, and deck machinery in addition to the new division for life boats and life-saving systems.

**WORLD'S LARGEST CONTAINER LINER NAMED** - In August Odense Steel Shipyard's Lindø Yard, Denmark, presented its latest newbuilding, an 11,000TEU container vessel, for the AP Møller - Maersk Group. This is thought to be the biggest container ship in the world, and is around 10% larger than any other vessel. However, it is currently being speculated that this ship might actually have a capacity 15,000TEU.

*Emma Maersk* is also thought to be one of the globe's largest refrigerated cargo ships, as she

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is able to carry 1000 40ft containers. It has been claimed that every cell on the ship can take high-cube containers which measure 9ft by 6in - 12in taller than normal containers.

The new ship has been applied with environmentally friendly silicone paint on the hull of the vessel below the waterline - reducing water resistance and cutting the vessel's fuel consumption by 1200tonnes per year.

*Emma Maersk* has been installed with probably the first-ever two-stroke 14-cylinder engine, a Wärtsilä RT-flex model which develops approximately 80,000kW. The ship, which has a length overall of 397m and a width of 53m, after delivery which is scheduled for this month (September), will enter Maersk Line's Europe-Asia service.

**CLASS SOCIETY UNION** - France-based classification society Bureau Veritas (BV) has joined forces with the growing Vietnam Register (VR). At a signing ceremony in Paris, the two societies entered into a long term cooperation agreement.

BV and VR have agreed to cooperate on the following services: classification/certification surveys of construction; transformation and major repairs of vessels and offshore structures; holding or intended to hold the dual classification/certification VR/BV; or the single classification/certification VR or BV; classification/certification surveys including survey of routine maintenance and repair works of vessels and structures in service holding or intended to hold the dual classification/ certification VR/BV or the single classification/ certification VR or BV; inspection at works of materials and equipment intended for vessels and structures; and classification and certification of new dry container boxes.

A key area of agreement covers training and development of VR surveyors, who will work through BV's highly structured training programme and on secondment with Bureau Veritas.

**FUEL CELLS INTRODUCE ULTRA-CLEAN SHIPS** - In the near future, fuel cell technology will transform the economics and environmental impact of commercial shipping, according to the joint industry project 'FellowSHIP'. The project recently concluded the first stage of its breakthrough scientific research on fuel cell technology on ships. This technology, it is claimed, can be up to 50% more efficient than today's diesel engines and at the same time open up for ultra-clean ships.

To date, the environmental requirements imposed on the shipping industry have been relatively mild compared with land-based industry. This, in combination with the continued use of increasingly expensive fossil fuel and the growing call for cut in greenhouse gas emissions, poses a global challenge. A significant solution to this will be the development of fuel cell technology for ships - which, compared with conventional power-generating equipment, offers improved efficiency and reduced atmospheric emissions.

The FellowSHIP project, initiated in 2003, aims to develop and demonstrate complete integrated hybrid fuel cell systems in ships, and to qualify that technology for future use. Results from the initial research phase conclude that fuel cell technology can be applied in commercial shipping in the near future. On this basis, a full-scale demonstrator of an auxiliary power plant is planned for 2008.

**FIRST COMPANY SIGNS UP TO HULL INTEGRITY** - Unicom Management Services (Cyprus) Ltd (Unicom), the ship management arm of Russian national shipowner Sovcomflot, has become the first tanker operator to sign up multiple ships to Lloyd's Register's new Hull Integrity service. Unicom has enrolled 17 of its tankers in Hull Integrity, from its Bridge class and Sea class fleets. Both series of ships are 47,000dwt product and chemical carriers. The deal was sealed following the launch of Hull Integrity at the Posidonia exhibition in Piraeus, Greece, in June.

Hull Integrity helps owners and operators to manage their vessels' hull structural integrity. The service comprises three key elements which enable a ship's crew to undertake hull inspections in a systematic and auditable manner: training in how to carry out inspections; ship-specific hull inspection guides; and Hull Integrity software for recording and analysis.

The Hull Integrity service is applicable to all ship types and is not a class requirement, so it can be used by owners and operators of ships not classed by Lloyd's Register. The advantages of the service are most immediately apparent for operators of tankers and LNG vessels, due to the regulatory and commercial third-party requirements that they face.

**CONFERENCE FOCUSES ON SHIP RECYCLING** - The solution to ship recycling can only be found globally, as all the relevant markets of shipbuilding, shipping, and recycling are global, by nature. Such solution can only be obtained as collective outcome of the good conduct of numerous stake holders from when ship is constructed and to when it is recycled. Therefore, the system design must draw upon a wide range of wisdom and expertise and take into account the practical aspects of each stage of a ship's life cycle.

The International Maritime Organisation has been making good progress in developing the mandatory instruments for ship recycling, and it aims at finalising the Draft International Convention for the Safe and Environmentally Sound Recycling by 2007. The Maritime Japan seminar (Tokyo, September 12th 2006) aims at mobilising a balanced mix of the expertise in all relevant sectors in order to establish a workable and reasonable global regime for ship recycling. The seminar, being held in Asia, could also trigger more proactive roles by the stakeholders in Asia where most of ship recycling and shipbuilding as well as much of shipping activity take place. For more details contact the Japan Ship Centre; Ground Floor, 9 Marshalsea Road, London SE1 1EP. Tel: +44 20 7403 1666. E-mail info@jsc.org.uk www.jsc.org.uk

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# Is a wake-equalising duct applicable to all ships?

As is well known, a wake-equalising duct (WED) is mostly used to improve propulsive efficiency. Such a device increases flow velocity at the propeller plane and reduces the non-uniformity of flow and separations. As technology develops, hull forms become more efficient in terms of hydrodynamics, and therefore a question arises whether or not a duct is applicable for all types of modern ship. Within this context, a modern ro-ro ship is considered here for application of a WED. A CFD tool was used to analyse flow around the hull with and without a duct. Fahri Çelik and Hüseyin Yılmaz from the Department of Naval Architecture at Yıldız Technical University, Istanbul, discuss the results, which are, of course, only applicable to this particular ship.



Fig 1. A typical wake-equalising duct [Ref 2].

THE wake-equalising duct is an aerofoil-type vane fitted in front of the upper propeller area in the form of two half-rings, as can be seen in Fig 1. The most well-known example is the Schneekluth patent design discussed in *The Naval Architect* 20 years ago (Ref 1). An important parameter for the effectiveness of the arrangement is the axis inclination of the half-rings.

After a WED application, the flow attachment to the hull should be better and the flow separation reduced. Inflow of the propeller will be accelerated in the upper region, where it is slow, and in the lower region, where the speed of inflow is normally higher, it will be retarded [Ref 2].

The advantages of using a WED can be expressed as follows [Refs 1 and 2]:

- improvement of propeller efficiency owing to the more axial flow and more uniform velocity distribution over the disc area
- reduction of flow separation at the after body
- lift generation with a forward force component on the aerofoil section, in a similar way to a Kort-type nozzle
- fewer propeller-excited vibrations
- improvement of steering qualities from more straightened flow to the rudder
- no constructional changes and no modifications in propeller design involved when the duct is fitted to an existing ship
- possibility of integrating devices for ice protection of the propeller.

The application of a WED for power saving is most evident for speeds between 12knots and

Table 1. Main particulars of the ro-ro ship studied.

Length, waterline.....	138.90m
Breadth.....	20.00m
Draught.....	7.00m
Displacement.....	14,000tonnes
Prismatic coefficient.....	0.6
Block coefficient.....	0.5

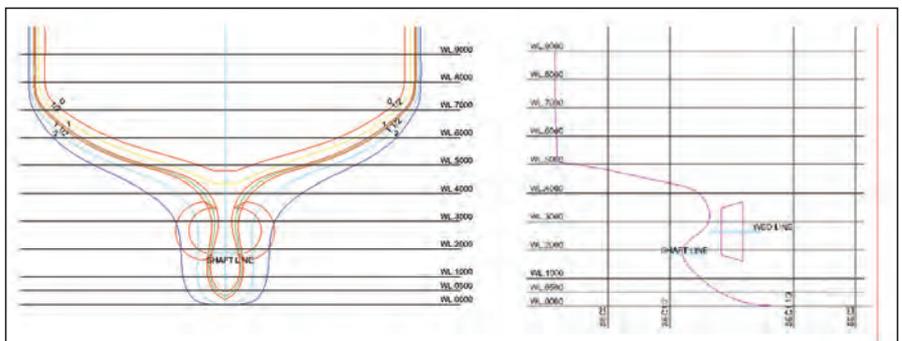


Fig 2. Location of the WED in the after body of the ro-ro ship used in the study.

18knots. Energy saving can reach to 14% with a proper WED design. The wake-equalising duct normally comes into consideration for moderate-speed vessels whose block coefficient exceeds 0.6.

A poorly designed WED could lead to additional drag forces in a ship, which would bring about decreases in hull efficiency. Computational fluid dynamics (CFD) are a useful tool for analysing viscous flow around a ship. In this article, a CFD technique is applied to study the flow around the after body of a ro-ro ship with and without a WED. A commercial CFD code, Fluent version 6.2.16 [Ref 3], was used for these cases. The main particulars of the ship are shown in Table 1, and the location of the WED in the after-body can be seen in Fig 2.

## CFD analysis

The CFD analyses were carried out in two stages. In the first stage, flow around the hull was analysed with and without a WED in the absence of a propeller. The inflow velocity at the propeller plane is obtained for both cases (Fig 3). In the second stage, the propeller performance is analysed using computed wake velocities. Table 2 gives the propeller details.

The benefit expected from a nozzle is improvement of the inflow to the upper region of propeller, so that propulsion efficiency of the propeller can be increased. As shown in Figs 3a and 3b, there is no significant increment in the velocities to the propeller blades; on the contrary,

the axial velocities at the upper region of propeller disc are slightly reduced.

In Table 3, propeller characteristics obtained from CFD analyses (with and without a nozzle) are given.

For both cases, the viscous drag force of the ship is almost constant, but the WED causes an additional drag force of 24.319kN. As can be seen from Table 3, the propeller becomes less efficient with a WED; it results in approximately 8.4% loss in terms of propulsive efficiency.

This result is supported by Jil-Pyo Ok's study [Ref 4] where extensive numerical investigations are reported on the scale effect of a WED for a tanker whose CB = 0.83. In that study, one of the significant conclusions was as follows; 'Contrary to the expectations of Schneekluth and some other authors dealing with these ducts, the duct decreases the longitudinal flow velocity of the water flowing through it, while the water flowing outside of the duct is accelerated by a small amount. This numerical result can be understood also theoretically'.

Because the duct is fitted at a position where the inflow velocity to the propeller is low (near the ship's centreline above the propeller axis), the duct does not act as a 'wake-equalising duct', as intended, but has just the opposite effect.

The conclusion is that the after body of the ship has a well-designed hydrodynamic form. There is no flow separation at the after body, and the upper and lower regions of the propeller operate in a good flow condition. It is clear that the use of

a wake-equalising duct in the ship with such an after-body form, where flow lines are not separated, could not bring about any additional benefit in the respect of stream lines.

**Conclusions**

Based on CFD analysis, the following conclusions are obtained:

- when the stream lines in the direction of shaft axis are examined, it is observed that inflow to a propeller has a uniform character. Under this condition, a WED will not perform its main duty and on the contrary it will disturb the proper stream lines, which may also lead to vibrations
- since the nozzle could not increase the flow velocity at the propeller plane, it will not make any contribution to the propeller efficiency.

The overall conclusion is that a CFD analysis becomes a useful tool to help the designer at the application stage of a wake-equalising duct. ⚓

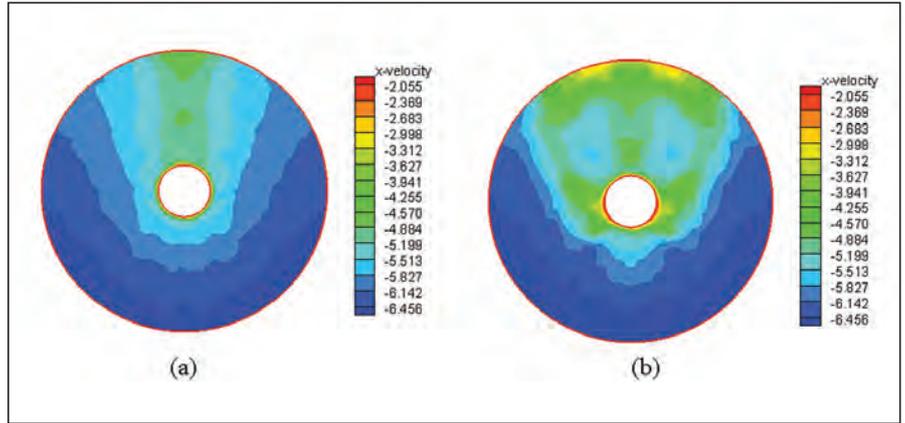


Fig 3. Axial velocity distributions at the propeller plane: (a) without nozzle and (b) with nozzle.

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 3. [http://www.wartsila.com/Wartsila/docs/en/ship\\_power/media\\_publications/marine\\_new](http://www.wartsila.com/Wartsila/docs/en/ship_power/media_publications/marine_new)

**Table 2. Propeller geometry.**

Design.....	Wageningen B-4.60
Diameter, D.....	4.30m
Pitch ratio at 0.7R, P/D.....	0.9015

**Table 3. Propeller characteristics for both cases.**

WITH WED	WITHOUT WED
0.1730K <sub>T</sub>	0.1759K <sub>T</sub>
0.02497K <sub>Q</sub>	0.02508K <sub>Q</sub>
0.603η	0.641η

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# Automotive design methods applied to marine transport design

In this article\*, by J Owen, director, Centre of Excellence in Teaching and Learning in Transport and Product design, Coventry University, UK, and I Drummond, professor of industrial design, Savannah College of Art and Design, USA, the authors report on an intent to migrate the process of industrial designers primarily in the automotive and transport sectors, to design for the marine sector.

COVENTRY University has a successful three-decade history in graduating industrial designers primarily in the automotive and transport sectors, and increasingly these skills are being recognised as relevant to the design of marine vehicles. Tovey and Owen have described verified techniques for teaching 3D design, based on automotive design studio practice, that have a direct link to the methods applicable to marine designers.

The skills from the automotive industry have also brought to light additional specific benefits to marine design especially fairing of surfaces such as hull forms. By using a combination of semi-rigid foam, automotive clay, and computer model visualisation, controlled development of complex surfaces and their intersections allow visual auditing of form at an early stage of the design process. More information about automotive clay modelling can be gained by consulting Yamada in the special edition of *Car Styling* magazine.

Considerable use is made of advanced 'intuitive' tools to enforce continuity across all surface edges when: curvature with constant rate of change of the rate of change of the curvature (G4) is required. In turn, fairing of hull surfaces, optimising changes in surface structure, permit inclusion of surface continuity across stepped forms, and the rapid manipulation of hull and topside surfaces is also improved.

Capturing physical hulls made from automotive hard styling clay or rigid foam using non-contact laser scanning is also described along with a discussion of the procedures of converting 'cloud data', first into polygons and then fitting computer splines onto this data are further explored for boat design. Export of data from any of the routes described to naval architecture software to check stability and performance, providing an iterative design and manufacturing process where hull optimization can proceed or it can be exported as milling data for use in full scale production of moulds is also described.

These methods are illustrated with case studies, following major sub-sections: use of Alias

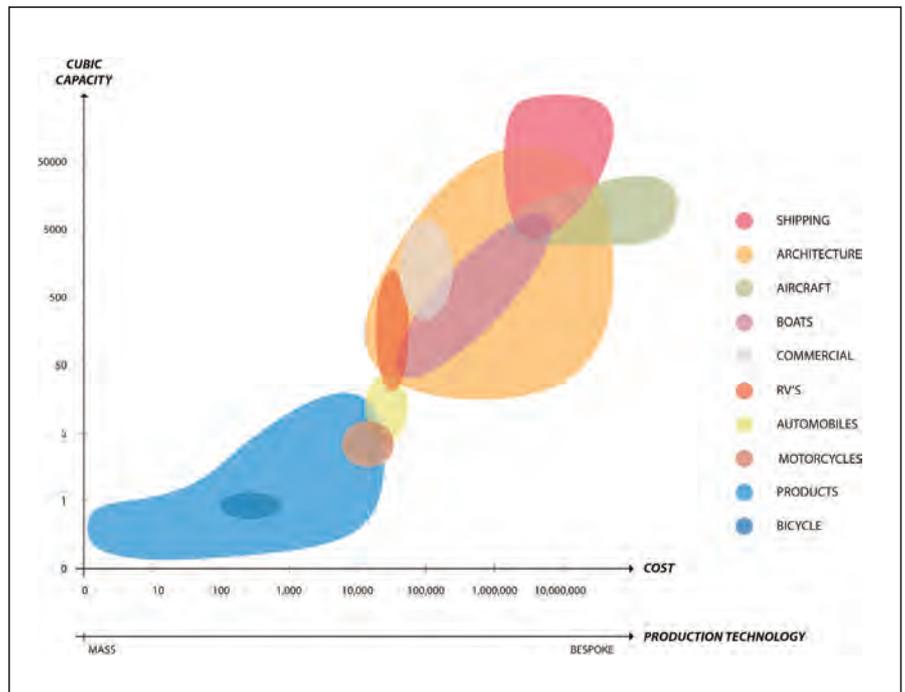


Fig 1. Scope of transport design in context.

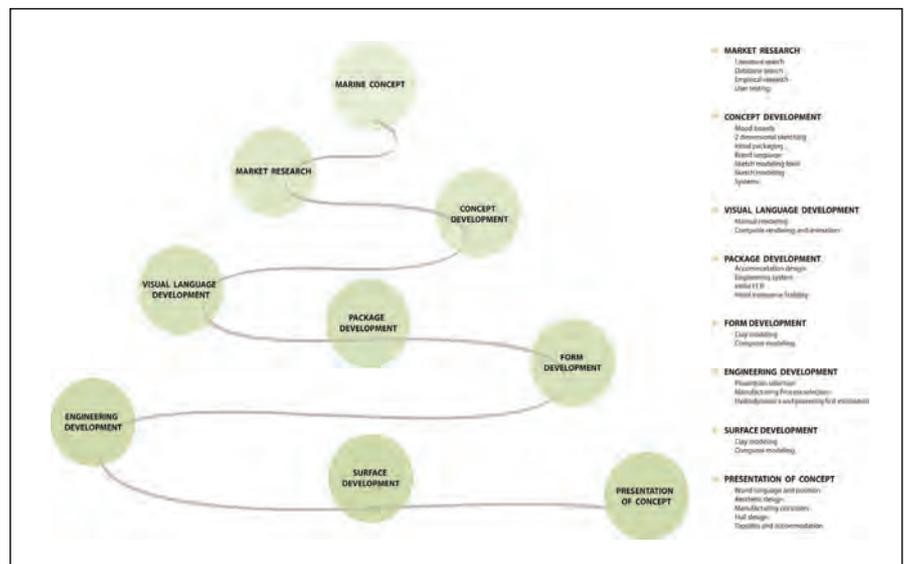


Fig 2: Proposed conceptual design process.

StudioTools in the visualisation and design of marine vehicles; the benefits of working simultaneously on computer and physical models; methods of translating and auditing 3D forms, including the use of foam modelling, laser scanning and manipulation of computer models; and use of diagnostic tools within Alias StudioTools to fair hull surfaces and enforcement of surface continuity.

## Conceptual design process within marine design

There is a commonality of process for all products designed for retail sale before they

come to market. Products start as conceptual ideas and are developed in iterative stages, with the necessary verification, to create a marketable commodity. Stuart Pugh coined the term total design to describe the iterative broad ranging decision-making process behind bringing products to market as practiced by industrial and engineering designers; he was able to differentiate this process from more traditional engineering version where modelling a system and optimising the design to mitigate failure or the role of the stylist as an aesthetic auditor.

The role of the industrial designer consists of a range of activities that are interdependent; there

\*Extracted from a paper first presented at The Royal Institution of Naval Architects' International Symposium on Marine Design, held in La Spezia, Italy, April 12-13, 2006.



Fig 3: 'Architectural' mood board.

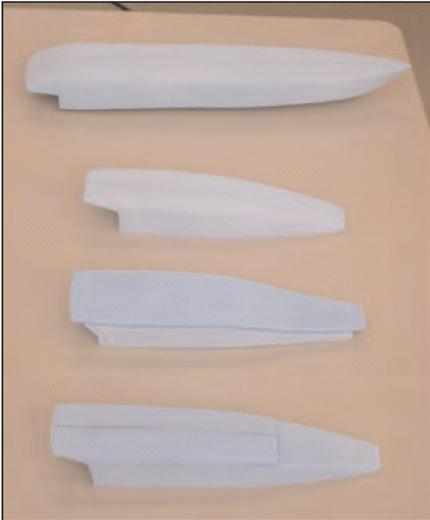


Fig 4. Foam sketch models.



Fig 5. Non-contact laser scanning.

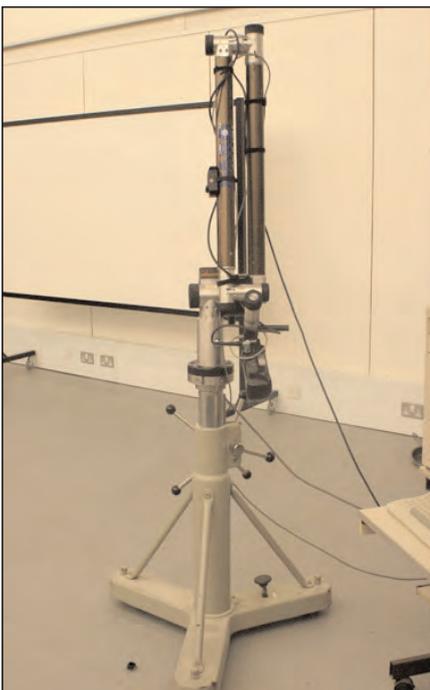


Fig 6. Scanner and close-up of camera and probe.

is a sense that aesthetics, engineering, ergonomics, and useability, materials and construction, market research and business modelling influence the development, feasibility, or production of a product and may best be described as a conceptual process where all aspects are carefully considered. A successful design outcome for any product may be audited against the following: aspiration, profit, and ideology.

Current markets demand innovative desirable products; manufacturing companies respond to market trends as rapidly as possible to

maximise profit while continuing to maintaining quality, fitness for purpose and brand values of their products' semantics; this is what underpins the need for effective concept design. It is in the interest of a manufacturing organisation to succeed in total design, the starting point is effective research of the market and strong original concept design and visualisation.

The conceptual design process is therefore relevant to all transportation design. Although the process has been more rigorously developed and studied in automotive design

where large companies have invested substantially in developing of concept design processes that are required to bring automotive products to market. It is the marine industries gain to study these processes and to map an appropriate method of developing aspirational, profitable marine transport products.

Many marine companies come under the umbrella description of small- and medium-sized enterprises (so-called SMEs) where design, development, and product semantics simply cannot be supported in-house, however knowledge of the process may allow better outsourcing and commissioning of early stage design. The case studies chosen reflect the breadth of manufacturing and diversity of scale a marine transport designer may be required to undertake. The area of marine products covers vehicles of between 1m<sup>3</sup> to over 500000m<sup>3</sup> in comparison to automotive design which is based on the design of approximately 15m<sup>3</sup> of space.

The process undertaken requires modification from automotive design taking into account specific engineering aspects required of marine transportation and the scale of the product, method of manufacture and size of production run; however the authors have observed the process most closely follows the simultaneous method as described in Tovey, Owen. The role of the marine transport designer may change, depending on the scale of the project, however a knowledge and understanding of the principles of naval architecture are required in any marine design and are therefore included in the conceptual design phase.

In terms of the 'design spiral' that is described in *Basic Ship Theory Volume 2* or the excellent *Principles of Yacht Design*, by Larsson and Eliasson, the conceptual design process proposed in this paper should be 'bolted on the top'. It does not replace the concept of iterative design development in terms of the vehicle as naval architecture, it augments it.

Here we will propose a conceptual design process based largely on experience gained during development of automotive design processes and give examples of marine design process as recorded at Coventry School of Art and Design in the UK, in the authors' own design work and at Savannah college of Art and Design, USA.

#### Proposed conceptual design process

The authors have sought to create a staged graphic representation of conceptual design of marine transportation (Fig 2) based on the following principles. The core method is based on the simultaneous method of automotive concept design reported by Tovey and Owen, one of three alternatives illustrating degrees of confidence in a single design direction.

The method recognises the function of sketching as a tool for evaluating and informing concept designs in automotive design as reported by Bouchard, Aoussat, and Duchamp and reflects the process of automotive conceptual design development over a 26-week period, which was broken



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down into general deliverables (Table 1, Tovey and Owen) which are paraphrased here into:

- issue of brief (week 1)
- review of influences/competition (week 2)
- informal selection of concept sketches (week 3)
- management review of concept (week 4)
- scale model presentation (week 7)
- presentation of reworked model (week 10)
- presentation of full size clay (week 18)
- re-presentation as required (week 22)
- approval of 3D model (week 26).

The basis of simultaneous sketching, physical modelling and CAD modelling development is couched in the development of factual attributes in tandem with semantic attributes where 'the former describe objective, measurable qualities of how something actually works, while the latter refer to the communicative aspects of a product's quality, what it says or should say to the user' Butter Successive experimentation of this method for improving teaching and learning related to Transportation design has led to permanent changes in course design at Coventry.

To reflect this, the authors have redefined the process in terms of marine transport design into general development headings of: market research; concept development; visual language development; package development; form development; engineering development; surface development; and concept presentation. These are further categorised in Fig 2.

The process incorporates early model testing and evaluation of usability as described in chapter 9 of *An Introduction to Modern Vehicle Design*, Porter and Porter or in the use of CAD modelling for packaging. The output should address excellent presentation of 3D form, be generated from a research platform, and have an 'integrity of concept' that complies with the fundamentals of naval architecture.

### Marine design case study 1

This is a brief record of a 20-week design programme for a large motor-yacht conceptual design. The designer sought to develop the design using a new aesthetic influenced by research into historical automotive and architectural form language.

As shown in the areas of design graphical representation (Table 2) the fields of product and transportation design vary widely in dimension, production method and cost, however in developing a product semantic or 'feel' it is a relevant design tool to use design metaphors from other 'disciplines' to frame the concept of an item and through research may allow technologic and aesthetic transfer. Therefore we can explore diversity with the following themes: the marine automobile, the product boat, and the architectural bicycle.

Inter-disciplinary research is seen to broaden form language and provide the possibility to inherit metaphorical product values by association and juxtaposition of terms. This becomes a criteria based constraint in the

development of the semantic in the context of factual decisions required during the development of a concept as outlined by Butter.

### Market research and concept development

Here the designer had undertaken market research into the large luxury motor yacht sector and identified the profitability of innovation. Initially the designer advanced ideas of architectural form in sketches and widened these to highlight possible areas of development in terms of a large motor yacht.

The premise was to purposefully develop a new visual language not seen in marine transport design to extend opportunity. The idea has its parallel in the development of car design styles which have developed through form development into discernable sub genres such as flow box, edge box, graph, retro, and baroque.

To aid in the communication of the idea to third parties the designer created 'mood boards' that helped to convey the emotion and brand values of the proposed concept; these boards have the added advantage that they could be used as an audit tool for later design outputs. The process progressed to the point that the designer had usable impression of scale; a possible form language and a range of interior ideas.

What developed most strongly from the architectural research was the notion of developing a single vehicle from a number of disparate or interlocking forms in the same way a group of buildings may be read as a whole within the urban landscape, the new super yacht could be developed out of separate volumes interpreted as a whole.

### Visual language development: sketch models and non-contact scanning

The designer developed several 'architecturally influenced' forms during the sketch evaluation and development phase; in order to evaluate the forms a series of sketch models were fabricated out of expanded polyurethane foam as shown in Fig 4. These models were then scanned using a non contact laser scanner (Fig 5) which created a cloud data file which could be exported to a conversion program.

Gathering cloud data with non-contact laser scanning devices provides a cloud of points as xyz ASCII positional data suitable for processing for reverse engineering or capturing form for further design work.

We have reported previously on using non-contact laser scanning to aid concept development where 'sketch' models, made from polystyrene foam, have been captured using a 3D scanner for rapid conversion into a data-set ready for further development in CAD software. Normally, the object is to produce an accurate, clean and time-saving array for verification of previously manufactured parts.

Clark illustrated scanning methods by focusing on how to handle large random point clouds; how to cut cross sections on the cloud data; how to fit NURBS curves onto clouds and production of meshes at different densities. The equipment

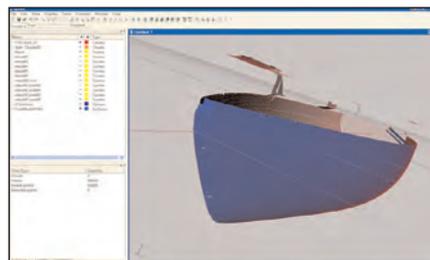


Fig 7. Polygon mesh in Spider.

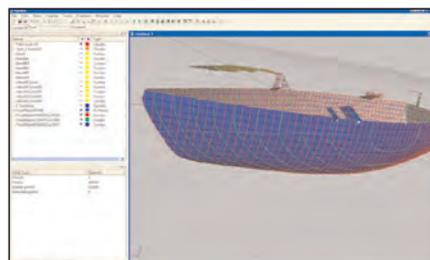


Fig 8. xyz sections in Spider.

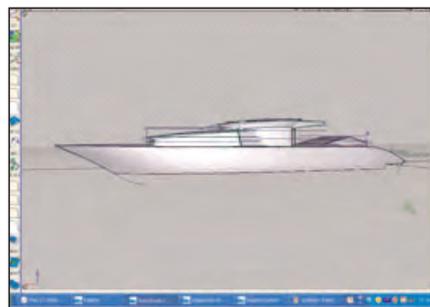


Fig 9. Form development in StudioTools.

used for this scanning session is a '3D Scanners' ModelMaker laser emitter and collection camera mounted on a 'gold' Faro arm that allows six degrees of freedom (DOF). Each of the seven rotating pivot points along the arm has an actuator that is calibrated against a known, dimensionally-stable, stock cube that is triangulated from a secure tripod stand. Both camera and arm are then aligned before scanning takes place.

The ModelMaker sensor projects a laser stripe across the object to be scanned; each viewed stripe forms a profile which is built up from several hundred measured points in each pass. The sensor is mounted on an articulated measuring arm, which captures an x, y, z position and an i, j, k vector for each profile; this information enables the profile to be located accurately in 3D space. Thirty profiles are captured and positioned in 3D space each second, resulting in a high accuracy high density 3D point cloud.

The authors have recently tested an ATOS 1 scanner made by GOM providing similar results in a reduced time frame. The ATOS 3D scanner uses the principle of triangulation; a sensor unit projects different fringe patterns onto the object to be measured, these patterns are then recorded by two cameras. In order to digitise an object completely, several individual measurements from various views are required. A series of 'pre-scanning' digital photographs are taken using a calibrated camera of a group of uniquely



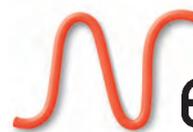
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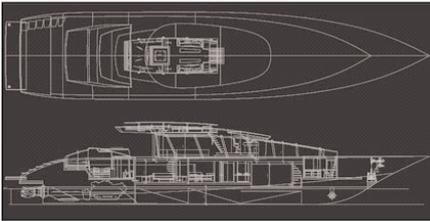


Fig 10. Package development.

patterned and accurately dimensioned reference bars to set up the scan volume. While measuring the object, the system also automatically identifies these reference markers that can be placed directly on the object, on surrounding geometry or on a predetermined fixture.

### Cloud data handling with Alias Spider

The Alias Spider utility program linked to Alias StudioTools processes cloud data by reformatting the raw 'cloud of points' data as polygonal meshes, skins or cross sectional line data. Cross-section degree 1 curves can be projected in three axes providing transverse or longitudinal illustrations of the hull form. If required, a reduction in cloud data density can be performed along with mesh smoothing and mesh partitioning. This is preferable in this case as the scanning is not being done to record a model for reproduction, but to record the forms for further manipulation in the StudioTools program.

### Early form development using StudioTools

To minimise development time and to be able to audit 3D designs quickly the role of CAD within the design process has become more integrated earlier in the concept development process. When Tovey, Owen outlines the stages of the automotive styling process over the first 26 weeks of a design the model or three dimensional output was mapped at week seven



Fig 11. Final render in StudioTools.

in the project, however the authors have observed a shortening of the time before CAD is used as a meaningful design tool, especially as student appetite and proficiency increases, a trend that has strengthened over the past few years.

CAD work has been added to the array of methods used by designers as an aid to increase visual language development within the proposed process. The form can be manipulated, changed, compared and developed in an iterative cycle until the initial balance of form and visual dynamic is achieved.

### Packaging development

External form development is reliant on a parallel development in internal space planning, packaging of power train, control systems, utilities and the initial regulatory compliance. At this stage, where stability has not been addressed, the compliance is based on the means of escape, bulkhead subdivision and the first estimate of appropriate freeboard based on previous experience.

The interior development is as complex as that of the exterior, thus the designer has to develop a feel for the negative space within a hull form and the coordination of a highly serviced interior architecture. A designer has to include provision for fit out services and more experience leads to an ability to design aesthetically and to coordinate services vertically and horizontally for economical routing of grey, black and potable water, electrical, heating ventilation and air conditioning services, provision of tanks within voids, compressors for air conditioning units, exhaust routes from engine bays and an idea of the functional workings of galleys, maintenance areas, and the bridge. The package will form the most complex weight control on a project, so an idea of densities of proposed materials and longitudinal symmetry can make this task simpler.

### Form development, initial engineering, and presentation

Once the designer has formed the basis of the concept that fulfils the criteria raised as part of

the initial research and is relatively confident that the form will provide adequate accommodation and be desirable within the target market, the surfaces can be developed, initial engineering undertaken and the presentation developed. The use of CAD can then develop the concept in engineering, useability, and presentation of the concept.

The process of developing clean faired surfaces in Alias studio tools is described in case study two. The initial displacement can be estimated by market research into vessels of similar WLL (waterline length), hull form, and construction. These aspects must be established at some point, it is as well to choose some data, if only to disprove it latter following investigation.

The initial waterline can be estimated in a similar fashion. The StudioTools programme allows complex forms to be cut at the estimated waterline and resultant form can be exported to a parametric modeller such as Solid Works where the volume and centroid of form to be found for the submerged section. If the displacement is insufficient, it is relatively simple to re position the initial waterline upward and re-interrogate.

Alternatively this process can done using cross sections of the model and Simpsons' rule. Once a displacement, centre of buoyancy and prismatic coefficient are established an estimation of powering needs can be established purely at this juncture to interrogate the volume requirements and weight distribution. This can initially be done by comparing other vessels, researching technical literature which can provide estimates based on displacement or by using published model resistance data for similar hulls, establishing a displacement Froude number and estimating power required. The outcome of this latter process gives power required without while taking note of efficiency losses.

It is assumed in this proposed conceptual process that hull resistance and optimisation occurs latter in the design process although it may be of greater importance in certain forms of craft at an earlier stage. Initial stability can also be estimated earlier as described in case study three, however it would be wise to reflect that all these tools are estimates that verify the concepts' form and would only form the basis of the initial design with the naval architect.

Fig 12. 95th percentile testing.

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Fig 13. 5th percentile testing.

In order to proceed the concept further, increasingly concepts are used to gauge customer feedback and desirability. The output of rendered models and appearance models is of great importance in communicating and idea. This process of simultaneous development of sketching, modelling, and computer modelling allows high-end visualisations to be created and a developed concept idea to be presented which should form the basis of future product development.

#### Marine design case study 2

This case study shows a group of students developing a kayak style craft which is suited to full scale prototype development but required stability analysis to be estimated quickly as the concepts were developed.

The group of students was working to a commercial brief to develop a leisure craft for family use. The project time frame was 10 weeks from initial brief to full size prototype.

#### Use of 'quick and dirty' ergonomics in package development

The idea of developing and auditing a full scale ergonomic test buck during the conceptual development is of great use for smaller hull forms or cockpit arrangements which mirror automotive scale interfaces and helps evaluate position of users within the hull and therefore helps in initial shaping and development of form.

Concepts were developed using sketching, mood-boards and were audited in line with the brief criteria until five concepts were selected for further development by the end of the third week. Foam models were built at sixth scale to evaluate form and initial stability. In parallel, a computer model was built as discussed in previous case studies and a full scale tape, foam and mesh buck was developed (Figs 12 and 13), and packaging was tested using as close to a 5th percentile female and 95th percentile male as available.

This initial layout testing established location of seating, control devices, mirage drive pedals and areas of storage, methods of boarding and stowage. From this testing an estimation of longitudinal and transverse centre of gravity could be estimated. Using an initial loaded weight of 165kg, including a hull based on the

weight of existing blow-moulded kayaks and the weight of the heaviest user profile, the displacement of the hull could be tested.

By week five, following a client critique of concepts, two further concepts evolved and further foam models were fabricated at sixth scale and tested to establish longitudinal and initial transverse stability. The payload was scaled, the formula is the estimated full scale displacement divided by the scale cubed.

#### Estimating initial longitudinal stability

The formula was used to estimate a scaled displacement to investigate longitudinal and then transverse stability. The resultant model displacement was found to be 0.763Kg which was made up of steel weights. The hull was then

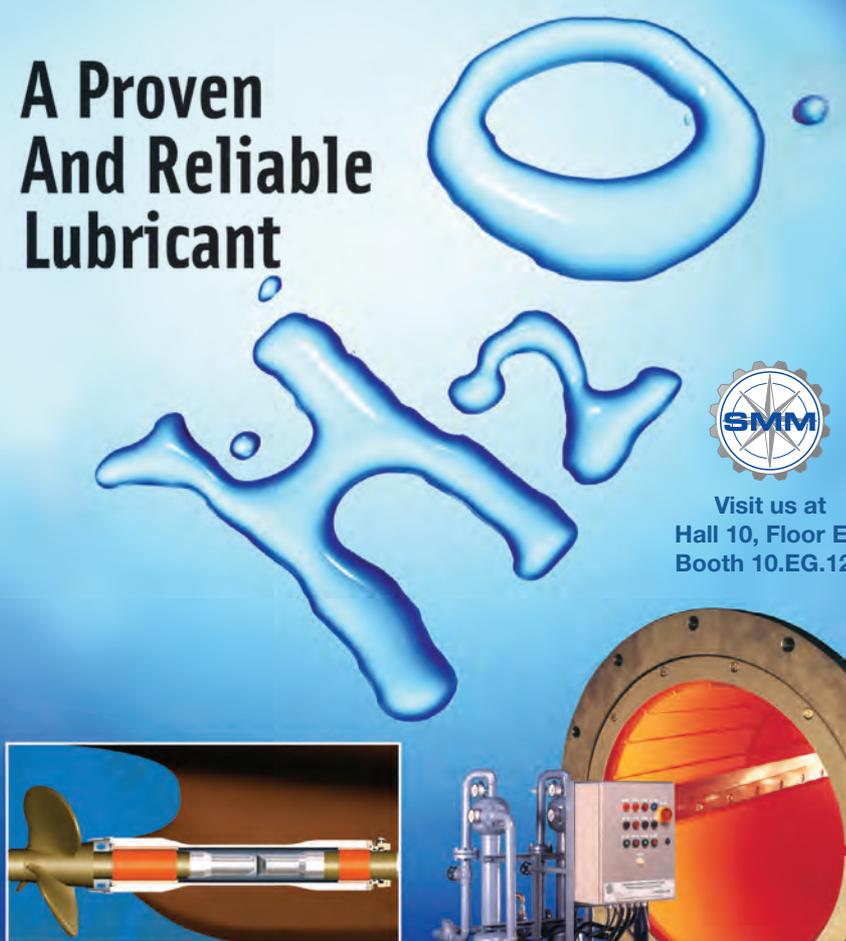
drilled at points along its centre line at points where it was estimated the centre of gravity would act.

The weights were hung below the hull through the drilled points to estimate a stable longitudinal sinkage. This allowed the designers to quickly modify deck edge hull chines and ensure that the vessel trimmed to stern with the user aboard. The foam was cut; repositioned and additional amounts adhered until the desired form was arrived at. The transverse condition was then considered.

#### Estimating initial transverse stability

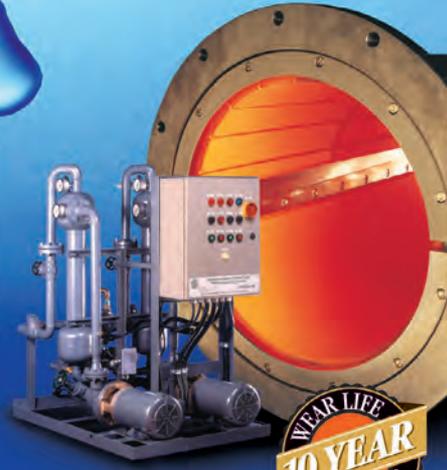
The weight was removed and a hole cut through the hull foam to allow the weight to be repositioned at the level of the estimated centre of gravity of the system, which in this case was

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estimated to be the hip line of the user. A magnetic inclination gauge was attached to the weight and the hull was inclined at various angles until the vessels GZ became negative and the hull capsized.

By doing this test the designers were able to establish if their concepts were within the design criteria laid down by the client, well before a full scale prototype was undertaken, and was used in conjunction with naval architecture software to estimate performance. Once the inclination along the centre line had been investigated the designers tested the hull reactions in combined yaw and pitch situations that may occur in surf and it was found that the rear load area required modification as wash destabilised the hull. The hull was modified and longitudinal and transverse tests carried out.

The weight was then split into the scaled hull lightweight weight which was located at the estimated centre of gravity of the hull and the scaled weight of the user which was attached to the hull in a location adjacent to the stern from the stern. In this way various user scenarios for the vessel were investigated and the hull developed to form an innovative concept for client appraisal.

### Marine design case study 3: Use of alias studio tools in form development

This study involved the hull for a yacht designed by the authors with the intent of achieving surfaces of continuity in 'the rate of change of the rate of change of curvature' (G4) in the hull surface. Alias StudioTools is a surface modeller developed in conjunction with the automotive and animation industries to provide a program that allows modelling of complex 3D form.

As such it is a desirable tool for the intuitive creation of complex forms such as hull forms. There should be no doubt that although this is not a parametric modeller it is possible to set up a scaled framework to set the model on and the program is a very powerful means to investigate and audit surface form and continuity. This hull was generated from three transverse lines; at the bow, transverse aft of midships, where the form is fullest and at the transom. These are joined by two longitudinals at deck edge and keel line. The surface is created using a 'bi rail' surface generator.

To get even surfaces it is vital to construct them out of as smooth a curve as possible. StudioTools allows the designer to form curves of 1deg to 7deg. Consequently, a 1deg line is defined by two points, that is to say a straight line; 2deg is defined by three points and forms an arc; and 3deg are defined by four points creating NURBs, and so forth.

Curve geometry is either defined by control vertices (CVs) that lie along hull lines or edit points that are positioned directly on the curve at knot points. Both methods may produce either chordal or uniform curves, designers generally make a personal preference although the edit point curve allows the designer to 'draw' the line directly in the program rather than defining its rate of change of curvature using CVs.

Most commonly the designer of complex form will use a 3deg curve as a starting point, with the minimum four points defining the shape, more

complex beginnings, 5deg or 7deg, increases the risk of producing unwieldy and complex geometry later.

There is an additional curve tool that is of interest to the marine designer; a full set of ships curves or Sweeps are provided in the 'Sweeps Control' menu, these predefined curves can be scaled both in proportion or stretched using the non-proportional scale tool. Once generator curves are established they can be audited using the 'curve curvature' tool in the locators menu.

This shows the tangential direction and 'pull' of the curve in relation to its rate of change of curvature and its end condition, or tangency. This is especially useful if another curve is to be joined to the end so that tangency and the rate of change of the rate of change of curvature is maintained, so called G4 continuity.

The skeletal frame can then be surfaced. There are host of surface options within alias with individual properties. This example was surfaced using the StudioTools Bi-Rail tool which is a surface generator that will permit building of surfaces where of G4 continuity is required across all borders, a so called advanced modelling tool. Completed surfaces are audited firstly using visual checks by the designer, diagnostic shaders provide the quickest feed back. This is a double horizon shader that allows close scrutiny of the surface and highlights any inconsistencies or 'cheeks' where the surface may have become a negative rather than positive form.

The surface can be modified by editing the control vertices of the generator or rail lines. The surface will regenerate based on the editing, unless G4 surface continuity cannot be maintained and the surface will not render.

Once a form is surfaced and is acceptable visually to the designer it can be used as the basis for presentation of the concept or used to look at packaging and usability of the proposal, as discussed in case study 1 or could be used as the basis of an initial full-scale usability buck as described in case study 3.

Alternatively the model can be exported to a five axis milling machine (x, y, z and 2degs of rotation) for rapid prototyping and model testing, or in tandem to this export to a VPP package such as WinDesign or CFD packages such as Fluent which allow comparative hull designs to be evaluated hydrodynamically. The use of StudioTools does not guarantee every design will be successful but the skill of the designer is at the forefront when using this tool. It is easy to make a surface, difficult to make a beautiful one.

This method is akin to sculpting rather than programming, the designer has to have a visualised idea of what form is acceptable before this program will prove rewarding. In line with all the processes described in the development of a conceptual design, this is not novice system; rather this is an expert system.

### Conclusion

As the cycle time of the design development phase becomes shorter and the software for visualisation becomes more sophisticated, it would seem logical that the designer use these tools rather than reinforcing the historical



Fig 14. First longitudinal testing.



Fig 15. First transverse stability.

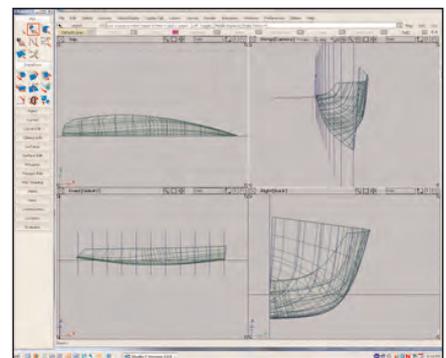


Fig 16. Hull transverse and buttocks.

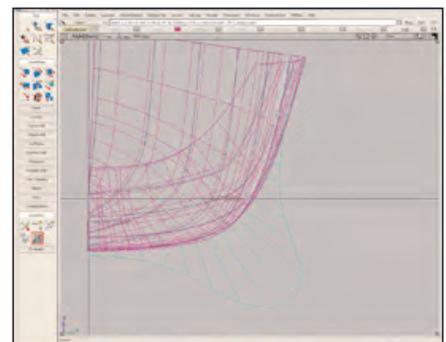


Fig 17. Diagnostic locator tool.

separation of role of a designer sketching and a modeller modelling and an engineer calculating. People need skill, knowledge and observation to be able to design well. This is aided by experience, either personal or collaborative and enthusiasm for the subject.

The use of automotive design practices are highly relevant to the creation and adoption of design methodologies such as simultaneous development of form in physical, virtual and drawn process; they have proven useful in proposing a marine form of the automotive conceptual design process. 

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## Positive outlook for German shipbuilding industry

Some of the newest technical news from Germany's strong marine sector is distilled by David Foxwell.

ADDRESSING a recent meeting of the German Shipbuilding and Ocean Industries Association (VSM) - which represents the political and commercial interests of the German maritime industry - the country's minister for economics and technology, Michael Glos, gave an upbeat assessment of the state of Germany's shipbuilding industry.

In his speech, the minister emphasised the significance of the maritime industry to the German economy. 'The federal government appreciates the sector's progress and its importance for the labour market. German shipyards are technology leaders in many sectors', Mr Glos stated.

In its annual report for 2005, the VSM commented that it was 'very satisfied' with the performance of the German shipbuilding industry. International orders reached a new peak in that year, improving significantly on the level of orders in 2004, which was also a good year.

The year 2005 also saw Germany consolidate its position as the fourth ranked shipbuilder in the world, and the top ranking shipbuilder in Europe. Sales by all shipbuilding companies (that is, yards building ocean-going vessels, inland waterways vessels, naval vessels and yacht builders, including yards handling repair/conversion projects) surged to €6.2 billion, leading to a stabilisation of the workforce at German shipyards of approximately 23,000. The shipbuilding industry in Germany also has a total of approximately 100,000 employees at shipyards and marine equipment suppliers.

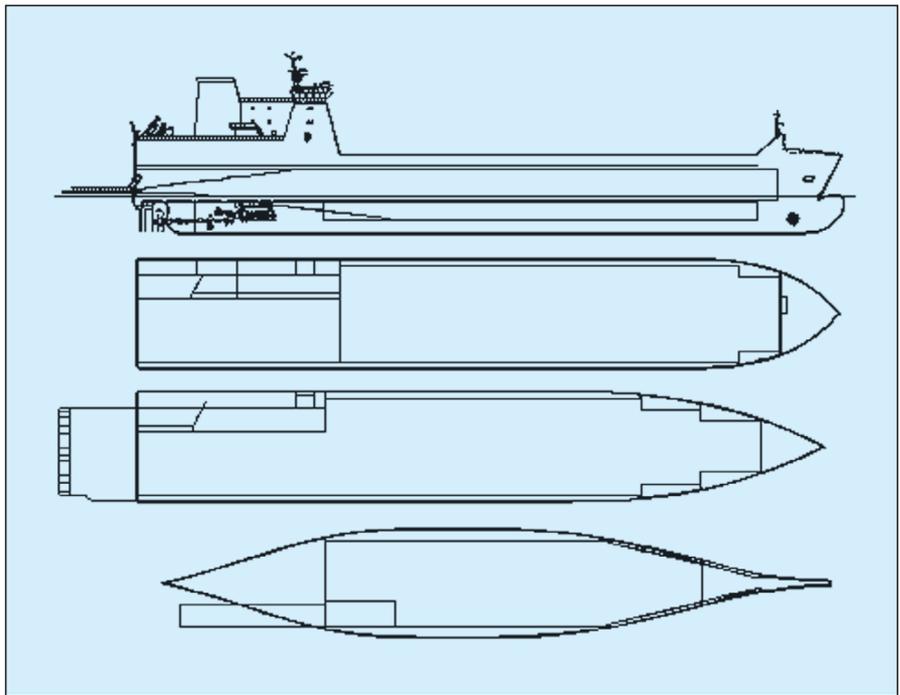
However, the VSM has again expressed concern about the massive expansion of shipyard capacity in the Far East, particularly in China, where over-capacity could develop in the medium term and, in the event of a slump in demand, lead to a dramatic increase in competition in the world market.

According to figures produced by the VSM, German shipyards delivered last year a total of 69 merchant ships, worth €2.6 billion, and booked new orders for 157 vessels, worth €4.1 billion. Orders in hand therefore increased to 231 ships, worth €11.1 billion, ensuring capacity utilisation up to 2008.

The largest share of deliveries was again accounted for by container ships, with a compensated gross ton (cgt) share of 65.3%, however, ferries, passenger ships, and megayachts also formed a significant part of overall deliveries.

Production is also stable at yards building for the inland waterways sector, the yards in this market being focussed mainly on deliveries of passenger ships and a quartet of ferries. These particular yards thus continued to benefit from the growth in tourism on German and European waterways.

Naval shipbuilding is the second largest sector of the German shipbuilding market after merchant vessels, although it is highly dependent on orders from the German Navy to maintain



General arrangement plans of the new 9500dwt ro-ro ships being built at the J J Sietas yard, in Hamburg, for the Finnish owner Godby Shipping. They are mainly designed for loading paper products, with three fixed cargo decks for up to 161 x 12.5m cassettes or 1900 lane metres of ro-ro space. Emphasis is being placed on 'green' credentials, with features including protective location of fuel tanks and a bilge water separator designed to give less than 5ppm discharge. A comparatively high service speed of 20knots is envisaged. More details of these ships appeared in our July/August issue, page 8.

core skills and expertise. 'Despite the tight budget situation, overdue follow-on orders should thus be placed', said the VSM, noting that 'development of alternative forms of financing could be helpful in this respect'. The VSM believes that what it describes as the technological leadership of the private-sector naval shipyards compared with the state companies in other European countries would be jeopardised without new orders from the German Navy. 'To close the looming gap in orders, it is necessary urgently to implement planned projects, such as the Class 125 frigate and the second batch of Class 212A submarines,' says the VSM.

Repairs and conversion orders are a mainstay of German shipyards and generated sales of €601 million, or approximately 10% of total sales in 2005, as in the previous year, and repair work undertaken on high-profile vessels such as *Queen Mary 2* in Hamburg and *Queen Elizabeth 2* and *Star Princess* in Bremerhaven are clear reminders of German yards' high level of expertise in this area.

As the VSM also noted, recent massive growth in the worldwide shipbuilding sector and the upturn in demand in global offshore markets, stimulated by high energy prices, have also led to increased business for German marine equipment suppliers. Companies active in this

market achieved overall sales of approximately €9 billion in 2005, and German marine equipment suppliers retained their position in second place worldwide behind Japan. In this respect, it should be noted that, as exports accounted for around two-thirds of sales, and Japanese companies depend greatly on their domestic market, German suppliers can be considered the leading exporter globally.

'Even if figures for 2005 are gratifying, the shipbuilding industry is concentrating on continuing to improve its competitiveness with the focus on innovations', said the new chairman of the VSM, Jürgen Kennemann. With the initiative 'LeaderSHIP Deutschland' programme, the industry has thus continued to follow the recommendations of the 'Boosting competitiveness' study commissioned by the federal Economics Ministry.

'Training, R&D, and innovations, along with the continuation of a reliable maritime policy are crucial for maintaining the competitiveness of German shipbuilding', said VSM's new chairman. 'If the activities of the federal government and the interests of management, labour, and industry are combined more successfully in an effective maritime alliance, the 5th National Maritime Conference in December could send a positive signal for more employment and growth'.

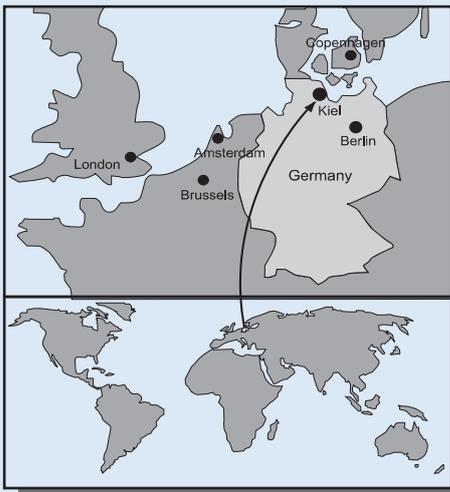
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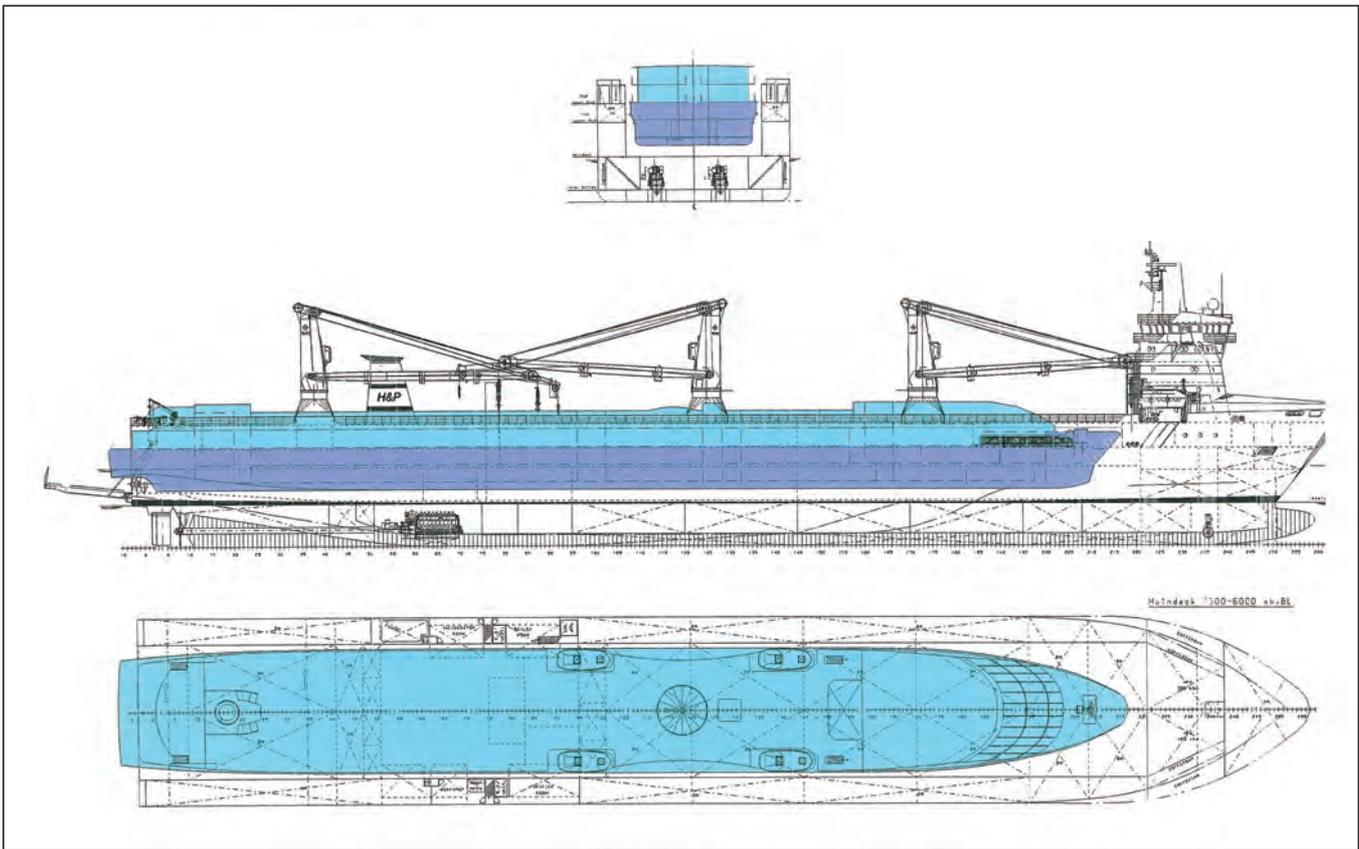
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Profile, cross-section and cargo deck plan of K/S Combi Lift's innovative heavylifters ordered from Lloyd Werft, which are due to be delivered in 2008.

## Lloyd Werft to build ro-ro heavylifters for K/S Combi Lift

LLOYD Werft, a company best known as a repair and conversion specialist, which recently entered into a new business arrangement with Italian shipbuilder and repairer, Fincantieri, has secured a contract from K/S Combi Lift, a German-Danish joint venture between Harren & Partner, in Germany, and Denmark's Poulsen Group, to build a pair of very versatile ships. These highly innovative 11,000dwt multipurpose designs are 160.70m-long and planned to be semi-submersible for loading very heavy cargoes such as complete ships.

Designed to transport a wide range of cargo types including barges of up to 135m length, the ships will have a breadth of 25.40m and a draught of 6.50m. Service speed will be 16knots, based on a pair of 4500kW main engines.

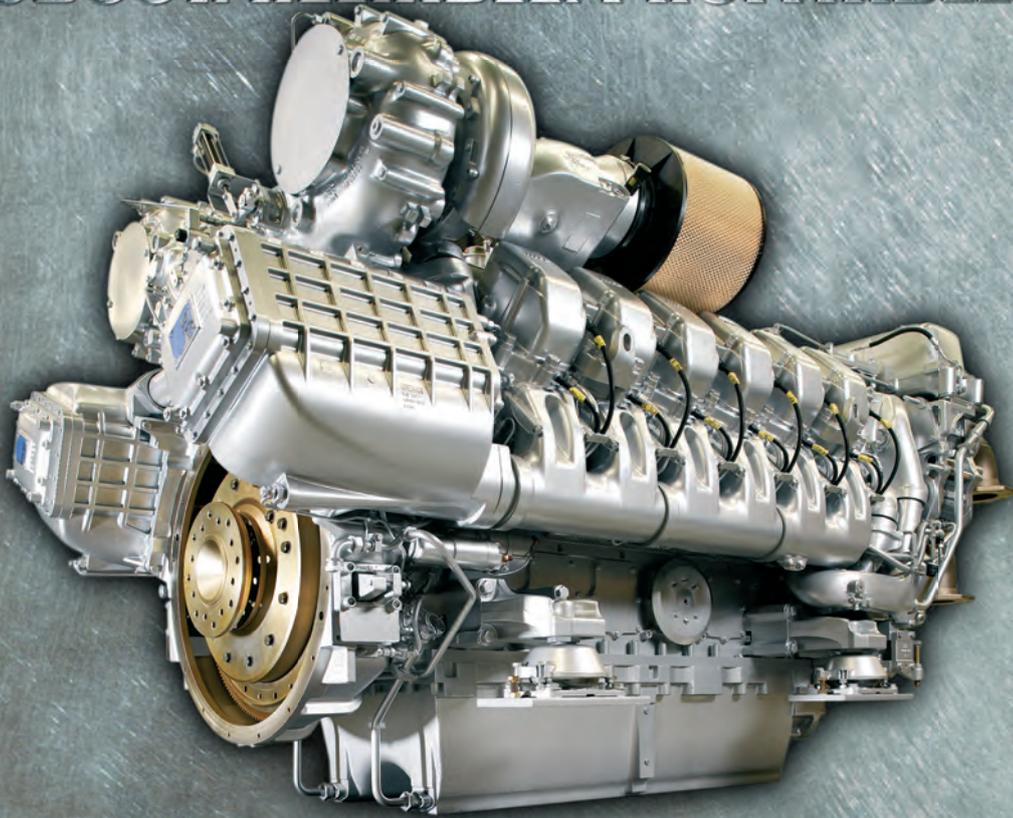
These new dock ships will be capable of transporting cargo that would be impossible to transport overland due to extreme dimensions and/or weight, and as shown in the accompanying illustrations, hulls such as inland passenger ships, with dimensions of up to 135m length, 17m breadth and 3m draught can be transported on these very specialised newbuilds, and loaded onto and offloaded afloat.

The two vessels, which are due to be delivered in January 2008 and June 2008, will bear the class notation GL +100 A5, E, IW, BWM-S, Floating Dock Vessel, Strengthened

### New financial deal for Lloyd Werft

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for Heavy Cargoes, MC, AUT, NAV.0 and will have a cargo deck measuring of 130m x 18m x 9.40m. With a depth of 4.5m they will be configured with an adjustable 'tweendeck, and will be fitted with a pair of 350tonne cranes and a single 200tonne crane. These will be used for cargoes that cannot be floated into the hold. Other heavy loads can access the hold over a flexible stern door/ramp.

In ro-ro mode, the newbuilds will be able to transport trucks, flat bed trailers, or mobile cranes, which can be driven into the loading space of the vessel over the stern ramp. The latter will be strengthened for this purpose and capable of accepting a maximum load of 700tonnes.

Also equipped for conventional project type cargo, such as sections of wind turbines for

the fast-growing wind energy market, the vessels will use their heavy-lift cranes - to be provided by Liebherr - to lift cargoes of up to 700tonnes, when the two larger cranes are working in tandem. To this end, the loading deck can accept load of up to 16tonnes/m<sup>2</sup>.

Characterised by very flexible loading arrangements, the dock ships will primarily be optimised for the sophisticated project cargo business, but will also be capable of transporting containerised cargo in the form of up to 1500TEU, as well as bulk goods.

Moreover, given the adjustable tweendeck which the design features, they will also be able to carry a wide range of cargoes using the tween deck hatch cover to separate the ship's holds, thus enabling them to accommodate several different types of bulk

cargo in the lower hold and to load containers or construction parts on deck at the same time.

As K/S Combi Lift points out, the very flexible and versatile design of the new vessels will enable the company to gain access to a wide range of cargo not normally carried on a conventional semi-submersible or a conventional heavy lifter. Only a very few vessels can offer charterers a storage space of 130m whilst also allowing for transportation of conventional cargo, such as bulk commodities and containers, at the same time. Moreover, as the company also noted, although there are a handful of dock-type vessels on order elsewhere, these are primarily designed for transporting oil rigs and platforms and are not intended for employment in the project shipping market. 

## Integrated solution for pipe fabrication

**S**PECIALIST in pipe-fabricating machinery Tracto-Technik has provided *The Naval Architect* with details of its newest technology, including a Robofix assembly unit for template pipes that it has delivered to the J J Sietas shipyard, in Hamburg. This machine, together with a Scopelink isometry system also used at the yard, provides Sietas with a fully automated solution for rationalised and simplified template pipe production.

Template pipe production is time- and staff-intensive work. To make the process as efficient as possible, apart from using the traditional method of producing template pipes using cage or wire models (iron mock-ups), an electro-mechanical concept solution has been applied which simplifies calculation of isometries, as well as reshaping and flange stapling of template pipes.

Recognising the advantages of an automated solution for template pipe production, Sietas had already been utilising the Scopelink technique for several years. This is an electro-mechanical isometry facility that can be applied whenever the geometry data for fitting pipeline connections has to be determined on site. The measuring device consists of fixed and variable lengths, bent and twisted elements which can be built in between two existing fixed points (flange or sleeve connections) in the way the intended pipe course requires them. A quick-locking system mechanically links the single elements together. Isometries for template pipes of up to approximately 2m length can be generated using this method.

Tracto-Technik notes that, compared with conventional methods using wire and cage models, Scopelink can reduce the time required for determining template pipe isometry to only 10 minutes-15 minutes, and the isometry data are calculated precisely, stored and recorded. Time taken for shaping the models and the routes between job site and pipe production is eliminated, and in the event of long distances between job site and pipe production, the isometry data can be sent directly to a computer in the pipe workshop via a network or the Internet, being available for processing immediately.



J J Sietas shipyard, in Hamburg, is now using Tracto-Technik's Robofix assembly equipment, in association with Scopelink software, for efficient template pipe production.

At the J J Sietas yard, the isometry data is converted into production data for the bending machine by means of Tracto-Technik's Pipefab software. While Scopelink delivers the output data for remodelling, the required data for the template pipe is passed to the Robofix assembly appliance via the software.

This device serves the purpose of placing two flanges in a space, their position in reference to each other as well as the position of their flange angles (master gauge) precisely reflecting the situation at the intended

assembly location of the template pipe. The Robofix is equipped with a linear guide and two 3D flanges - attached to two tie-bars - to copy the flange positions.

With these new systems, J J Sietas should be able to assemble template pipes onboard with a maximum level of prefabrication. The finished template pipe is transported only once to the installation site and assembled there, while the high level of inherent accuracy and an ability to carry out collision control when generating the isometry allows for perfect integration of pipes produced. 

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## Contract for new Canadian ferry

CANADIAN BC Ferries has commissioned the building of a new vessel to replace the 40-year-old *Queen of Prince Rupert* operating in northern BC. Following a competitive bidding process, the company selected Flensburger Schiffbau - Gesellschaft (FSG), of Germany, to build the new northern-route vessel. The contract has a total value of €91.8 million (approximately Can\$133 million).

The new ferry will operate between Port Hardy and Prince Rupert on the Inside Passage route. Following BC Ferries' specifications, the 150m vessel will accommodate 130 vehicles and 600 passengers. Among its many features, the vessel will offer 55 modern cabins for passengers and an expanded range of food services and other amenities for local residents and tourists. The vessel, it is hoped, will be in service in the spring of 2009.

In addition to this new northern ferry, BC Ferries is continuing to negotiate an agreement to acquire a vessel to replace *Queen of the North*, which was lost in March this year.

In other news, BC Ferries has announced that after nearly two years of design work and testing, construction of the new Super C-class vessel, *Coastal Renaissance*, began at the end of August at Flensburger.

The three new Super C-class vessels that are set to be constructed are the cornerstone of BC Ferries' plan to replace 22 vessels over the next 15 years and the vessels will be the most advanced in the BC Ferries fleet. They will feature a diesel-electric propulsion system that is the largest and most fuel efficient of its kind, and will be the largest double-ended ferries in the world, featuring state-of-the-art safety equipment.

The three 160m, 21,980gt vessels will be built from 88 large steel sections at Flensburger's state-of-the-art shipbuilding facility. Customers will have access to two passenger decks and a variety of new innovative facilities, including enhanced food and retail offerings, more comfortable seating areas, and expanded services and amenities. The new vessels will accommodate more vehicles and passengers than the current C-Class ferries and will have a service speed of 21knots. ⚓

### Seatrade work for Schiffko as boxship design passes milestone



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## Busy times at Caterpillar Motoren Rostock

LEADING engine builder Caterpillar Motoren Rostock reports that in June another two MaK 9M43C engines left the company's production facility, destined for Meyer Werft at Papenburg. Together with two engines delivered in mid-April, they are being installed on *AIDAdiva*, the first of four new cruise ships for Aida that are on order at that yard.

For Caterpillar Marine Power Systems, this is another major step in its long-term cruise sector strategy. A year ago, just in time for Miami Cruise Shipping Convention in March 2005, Meyer Werft formally signed the contract for four MaK 9M43C engines destined to power, in a diesel-electric arrangement, the next generation of AIDA cruise vessels.

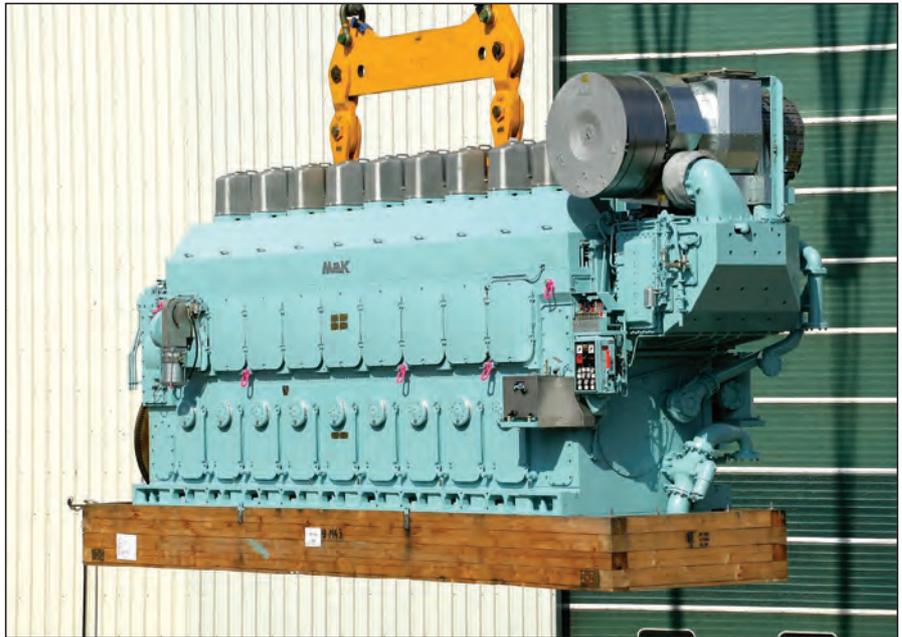
Late last summer, AIDA Cruises, a subsidiary of Carnival Corp, opted for a third so-called Sphinx class vessel, and ordered a fourth vessel from Meyer Werft. Construction of the first ship commenced in October 2005, with the keel-laying ceremony celebrated in Papenburg in March 2006. Delivery of *AIDAdiva* is scheduled for April 2007, after a 400-day construction period. The other three ships will follow in 2008, 2009, and 2010 respectively.

Each of the new AIDA ships has a gross of 68,500gt, an overall length of 252m, beam of 32.20m and accommodation for 2050 passengers in 1025 cabins. Power is provided by the four MaK 9M43C engines with a total output of 36,000kW. Their alternators will supply electrical power to two propulsion motors, as well as two bow thrusters and two stern thrusters. In addition, the plant produces the electrical power for all other high-consumption units on board, including air conditioning, restaurant, and health spa. Even then, there are sufficient reserves of power to propel the vessel at a top speed of in excess of 21.00knots if required.

The MaK M43 design was introduced in 1998, adding a powerful fourth type to the new MaK long-stroke medium-speed marine engine generation, which then consisted of the M20, M25, and M32 models. In the meantime, Caterpillar Marine Power Systems has sold around 500 examples of the M43, in six-, seven-, eight-, nine-, and 12-cylinder versions. Sales represent a total power output of more than 3600MW.

Following extensive discussions with cruise operators, in 2004 a new M43C version developing 1000kW/cylinder was made available. Further to this increase in cylinder output, safety levels have been enhanced according to latest SOLAS regulations: the M4 C now features an explosion protection cover for the engine block, cladding over the complete fuel system and exhaust gas pipes, and turbine casings in stainless steel.

To further strengthen engine reliability and safety, AIDA opted for a customised version of the M43C, featuring a slow turning device to enable safe remote engine starting, a big-end bearing temperature monitoring system designed to prevent bearing seizures, and advanced resilient mounting of the engine to minimise engine vibrations and their transmission to the hull. In addition, all engines will be monitored by



One of four MaK 9M43C engines for the new cruise liner *AIDAdiva*, which is being built by Meyer Werft. The engines form the heart of a diesel-electric propulsion system.

the Dicare programme, which allows engine operating data to be called up at any time, even from locations ashore.

Importantly for cruise operations, each MaK 9M43C will be equipped with the designer's flexible camshaft technology (FCT), a proven part of Caterpillar's ACERT technology. FCT was developed to reduce soot emissions below the visible limit at all loads and to minimise other exhaust emissions well below IMO requirements - a major advantage for cruise operators that also convinced Holland America Line (HAL), another Carnival subsidiary, to specify four MaK 12M43C and two MaK 8M43C engines for its forthcoming Signature-class vessel.

### Extensive customer acceptance tests

The additional features of the MaK 9M43C designed for AIDA Cruises generated special attention at the customer acceptance test. Here, representatives from AIDA Cruises, Meyer Werft, classification society Germanischer Lloyd, Carnival Corp Shipbuilding, and the Caterpillar dealer Zeppelin/MaK Deutschland attended a two-day trial run on the testbed at Caterpillar Motoren's Rostock assembly plant.

In preparation for the test, all standard safety checks were completed before the engine was run-in and the firing pressure for every cylinder was carefully adjusted. Caterpillar staff also verified the electrics and the various connections to the engine control cabinet. During the test, engineers measured and thoroughly analysed a wide range of temperatures, pressures, vibrations and emissions values, taken at standard load increments.

According to classification society requirements, proper functioning of the engine emergency shutdowns and engine start interlocks were also demonstrated. Thereafter, functionality of the engine control cabinet and its interface to the vessel's automation system (integrated alarm, monitoring, and control system, IAMCS) was tested.

On the second day, focus was on hands-on inspection of dismantled major engine components: the representatives carefully examined the main running gear, the camshaft drive, one FCT drive, one big-end bearing, one main bearing, one piston, two valves and all injectors for visible wear. No deviations from calculated values were found.

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Finally, after two days of hard work and fruitful discussions, results were on the table, and all the parties involved agreed upon the final report of the MaK 9M43C customer acceptance test. This turned out to be very positive - the new vibration dampers proved highly successful, all engines started even with very low air pressure available, and the MaK FCT demonstrated outstanding effectiveness in reducing smoke emissions.

'We are looking forward to seeing this engine in service where we expect reliable operation and good fuel economy', reported Chris Joly, principal manager, marine engineering, for Carnival, 'however, most of all, we are enthusiastic about the flexible camshaft technology and its guarantee of extremely low smoke levels even at minimum power - this is a perfect match with Carnival's focus on sustainable development and environmental protection'.

The particularly strict requirements for vibration levels led to careful examination of vibrations and their influence on attached equipment, also vibrations transmitted to the engine foundations, which strongly influences passenger comfort. However, the new elastic dampers proved their efficiency, and all measured vibration values were well below the prescribed limits.

Special emphasis was put on the new automation arrangement for the engine plant, requested by the yard and developed in close cooperation between Caterpillar and Meyer Werft. This system incorporates a safety

management system and an alarm/monitoring system which utilises a bus link to the vessel's overriding automation system. Its function and interaction with the engines was completely verified on the testbed. The connecting cables

have a plug-and-play design, allowing class approval of the whole system during factory acceptance tests - a major advantage for a yard, saving a great deal of time and money during engine commissioning. 

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## Allweiler single-source-supplier pumps for container-ship series

GERMAN shipbuilder Nordseewerke has turned to Germany's oldest pump manufacturer for a complete package of oil and water pumps on its latest series of container ships. According to Allweiler, 30 to 40 pumps supplied by the company are installed on each of the 27,000dwt vessels, and new class of 34,000dwt vessels to be built by the yard will also use the same type of pumps.

In 1994, Nordseewerke decided to source all of the pumps it needed from a single supplier, having preferred Allweiler water pumps for several years.

In the current container ship series, approximately two thirds of the pumps move water, the Allmarine NIM series being the primary type for this application. These water pumps move between 200m<sup>3</sup>/h and 1000m<sup>3</sup>/h at a pressure of 2bar-4bar.

The remaining one third move oil and fuel. Most of these three-spindle screw pumps belong to the SN series, having capacities between 5m<sup>3</sup>/h and 60m<sup>3</sup>/h at 2bar-6bar. The maximum flow rate of these pumps is 5300 litres/min. When configured as HFO pumps, they are equipped with magnetic couplings, enabling them to handle oil temperatures above 100°C without seal problems.

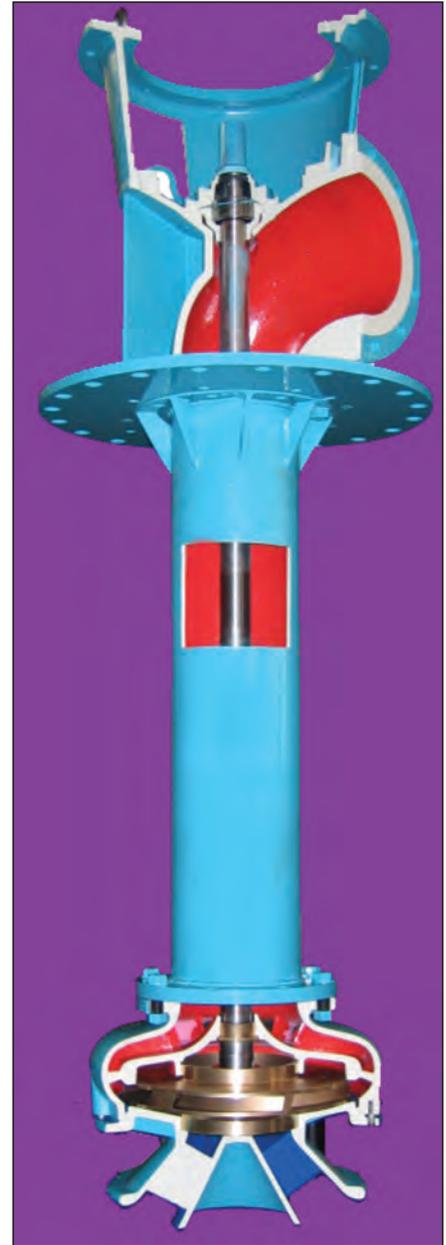
Allweiler reports that Nordseewerke is additionally turning to a new development, the new high-performance MELO centrifugal pump, which is said to be especially useful for pumping large volumes of lubricating oil. Traditionally, screw pumps have been used for this purpose, but more shipbuilders are claimed to be discovering the benefits of the new MELO volute-centrifugal models. They generate only low levels of noise, but exhibit very good suction capacity because they are installed vertically in the oil container.

Available in several different sizes, MELO pumps achieve a flow rate up to 1600m<sup>3</sup>/h and can handle oil temperatures as high as 100°C. Their two-stage design can accommodate pressures as high as 10bar. An intermediate bearing permits flexible immersion depths up to 3700mm.

A special seawater-resistant aluminium bronze alloy that Allweiler produces in its own foundry makes a major contribution to the pumps' high quality and long service life. For a yard, notes Allweiler, there are number of benefits from the wide range of pumps the company offers. Depending on the product series, these include a choice between horizontal or vertical installation, axial or in-line connections, rotating suction and discharge flanges, immersed versions and pumps with magnetic couplings, and the ability to meet an individual shipyard's requirements whilst keeping costs low.

Allweiler says the new MI/MA series of pumps is a good example of how such a large selection delivers real advantages for designers. A split bracket and various connection possibilities make these water pumps very simple and flexible to install. Their modern hydraulics also give them better NPSH values and higher efficiency. As a result, these pumps are said to match the performance of comparable units while using a smaller motor. This can save the customer money both at the time of procurement and during operation. ☺

**Allweiler's high-performance MELO pump is said to be particularly useful for lubricating-oil duties.**



## New Germanischer Lloyd rules for inland vessels

NEW rules for inland vessels have been developed jointly by Germanischer Lloyd and Bureau Veritas. They have entered into force with effect from August 1 2006, for all inland vessels with the French and German classification societies and contracted for construction on or after that date. In addition, the rules will apply to existing vessels that have been technically updated and which comply with the necessary safety requirements for inland navigation vessels.

These new rules comprise four sections, dealing with: classification and surveys; hull design and construction; machinery, systems and

electricity; and additional requirements for notations. They cover survey requirements, class verification and construction rules for modern inland navigation vessels, and make provision for continuing improvements in pushing units, double hulls, and dangerous goods regulations.

The rules, which will be updated regularly, comply with statutory regulations and are compatible with ADNR (Regulation for the Carriage of Dangerous Goods on the Rhine). The rules are published on the websites of Bureau Veritas and Germanischer Lloyd.

In July, GL also announced that in the most recent evaluation of all port state inspections of

ships during the past year within the scope of the Paris memorandum of understanding, it claimed to have, once again, taken first place, as in the previous years. The Paris memorandum determines the number of class-related detentions for each classification society and expresses them in relation to the total number of port state inspections during the years 2003-2005. For Germanischer Lloyd, only 43 detentions were noted out of a total of 11,882 inspections. This yields a calculation factor of -1.57, which is the lowest value for the 25 societies considered. ☺

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## More orders for innovative Futura Carrier concept

COMPLETION of the first example of a completely new type of sea-river vessel with unit-based modular construction, intended for use in shallow water on Europe's inland waterways, dubbed the Futura Carrier by developer New Logistics, was badly delayed earlier this year when the yard entrusted with construction of the vessel, Con-Mar Ingenieurgesellschaft in Brake, Germany, ran into financial problems.

However, New Logistics reports that a solution to the problem is close to being agreed, with a new yard understood to have been found to complete the vessel, which is currently 95% finished. At the same time, several new orders for vessels using the Futura Carrier concept (comprehensively discussed in our September 2005 issue, page 56) have recently been placed.

In addition to the first vessel, two MPC 875 Futura Carriers have been ordered by Schram Group, from Brunsbüttel, Germany. Both of the steel hulls for these are under construction in Polish yards and will be transferred to Kiel in Germany for final outfitting and trials. Both are due to be delivered by the end of December 2006.

Also, Gerhardt & Deymann, based in Haren/Ems, has ordered a C-1100 Futura Tanker - a double-hull tanker for the inland waterways (an impression appears on page 1). The steel sections for these have also been built and, apart from one large section, transferred to the Kötter Yard, also in Haren/Ems, where final outfitting and completion will take place. Delivery is planned for the end of this year.

More recently, New Logistics has also signed a letter of intent for the construction and delivery of a quartet of Futura C-1100 double-hull tankers with R Eckelmann Logistics, of Hamburg, Germany, with delivery planned for the end of 2007 and beginning of 2008.

As detailed in our September 2005 issue, the Futura Carrier was designed by former Schiffko naval architects at New-Logistics, in Kiel, working closely with Schiffko, and is primarily intended for use on inland waterways and in sheltered, coastal waters.

The first example of this innovative new design is 97.5m overall with a breadth of 13.6m, draught of 4.15m, cargo hold of some 5000m<sup>3</sup>, and a deadweight of approximately 3000dwt, and is tailored to carry a mix of rolled paper and steel coils with containers on deck. Propulsion will be provided by two pairs of MTU Series 2000 main engines, each rated at 600kW, driving a quartet of HRP 5000 rudder propellers at the four 'corners' of the vessel.

*RMS Kiel*, as the vessel will be named, combines a novel hullform, innovative propulsion and propulsors with an optional air bubble lubrication system designed to reduce resistance - a combination that New-Logistics believes will provide a number of advantages compared with existing, conventional inland and coastal vessels. These include: greater freight carrying capacity at the same draught or the same freight carrying capacity with reduced draught; low fuel consumption, and hence reduced operating costs and reduced



Construction of the first Futura Carrier, to be named *RMS Kiel*, was delayed by problems at the Con-Mar yard but now a new yard is understood to have been found to complete this innovative vessel.

extreme water flow conditions often experienced in shallow water and in restricted waterways.

The location of the propulsors was selected in such a way as to ensure that they are always provided with good water flow conditions, even when in shallow or restricted waters. The propulsion system is based on four identical, fully azimuthing units, which provide excellent manoeuvrability with relatively small propeller diameters and contribute to ease of operation in shallow waters.

To-date, the German company has produced a trio of proposed Futura Tanker designs, ranging in length from 85m to 110m, and in deadweight from 1500dwt to 2900dwt. It has also developed a family of basic container ships, ranging in length from 85.00m with a deadweight of 1600dwt carrying up to 84TEU, to a much larger vessel of 135m length overall with a deadweight of 6700dwt and carrying 490TEU.

environmental impact; very high levels of manoeuvrability; reduced space required in port (any berth that provides the ship's length plus a minimum tolerance of approximately 1m-2m fore and aft can be reached quickly and easily), and a high level of operational safety.

Unlike a conventional displacement hullform of the type normally used on an inland navigation vessel, the novel hullform selected for the Futura Carrier, for which a patent has been applied, has a tunnel running the length of the vessel which reduces wetted areas and frictional resistance. The geometry of the bow and stern has been optimised to operate in the



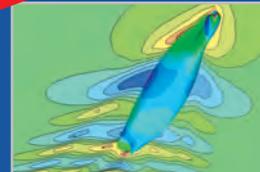
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## Meyer Werft busy with tankers and cruise/passenger ships

IN July, Hamburg-based shipping company Harpain Reederei GmbH & Co KG, a joint venture comprising Harpain Shipping and Hansa Hamburg Shipping, confirmed that it had placed an order for a quartet of ethylene/LPG carriers at Meyer Werft, in Papenburg. The new ships will have a length overall of 154.90m, breadth of 22.70m, and a cargo capacity of 17,000m<sup>3</sup>. They will operate at a speed of 17knots, and when fully loaded with ethylene cooled to -104°C, the ships will have a draught of 8.10m.

In addition to ethylene, the tankers will also be able to carry vinyl chloride monomer, ammonia, and propylene oxide, cooled to -48°C; they are scheduled for completion in 2009 and 2010. On delivery, they will operate in the GasChem pool, and the new orders increase the number of gas tankers built by Meyer Werft to 55.

At the end of June, Meyer Werft also received another order from a longstanding customer in the form of the Republic of Indonesian authorities, for whom it will build yet another passenger vessel, thus continuing a series of 23 ships the yard has built for that owner, the last of which was delivered in 2004. This latest newbuild is a development of the *Labobar*. In addition to carrying passengers, it will also carry a total of 98 containers. The new vessel will have a length overall of 146.50m, a breadth of 23.40m, and a draught of 5.90m; it will be built in accordance with the rules and regulations of the Indonesian classification society BKI, being designed to carry 1583 passengers and 141 crew.

Already under construction in Papenburg is *Norwegian Gem*, for which a total of 67 steel

blocks for this new 93,500gt cruise ship have been put in place. *Norwegian Gem* is the seventh ship that Meyer has built for Norwegian Cruise Line (NCL). Due to be delivered in the autumn of 2007, the ship will be, it is claimed, one of the world's largest

Panamax-dimensional cruise ships built to date, and is 294.13m overall with a breadth of 32.20m. Able to reach a speed of more than 25knots, *Norwegian Gem* will carry 2384 passengers accommodated in 1188 cabins, and will have a crew of more than 1000.

### Voith moves into waterjets



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## Winch drive replaces maintenance-intensive electro-hydraulics

GERMAN manufacturer Hatlapa, which specialises in deck machinery, compressors, and steering gear, has provided *The Naval Architect* with details of an innovative, stepless drive for deck machinery such as winches, which it believes provides owners with a number of important advantages compared with conventional electro-hydraulic drives. This new technology was successfully fitted recently on Matson Navigation's 220m-long, 2100TEU container ship *Kauai*, during a scheduled drydocking at Nantong Shipyard, China.

The work undertaken by the Chinese yard saw the ship's existing electro-hydraulically driven mooring winches (originally supplied by German manufacturer Kocks) replaced, and the ship's combined anchor and mooring winches, with chain of 68mm/Grade 3 and a rope pull of 150kN, upgraded with new drives developed by Hatlapa. The stepless drives for deck machinery developed by Hatlapa make use of an asynchronous motor with frequency inverter.

As the company explained, drives for winches can be divided into two groups - electric and hydraulic (or steam, which is hardly ever used today). Hydraulic drives have advantages such as good controllability and the possibility of stepless winch operation. Electric drives, of which there are three main types - DC motor, pole-changing and AC motor, and AC asynchronous motor with frequency inverter - have their own advantages, as the conversion on *Kauai* demonstrated.

For many years, the DC motor was the type most frequently used as an electric drive for winches, being distinguished by its stepless operation and design. The disadvantage of that system includes the demands made on switches and contactors with which the motor is activated. These motors require frequent



Hatlapa has developed a new type of stepless AC electric winch drive for the container ship *Kauai*.

maintenance, and the brushes and carbon must be changed frequently, thereby reducing availability of the winch.

Moreover, today, direct current is rarely found on-board and is replaced by alternating current, which is easier to switch, resulting in the increased use of AC motors, which require very little maintenance. Speed control of AC motors is possible in a number of ways, using pole-changing motors, slip-ring induction motors, and asynchronous motors with

frequency inverters. Pole-changing motors are the mostly widely used, and are of sturdy construction, but have the disadvantage that stepless speed operation of the winch is not possible.

Slip-ring motors can be driven in an almost stepless manner, but have the disadvantage of increased switchings, and the speed cannot be controlled as well since this type of motor is greatly load-dependent. Furthermore, a certain amount of maintenance is required when using slip-ring motors, including maintenance of resistors, main contactors, and slip-rings.

The use of power electronics allows stepless control of the speed of a standard asynchronous motor, and is a technique that effectively unifies the sturdy AC asynchronous motor with squirrel-cage induction, with improved power electronics together with the use of microprocessors, allowing stepless winch operation. The frequency inverter establishes a disconnection between a mains supply - which normally would drive the motor - and the motor. At the input of the inverter there is a rectifier, which creates direct voltage from the mains AC voltage.

This Hatlapa winch drive system with frequency inverter was developed in very close cooperation with the manufacturer of the frequency inverter, and the software for the inverter was designed and developed with the experience of how a winch with frequency inverter should work. The design and development was tested and improved on the Hatlapa test bench, and confirmation of this development work was made on the vessel itself.

### Automated handling system from Becker Marine Systems



Speed control is achieved steplessly from standstill to nominal maximum speed (the maximum speed of standard AC motors is 3600rev/min-4000rev/min). Acceleration and deceleration times, as well as maximum speed are adjustable, and the full nominal torque is available from standstill to nominal speed.

Torque is reduced from nominal speed up to maximum speed, and operation is carried out under constant load (slack hawser), the torque being reduced with the square of the speed, a technique that offers a number of advantages.

These include: no high starting or change-over currents, and thus lower expenditure on cabling and lower load on the generators; gentle starting and stopping - even at overload of the

winch, the nominal current is not exceeded, and the mechanical motor brake is subject to very little wear, as it is only applied at 'zero' speed; mechanical reversing requires no mechanical application.

Hatlapa believes the new winch drive has a number of advantages compared with winches with pole-changing motors and hydraulic drives, such as reduced cabling expenditure for shipyards; much lower noise levels (particularly important on passenger vessels); speed control is steplessly variable; and high slack hawser speeds are possible (three-to-four times nominal speed).

Another advantage is reduced load on the current supply network, since there are no high

starting and change-over currents as in the case of pole-changing motors. Wear on contactor contacts is reduced considerably, since switching under load is no longer necessary, and no light arc is produced which gradually burns-off contacts.

The mechanical motor brake is subject to almost no wear, because it is only applied at zero speed, and motor reversing does not require the use of mechanical braking. In emergencies, should the inverter fail, there is a by-pass switch in the contactor cabinet, which allows motor operation without the inverter in both directions with nominal speed, and if auto tension for the winch is required, there is no difference in cost. 

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## SEC Bremen twistlocks 'not affected' by recent concerns

SEC Bremen, the well-known designer and manufacturer of fully automatic twistlocks (FATs), says that its particular model is not among those twistlock designs, about which concerns have recently been expressed by classification societies and P&I clubs. These follow a spate of overboard losses of containers and collapsed stacks.

The company said none of its twistlocks have been involved in any of the much publicised incidents possibly involving FATs, and said its design has the full confidence of classification society Germanischer Lloyd. Additionally, the company noted that it has recently secured judgements in the courts against manufacturers which, it believes, copied FAT design, but produced an inferior product in the process.

In a recent statement, SEC Bremen said: 'We would like to refer to the *Loss Prevention Circular 05-06*, published by P&I club Gard A/S, in which several container losses from bigger container ships are mentioned. All the concerned vessels were equipped with fully automatic twistlocks. The fully automatic twistlocks developed by SEC and patent-protected are not involved in the incidents described by Gard, nor do we have knowledge of a vessel losing containers due to failure of our TL-FA. Gard confirmed to us that only a certain type of one supplier is responsible for those losses'.

SEC noted that its TL-FA has been in service for more than two and a half years, and more than 500,000 units have been supplied to more than 100 seagoing ships, with capacities ranging from 360TEU to 9200TEU. None of them had experienced problems with its fully automatic twistlocks.

'Before granting type approval, class society Germanischer Lloyd required a number of individual testing procedures to guarantee safety of containers on-board', said SEC Bremen. 'For one test, the rolling and pitching of a four-tier high container stack was realised by means of a crane to prove that our FATs remain safely locked under the worst conditions'. Another test, an endurance type, demonstrated that the company's FAT is not subject to deformation in the container corner casting, which could have weakened the container casting resulting in a safety risk.

SEC Bremen says the type of fully automatic twistlock involved in the incidents differs in a number of fundamental respects from the TL-FA, particularly in as much as its competitors' models do not have a flange (as does the FL-FA). The lower locking nose of the TL-FA is 9mm longer; the lower locking nose of the TL-FA has an angle of only 30deg to the horizontal; and the lower cone in the TL-FA has a sharper form to ensure that it slides completely into the locking position after lowering the container.

As a part of its investigation of container losses, Gard conducted a survey amongst some of its members. 'The survey has revealed that the losses experienced by the members of Gard seem to be limited to one type of FAT available in the market', said Gard. 'In a letter from Germanischer Lloyd dated March 16 2006, the potential problem was highlighted and future limitations in the use of FATs were discussed', continued Gard. 'However, in its letter of 27 April 2006, Germanischer Lloyd clarified its current position: the letter states that the approved container stowage plans, with their respective stowage systems, continue to be valid unconditionally and that a general and type independent recommendation for the substitution of FATs should not be issued'.

As SEC Bremen highlights, Gard then noted: 'GL's tests also confirmed that FATs with a flange and sufficiently dimensioned locking nose (this being the type of FAT manufactured by SEC Bremen) obtained good results'. GL approved the design, operational features and strength and safety of SEC Bremen's TL-FA type FAT in April 2003, without objections. In the autumn of 2003, the first ship (a 700TEU container vessel) received SEC's TL-FAs for securing all deck containers, since when many other owners have decided to adopt the TL-FA design. All of the feedback received by the company is said to have been very positive.



Bremen's TL-FA fully automatic twistlock is said to differ in a number of important respects from other FATs that have experienced problems recently.

The TL-FA is of special asymmetric design, and its combination of inclined surfaces should hold containers safely in position during all operating conditions. Pressure on one side of the container prevents the FAT from the opposite side from slipping out of the corner casting.

The company says it believes that the TL-FA FAT has a number of advantages compared with conventional twistlocks. These include the fact that, apart from the unique principle of operation, which other FATs based on its design are claimed not to have, the TL-FA meets OSHA rules and requirements. It is comprised of a single, robust housing made of high-tensile cast steel with large surface area, according to GL's requirements for highest pressure force possible. The design is said to be easy to maintain, having a limited number of movable parts; and assembly parts do not protrude over the container corner castings while stowed, thus avoiding damage during loading/discharging of adjacent containers.

The TL-FA is also easily handled when being inserted and removed from the corner casting at a quayside, and operation of the TL-FA should be unaffected by external influences such as low temperatures, icy conditions, swell, heel, and trim. When using the TL-FA, vertical movement between the containers is limited to 12mm, according to ISO 3874, thus avoiding the possibility of overloads on lashings. The TL-FA can also be used without problems during a twin



lift of two 20ft containers stowed longitudinally, and unlike 'twistlock'/'midlock'-type units, allows for simultaneous operation with a pair of

20ft containers in block stowage (with ISO Gap); the design should therefore help to provide significant time/cost savings in terminals. ⚙️

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## Repeat contract from Norilsk Nickel for Aker Ostsee

THE two Aker Yards site in Germany which today form Aker Ostsee (the former Warnow Werft and MTW yards) have secured a significant contract from Russian operator Norilsk Nickel for the construction of a quartet of container/cargo ships for Arctic operations, with an option for a fifth newbuilding.

This most interesting order follows Norilsk Nickel's recent deployment of the prototype vessel of this innovative class, *Norilskiy Nickel* (featured in *The Naval Architect* February 2006, page 20). She was constructed at Aker Yards' Helsinki site. The new German-built vessels are scheduled for delivery by Aker Ostsee from the third quarter of 2008 through to the first quarter of 2009.

Like *Norilskiy Nickel*, the highly specialised container/cargo vessels will have a patented double-acting hull form and propulsion system developed and patented by Aker Yards. When transiting heavy ice conditions, the vessel is designed to move stern-first to break its way through ice up to 1.5m thick. When returning to light ice conditions or open waters, the vessel turns 180deg, also turns its Azipod 180deg, and sails in conventional manner, bow first.

The Norilsk Nickel vessels are also noteworthy for being diesel-electric ships, and having podded, azimuthing propulsors, and will be 169m long with a breadth of 23.10m, draught of 9.00m for winter deployment under heavy ice conditions, and deadweight of 14,500dwt (summer draught and deadweight will be 10,00m and 18,000dwt, respectively). Their container stowage (a special type for semi-finished metal products) capacity will be some 650TEU with the ability to transport other cargo as well.

Aker Yards delivered *Norilskiy Nickel* to Open Joint Stock Company (OJSC) MMC Norilsk Nickel in April this year, this being the prototype of the design and built as a collaborative project between Aker Yards in Helsinki, Finland, and Warnemünde, Germany.

Since entering service in April, *Norilskiy Nickel* has successfully demonstrated her capability on the Dudinka-Murmansk route. A decision to order four additional vessels (plus the optional fifth ship) was based on the outcome of successful ice



Aker Ostsee has secured an order to build four more Russian icebreaking container/cargo vessels with a double-acting hullform, following completion of the prototype, *Norilskiy Nickel*, at Helsinki (above). They are all planned to load mainly semi-finished metal products from Arctic mines in special containers.

trials of *Norilskiy Nickel* in the Kara Sea during March 2006. The ship exceeded all contractual performance requirements, moving efficiently through ice ridges with depth of more than the ship's own draught as well as the flat, 1.5m thick ice specified in the vessel's newbuilding contract.

### 900th ship from Ostsee yards

Meanwhile, in July, Aker Yards Germany (Wismar and Rostock-Warnemünde) delivered their 900th ocean-going newbuilding built by those yards in the last six decades. The vessel in question was a sixth container vessel of the Baltic CS 2700 type, built for Schoeller Holdings, based in Limassol, Cyprus.

Schoeller has placed orders for a total of eight vessels of this type, five of which had been delivered prior to the latest delivery; the latter is named *Fesco Baykal* (on delivery, *Fesco Baykal* was taken over by the Far Eastern Shipping Co (FESCO), in Vladivostok, Russia, after which it will bear the name *Cap Blanche* and be integrated into a service run by German owner Hamburg Süd between Europe and South America).

June saw the delivery of another Baltic CS 2700 to Thien & Heyenga, being the first vessel of this type for this particular owner. The ship was named *Stadt Wismar*, and will be integrated into a time-

charter service operated by Italia Marittima SpA in Trieste, a subsidiary of container vessel owner Evergreen in Taranto, Italy, between the Mediterranean and US East coast. Thien & Heyenga and partner König & Cie have ordered a total of four vessels of this type to date.

May saw the delivery of the first example of the newly developed Aker CS 1700 container ship design from Aker Yards' German shipyards. This vessel, for Thien & Heyenga, is named *Stadt Papenburg* but will be chartered under the name *Delmas La Perouse*. She will be integrated into a service operated by CMA CGM between Europe and East Africa.

Thien & Heyenga has ordered four vessels of this CS 1700 design, which is 182.5m long with a breadth of 25.2m wide, deadweight of 23,800dwt; container capacity is 1674TEU, with 300FEU reefer sockets. Propulsion machinery takes the form of a four-stroke main engine of 12,600kW, giving the ship a service speed of 20knots.

Aker Ostsee notes that the CS 1700 design has been engineered in such a way that construction of smaller versions, dubbed CS 1500 and CS 1300, could easily be undertaken. Production facilities at Aker Yards' Tulcea site in Romania have been taken into account when fixing the ship's breadth at 25.20m. ⚓

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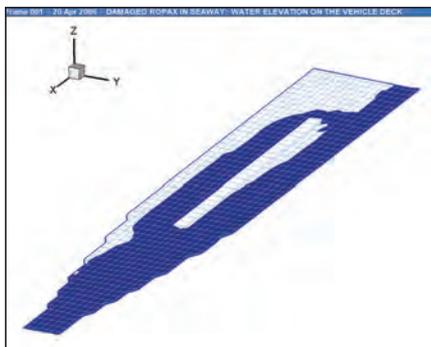
## HSVA to model *Estonia* tragedy

THE Hamburg Ship Model Basin (HSVA), in Germany, is using a unique approach to modelling evacuation times from large passenger vessels such as ro-pax vessels. This is in response to data suggesting that the number of lives lost in accidents involving passenger vessels is disproportionately high for ro-pax ships, and has recently been asked to model the events leading to loss of the ferry *Estonia* in 1994.

Impetus for the model basin's work arises from the fact that existing safety regulations require ships to have sufficient hydrostatic stability to survive certain types of damage involving flooding, but the required damage stability does not guarantee the survival of a ship, especially if an accident takes place in unfavourable weather conditions. In such a case, the time available for evacuation of passengers may be limited, and evacuation times longer.

The HSVA believes that new safety criteria are required, in which probable evacuation times would be compared with survival times for a vessel in a range of sea states and weather conditions, leading ultimately to the development of a 'safety index', which would accurately describe the safety level of a ship having a large number of passengers.

As HSVA points out, the safety index concept is not new - HSVA first presented a proposal on the concept at the SLF45 subcommittee of IMO in 2002 - but has recently been given fresh impetus



Water accumulation on the vehicle deck of a ro-pax ferry.

in a project funded by the Federal German Ministry of Transport's research project 'Time-dependent Survival Probability of a Damaged Passenger Ship'.

At SLF45, HSVA presented a technique that used ship motion simulation until capsized to predict survival times of a damaged passenger ship in seaway. The simulation of a ship's motions in a seaway together with the time-dependent flow in and out of the damaged compartments and vehicle deck was carried out using a software program called ROLLS. A method was developed to evaluate the average survival times of a ship after a collision at sea as a function of the cumulative survival probability based on wave statistics. The goal of the ongoing research project is to further develop this approach.

According to HSVA, its approach demonstrates that, depending on the conditions modelled, and the type of damage incurred by a vessel, time-to-capsize varies significantly, and rapid capsizing is sometimes a possibility. 'Looking at survival time alone has a limited value if it is not also possible to evacuate passengers and crew before capsizing, either because of the angle of heel or the sheer number of passengers onboard. For this reason, it is important to estimate the evacuation times under the influence of ship motions and compare these with the survival times', says HSVA.

The model basin has been using an enhanced version of a well known software program called AENEAS, combined with input data from ROLLS to determine actual evacuation times.

An analysis of an evacuation of a typical ro-pax ship compared the number of passengers safely evacuated from an intact ship in calm water with the number safely evacuated from a damaged one in a seaway with significant wave heights of 5.00m, 5.50m, and 6.00m. Far fewer people were safely evacuated in the latter cases.

HSVA says that ship motions caused by a seaway slow evacuation times down significantly, and believes that the approach it is pioneering shows a great deal of promise. With this in mind, HSVA and the Technical University of Hamburg-Harburg (TUHH) have recently been awarded funding by the Swedish Governmental Agency for Innovation Systems (VINNOVA) to investigate the capsizing and sinking of *Estonia*. ⚓

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**Cargo access equipment for car carriers**

Sweden's TTS Ships Equipment, Gothenburg, has won an order for the design and supply of cargo access equipment (CAE) from South Korea's Hyundai Heavy Industries (HHI), involving a series of four 6000-unit pure car and truck carriers (PCTC) building for EUKOR. These vessels are sisters to eight currently on order for the three associated companies, Wilh Wilhelmsen (Norway), Wallenius Lines (Sweden), and EUKOR (South Korea), all 12 ships in the series having a TTS package as part of the main design. These latest four vessels will be built at HHI's Samho Shipyard, hull numbers S329-332.

The cargo access equipment to be supplied by TTS comprises quarter and side ramps, internal ramps, and covers, including necessary hydraulic and electric systems. Each set has a gross weight of around 615tons. TTS' contract includes delivery of design, vital parts, and supervision of installation.

This TTS equipment is scheduled to be completed by January, February, March, and May 2008, respectively, and the ships are due for delivery by September, October, November 2008, and January 2009, respectively.

TTS Ships Equipment is also to supply access packages to two new cruise ferries ordered from Aker Finnyards: a 34,000gt fast design (yard no 1358 at the Rauma site) for Finland's Viking Line, and a 2800-passenger vessel for

the Estonian company Tallink - a sister to the newly delivered *Galaxy* and the latest in a line of new ships for this expanding operator.

Contact: Nils O Ericsson, sales director, TTS Ships Equipment AB, Sweden. Tel: +46 31 725 7902.

**Radio Holland Group now part of Imtech**

Radio Holland Group BV and Imtech NV (the technical services provider) recently announced that the intended acquisition of Radio Holland Group, the specialist in marine satellite and radio communications, automation, and observation and navigation systems is definite. The acquisition has been approved by both the NMA (Dutch Competition Authority) and German Bundeskartellamt (German Federal Cartel Office). In the international marine market, the acquisition will almost double Imtech's revenue to around €350 million and increase its staff to approximately 1700 maritime specialists.

Together Imtech and Radio Holland Group cover all market segments, that is, naval vessels, megayachts, and cruise liners, as well as general merchant ships. The merger results in an extensive customer portfolio which offers continuity; Radio Holland Group can serve as a platform for the sale of Imtech's products, such as platform automation, integrated ships' bridges, and electric propulsion. Imtech is also now acquiring a position in the USA, a country where the company is not yet active. Imtech is also strengthening its position in the rapidly growing marine market in the Far East, especially in China.

Contact: Radio Holland Group, Westerlaan 1, 3016 CK Rotterdam, The Netherlands. Tel: +31 10 266 9876. Fax: +31 10 266 9877. [www.radiohollandgroup.com](http://www.radiohollandgroup.com)

**Propeller shaft coating to complement water-lubricated bearings**

A leader in grease and oil-free bearing solutions, Thordon Bearings Inc, has introduced Thor-Coat, a new proprietary shaft coating especially formulated to address the recognised risk of traditional coating failures on water-lubricated propeller shafts. Thor-Coat was specifically developed to complement Thordon's COMPAC water-lubricated propeller shaft bearing system, with the objective of providing corrosion protection for a minimum 10-year period in service.

Thor-Coat addresses the issue of current shaft coating systems not being sufficiently reliable to allow extension of shaft withdrawal periods beyond five years. Thordon is also working closely with classification societies to develop approval for other techniques, such as borescoping, which facilitate inspection of both bearings and coating without withdrawing a shaft.

A toughened, two-part epoxy coating, Thor-Coat, it is claimed, is up to nine times more flexible than existing products currently approved for use as propeller shaft coatings. Thor-Coat was subjected to a full-scale 180deg bend test and did not crack, whereas all other

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products tested, says Thordon, showed initial cracking at a much lower bend angle. In a propeller shaft application, or in other similar applications where a coating must be durable, yet flexible, Thor-Coat's enhanced elasticity and toughness should provide corrosion protection over longer service periods. Applied with a brush and trowelled smooth to a thickness of 2mm, application is said to be straightforward, since Thor-Coat is a one-coat product.

Should Thor-Coat suffer impact damage, it tends to fail locally, resulting in some of the coating remaining on the shaft and continuing to offer corrosion protection. If the coating is damaged to the point where corrosion does occur, that corrosion is limited to the damaged area only and should not migrate along the shaft under the coating to unexposed areas. Localised damage can be easily repaired if necessary.

Thor-Coat currently has provisional approval from Lloyd's Register, ABS, and Bureau Veritas while being noted by DNV. Other classification society approvals are pending and expected shortly.

Contact: Craig Carter, Thordon Bearings Inc, 3225 Mainway Drive, Burlington, Ontario L7M 1A6, Canada. Tel: +1 905 335 1440. Fax: +1 905 335 4033. E-mail: craigc@thomson-gordon.com www.thordonbearings.com

### New mini evacuation slide from Viking

A brand-new design of marine evacuation slide has been launched by Viking Life-Saving Equipment as an alternative to the company's MiniSlide, to provide an even more flexible means of evacuation from medium and low disembarkation heights. Two innovative features are a brake cushion system planned to make passenger descent safer and easier, and a new bowing technique.

The prototype package has been installed on a new ferry, *Lote*, built by Fiskerstrand Verft for the Norwegian operator Fjord 1; it will operate in association with a 150-person liferaft - the largest produced by Viking. This can be supplied with or without a canopy. Operators requiring smaller capacities can specify rafts alternatively sized for 101 or 50 persons.

The patent-pending brake system gives evacuees a clear stopping point at the bottom of the slide, and a soft stop at the interface with the liferaft. Standing at the top of a slide can be a daunting prospect, especially in difficult weather and sea conditions. A clear, effective, and safe stopping point should, claims Viking, mean calmer passengers and increased clearance efficiency at the base of the slide.

The single bowing line (also the subject of a pending patent) should require only one crew member for positioning the liferaft, thus freeing other crew members to attend to other evacuation duties. One winch creates the correct pull in the correct places, to ensure that the raft is swiftly, and safely pulled into position, ready for evacuation.



Innovative features of the new mini slide system from Viking for low and medium evacuation heights - seen here on test - are a brake cushion system and single-line bowing.

Contact: Mrs Stephanie C Pedersen, marketing coordinator, Viking Life-Saving Equipment, Esbjerg, Denmark. Tel: +45 76 11 82 08. E-mail: sp@viking-life.com www.viking-life.com

### Cruise solutions with heat-rejecting blinds

Solar Solve Marine - the UK manufacturer of Solasolv roller screens, Rolasolv fabric roller blinds, also a supplier of adhesive window film - offers some innovative solutions to heat and glare problems for cruise ship and ferry operators. Cruise vessels tend to operate in sunnier climes, which means that windows on such vessels are often exposed to high levels of the sun's rays, which creates various problems for the passengers and crew.

Hot rooms means there is a greater need for a ship's air-conditioning, which is expensive to run, meaning increased fuel costs. More importantly, when air-conditioning systems develop faults or fail, there is no protection against heat build-up so passenger comfort is compromised.

A simple solution is to install Rolasolv heat-rejecting fabric roller blinds at cabin and public area windows. These blinds act as a shield and stop the sun from heating interior spaces. The range includes basic roller blind systems and complete blackout systems, so passengers and crew can sleep during the day, if they wish, in complete darkness. There is a wide range of fabric colours and types, including Lyverscreen, which is an open-weave fabric to give a partial view of the outside world.

Some cruise operators are also installing window film on their cruise ships; this rejects the sun's energy, allowing very little long-wave radiation conversion to take place. Owing to this fact, heat build-up is greatly reduced but passengers and crew are also able to have a clear exterior view.

Contact: Solar Solve Marine, Unit 3A, Tyne Dock East Side, South Shields, Tyne and Wear NE33 5SQ, UK. Tel: +44 191 454 8595. Fax +44 191 454 8692. E-mail: info@solasolv.com www.solasolv.com

### MacGregor equipment for builder's 45 ships

A remarkable long-term agreement has been signed by the MacGregor group and the Japanese shipbuilder, the Shin Kurushima group. This will cover the design and manufacture of ro-ro packages for a total of 45 ships to be built at the Toyohashi and Shin Kurushima Dockyard sites. All the vessels are car/truck carriers with capacities ranging from 4000-car units to 6500-car units and will be operated by both domestic Japanese owners as well as for foreign account. Equipment will cover stern quarter ramps, side ramp systems, internal ramps and covers, and mobile deck lifters.

Contact: Karl-Axel Persson, sales manager, MacGregor ro-ro ship division, Sweden. Tel: +46 31 850 700. Fax: +46 31 428 825. E-mail: karl-axel.persson@macgregor-group.com

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# Innovative propulsion plants for large merchant ships

Some ingenious new propulsion plant alternatives\* are proposed by K Tigges, MSc, from Siemens AG/Marine Solutions, Hamburg, and Professor C Gallin, of Gallin Marine Consultants, Baden-Baden\*\*. One of the targets is to save energy, ie, to minimise fuel consumption, as well as emissions, at a time of record fuel prices. Another is to give a ship additional power and, by means of a booster device, to increase her speed or to dispose of a supplementary 'sea margin'. This is particularly important for container ships operating under strict time schedules.

To reach these goals, three main components have been chosen for the proposed alternatives: a waste heat recovery (WHR) plant, an electric motor concentric on the propeller shaft (booster), and a power management system (PMS). Under the leadership of Siemens AG, a group of leading suppliers has been organised to deliver offers to shipping companies open to innovations. Group members are: Aalborg Industries (Denmark), Peter Brotherhood Ltd (UK), and Siemens AG (Germany).

Additionally, Wärtsilä Switzerland Ltd and MAN B&W Diesel A/S are partners of this group, while the independent concern Gallin Marine Consultants, from Germany, and the Finnish consultancy Deltamarin, both design offices specialising in the optimisation of ships and their propulsion plants, received contracts to evaluate objectively the pros and cons of all possible alternatives.

Several alternative propulsion plant concepts for large container ships are compared with a conventional one, corresponding to the 'state of the art'. In order to obtain realistic results, one significant, recently built, large container ship, equipped for loading refrigerated boxes, is taken as an example. Based on capital and operational costs, economic criteria of merit, such as pay-back period (PBP) and net present value (NPV) are determined. A sensitivity analysis evaluates the impact of fluctuating fuel prices on the results, while environmental aspects have not been forgotten.

## Recovered power and its application modes

A waste heat recovery system (WHRS) can extract substantial amounts of energy

\* This article is an improved, updated, and condensed version of a lecture given in London at the WMTC 2006 conference.

\*\* Readers may also like to study an earlier detailed investigation by Prof Gallin and colleagues into the combined diesel-mechanical and diesel-electric (CODMAE) concept, which was presented in *The Naval Architect* March 2003, page 23.

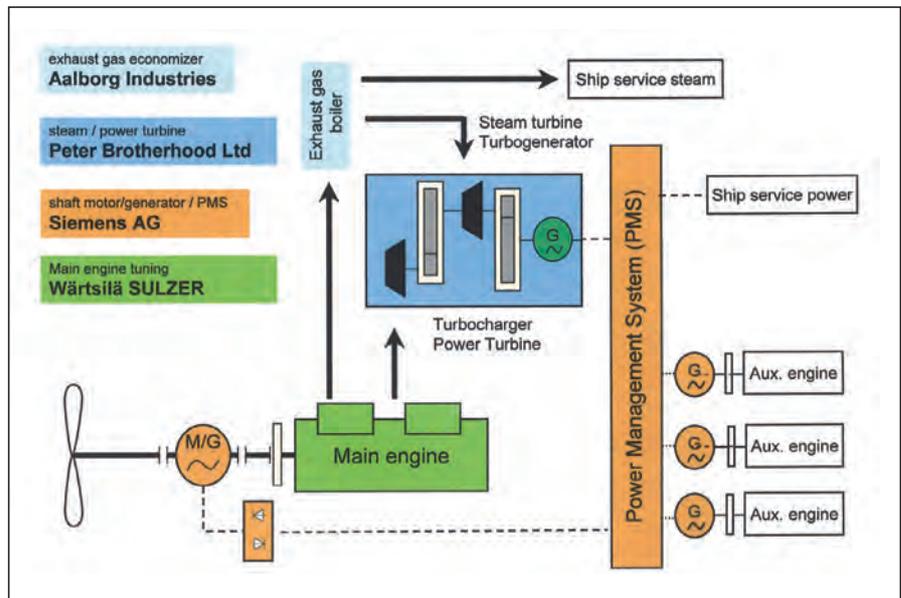


Fig 1. Schematic diagram of a typical waste heat recovery system (WHRS).

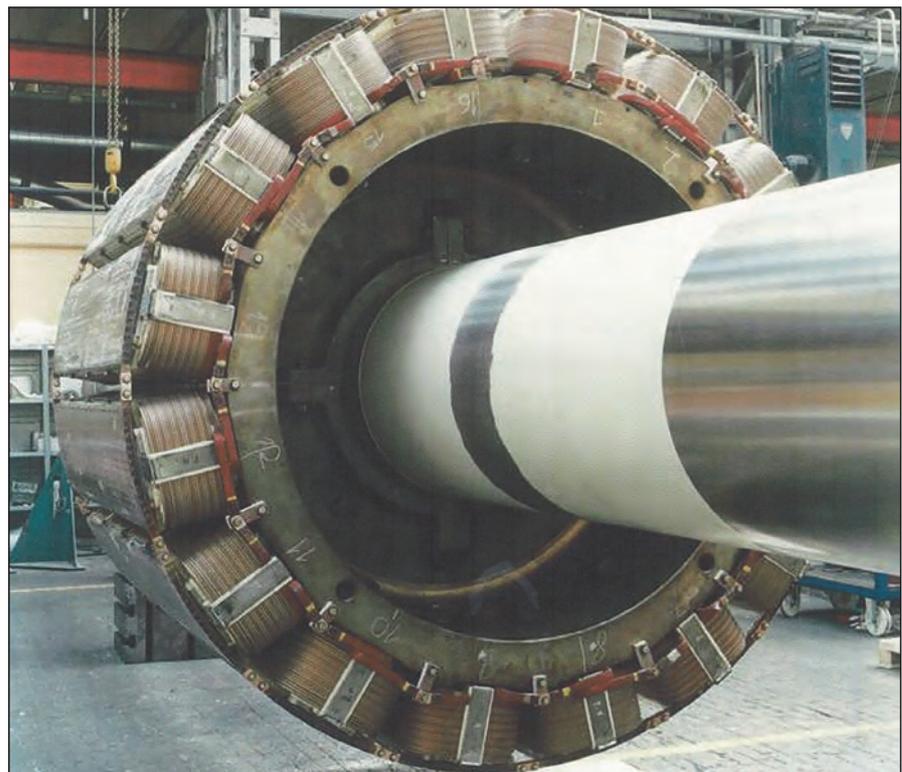


Fig 2. A typical large shaft generator mounted directly on a propeller shaft. The generator can also double as a shaft motor (booster for the main engine output).

otherwise lost in the exhaust gases. This facility is currently extremely important due to steadily rising fuel prices and to increasing power demands onboard large container ships.

Questions that arise are: what can be done with the additional power (between 10% and 12%) available onboard and what would be its

best application? In principle, there are four distinct modes of applicability (in no particular order):

- assuming a constant ship's speed, ie, total propulsion power required, the continuous service rating of a main engine could be

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Strategic Overview of Propulsion Plant Alternatives						
Propulsion Plant Alternative		A	B <sup>1)</sup>	C	D	E
Plant Configuration	Cylinder Number of Main Engine (ME)	12			11	12
	WHR Turbo Compound System	—	—	Dual Pressure Steam plus Power Turbine	Single Pres. Steam Turb.	
	Shaft Motor (SM) and/or Shaft Gen. (SG)	SG	SM / SG			
Basis for Comparison						
Target of Less Fuel Consumption	Energy Savings i.e. Fuel Economy					
	Emissions Reduction					
	Decreased Maintenance of Main Engine					
Target of Add. Power	Higher "Sea Margin" i.e. Delays Recovery					
Target of Minimum Investment		—	—			
Target of Maximum Financial Efficiency		—	—			

<sup>1)</sup> Alt. B is not considered in this study

Table 1

reduced by the same amount as delivered by the WHRS. This means less fuel consumption, ie, operational costs

- alternatively, the installed output of the main engine, ie, number of cylinders, could be correspondingly reduced. This would mean less investment and maintenance costs
- the power contribution of the WHRS could be considered as a reserve (supplementary sea margin) in order to keep the ship's service speed constant under heavily adverse weather and sea conditions, or to recover time lost by delays
- additional power obtained through the WHRS could be used to reduce the running time of auxiliary engines during sea passages. As it is well-known,

medium- or high-speed auxiliary engines driving gensets have higher specific fuel consumptions and need more maintenance than a large two-stroke propulsion engine.

It should be noted that the first and last of these modes described can also be applied in combination, thus reaping even higher economical benefits.

All the applicable modes described above imply the need for an electric motor, installed on the propeller shaft and fed with energy, via a converter, from the switchboard. Normally, such a shaft motor, usually called a 'booster', can also double as a shaft generator.

This booster must also function as a buffer during cases when the energy delivered by the WHRS is not entirely absorbed by the

variable consumers onboard. The design principle of the WHRS and an illustration of a typical motor/alternator are shown in Fig 1 and Fig 2 respectively.

### Main components of a waste heat recovery system

The proposed WHRS is designed and manufactured according to the latest technology of the group companies. As can be seen in Fig 1, the turbo-compound system consists of a power turbine, a steam turbine, and a generator. The power turbine is usually driven by exhaust gas separated from the main flow.

The steam turbine is of dual-pressure type (high and low pressure). Exhaust-gas outlets from the main engine turbochargers are connected to an exhaust-gas boiler. The turbo-generator can operate as a single unit or in parallel with other generators, depending on available exhaust gases and the load situation. All run-up and shut-down sequences are fully automated.

The propeller shaft motor/generator, working in the motor mode, produces additional propeller torque, which leads to a boost in the ship's speed, whereas while working in generator mode, it can supply electrical energy for onboard needs and for container refrigeration. This motor/generator can be concentrically mounted on the propeller shaft, driving it directly without the help of any gears.

For the propulsion plants of any ship, but for very large and ultra-large container liners in particular, the highest priority is given to reliability and simplicity of components. As the German poet and philosopher Goethe once said: 'where simplicity ends, genius is gone'. Therefore, it is no wonder to see that for those types of ships, the motor/generator concentric configuration on the propeller shaft has been widely adopted and that is why it has also been considered in this study. In such an installation, the unit must be controlled by speed or torque - for constant ship operation or for lower engine load respectively.

From the perspective of a ship designer, the modest dimensions of a gearless shaft motor/generator, and its concentric location

Table 2

Particulars of the Ship Example Postpanamax Container Ship 7500 + TEU			
Ship's Particulars	Length overall		335.0
	Length btw. perpendiculars		320.0
	Breadth extreme	M	42.8
	Design draft		14.5
	Average draft values <sup>1)</sup>		13.0/11.0
	Container stowage total	TEU	7 500 +
	Reefer containers	FEU	700
Service Speed at CSR <sup>2)</sup>	KN	25.2	
Main Engine (ME)	Make & Type	Wärtsilä Sulzer RT-flex 96C	
	Cylinders	—	12
	MCR	KW	68640
	Speed	RPM	102
	CSR = 0.9 MCR		61780
Diesel Generators	Number × Output	3 × 3 600 = 10 800	
Bow + Stern Thrusters	Input	1 × 2 200 + 2 × 900 = 4 000	

<sup>1)</sup> Acc. to operational reports, during Eastbound / Westbound voyages between Japan and U.S.A.  
<sup>2)</sup> Acc. to a leaflet issued by the shipping company

Table 3

Particulars of the Propulsion Plant Alternatives for the Ship Example Postpanamax Container Ship 7500 + TEU						
Propulsion Plant Alternative		A	C	D	E	
Main Engine (ME)	Make & Type	Wärtsilä Sulzer RT-flex 96C				
	Cylinders	12		11	12	
	MCR	KW	68640		62 920	68 640
	Speed	RPM			102	
	CSR = 0.9 MCR		61780		56 630	61 780
Diesel Generators	Number × Output	3 × 3 600 = 10 800				
Bow + Stern Thrusters	Input	1 × 2 200 + 2 × 900 = 4 000				
WHR Turbo Compound System (TCS)		—	Dual Pressure Steam plus Power Turbine	Single Pressure Steam Turbine		
Waste Heat Recovery	Output <sup>1)</sup>	0	6 200	5 700	4 600 <sup>2)</sup>	
Shaft Motor (SM) / Shaft Generator (SG)	Output SM/SG	—/2 000	6 080/2 000		2 000/2 000	
Maximum available CSR	<sup>3)</sup>	61 780	67 780	62 630	63 780	
Ship's Speed (loaded) <sup>4)</sup>	Only ME	26.2	26.2	25.6	26.2	
	ME + SM	—	26.8	26.3	26.4	

<sup>1)</sup> Mean value round 10%, acc. to data delivered by the engine's manufacturer  
<sup>2)</sup> Output of single pressure steam turbine ≥ 74% of dual pressure steam plus power turbine.  
<sup>3)</sup> Maximum available CSR = Output ME + SM  
<sup>4)</sup> Acc. to model tests for eastbound voyage (11.5 m draft)

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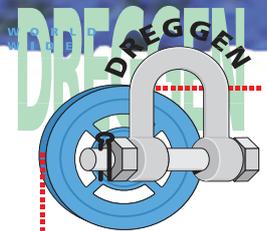
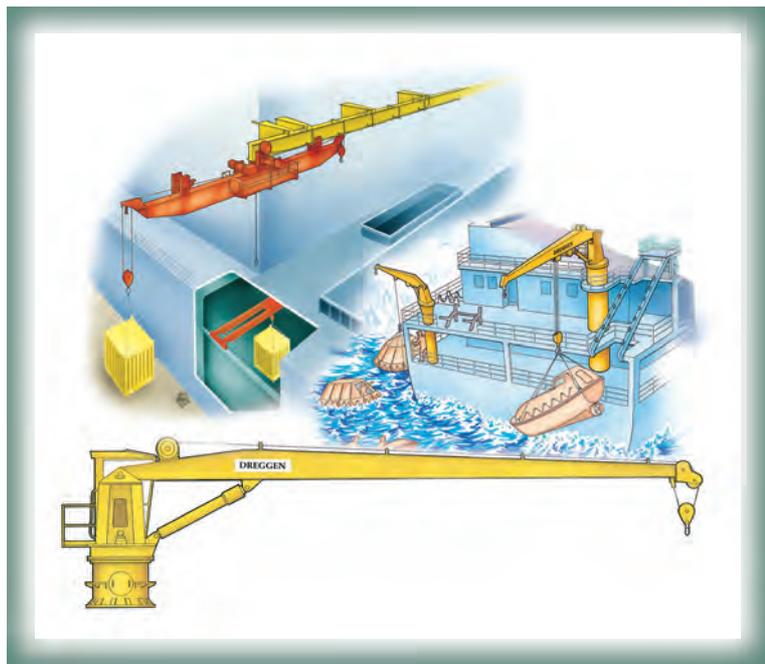
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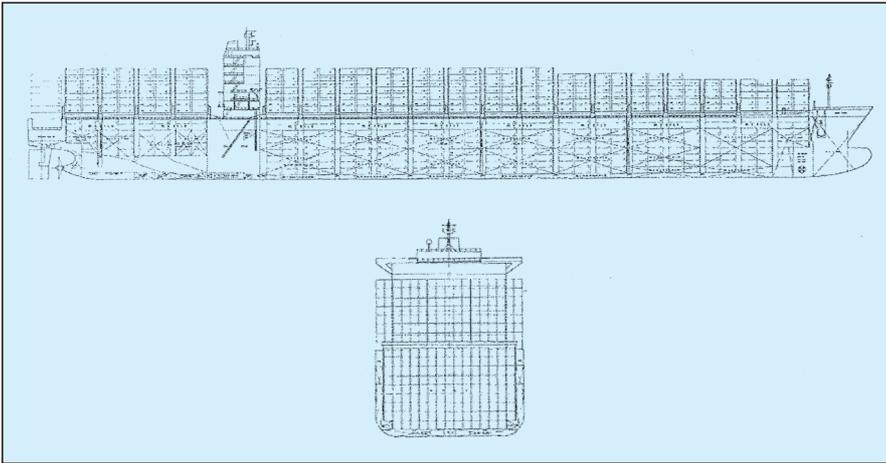


Fig 3. Profile and cross-section of the 7500TEU-plus container liner used as a basis for the studies.



Fig 4. Typical voyages of the 7500TEU-plus container liner used as a basis for the studies.

on the propeller shaft, lead to a great advantage in that the installation does not change the hull dimensions and cargo capacity remains intact.

The power management system is designed to ensure uninterrupted and sufficient electrical power flow to a ship's systems. It controls the volume of electrical power, as demanded by various consumers, and enables the ship to take full advantage of all the recovered waste heat.

Such a system is normally set for an economical sharing mode that loads the turbo-generator as much as possible and feeds surplus power to the propeller shaft whenever possible. Automatic operation is also essential for undisturbed operation of the vessel in both normal and emergency conditions. Moreover, this relieves the crew from tiresome and sometimes risky tasks.

### Propulsion plant alternatives

Five propulsion plant alternatives have been assumed for the same large (reefer) container

ship, taken as an example. At a glance, Table 1 offers an overview of the strategy of this research work, while numerical data of the ship and alternatives are given in Tables 2 and 3.

#### Alternative A

This is a conventional ship propulsion plant composed of a Wärtsilä Sulzer 12RT-flex96C two-stroke diesel engine, with a maximum output of 68,640kW at 102rev/min, driving a FP propeller directly. As usual, a shaft generator of 2000kW is fitted on the propeller shaft and this is connected, without a converter, to the ship's electrical net. Besides this, three diesel-generator sets, each of 3600kW output, are installed. The scope of this alternative is solely to serve as comparison basis for the others.

#### Alternative B

This is almost identical to Alternative A, except that the shaft generator is replaced by a shaft motor of 6000kW, which can also be used as shaft generator for supplying 2000kW. The

target of this alternative is only to improve the ship's speed in general or simply to increase her 'sea margin' against possible delays. Alternative B has been left out of the present (financial) comparison.

#### Alternative C

This is a classic example of the combination of waste-heat recovery and shaft motor/generator systems in a propulsion plant.

#### Alternative D

This is the case when for a given continuous service rating, a WHRS gives compensation, and one cylinder of the main engine can be omitted. Thus, an 11-cylinder engine is naturally cheaper. Indeed, the 1/12th of the output (5720kW) is covered by, say, at least the 1/10th power obtained with the WHRS ( $\approx 6200$ kW). The eliminated power of one cylinder, substituted by the WHRS, can be transferred to the ship's propeller via the shaft motor.

#### Alternative E

This solution pursues another radical way to reduce the investment. The power turbine of the turbo-compound system in the waste-heat recovery plant (Fig 1) is totally eliminated, and the dual-pressure steam turbine is replaced by a single-pressure model. In such a case, the total power recovered only by the steam turbine, via the boiler, will certainly be less; according to the manufacturer, about 74% remains available.

The targets of alternatives C, D, and E are devoted to determining the benefits yielded by adding a WHRS to Alternative A. As by-products of the alternatives, as described above and assuming the same ship's speed and sailing conditions, the saved energy can lead to a reduction in emissions generated by the main engine also less work and spare parts for its maintenance.

### Significant ship example

For the purpose of quantitatively comparing alternatives of ship propulsion plants, at least one significant ship example had to be taken as example. 'Significant' means that the ship type and size are not only adequate for the investigated topic, but also representative of similar vessels already existing on the market and/or of an identifiable trend in newbuilding orders.

In this study, the example has a transport capacity of 7500TEU-plus, and 700FEU (1400TEU) of them can be reefer units. The main particulars of this ship are given in Table 2, and the general arrangement can be seen in Fig 3.

### Typical voyages

Typical voyages of the ship taken as example, from China to the USA and return, are displayed in Fig 4. Average data have been determined from more than 12 operational records, leading to important observations for the present study, as follows:

- speed of the ship on two real draughts can be determined in Fig 5 as the function of any propulsion power value



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Yearly Operational Time of the Main Engine (ME) of the Ship Example on the China-USA Route				
		Eastbound	Westbound	Total
Average Sea Passage Time	Hours	285	261	546
Sea Time between Chinese Ports		2 × 24	—	48
Cargo Handling in Ports		5 × 24	3 × 24	192
Total Round Voyage Time		453	333	786
	Weeks	786 : (7 × 24) = 4.7		
Ditto, with Weekly Departures		5		
Number of Voyages each Year <sup>1)</sup>	—	362 : (5 × 7) = 10.34		
Operational Time ME	Each Voyage	546 + 48 = 594		
	Per Year	594 × 10.34 = 6 142 ≈ 6 150		

<sup>1)</sup> 365 – 3 shipyard days = 362 service days each year

Table 4

Estimated Investment (Capital Costs) for Power Alternatives of the Ship Example					
Propulsion Plant Alternative		A	C	D	E
WHR Turbo Compound System (TCS)		—	Dual Pressure Steam plus Power Turbine		Single Pressure Steam Turbine
Cylinder Number ME		12		11	12
Power Savings		0	6 200	5 680	4 600
Output SM / SG		— / 2 000	6 000 / 2 000		2 000 / 2 000
Savings Invest ME		0	0	- 1 600	0
Investment	TCS	0	2 570	2 360	1 900
	Boiler	0	1 020	930	750
	SM / SG	150	1 780		660
	Total	150	5 370	3 470	3 310
Engineering + Performance Guarantee + Commissioning		50	1 330		830
Total Supply		200	6 700	4 800	4 140
Handling Fee (≈ 4.5%) <sup>1)</sup>		10	300	220	190
Assembly + Installation at Shipyard (≈ 20%) <sup>1)</sup>		40	1 340	960	830
Additional Investment	Total	250	8 340	5 980	5 160
	Diff. versus A <sup>2)</sup>	0	8 090	5 730	4 910
		0	10 270	7 280	6 240

<sup>1)</sup> Percentage of total supply costs  
<sup>2)</sup> Exchange rate: 1 EUR = 1.27 US\$, as valid in July 2006

Table 5

Power Dependent Yearly Operational Costs of the Ship Example at Fuel (HFO) Price 320 US\$/Ton					
Propulsion Plant Alternative		A	C	D	E
WHR Turbo Compound System Type		—	Dual Pressure Steam plus Power Turbine		Single Pressure Steam Turbine
Cylinder Number Main Engine (ME)		12		11	12
ME Output	MCR	68 640		62 920	68 640
	CSR = 0.9 MCR	61 780		56 630	61 780
WHR Savings <sup>1)</sup>		0	6 800	6 230	5 030 <sup>5)</sup>
Fuel (HFO)	S. F. C. <sup>2)</sup>	G/KW × H	171 × 1.05 = 179.5		
	Quantity of Savings	Tons/Hour	0	1.221	1.118
		Tons/Year	0	7 509	6 876
	Price	TU\$/Ton	0.320		
Yearly Fuel (HFO) Savings <sup>3)</sup>		0	2 403	2 200	1 777
Savings of Lube Oil (6.2%) <sup>4)</sup> and Maintenance (3.1%)		0	0	176	0
Total Yearly Savings of Operational Costs		0	2 403	2 376	1 777

<sup>1)</sup> WHR savings ≈ 11%, acc. to engine manufacturer for average old engine under tropical conditions  
<sup>2)</sup> Specific Fuel Consumption (S.F.C.)  
<sup>3)</sup> From Table Yearly operational time of the ME is 6 150 Hours/Year  
<sup>4)</sup> Due to one cylinder less and assumed proportional to the fuel savings, but only for the Alt. D  
<sup>5)</sup> Only 74% of the total waste heat recovered by Alt. C

- on eastbound voyages (Shanghai, China, to Long Beach, USA), container ships are heavily loaded, say between 75% and 100% of the maximum possible cargo capacity. The average draught on this voyage is around 11.50m, ie, less than the design draught of 13.00m
- on westbound (return) voyages, the cargo weight is much less, between 25% and 50% of the maximum, and 'missing' cargo is partially replaced by additional water ballast and/or by empty containers. Consequently, the average draught on the westbound voyage is lower, around 9.50m
- a remarkable fact is that, in practice, the rest of the propulsion power available on the shallower draught is not being used to increase the vessel's speed. Average speed does not fluctuate by more than one knot, and the explanation is that container ships are normally operated in pools and according to strict time schedules, mostly weekly departures. These facts allow for neither excessive service speeds nor delays.
- in Table 4, average values are taken as a basis for calculation of the minimum number of voyages (10.34) each year, which further leads to 6150 hours of average sea passage time, including sea time between Chinese ports. The number of voyages each year is needed for the calculation of economics.

#### Capital costs (investment)

In the present study, the additional capital costs required for the alternatives described above, have been estimated by the suppliers of these components. All these costs are shown in Table 5.

The investment required is an important parameter in economic calculations. Price data are also subject to negotiation. In the present study, the capital costs have been calculated in Euros by the suppliers, as is usual in Europe (Table 5). On the other hand, those power-dependent operational costs, mainly fuel costs, have been calculated, also as usual in shipping, in US dollars (Table 6). The exchange rate of €1.00 = US\$1.27 has been assumed (as an average valid value in July 2006).

#### Power-dependent operational costs

These costs are mainly generated by fuel, lubricating oil, and maintenance (labour and spare parts). The total of such costs is a function of the ship's service time at sea for a given time period, say a year. Corresponding calculations are clearly displayed in Tables 4 and 6:

- in Table 4, in order to obtain the total time required for a round voyage to be performed, calculations were made in hours first, then transformed into weeks, and afterwards rounded up to whole numbers of five weeks. This procedure takes into account that such ships are operated in pools with weekly departures
- in Table 6, fuel consumption of the main engine has been determined by hours each year. The specific fuel consumption values

Table 6

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given by the main engine manufacturer in the company's technical documentation have been used, and an allowance of at least 5%, also customary, was then added. Good agreement was found between recorded and calculated data

- consumption of cylinder oil of the chosen two-stroke main engine has been determined in the same way. The other kind of oil for such engines, system oil, is economically insignificant and was omitted. Maintenance costs have also been calculated based on documentation offered by the main engine manufacturer. Costs for both lube oil and maintenance have been added and referred to as the established percentage (9.3%) of the annual fuel costs
- finally, the total savings of annual operational costs were calculated with the updated HFO prices of July 2006.

### Evaluation of economics

In previous sections, the additional capital and operational costs due to the proposed propulsion plant alternatives were determined for the 7500TEU-plus container ship taken as an example and for the voyages investigated. Savings on the operational costs by introduction of the WHRS have been assumed to be around 11% - the mean value of the range indicated by the engine manufacturer (between 10% and 12%) for an average old engine under tropical conditions.

#### Assumptions for calculations:

- ship's operational life = 20 years
- interest on borrowed capital = 6%
- capital costs (investment) required, ie, price data of main components and mounting work, taken as obtained from suppliers (Table 5)
- savings of operational costs, only when power-dependent (Table 6)
- investigated impact of fuel (HFO) price is displayed in Tables 7a, 7b and 7c
- assumed exchange rate: €1 ≅ US\$1.27

These are all average values, valid in July 2006.

### Sensitivity analysis

When researching the economics of ship propulsion plants, the most difficult parameter is the fuel price. On one side, it is a determining factor for the economy of those plants and, on the other side, fuel prices undergo great fluctuations. In July 2006, heavy fuel prices were lying between US\$320 and US\$350/tonne, depending on the location of bunker suppliers.

Taking into consideration the actual world energy and political scenarios, a decline in oil prices cannot be expected in the near future. In fact, the trend is quite contrary; therefore, for updating in a sensitivity analysis, the following range of fuel prices has been seen as most adequate: US\$320/US\$350/US\$380/tonne.

### Economic criteria of merit

In the current case study, the economical criteria-of-merit 'pay-back period' (PBP) and 'net present value' (NPV) have been used.

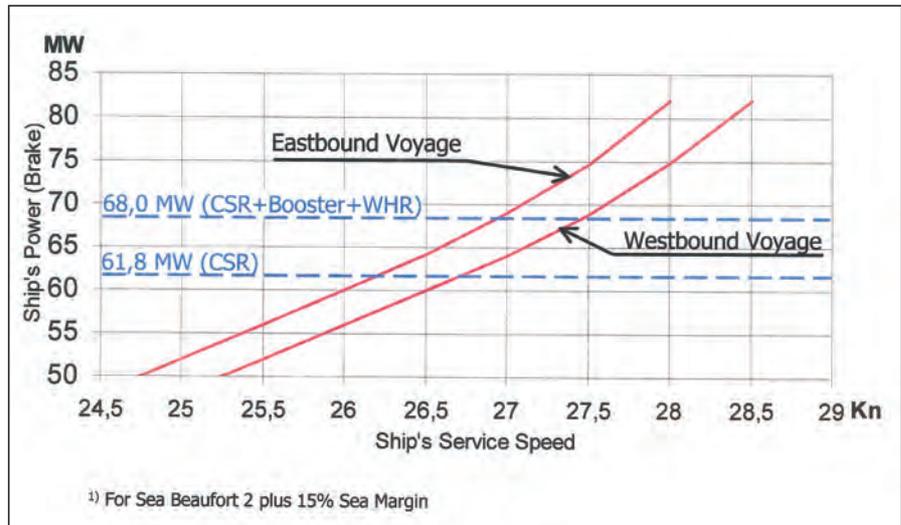


Fig 5. Propulsion power versus service speed on typical voyages of the example ship.

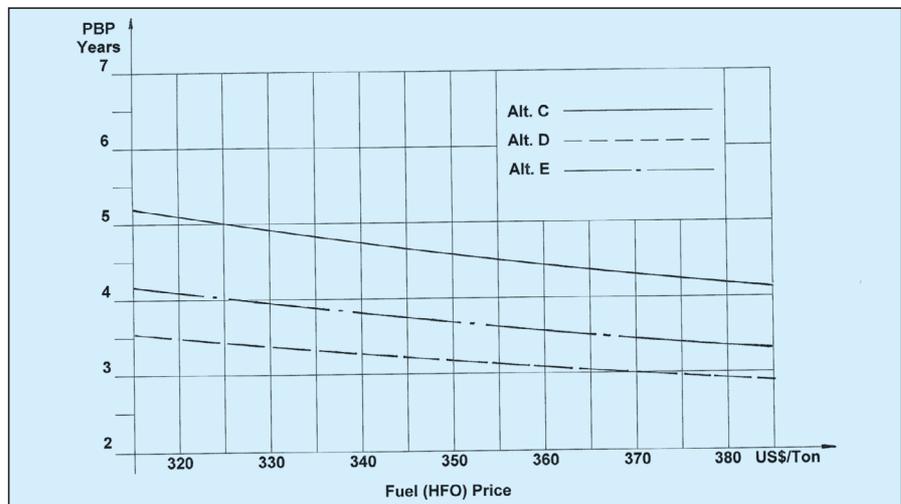


Fig 6: A graph illustrating pay-back period (PBP) as a function of heavy fuel (HFO) prices.

- PBP is the time it takes for the savings to pay back the additional investment. The PBP is suggestive and a frequently-used criterion when comparing alternatives by shipowners, too. However, the PBP criterion does not indicate the benefit during the rest of the ship's operational life, after the date when the whole additional investment has been paid back
- NPV criterion is generally recognised as the most logical and objective. It stands for the present value of all the additional revenues or, in this case, of all the operational costs savings made by the WHRS over the entire operational life of a ship, after deduction of the additional investment for it

### Results

The results of the calculations for all the propulsion plant alternatives investigated are given in Tables 7a, 7b, and 7c, and are graphically displayed in Figs 6 and 7.

### WHRs contribution to environmental protection

Climatic changes and protection of the atmosphere against harmful gases emitted by marine diesel engines are important items on the agenda of international organisations,

governments, political parties, customers, and suppliers of goods of any kind. Of such gases, the main ones are oxides of nitrogen (NOx), sulphur (SOx), and carbon (COx).

Unfortunately, all devices and measures used to reduce emissions cost money to be installed and operated. Emissions of diesel engines depend on how much fuel is being burnt and are a function of propulsion and auxiliary power required on a ship.

Thus, logically, a WHRS adopted primarily to reduce fuel consumption, ie, operational costs by, say, 11%, will have an attractive costs-free benefit as by-product, consisting of approximately the same amount of emissions reduction.

With reference to the available practical measures for the reduction of each of three main gases, the impact of a WHRS is as follows:

- regarding NOx, a lot of research has already been carried out, and progress achieved by engine manufacturers. Diesel engines now comply with the requirements of MARPOL 73/78 Convention of the IMO, Annex VI. A WHRS contribution through a reduction in the quantity of fuel burnt is supplementary in this case, too
- with reference to SOx, the benefits brought by a WHR in this case are even more interesting and should be appreciated,

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Economics of Propulsion Plant Alternatives for the Ship Example and Fuel Price = 320 US\$/Ton						
Propulsion Plant Alternative		A	C	D	E	
WHR Turbo Compound System Type		—	Dual Pressure Steam plus Power Turbine		Single Pressure Steam Turbine	
Cylinder Number ME		12		11	12	
Additional Investment <sup>1)</sup>		TU\$	0	10 270	7 280	6 240
Fuel (HFO) <sup>2)</sup>		TU\$	0	2 403	2 200	1 777
Price Factor		1.0				
Fuel Costs Savings		TU\$ / Year	0	2 403	2 200	1 777
Lube Oil and Maint. Savings <sup>2)</sup>		TU\$ / Year	0	0	176	0
Total Savings		TU\$ / Year	0	2 403	2 376	1 777
Capital Recovery Factor		—	0	0.2340	0.3264	0.2848
Pay Back Period (PBP) <sup>3)</sup>		Years + Months		5Y + 1M	3Y + 6M	4Y + 1M
Net Present Value (NPV) <sup>4)</sup>		TU\$	0	17 290	19 970	14 142

<sup>1)</sup> From Table 5 versus Alt. A  
<sup>2)</sup> From Table 6 versus Alt. A  
<sup>3)</sup> At 6% interest  
<sup>4)</sup> Ship's operational life = 20 years

Table7a

Economics of Propulsion Plant Alternatives for the Ship Example and Fuel Price = 350 US\$/Ton						
Propulsion Plant Alternative		A	C	D	E	
WHR Turbo Compound System Type		—	Dual Pressure Steam plus Power Turbine		Single Pressure Steam Turbine	
Cylinder Number ME		12		11	12	
Additional Investment <sup>1)</sup>		TU\$	0	10 270	7 280	6 240
Fuel (HFO) <sup>2)</sup>		TU\$	0	2 403	2 200	1 777
Price Factor		350 : 320 = 1.094				
Fuel Costs Savings		TU\$ / Year	0	2 629	2 407	1 944
Lube Oil and Maint. Savings <sup>2)</sup>		TU\$ / Year	0	0	176	0
Total Savings		TU\$ / Year	0	2 629	2 583	1 944
Capital Recovery Factor		—	0	0.2560	0.3548	0.3115
Pay Back Period (PBP) <sup>3)</sup>		Years + Months		4Y + 7M	3Y + 2M	3Y + 8M
Net Present Value (NPV) <sup>4)</sup>		TU\$	0	19 880	22 350	16 050

<sup>1)</sup> From Table 5 versus Alt. A  
<sup>2)</sup> From Table 6, versus Alt. A  
<sup>3)</sup> At 6% interest  
<sup>4)</sup> Ship's operational life = 20 years

Table7b

Economics of Propulsion Plant Alternatives for the Ship Example and Fuel Price = 380 US\$/Ton						
Propulsion Plant Alternative		A	C	D	E	
WHR Turbo Compound System Type		—	Dual Pressure Steam plus Power Turbine		Single Pressure Steam Turbine	
Cylinder Number ME		12		11	12	
Additional Investment <sup>1)</sup>		TU\$	0	10 270	7 280	6 240
Fuel (HFO) <sup>2)</sup>		TU\$	0	2 403	2 200	1 777
Price Factor		380 : 320 = 1.188				
Fuel Costs Savings		TU\$ / Year	0	2 855	2 614	2 111
Lube Oil and Maint. Savings <sup>2)</sup>		TU\$ / Year	0	0	176	0
Total Savings		TU\$ / Year	0	2 855	2 790	2 111
Capital Recovery Factor		—	0	0.2780	0.3832	0.3383
Pay Back Period (PBP) <sup>3)</sup>		Years + Months		4Y + 2M	2Y + 11M	3Y + 4M
Net Present Value (NPV) <sup>4)</sup>		TU\$	0	22 480	24 720	17 970

<sup>1)</sup> From Table 5 versus Alt. A  
<sup>2)</sup> From Table 6 versus Alt. A  
<sup>3)</sup> At 6% interest  
<sup>4)</sup> Ship's operational life = 20 years

because SOx can practically only be limited through the chosen quality of a more expensive fuel and of the burnt quantity

- regarding the percentage of sulphur content in fuel, there are three limits to be considered, as prescribed by the Sulphur Directive 1999/32 issued by the EU.
- in the case of COx (CO<sub>2</sub>), some activities have been initiated and performed by IMO and the EU as well. On August 1 2005, the Marine Environment Protection Committee (MEPC) of IMO issued 'Interim Guidelines for Voluntary Ship COx Emissions Indexing for use on Trials'. It can be expected that the corresponding rules and regulations will be further pursued and improved. Consequently, the contribution of the WHRS in this direction will gain ground, too.

## Conclusions

### Input data

The conclusions (below) of this study have been drawn based on collected input data and performed calculations. These are realistic, the authors believe, because:

- calculations are based on an actual ship example
- three out of 12 operational records of voyages were selected
- technical directors of three shipping companies have been consulted.

### Main engine of the example ship

The large container ship, taken as an example on typical round voyages and with fixed sailing schedules, needs 5% to 10% less propulsion power on return voyages. Therefore, for part of the service time, the engine operates at reduced load. The conclusion is that one cylinder of the main engine could be eliminated if substitute power (WHR and a booster) could be provided in special cases.

### Booster, WHR and power management systems

These systems are attractive, because:

- additional propulsion power is offered
- for the same power demand, fuel is saved
- emissions are also reduced by about the same amount
- less fuel also means reduced bunker tanks capacity and piping, ie, building costs
- no sacrifice in cargo hold space is required
- moreover, for Alternative D (a main engine minus one cylinder), less engineroom length is needed.

### Operational data

With the propulsion power supplied by the main engine at its CSR output together with the waste heat recovery plant (Table 3), the loaded ship's speed for Alternative A (without WHRS) is 26.20knots, whereas for Alternative C, it is higher (26.80knots). The conclusion is that the extra investment required for Alternative C offers as a reward a surplus in speed, useful to recover ship delays. In the present case, the calculated

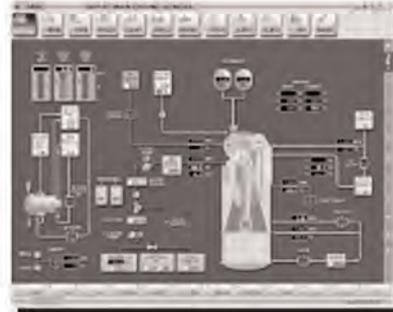
Table7c

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recovery, due to a booster and WHR plant, is five and a half hours, say six hours, for each one-way voyage.

**Economics**

Three alternatives have been investigated (Tables 1 and 3) versus Alternative A = conventional propulsion plant (as follows):

- Alternative C = Alternative A + Booster + WHRS (power turbine and dual-pressure steam turbine)
- Alternative D = Alternative C, minus one main-engine cylinder
- Alternative E = Alternative A + Booster + simplified WHRS (only single-pressure steam turbine).

The first economic criterion used, the pay-back period (PBP), is the time needed in years and months to pay back the investment: for the mean value of the investigated fuel price range (US\$350/tonne, Table 7b), the obtained PBP values are:

- Alternative D..... 3 years + 2 months
- Alternative E..... 3 years + 8 months
- Alternative C..... 4 years + 7 months

The conclusion is that all PBP values are excellent (surprisingly low), whereby Alternative D (with one main-engine cylinder less), needing the shortest PBP, is the best.

The PBP, under the impact of fuel price fluctuations of plus/minus US\$30/tonne for all alternatives, is respectively shorter or longer by approximately half a year or less.

The second economic criterion used, the net present value (NPV), is the sum of all the additional revenues (operational costs savings) made over the entire operational life of the ship, after deduction of the additional investment: at the same assumed fuel price of US\$350/tonne, the NPV values of the savings (Table 7b), in US dollars, are (rounded values):

- Alternative D..... US\$22 million
- Alternative C..... US\$20 million
- Alternative E..... US\$16 million

The conclusion is that all the above NPV values are impressive saved sums and, from

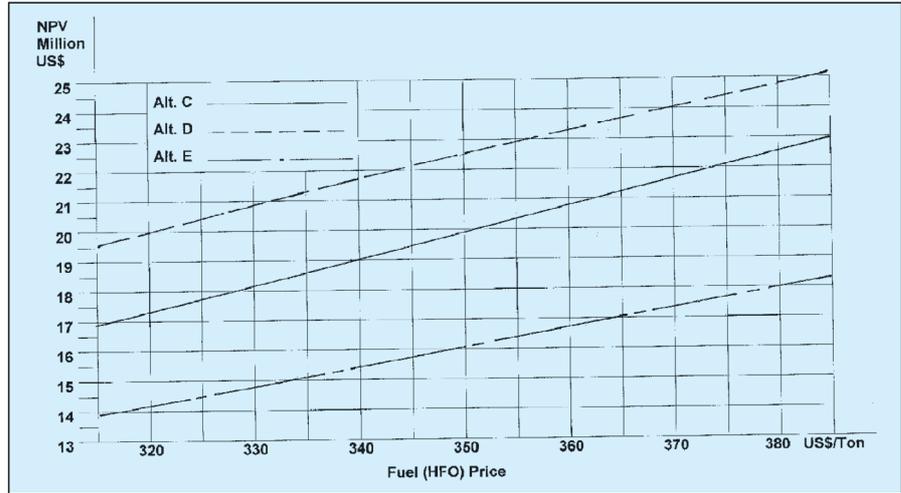


Fig 7. A graph illustrating net present value (NPV) as a function of heavy fuel (HFO) prices.

the NPV perspective, Alternative D is the best, with Alternative E the least beneficial. Fluctuation in fuel prices by plus/minus US\$30/tonne changes the NPV results respectively by approximately US\$2 million or more.

In summary, an interesting conclusion of this study, which goes against the general trend, is that, in cases of high power demand, the best solution is not always to choose the maximum number of main-engine cylinders (12 or 14), but to reduce their number and to add a WHRS to the propulsion plant.

A supplementary conclusion is that the WHRS presented here is beneficial not only for large container carriers but also for other large merchant ship types, such as tankers, bulk carriers, OBOs, or even ro-ro vessels. However, the PBP of the additional investment required for the WHRS for such ships would be logically longer due to the lower propulsion power and respective savings involved.

Approximate calculations carried out for Suezmax tankers and Capesize bulk carriers have shown that the PBP, for the highest fuel price assumed here, will exceed the PBP values calculated in the present study by

approximately three to four years each. More accurately detailed, tailor-made calculations are possible in a similar way.

**Conclusions regarding environmental protection**

A WHRS plant can reduce exhaust gases by round 11% and thus also their content of NOx, SOx, and COx. Therefore, it is always better to cure the causes than their negative effects, and in this case, too.

Annex VI of the IMO's MARPOL regulations, which came into force in May 2005, as well as the Sulphur Directive 1999/32 of the EU in 2005, plus the upcoming ones in 2007 and 2008, will augment pressure on owners and charterers to operate so-called 'green' ships. Therefore, the contribution to emissions reduction of WHR systems will be increasingly appreciated in the near future.

Emissions reduction valid for all kinds of harmful gases, as a by-product of a WHR system, does not need nor cost anything extra. Therefore, alternative propulsion plants, including WHR, are attractive proposals not only from an economical but also an environmental perspective.

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# New coating system with power feeder launched

The coatings industry, like so many others, has become increasingly concerned with environmental problems and continually seeks methods and materials that are less hazardous and wasteful. Among the concerns are the environmental problems associated with volatile organic compounds (VOCs), which led the US Environmental Protection Agency (EPA) to embark on a programme to remove VOC-bearing coating materials from the market as alternatives became available. This effort continues today with increased urgency. Painting contractors facing increasing regulatory pressure in the use and handling of all paints are looking for viable alternatives. In this article by Thomas Gardega, executive vice-president, and Linda Comac, director of marketing, Xiom Corp, New York, USA, discuss a new type of coating system and some new polymers, both with possible relevance to shipbuilding.

**B**EGINNING in the 1960s, the electrostatic powder spray process (EPS) became the standard for applying organic polymer coatings. This process is commonly referred to as 'powder coating', and EPS is applied to plastic powder coatings followed by oven curing at approximately 400°F, where melting and film formation take place. In the early to mid-1980s, having little or no VOCs was one of the recognised benefits of factory powder coating.

Other benefits included reduced waste, easier clean-up, good barrier protection, and reclaimable and re-usable overspray. However, the materials, methods, equipment, and knowledge of applications still had a long way to go.

Even in the early days, shop powder coaters and field paint contractors were expressing both a desire and the need to apply powder paint on site.

The thermal spray industry attempted to address this need, beginning with the flame spraying of thermoplastic powders. But 20 years ago, results were not too promising.

Two main problems were behind this disappointing beginning. First, the materials available then were limited and not as advanced as now. Second, the thermal spray equipment available was not suitable for low-melting-point polymers.

The plastic powders being sprayed were the same as those used in the EPS process. No effort was made to modify powder particle size distribution to meet the requirements of thermal spraying. In addition, no effort was made to design new polymer coating formulations for on-site thermal spraying. Coating adhesion, function, and decorative value suffered as a result.

The thermal spray equipment was not suitable for low-melting-point polymers. It had been designed primarily for spraying high-melting-point-metal powders and then adjusted to handle polymer powders. These modifications did not



The Xiom1000 system, seen here being applied on a small-craft hull, solves the problems of temperature and inconsistent feed rate with a patented gun and powder feeder.

adequately prevent polymer powders from overheating and burning; therefore, coatings did not always achieve their intended physical and chemical function.

Flame temperatures designed to melt metals were far too high for powder paint polymer feedstock materials. Propane is the normal heat source required for these materials because it has a lower flame temperature but higher BTU content than acetylene. In addition, propane hoses can safely be run at longer distances, and historically propane is more economical. Simple propane/air and propane/oxygen mixtures have been tried, but both produced too high a temperature to successfully deposit low melting-point materials.

In addition, existing powder feeders could not provide simple, inexpensive, consistent, and reliable feed rates. A consistent feed rate is particularly important for low-melting-point polymer materials because there is a small window between the melting point and ignition. Also, if the feed rate load is too high or is pulsing, polymer materials can act as a fuel source. This was the main problem with previous technology.

Besides having too high a temperature and material feed pulsing, previous technology consumed up to 50% of the coating material and in many cases, even damaged the substrate. The flame measured up to 304mm long, and the

temperature was increased by the ignition of the feedstock material. The increased flame temperature was a further detriment to the coating once it was deposited.

Today, as job shop powder coaters face increased competition, many see the on-site market as untouched potential. Recent attempts by the thermal spray industry to provide equipment for field-applied powder coats have had more success than the earlier efforts, but this is mostly due to improved materials. Efforts in equipment development failed for one major reason: plastic powders often act as a fuel source and a short 76mm flame becomes a 0.6m-0.9m flame if the heat source's temperature is too high for the powder material being applied.

Now, Xiom Corp claims it has solved both problems of temperature and inconsistent feed rate with a patented gun and powder feeder. In its system, oxygen and propane gas are mixed by means of a chambered double-reversing vortex, eliminating the complicated siphon plug of previous systems. This is a simple device that is easy to machine with few parts.

Also, the nozzle of the gun provides for a shroud of air between the flame and the feed stock polymer material, which clips and reduces the flame temperature. Additionally, an air distributor cap creates a compression wave, which allows for the rapid transfer of heated air to the material to be melted.

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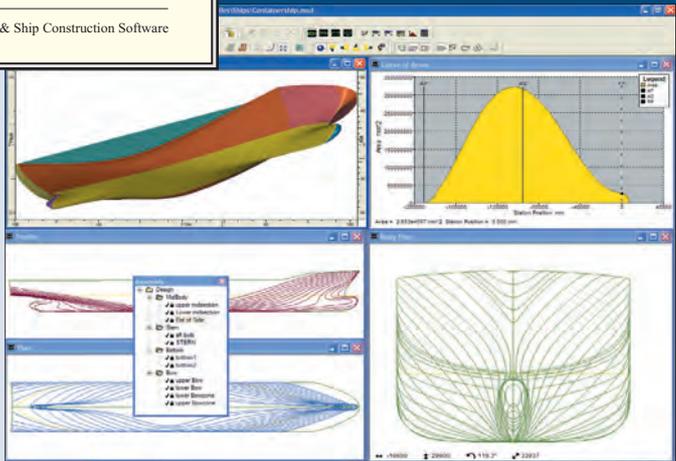
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The compression wave is analogous to a pressure cooker; however, it is an open rather than closed system. The gun has a visible 25mm to 76mm flame, and polymer feedstock material is visible as a stream beyond this point. The system does not consume the material and can achieve deposit efficiencies of up to 99%.

#### Patent powder feeder

The second breakthrough of this system is a patented powder feeder. This simple and inexpensive feeder provides stable material feed due to its open coupled double venturi. This approach eliminates all pocketing of material in the feed hose. Back-pressure surging is virtually non-existent and has no effect on the feed rate.

The flaw of all prior powder feeders is that they have one venturi, which siphons up the material from either a fluid bed or feed screw and then conveys it to the nozzle discharge. However, the material feed rate and material delivery rate are two separate functions and therefore require two separate venturis.

The material feed rate must be matched to the available BTUs and system geometry for each separate material. In addition, the material delivery rate must be matched to the dwell time and/or particle velocity required to melt the material.

In existing powder feeders, material builds up in the feed hose, creating a back pressure, which reduces the vacuum of the single venturi. The material rate is constantly changing and the

delivery of material is constantly pulsing and surging. This problem increases with hose delivery length.

The Xiom powder feeder is designed to work with thermal spray equipment and in factory powder paint systems. The total system consists of the powder feeder, console and hoses and weighs approximately 318kg.

#### Other advances

Xiom Corp has also designed a line of mixed polymers that are completely free of VOCs. Little or no preheat is required to easily apply the materials to a wide range of materials, including metals, glass fibre, plastics, and wood.

Powder innovation is particularly evident in coating adhesion to various substrates without the need for liquid primers. Surface preparation for most substrates now requires only cleaning and roughing to achieve reliable and reproducible bonding.

For instance, Xiom is claimed to be the first to produce thermal sprayed epoxy/zinc primer/bond coatings delivering very high quantities of zinc to the substrate for corrosion control. These epoxy/zinc primer coatings were designed for secure bonding to steel substrates and to enhance bonding of sprayed plastic coatings by leaving a suitable rough surface for proper adhesion. Xiom also produces grip and release coatings, coatings for tank linings, concrete and steel structures, and anti-microbial coatings for surfaces that come in contact with food and water.



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# Tsuji's factory extends output to complete ships

The Chinese plant of Japanese manufacturer Tsuji Heavy Industries has now added complete ships to its portfolio. Trader-class standard bulkers have been chosen as the first project, and these are being assembled, using an on-ground technique.

IN 2002, Tsuji Heavy Industries, the Japanese company primarily known for its hatch covers and cranes, opened a wholly owned large-scale manufacturing facility in China, known as Tsuji Heavy Industries (Jiangsu) Co Ltd. This Zhangjiagang factory covers 330,000m<sup>2</sup> of land located on the Yangtze River, and close to Shanghai, and was mainly planned to fabricate hatch covers and ship sections. The company employs around 1700 Chinese workers, with a Japanese management team.

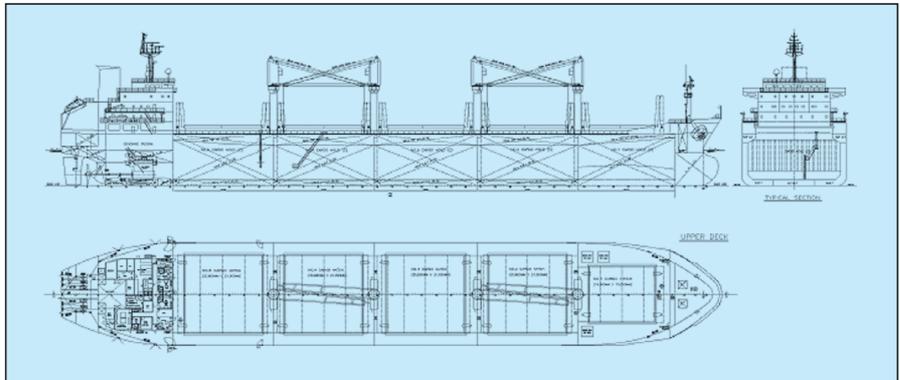
In addition to what is claimed as the world's largest single-line hatch cover plant, Tsuji started producing megablock hull sections, enginerooms, superstructures, and funnel casings as a subcontractor for major Japanese shipbuilders (*The Naval Architect*, February 2004, page 78, and February 2005, page 94)

With average capacity having reached up to 8000tonnes of steel monthly, the company was looking for further expansion opportunities. The chance came when earlier this year the Chinese government granted Tsuji Heavy Industries China permission for the building of commercial vessels up to 100,000dwt.

In May, the company succeeded in winning its first contract - for a series of 12 30,000dwt Handysize bulk carriers, with deliveries up to the end of 2009. Tsuji becomes the third Chinese licensee for the Trader design (the other two being Shanhaiguan and Nantong),



The Jiangsu site of Tsuji Heavy Industries is located in Zhangjiagang, on the Yangtze River. At first, this shipyard was set up to produce megablock hull sections, engine rooms, superstructures, and funnel casings but had now added complete ships to its portfolio. The latter are constructed using an on-ground technique without a berth or drydock.



General arrangement plans of the 30,000dwt double-hull Trader bulk carrier, created by GTR Campbell and Algoship Designers.

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Gross.....	20,000gt
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which was created by GTR Campbell and discussed in *The Naval Architect* March 2006, page 12. The choice of a standard design from a respected consultancy should certainly help to speed production. Focus will remain on the building of vessels of this type, which Tsuji claims is an underdeveloped niche market.

The ships will be built on land without a drydock or slipway, using the APS air-pad system with skid rail, now in use at several Korean and Chinese shipyards. Further large investments will be made in the shipbuilding facilities, including additional hull section manufacturing factories, a second painting factory, and yard cranes. The first ship is anticipated for May 2007 delivery, and the last in February 2009.

### Benefits of the Trader design

The double-hull bulk carrier Trader design complies with latest IACS common structural rules and IMO regulations, and the first examples are now being delivered from the Cochin Shipyard in India for the Clipper group. The series has been designed by GTR Campbell, in cooperation with its associated concept design firm - Algoship Designers Ltd, of the Bahamas.

In the past, Algoship has developed other advanced double-hull Handysize bulk carriers

such as the Fantasy and Valiant types (built at Dalian Shipyard), also the double-hull Handymax bulk carrier of the Galaxy type. Algoship was also instrumental in introducing the Fortune Mk 2 and Festiva-type Handysize single-skin bulkers. All these were built at various Chinese yards. Tsuji has also retained Mastek Heavy Industries, of Busan, Korea, a company closely associated with Algoship, to carry out the basic and detail design.

The highly optimised Trader design incorporates advanced machinery and equipment with safe margins, high-specification coatings including tar-free light-coloured paints for ballast tanks, tin-free antifouling paints with 60 months life, and a 1300mm-wide double hull giving ample access for surveys and inspections.

The characteristic Algoship wide hatches (75% of the beam) with minimum overhang, large cargo hold tanktop footprints with small side hoppers and square bulkhead stools, and four sets of 30tonne Tsuji cranes fitted with radio-controlled grabs, enable the Trader design to handle cargoes without the need for equipment such as forklifts or pay-loaders. So far only Cochin Shipyard, India, has delivered any Trader vessels, in April and August this year. The first Shanhaiguan Trader is expected to be delivered this month. ⚓



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The relationship between Germanischer Lloyd and Qingshan Shipyard started in 1996 with the construction of four 818TEU multipurpose vessels of 9000gt for a German owner; the first ship was delivered in 1996. Since then, 27 vessels have been completed, and a further 33 ships are under construction or on order. In total, more than 750,000dwt has been constructed with GL class at Qingshan Shipyard.

Qingshan Shipyard, part of the China Changjiang National Shipping Group, has over 50 years experience in shipbuilding. It has 3800 employees and is located at Wuhan on the Yangtze River. Up to seven vessels of a maximum 50,000dwt and 220m length can be constructed simultaneously. Qingshan Shipyard claims to have the biggest ship export base in the province, its main deliveries including oil and chemical tankers.

Since 1996, GL has inspected and provided service for many vessels built at Qingshan, including 502TEU, 660TEU, 818TEU, and 1100TEU container vessels; a 12,000dwt bulk carrier series; and 18,500dwt chemical/products tankers. Output has improved rapidly from an original two vessels annually to more than eight vessels in 2006.

GL has built up a large network in China, serving shipyards, the supply industry, and shipping companies. More than 350 container ships, multipurpose vessels, bulk carriers, and oil/chemical tankers are on order at almost 50 shipyards to Germanischer Lloyd class.

GL has bases in Shanghai, Dalian, Guangzhou, Hong Kong, Jiangyin, Nanjing, Wuhan, and Kaohsiung (Taiwan), and in March 2006, this class society also opened a new station in Ningbo. Two additional stations will be opened within the forthcoming months.

Shanghai is the location for the principal country office, as well as being the area office for China, the approval centre for east Asia, and the division office for east Asia. In total, GL employs a workforce of over 175 people in the China region. Ⓢ

## Second of six tankers named

HELLESPONT Hammonia has named the first and second of its six new tankers, *Hellespont Pride* and *Hellespont Progress*; they are under construction for the company at New Century Shipbuilding Co Ltd, in Jingjiang, China. These Panamax product carriers are the first two in a series originally ordered in 2004 by Seatramp Tankers Inc. Charterer of both ships is the Sanko Steamship Co Ltd, of Tokyo, Japan. The vessels will be managed by Hellespont Hammonia GmbH &

Co KG, a joint venture between the Hellespont group, from Piraeus, and Hamburg-based Peter Döhle.

The two ships have an overall length of 228.60m and a deadweight of 73,400dwt on a scantling draught of 14.30m. Cargo capacity is 85,300m<sup>3</sup>, and each is powered by an MAN B&W 5S60MC-C slow-speed engine with an output of 13,830bhp at 101.4rev/min. The ships will be ABS-classed and registered in the Marshall Islands. Ⓢ

## New single-nozzle tank-cleaning machine

TO help overcome some of the difficulties discussed in last month's Editorial Comment, Alfa Laval has launched a new single-nozzle tank cleaning machine for product and chemical tankers, the Gunclean Toffejorg i65S. This can be supplied as a single- or a multi-level unit. Of course, to extract the best benefits for such a unit, operators should use it in association with a properly designed overall system, which includes the use of the G-Pass software.

The principal feature of the new machine is the employment of an hysteresis clutch, which aims to overcome potential problems of a magnetic coupling. In the case of the latter, two strong magnets are installed, one on the turbine side and an opposing one on the gear side. The two have to be synchronised in order for the machine to operate but they can slip and remain disconnected in the event of water hammering or sudden pressure surges - common features at the start of a cleaning cycle. When this happens, the nozzle does not rotate and the cleaning cycle stops.

An hysteresis clutch - well known in other industries - comprises an hysteresis plate on one

side and six 'supermagnets' on the other. This arrangement creates an even magnetic field that does not require synchronisation, and allows the clutch to act as a soft starter for effective engagement of the transmission.

In addition, the hysteresis clutch design gives protection against leakage and cross-contamination, since speed adjustment is built into the clutch itself and does not require a separate adjustment shaft on the turbine side, with its necessary extra deck penetration. The latter is a potential source of seal failure, which can increase the risk of gas leakage and contamination of sensitive cargoes. As a result of the new design, speed adjustment on individual pumps is easily made by removing the top of the gear unit and adjusting the relationship between the magnets and the hysteresis plate.

Extra features of the i65S designs include an improved turbine design and use of ceramic balls and plates in place of traditional steel or Teflon ball bearings. The new design is currently being tested on a 16,500dwt chemical tanker. Ⓢ



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## New electric solid-top cooker range launched

FOR more than 80 years, the Greece-based company Aluminox SA has been producing galleys and galley equipment for the marine industry. Recently it has released a new product, an electric solid-top cooker range.

The patented solid-top range replaces the usual hot plates with a 1.5cm thick plate of satin-finish steel, divided in two heating zones. This plate of special steel is said to give up to 100% heat capacity at the surface of the cooking plate, needing less energy and providing better cooking quality with a uniform heat transfer over the whole cooking surface.

This range is said to answer two basic problems within a galley: that of hygiene and maintenance cost. Lack of gaps on the solid plate give the maximum level of hygiene, and the U-shaped channel around the plate makes it easy to clean. The only elements that require replacement, in case of failure, are those for heating which means that, in general, repairs are quick, easy, and low-cost.

A number of shipyards use Aluminox products, including Hyundai Heavy Industries, DSME, China Shipbuilding Corp, Fosen Mek Verksteder, Namura Shipbuilding Co, and Shanghai Waigaoqiao. Aluminox offers a variety of products, such as equipment for preparation, cooking, food serving, dish washing, bar and pantry items, refrigeration and laundry gear, as well as self-service and stainless-steel furniture. All appliances have CE approval so they comply with European Community quality standards, and the production procedure is ISO 9001

certified. In addition, the company has developed its production to meet the strict regulations of the United States' Public Health authority.

Aluminox has also developed a technical support department. Engineers and designers,

using CAD systems, are able to provide the most efficient layouts and technical drawings tailored to the specific needs of each customer. The company offers this service to its customers free of charge. ⚓



**This new electric solid-top cooker provides 100% heat capacity at the surface of the cooking plate.**

## Fuel savings with an improved hull form

FUEL costs take an increasing share of operational costs of ferries and cruise ships - even more so today in an era of high prices. It is therefore extremely important to ensure the best possible performance for a hull form, for all prevailing service conditions.

In the past, Deltamarin, of Finland, has developed modern hull forms with high-performance characteristics in heavy seas, shallow water, narrow channels, restricted harbours, and other service requirements. Recent successful applications in ferries and cruise ships include wave-piercing stems, bulbous bows, and trim wedges incorporated into a ducktail. However, this consultancy's most recent invention is the Interceptor configuration.

Interceptor is a plate, a simple solution, which can be designed and installed easily, even on to existing ships. It comprises an immersed plate under the transom, which is faired into the hull forward, normally for a short distance. As a simple construction piece, it is relatively easy to manufacture and the weight is only a few tonnes. The payback time should therefore be short, it is anticipated.

The optimum design for fairing for the first test cases was carried out and verified, using the Ranse-type CFD code, by Safety at Sea, in Glasgow (with whom Deltamarin has

previously worked on various projects). Model tests at MARIN, in Wageningen, The Netherlands, for a cruise liner showed an improvement of up to 10% in propulsion power. The reference level was reached with a ducktail and the interceptor installed underneath.

The performance level with the reference hull shape without an Interceptor was already considered good in comparison to present industry standards. Several test series are still ongoing for different types of applications in ferries and cruise ships, both newbuildings and retrofits.

Other areas of potential fuel savings include optimising all recesses, such as those associated with fin stabilisers, sea chests, and bow thruster tunnels, as well as ensuring optimum surface roughness of a hull, and efficient painting systems. Savings of 10%-18% have been reached with the best combinations of bulbous bow, ducktail, interceptor/trim wedge, and optimised recesses.

### Engineering office established

As reported briefly in our May 2006 edition, Delta-Sigma Ltd (the owner of Deltamarin Ltd and Deltamarin Contracting Ltd) and the Chinese state-owned company Shandong

Shipbuilding Heavy Industries Co Ltd have established a joint venture company to provide technical and engineering services to Chinese shipbuilding and marine industry markets.

The new company is called Shandong Deltamarin Ship Design Co Ltd, and its office is located in Weihai City, Shandong Province. The company will start working with personnel of around 30 people, the majority of them coming from the engineering department of the shipyard. In the beginning, most of the engineering will be provided to local shipyards but in coming years the number of personnel will rise to approximately 100 and the market expanded, respectively.

Mr Wu Jian Chun, former director of engineering at the shipyard, has been appointed as managing director of the new company. Shandong Deltamarin will provide to its customers advanced quality engineering with a competitive price. Together with the Deltamarin group of companies, the joint venture will produce more efficient ship concepts, contemporary basic design solutions, and production-friendly detail engineering. By integrating the services to the overall portfolio of Deltamarin Group, the entire field of engineering including project management, planning and procurement support will be covered. ⚓

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# Advanced diesel-electric tankers for Everard

David Tinsley reports on some of the newest advances in a sector that continues to grow rapidly.

**A**N innovative new class of diesel-electric coastal tanker now being introduced into the fleet of UK shortsea specialist FT Everard & Sons provides a showcase for design and integration skills of The Netherlands-based company Imtech Marine & Offshore. Series-leader *Speciality* was introduced to the UK and northwest European distributive trades earlier this year. The schedule for the subsequent three vessels of the 4426dwt design foresees deliveries at six-month intervals from the Qingshan Shipyard at Wuhan, in China's Hubei province.

This Everard series is based on the Skipskonsulent SK4210 design, and represents a further advance on the *Asperity* class of ships, built by Singmarine Dockyard & Engineering, which set a new industry benchmark in the shortsea field when introduced in 1997. One of the distinguishing features of the latest project is the owner's adoption of the diesel-electric mode, chosen for reasons of cost-effectiveness, operational flexibility, and minimised environmental impact, particularly as regards low external noise signature. The powering system enables engine loadings to be optimised and emissions reduced, while the multiple prime move arrangements also confer a high level of redundancy.

Imtech was nominated to provide each shipset of automation equipment, main switchboards, motor control centres, and electric motors, including the propulsion frequency regulators, bow thruster drive, and the cargo, ballast, and slop pump drives.

The six main generator sets - a large number by most standards - were supplied by the German company Lindenberg-Anlagen, and comprise



An impression of the new class of 4426dwt coastal product tankers now entering service with FT Everard, headed by *Speciality*. A significant feature is the choice of diesel-electric machinery, using Imtech electrics.

## TECHNICAL PARTICULARS *SPECIALITY*

Length, oa.....	95.14m
Length, bp.....	87.11m
Breadth.....	17.12m
Depth, to main deck.....	7.71m
Deadweight, summer.....	4426dwt
Draught, summer.....	5.89m
Gross tonnage.....	3859gt
Cargo capacity (98%).....	4510m <sup>3</sup>
Slop tank.....	42m <sup>3</sup>
Cargo pumps.....	6 x 375m <sup>3</sup> /h
Main generators.....	6 x 486kW
Propulsion motors.....	2 x 900kW
Speed, service.....	11.50knots
Speed, maximum.....	13.00knots
Class.....	Lloyd's Register +100A1 Double Hull Oil Tanker, ESP, LI, EP(V), +LMC, UMS, PMR*, CCS, ICC, ShipRight (SERS, SCM), SBT

MAN high-speed diesel engines driving Leroy Somer alternators. The prime movers are D2840 models, producing 486kW at 1800rev/min.

All motors onboard are driven by frequency regulators to a total power of 3.2MW, comprising two 900kW water-cooled frequency converters for main propulsion, a 350kW unit for the tunnel thruster drive, six 150kW units for the cargo pumps, and three 52kW units for the ballast and slop pumps. The propulsion motors are of Imtech design, and were manufactured in Spain by Alconza Berango. Speed control is exercised through 900kW water-cooled Vacon NX drives, which are claimed to result in significantly lower fluctuations in the ship's electrical power system and which also offer scope for increased flexibility in generation and distribution.

One of the key criteria for Everard's new generation of coastal tankers was the stipulation of a low noise signature, given a trading profile entailing regular working in and out of smaller ports and harbours in the vicinity of residential areas. Electric motors have intrinsically low noise levels, which are reduced even further when the motors are powered by liquid-cooled drive units. Liquid-cooled drives obviate the need for large fans, and do not require additional air conditioning or forced ventilation systems.

## 45dB(A) maximum noise levels specified

The shipowner specified a maximum noise level of 45dB(A) at 25m, in keeping with the sensitivities to noise pollution in residential harbours against the backcloth of trading requirements which may call for round-the-clock working of the ship. The use of electric rather than hydraulically powered cargo pumps and deck machinery also reflects the extensive analysis initiated by Everard into potential noise sources and noise attenuation measures. Sound attenuation has also been applied to the genset installation.

Diesel-electric power also offered the possibility of operating diesel engines under conditions that would yield the lowest possible fuel consumption and noise level. The main diesel generators supply power to the AC drives of the propulsion system. When the ship is not under way, this power is available for the frequency converters of the cargo discharge pumps. According to Imtech, the six cargo pumps and three slop/ballast pumps, which have specially designed motors for loading and discharging the cargo, do not present any noise problems when the ship is in port. Imtech selected liquid-cooled drives on account of a

highly compact construction, yielding space savings of more than 70% compared with air-cooled solutions. While space availability is always a critical factor, not least in the design of small trading vessels, equipment compactness offers greater opportunities for increasing cargo volume within given hull dimensions.

The Dutch firm claims that the drives have an efficiency factor in excess of 97%. The liquid cooling technique employed is designed so that the dissipated heat has no effect on the surroundings. All frequency regulators are built as modular assemblies as regards both hardware and software.

Maintenance and repair of the Imtech-supplied system will be undertaken by the company's branch at Billingham, on the river Tees, a vital port for the UK chemical industry.

*Speciality* and her sisters (to be named *Seniority*, *Superiority*, and *Supremity*) each embody some 4510m<sup>3</sup> of revenue-earning capacity in six phenolic epoxy-coated cargo tanks, offering scope for chemicals of D-pollution category as well as refined oil products. The cargo control and monitoring software installation has been developed in conjunction with Damcos, formerly Danfoss Marine Systems, to meet the specific requirements of the project. Using software originally configured for Everard by Saab Marine Electronics as a starting point, the shipowner has further developed the system's integrated monitoring capabilities.

An array of class notations bestowed on the vessel by Lloyd's Register includes PMR\*, recognising the high degree of redundancy

conferred by the propulsion machinery arrangements, whereby the vessel can retain availability of propulsion power in the event of the total operational loss of one of the propulsion machinery compartments. The CCS (centralised control station) and ICC (integrated computer control) notations reflect the ship's automation level, with a single, central control room located in the totally enclosed wheelhouse, providing navigation, machinery and cargo controls.

Everard acknowledges that the technical sophistication and task-orientated nature of the *Speciality* class has increased the capital cost relative to more conventional designs of coastal tanker, but considers that this will be compensated for by improved productivity and efficiency, which should enhance the company's reputation among its customers. 

## Converteam systems for cruise liners and LNG carriers

WITH a broad-based industrial market presence, electrical engineering specialist Converteam is another company that reports a growing trend for electrical solutions to be used in place of mechanical technologies, reflecting perceptions of greater reliability, consistent availability, and reduced environmental impact.

As one of its core sectors, the company's marine and offshore business has attracted a tranche of new contracts arising from cruise ship, LNG carrier, and offshore vessel construction projects.

Known up to the end of March 2006 as Alstom Power Conversion, the company had been a division of the Alstom group until November last year, when it became an independent concern with a new shareholder, Barclays Private Equity.

Fincantieri has recently awarded Converteam orders covering the electrical power and propulsion systems for two further, large cruise liners placed with the Italian builder by the US-based Carnival Corp. One is destined for Carnival Cruise Line and the other will serve the group's Italian 'brand', Costa Crociere.

The latest additions to the programme in Italy broadly follow the design concepts applied in *Costa Concordia*, *Costa Serena*, *Carnival Freedom*, and *Carnival Splendor*, all of which were specified with Converteam electrical propulsion, using Wärtsilä or Sulzer medium-speed diesel prime movers in the main gensets. The 112,000gt *Costa Concordia* was delivered in July this year, while the 110,000gt *Carnival Freedom* and 112,000gt *Costa Serena* are scheduled for 2007 handover from Fincantieri, to be followed in mid-2008 by the 110,000gt *Carnival Splendor*.

The 2006 work inflow has also included electrical propulsion systems for three cruise ships booked in France by Mediterranean Shipping's MSC Cruises. Two of the newbuilds, the 133,500gt sisters *MSC Fantasia* and *MSC Serenata*, will be among the largest passenger ships worldwide, while the 90,000gt *MSC Poesia* will be of the *MSC Musica* type. As with the recently commissioned *MSC Musica* and second-of-class *MSC Orchestra*, the latest additions to the fleet development programme will come from the

St Nazaire premises of Aker Yards, formerly Chantiers de l'Atlantique. *MSC Fantasia* and *MSC Serenata* will offer a 3300-passenger capacity on the basis of lower berths, and will each be equipped with a pair of 20.2MW synchronous motors, fed through synchroconverters. Converteam's contractual remit also includes the propulsion transformers, advanced digital propulsion control, and remote control system. The latest contracts will extend the number of Converteam electrical propulsion-fitted MSC cruise ships to nine.

In a different sector, Converteam equipped the St Nazaire-built, 74,000m<sup>3</sup> *Gaz de France Energy*, which provided a breakthrough for electric drives and dual-fuel diesel engine prime movers in the LNG carrier market (this ship is still awaiting delivery following problems with the prototype CSI membrane cargo containment system).

The dual-fuel electric mode has subsequently been specified in a succession of newbuild projects in the 150,000m<sup>3</sup>-155,000m<sup>3</sup> category. Converteam thereby attained another industry milestone through its nomination for the systems in the first electric-drive LNG carrier newbuilds to have been ordered in South Korea. The contract emanating from Hyundai Heavy Industries calls for electric propulsion and control systems to be fitted in a series of six gas carriers booked by BP Shipping and Teekay Shipping.

Converteam technicians were expected to start commissioning the electric drives and automation for the first BP vessel in September this year. This ship is scheduled for handover during the second quarter of 2007, and is installed with two 14.8MW synchronous motors. BP's new generation of 155,000m<sup>3</sup> dual-fuel electric LNG carriers will support the supply chains for its expanding worldwide business in LNG.

Endorsement of Converteam's electric propulsion system and Wärtsilä's dual-fuel engine technology was accompanied by the nomination of GTT Mk III membrane cargo tanks. Some 39.9MW of primary power will be engendered by two 12-cylinder vee-form models of the Wärtsilä 50DF engine and two 9-cylinder in-line versions, driving the main gensets. This configuration will

enable various operating modes to be matched in the most efficient way, catering for fully-laden powering needs, in-harbour loads, and in-ballast voyaging, while the overall power concentration will provide for a speed of 20knots.

There is a further dimension to Converteam's involvement in the buoyant LNG carrier newbuild market, in the shape of its role as a supplier of electric variable-speed drives for the gas compressors used in the new generation of ships destined to transport LNG from the Gulf. The Hyundai and Samsung yards have ordered such equipment for a total of 11 newbuilds booked under the Qatargas II and RasGas III projects.

Two PWM MV7000-type power converters of 5.4MW will serve the compressor motors in each vessel. Efficiency, reliability, compactness and smooth, safe operation are the claimed attributes of the Converteam-designed drives. MV7000 medium-voltage PWM converters, in combination with high torque density induction motors, offer a new solution in electric propulsion systems, combining the requisite technical performance with scope for reduced operating and maintenance costs.

### Offshore work

In the offshore domain, Converteam has secured a substantial order from Bender Shipbuilding relating to six diesel-electric anchor-handlers entrusted by Seacor to the US yard. The scope of supply embraces 690V and lower-voltage switchboards, 24-pulse drive trains for main propulsion, star/delta soft starters and tunnel thruster motors, along with 'A'-series DP class 2 and 'A'-series vessel control systems. The deal includes an option covering a further four newbuilds.

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## New-generation techniques from Stadt

**T**ARGETING vessel applications where there are particular demands as regards compact size, low noise profile, and moderate cost, the Norwegian power technology specialist Stadt has unveiled a new generation of electric propulsion systems. The Stascho solution is the outcome of three years' R&D work. It is viewed by the company as a technological breakthrough, because the system combines the unique features of sinusoidal, pure electric power, as regards delivery to the main switchboard, electric motors and other consumers, with cost-effectiveness and minimum space occupation.

The idea of creating unique solutions based on sinusoidal power is an approach developed by Stadt in close cooperation with the Swedish firm NFO Drives. The two companies' resultant offering of state-of-the-art electric drives to the shipping and offshore industries covers the power range from less than 1kW/20V up to 25MW/15kV. Environmental merits deriving from this type of propulsion mode relate to low levels of both noise and pollutant emissions.

Integrated electric power and propulsion systems from Stadt can typically encompass four generators, one or two main propellers, side thrusters, and other consumers such as winches and compressors. High energy flexibility is an attribute of the fully-electric concept, whereby available energy can be harnessed for whatever purpose onboard at any time or point in the ship's operating profile.

Stascho is regarded as especially well suited to fishing vessels, seismic ships, and other specialised offshore vessels. In addition to performance, compactness, low noise signature and reduced noxious exhaust emissions, Stadt maintains that the system promises a major reduction in fuel consumption, with an attendant benefit in lessened CO<sub>2</sub> emissions.

The innovative diesel-electric Stascho solution can also be adapted to gas-fuelled and fuel-cell shipboard power generation. Stadt has pursued the development of marine electric propulsion systems since 1986, and can bring all this experience to bear into providing a total 'package' responsibility from generators to switchboards, control systems, and water-cooled electric propulsion motors. The company also has close links with several propeller manufacturers, and can draw on the full scope of supply in delivering solutions based on the new Stascho concept.



A typical arrangement of Stadt's new Stascho electrical power concept. This system is claimed to be of special benefit for ships sailing on long transits, where high efficiency is important. Stadt says that by reducing the number of components and harmonic losses, power-chain losses are significantly reduced from 12% to 4% or 5%.

Several contracts have already been signed for Stascho installations, and Stadt is of the view that the system will help open up new markets for electric propulsion. A key factor which has generated interest is the substantial reduction in component count and system

complexity, with accompanying cost savings. The new approach is expected to prove attractive to the fishing vessel sector, for instance, where in recent years, electric propulsion drive technology has had little impact. 

## Imminent delivery of US superconductor motor

**A**MERICAN Superconductor Corp (AMSC) is set to achieve a milestone in high-temperature superconductor (HTS) propulsion technology with the imminent delivery of a 36.5MW motor to the US Navy's test facility in Philadelphia. This project has been jointly pursued by AMSC and Northrop Grumman under a contract from the Office of Naval Research. The propulsion motor has been designed for a new generation of electric warships, and has been sized for the navy's future DD(X) surface combatants. A machine of this scale is also

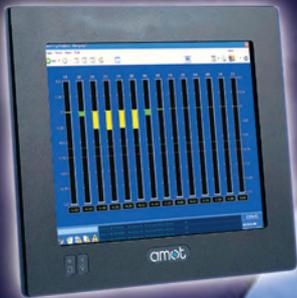
considered to hold great potential for large next-generation cruise liners as well as larger commercial or military vessels.

Construction of the 120rev/min, 16-pole AC synchronous motor of 36.5MW was preceded by the manufacture and testing of a scaled-down version of 5MW. The prototype rotates at 230rev/min and generates 200,000Nm of torque at full power, and has been put through its paces at the Centre for Advanced Power Systems in Florida. The power output of the smaller HTS

machine is well suited to offshore support vessels, small product tankers, hybrid-propulsion naval vessels and similar ships.

A fundamental merit of HTS motors is ultra-compactness, measuring as little as one-third of the weight and one-half of the size of conventional copper-wound motors of the same power and torque. In the case of a commercial ship, this allows more of the given hull envelope to be used for revenue purposes, while naval applications provide more space for weapons or services. 

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## Innovative technology for new Norwegian vessels

WITH her delivery imminent, the first of a highly versatile new class of Norwegian coastguard vessel will provide an important reference for an innovative diesel-electric power and propulsion system using low-harmonic, liquid-cooled Vacon drives.

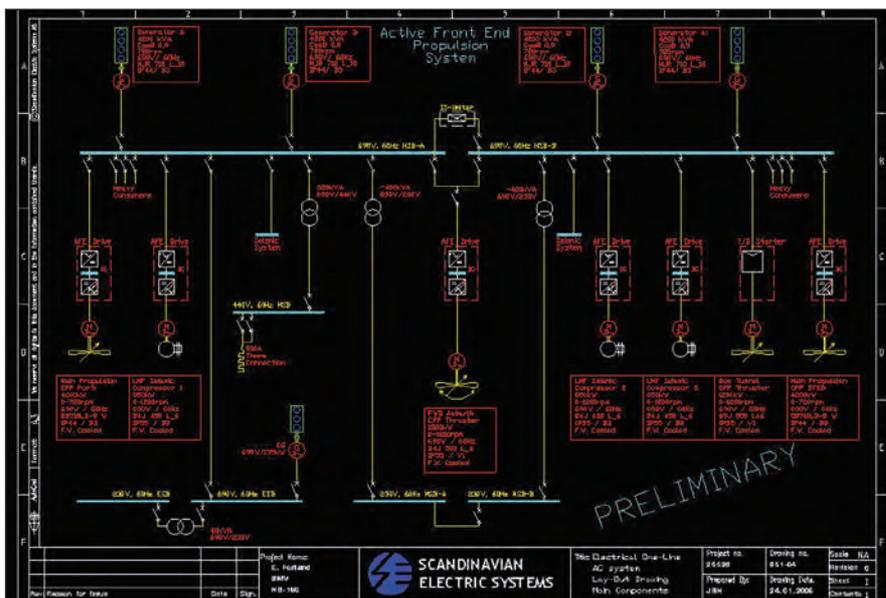
Based on the Skipsteknisk ST-610 design, the 47m *Nornen* leads a series of five ordered from the Gryfia yard in Szczecin, Poland, by Remoy Management and Remoy Shipping, on the back of 15-year charters to the Kystvakt. There are options covering a further five such newbuilds. The 17knot breed will patrol Norway's long, fjord-indented coastline and coastal waters up to 24nm offshore. Relative to the five vessels that it will supersede, the new class signifies an advance in performance and capabilities in terms of seaworthiness, towing capacity, firefighting, oil pollution protection, and coastal surveillance.

The flexibility of the diesel-electric system is such that the number of gensets engaged at any one can be matched to actual speed and power requirements, and run at optimum capacity. The propulsors used in each diesel-electric installation are two stern azimuthing, Wärtsilä-Lips thrusters, complemented by a bow tunnel thruster.

Testament to an enduring and evolving business relationship between Finland-based Vacon and Scandinavian Electric Systems (SES), of Bergen, the Norwegian company was entrusted with responsibility for delivery of the complete diesel-electric propulsion system of the so-called active-front-end (AFE) type.

The plant in this compact new coastguard ship features four main generators, comprising two aggregates rated at 940kW, one of 460kW, and one of 200kW, using Cummins high-speed diesel engines. Main propulsion is controlled by two liquid-cooled Vacon drives of 1100kW/1640A, and the tunnel thruster drive is also effected through Vacon frequency converter.

Benefits claimed for adopting AFE-type frequency converters for the main propulsion and transverse thruster include very low harmonic voltage distortion, without requiring extra filters, extremely low heat losses, and improved fuel efficiency. Generator size can be limited, since the power factor is close to 0.99 and generator load can be fully utilised. Another advantage is that the arrangements



A Vacon/SES electric circuit diagram, showing the principal components of the diesel-electric system for the new seismic ships being constructed at Bergen Yards for E Forland and Fugro Geotem.

obviate any need for phase-shift (12-, 18-, or 24-pulse) transformers, with corresponding space savings and reduced steelwork, foundation, termination, and cabling work.

### Contract for new seismic ship

A bastion of diesel-electric plant has long been the research vessel fleet, and a recent SES contract for a sister to the 101m x 24m newbuild seismic ship *Geo Celtic* offers the prospect of a further boost to the Nordic electro-technical sector. The Skipsteknisk ST-327 blueprints adopted for this class make for one of the world's largest, purpose-built seismic vessel designs, and *Geo Celtic* has the added distinction of having been specified with an exceptionally extensive low voltage diesel-electric installation.

Whereas *Geo Celtic* was booked from the BMV site of Bergen Yards by Norwegian shipowner E Forland for delivery in May 2007, the newly-ordered *Geo Caribbean* is to the account of Fugro Geotem, of Oslo, the long-term charterer of *Geo Celtic*, and is scheduled to come from the Bergen yard in October 2008.

Scandinavian Electric Systems is supplying the complete diesel-electric propulsion system for *Geo Celtic*, based on the AFE solution. This order encompasses system design, engineering, production, testing, delivery, and commissioning, and includes four generators totalling 16,800kVA, main and emergency switchboards, liquid-cooled Vacon AFE drives, two main electric propulsion motors of 4200kW apiece, and two thrusters of 1500kW and 1200kW. Included in the total package is the ship automation system from Kongsberg Maritime.

AFE converters are also central to an SES package which is being provided to Fosen Mekaniske Verksted in western Norway for installation in an ROV-equipped, multi-role offshore service vessel ordered by Volstad Maritime. The low-voltage diesel electric system for this Skipsteknisk ST-256 support ship features four generators yielding a maximum total power of 14,400kVA, two main propulsion motors of 3000kW each and AFE drives, four thruster motors and associated converters, plus starters, and switchboards.

## Optimising power through electric drives

ACCORDING to Rotterdam-based Imtech Marine & Offshore, it can generally be said that ships with diesel-electric propulsion generate and distribute energy more efficiently and at lower overall cost compared with more standard arrangements.

Fuel economy and the reduced emissions attendant to efficiency and optimised power generation can be expected to become more and more important issues influencing system choice. Maintenance costs are also said to be

lower than for ships with direct diesel propulsion because the speed and load can be optimised.

The constantly increasing capacity of water-cooled frequency converters (up to 4000kW at 690V AC) and associated space savings will play an increasingly important role in the future, believes Imtech. The company claims a technological head start in this area, and is continuing to pursue new developments in electric propulsion.

Over the past three years, Imtech Marine & Offshore has received orders involving 25 vessels with electric propulsion, including four Alternative Landing Ship Logistics (ALSL)-class vessels for the UK Royal Navy, one Landing Platform Dock (LPD) for the Royal Netherlands Navy, two self-propelled barges, two luxury megayachts, a buoy layer, and two ro-ro inland waterway vessels designed to carry Airbus components. The sales tally also takes in Everard's new coastal product carriers.

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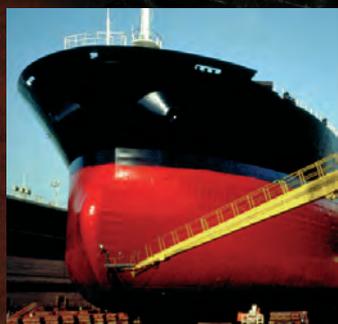
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## Azipods for the Arctic from ABB

AS a bastion of Arctic maritime technology, Finnish industry is realising new business opportunities arising from Russia's economic development and exploitation of resources in its harsh northern environs. The design, construction and engineering of the 14,500dwt diesel-electric special container ship *Norilskiy Nickel*, commissioned in April this year and purpose-built for year-round service on Russia's Northern Sea Route, was a largely Finnish endeavour (*The Naval Architect* February 2006, page 20).

Adoption of a podded electric propulsion solution gave further business width to the Azipod system, in a project which also had tremendous significance in marking a new stage of investment in the Russian Arctic cargo carrying fleet after a break of many years and following excellent experience with the converted Azipod-powered tankers *Uikku* and *Lunni* (subsequently renamed *Varzuga* and *Indiga*). The debut of *Norilskiy Nickel* into her industrial owner's traffic between Dudinka, on the river Yenisey, and Murmansk, has recently been followed by a commitment to a further four newbuilds of the same type.

Although shipbuilder Aker Yards has placed the latest quartet with its Aker Ostsee facilities in Germany, rather than with the lead-vessel constructor Aker Finnyards, the new series will perpetuate the Finnish-conceived, heavily ice-reinforced, double-acting design and its Finnish-designed power plant, power conversion and propulsion arrangements.

The bespoke design has been developed to serve both inward and outward cargo flows generated by MMC Norilsk Nickel's industrial complex located in Russia's remote far northern regions, and accommodates 650 containers of a design specific to the company, but similar to conventional 20ft units.

The newbuild generation is central to the modernisation of the nickel producer's logistics, using container-dimensioned pallets to carry pre-rolled nickel plates on flats or frames of standard size. For the past two decades, SA-15-class cargo ships, built during the 1980s by the former Wärtsilä and Valmet yards in Finland, have been the mainstays of the traffic and the Russian Arctic trade at large.

The new ship's hull design and electric podded drive, using a single 13MW Azipod propulsor, combine to offer the patent double-acting capability, whereby the ship can navigate sternfirst in the most difficult ice conditions. Independence from icebreaker assistance has been a key objective. Electrical energy for the propulsion and all other shipboard consumers in *Norilskiy Nickel* are supplied by three main diesel generators based on 6000kW Wärtsilä 12V32 engines. For the follow-on ships, Aker Yards says that unit generator ratings will be slightly higher at 6650kW. *Norilskiy Nickel* ranks as the first dry cargo vessel or container ship employing the double-acting concept to emanate from Aker Arctic Technology's predecessor Masa-Yards Arctic Technology Centre (MARC).

Electrotechnical specialist ABB Marine, far-and-away the most active company in the market



A close-up view of the 13,000kW ABB Azipod on the recently completed double-acting Arctic container ship *Norilskiy Nickel*, completed earlier this year at Aker Yards' Helsinki site.

for podded propulsion systems at the present time, had won contracts for a total of 154 pod units by the end of July 2006, some 16 years after Azipod made its operational debut. The sales list comprises 45 Compact Azipod units and two CRP Azipods, as well as 107 examples of the Azipod range. At that juncture, overall running time for the pods in service had topped 2 million hours.

### Azipods for Samsung icebreaking tankers

Another current ABB project arising from investment in trade out of northern Russia is the

company's deal with Samsung Heavy Industries to provide Azipod propulsion systems and electrical power plant for a new generation of 70,000dwt Arctic crude oil carriers. Each of the three Sovcomflot newbuilds will have two 10MW pods, and will be deployed in the shipment of oil from the Varandey terminal in the Pechora Sea to foreign markets. The hull form is that of a traditional icebreaker, with heavily cutaway bow and without the double-acting capability. Such is the uptake of podded electric propulsion systems that ABB has implemented plans to build new production facilities at Helsinki's Vuosaari port area so as

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to raise manufacturing capacity and enhance competitiveness. Also, given the space and access challenges associated with inspection, maintenance and emergency procedures in pods, the company is now offering safety training courses to customers. A mock-up of an Azipod 14MW unit at its actual size has been installed at a training facility in Lohja, near Helsinki, under a joint initiative with state-owned Meriturva, which provides training in ship simulation, firefighting, and basic safety.

**Electric power for Japan's first diesel-electric LNG carriers**

ABB also has a central involvement in what is claimed to be the first LNG carrier shipbuilding contract in Japan to have nominated the use of diesel-electric propulsion. Two 157,000m<sup>3</sup> newbuilds entrusted this year to Mitsubishi Heavy Industries by Malaysian International Shipping Corporation will feature ABB electrical power systems and Wärtsilä dual-fuel engines.

Other recent LNG carrier references include six 153,200m<sup>3</sup> diesel-electric LNG carriers on order at Samsung, in Korea, four for AP Møller and two for K Line. For each, ABB will supply four alternators, along with two 6.6kV medium-voltage main switchboards, two 6.6kV medium-voltage cargo switchboards, and a package of other ancillary equipment. Twin ABB medium-speed propulsion motors, geared to a single shaft, will deliver a total output of 25,300kW.



A model of the new 70,000dwt conventional icebreaking tankers on order at Samsung for Sovcomflot. Each will be powered by twin Azipods - 2 x 10,000kW.

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The requested pressure rating was 18 bars and the type 803 was only suitable for pressures up to 6 bars. The new model 806 was successful from the beginning. The simplicity of the design made it extremely reliable with very low maintenance requirements.

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## Advanced Siemens electrics for new AIDA cruise liners

WHILE well established as the mode of choice in the province of large cruise vessels, electric propulsion continues to find new dimension throughout the cruise ship market. A series of innovative diesel-electric newbuilds contracted with Meyer Werft expresses AIDA Cruises' determination to consolidate that line's leading position on the German cruise market. Although ultimately controlled by US-based Carnival Corp, AIDA's business bearing and product is unequivocally German. The fact that the powering and engineering technology input to the new class of 68,500gt 'club-type' ships is essentially home-grown, and predominantly entails assembly in German factories, gives added national value to the project.

First-of-class *AIDAdiva* is due to be completed by the Papenburg yard in April 2007, and is scheduled to be followed at approximately 12-month intervals by three further vessels of the type. Each of the new ships will have a passenger capacity of 2030, on the basis of lower berths, up to a maximum of around 2500.

The design as embodied in *AIDAdiva* will provide a milestone reference for MaK medium-speed diesel machinery in the cruise ship field, and will create a new platform for Siemens as a builder and supplier of power generation, electric propulsion machinery, and marine automation systems.

The 'power station' will be made up of four MaK M43C engines in nine-cylinder format, of 9000kW each, connected to rigidly-supported Siemens generators by means of flexible Vulkan couplings. The four gensets will produce a total power of some 48,000kVA, providing the energy source for two 12.5MW Siemens propulsion motors, two bow thrusters, two stern thrust units, and all other consumers, including the air conditioning plant and hotel/restaurant service networks. The power concentration in the twin-screw *AIDAdiva* should ensure a speed of at least 21knots.

A key feature of the propulsion motors will be an extremely low level of noise and vibration, in keeping with the owner's acknowledgement of passenger comfort as a vital factor influencing level of service and, ultimately, return business volume. To the same end, a new flexible support arrangement has been adopted for the MaK engines, so as to reduce engine-induced ship structural excitation.

AIDA also lays particular value on environmental protection. The nature of a diesel-electric installation, offering flexibility in matching engine numbers to actual power needs throughout the ship's operating profile, and enabling individual engine running to be optimised, militates in favour of reduced overall emissions. The preparation of the M43C engine for Caterpillar's Flexible Camshaft Technology also provides the means for taking soot particle emissions to below the visible limit.

Siemens' Siship Drive MP propulsion system specified for *AIDAdiva* is based on the 'synchro' concept, in which the synchronous motor is fed through a line-side converter, a DC link, and



Two of the four MaK 9M43C engines installed in the new cruise liner *AIDAdiva* at Meyer Werft. Each will drive a 12,000kVA Siemens alternator through a Vulkan coupling.

load-side converter. The propulsion systems will be governed by a Simadyn-D digital dynamic control system.

Each motor will incorporate two winding systems, fed from separate converters, so as to improve propulsion system availability. In the event of a malfunction in one of the phase windings, the affected motor will still be able to produce 55% of its rated output.

The four Siemens main generators will be of synchronous type, and power distribution will be undertaken by a proprietary management system. At the heart of the distribution arrangements is the German company's NXAir medium-voltage switchgear, rated at 11kV and 31.5kA. Under normal circumstances, all the generators will feed into linked, medium-voltage busbars, ensuring easy matching and adjustment of the output in relation to actual onboard load at any time.

All incoming and outgoing feeders will be equipped with Spirotec protection devices, while the various components of the power distribution system will be linked by fibre-optic conductors

in a redundant, Profibus ring network so as to improve fault tolerance. The energy management system on the new AIDA generation will also feature an open interface for the Siemens-developed Siship Imac marine automation system.

Recently commissioned from Ulstein Verft, the powerful offshore support vessel *Bourbon Orca* breaks the mould by virtue of her inverted bow shape, giving operational form to the western Norwegian yard's X-BOW concept.

This vessel is also innovative in certain other technical aspects, and provides an important reference for diesel-electric propulsion in the anchor-handling field. Siemens electric motors are central to the installation. Although Norwegian operators, in particular, have been in the vanguard of the adoption of electric propulsion for the offshore sector, this has hitherto mainly been applied to platform supply ships, and to subsea construction and maintenance vessels, rather than to anchor-handlers.



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The 86m-long *Bourbon Orca* is one of the first anchor-handling tug/supply vessels worldwide to be equipped with diesel-electric propulsion, chosen by owner Bourbon Offshore Norway out of consideration of overall fuel efficiency and operating flexibility, maintenance costs, power availability and redundancy, vessel manoeuvrability, and environmental impact.

The six main gensets are driven in each case by a Wärtsilä medium-speed diesel engine, with an overall plant power rating of 14,200kW. Propulsion power is transmitted through two 5000kW steerable Lips thrusters in nozzles, complemented by a 1800kW retractable, azimuthing thruster at the forward end of the hull, and a 1200kW bow tunnel thruster. The arrangements confer a maximum bollard pull of approximately 183tonnes, and a free-running speed of some 17.1knots at the 6m design draught. One of the most significant aspects of the power conversion system is the combined use of frequency-controlled and direct-drive, Siemens electrical propulsion motors on each of the two drivelines. Two compact motors of 3000kW and 2000kW act on each propeller shaft, providing a maximum power of 5MW in series and a high degree of operating flexibility and economy through a tandem arrangement. The 3000kW electric propulsion motors are equipped with transformers and frequency converters, while the system's two 2000kW motors are direct-driven from the generators. Two of the machines thereby deliver from zero to 3000kW

over the speed range zero to 720rev/min, while the 2000kW units produce their rated power at a fixed speed of 720rev/min.

The 3000kW machines employ standard 690V frequency converters and contribute up to 60% of total propulsion power, sufficient to cover most vessel duties where maximum bollard pull is not required. The 2000kW motors alone can run the ship at a very economical transit speed, the direct 'coupling' with the generators eliminating the electrical losses incurred in transformers and converters. The combined use of frequency-controlled and direct-drive motors can produce up to 5000kW on each propulsor driveline, for the most power-demanding tasks, while medium-power bollard pull and tugging requirements can be met by the two 3000kW motors plus the 1800kW forward retractable thruster. Both the bow tunnel thruster and retractable thruster forward have frequency-controlled drives.

This solution adopted for *Bourbon Orca* has enabled the use of standard 690V frequency converters, and smaller and lighter transformers and electric motors, obviating the need for high-voltage equipment.

**Advances in superconductor technology**

Siemens is expected to provide a window on its work on high-temperature superconductor (HTS) technology, in application to shipboard power generation, at this year's SMM Exhibition in Hamburg. Following on from earlier long-term tests with a superconductive, 400kW demonstrator motor, Siemens has been running a

4000kVA synchronous generator, incorporating HTS windings, at the group's Nuremberg test facility for electric drives.

Highlighted features to be expected of the new kind of generator are savings in terms of mass, volume and electrical losses, all of which offer benefits in terms of ship design and efficiency. In addition, the motor offers high power density and silent, vibration-free operation, with a capability for multiple overload and tolerance of rapid load changes. The energy savings potential offered by the 'low-loss' attributes of HTS technology are reckoned to be considerable, especially in the context of all-electric ships.

The HTS wire in the 4MVA generator at Nuremberg has been designed and manufactured by European Advanced Superconductors, of Hanau, Germany. HTS wire in the rotor field windings, used instead of conventional copper wires, operate at the temperature of liquid nitrogen, and are claimed to carry approximately 10 times the current of comparable copper wire. These characteristics result in machines that are substantially smaller and lighter than their conventional counterparts, delivering considerably more power per unit weight and increasing drive efficiency due to the near-elimination of electrical losses. Current limiters to guard against short-circuits, and to protect shipboard power supply systems, is another marine application for HTS under development by Siemens. The proposed protection device is effectively self-resetting, and anticipated key benefits of the new-technology current limiters are improved system availability and reliability. ⚓



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## Bakker systems for new offshore pipelayers

HAVING brought the electro-technical skills and shipbuilding experience of its partners to bear on the market to increased effect, the Croon Bakker Combination was this year assigned a turnkey engineering contract covering a second, highly sophisticated offshore vessel ordered in The Netherlands by Scotland-based Subsea 7 (*The Naval Architect* May 2006, page 40).

As with the previously booked newbuild pipelayer *Seven Oceans*, construction of the 15,000gt *Seven Seas* has been awarded to Merwede Shipyard at Hardinxveld-Giessendam, to incorporate diesel-electric power and propulsion, and full dynamic positioning. Although similar in hull form, size, and suitability for ultra deepwater construction tasks, the two ships will have complementary faculties. *Seven Oceans* has been designed mainly for laying rigid pipes, while *Seven Seas* will offer the capability for flexible as well as rigid pipe.

Following its retention for the earlier order, Croon Bakker, the joint endeavour of Bakker Sliedrecht and Croon Marine & Offshore, has been entrusted with the design and provision of the complete electrical installation for Subsea 7's latest order. The Dutch combination's scope of supply thereby includes the delivery and installation of the generators, propulsion motors, frequency drives, high and low voltage power distribution, and all other shipboard electrical systems, plus the vessel's entire cabling (*The Naval Architect* May 2006, page 28). The innovative vessel will be highly automated.

Scheduled for completion in the second quarter of 2008, Subsea 7's flexible pipelayer and construction ship will have a 6.6kV integrated electric power generation system and propulsion by three electric-motor driven FP propellers in azimuthing nozzles aft. Two retractable azimuth thrusters will be fitted in the forward part of the hull, and one transverse thruster will be arranged in a tunnel forward.



An impression of one of the two new Subsea 7 pipelayers (the rigid-reel version) at Merwede, for which Croon Bakker Combination is supplying the complete electrical package.

The technical sophistication and capital-intensity of the 151m-long ship is implicit in the reported capital cost in the range of US\$170m-US\$200 million. The design is the result of close cooperation between Merwede Shipyard, specialist contractor Subsea 7, and Huisman-Itrec, the manufacturer of the lifting and pipelay installation. Croon Bakker is responsible for the complete design, delivery and commissioning of the diesel-electric propulsion plant and all other electrical systems.

*Seven Seas* will be fitted with a deepwater crane of 400tonne capacity, and flexi-pipe storage on two 1250tonne carousels below deck and one

3000tonne carousel on deck, and will permit the precise positioning and anchoring of pipes at water depths as great as 3km. For operations at extreme depths, she will be equipped with an ROV (remote-operated vehicle) and a versatile exploration system.

Subsea 7's reeled rigid pipelayer *Seven Oceans* is due to be handed over from the Hardinxveld-Giessendam yard in 2007. She will have a total of six diesel alternators of 3600kVA apiece, making for an installed generating capacity of 21,600kVA. The genset aggregates will supply power to three 2950kW

FP propellers fitted in azimuthing nozzles aft, also to a 2200kW bow thrust unit and two 2400kW retractable thrusters forward. All propellers and thrusters will be controlled by Bakker frequency converters, linked to a Kongsberg Maritime automation system.

The diesel-electric propulsion and energy concept employed is redundant in nature, divided over two separate engine rooms, two propulsion rooms, and two switchboard compartments. The main 6.6kV supply system will power not only the propulsors, but also the pipelay installation and large deck crane, through transformers. In addition, current will be transformed to 440V and 230V for smaller consumers. The configuration is intended to guarantee power supply to main propulsion units, thrusters, pipe handling and laying plant and other vital parts of the shipboard electrical mains under the most extreme conditions. ⚓

An example of Bakker's next-generation water-cooled frequency-drive systems, based on ABB inverter units. These offer high-voltage powers up to 25MW or 5600kW at low voltage.



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### From T-2 to Supertanker: Development of the Oil Tanker, 1940-2000

By Andrew G Spyrou. Published by iUniverse (www.iuniverse.com), 2006, 331pp. ISBN 13 9780595806041. Hardback. US\$33.95.

As a naval architect of long experience, Andrew G Spyrou is well qualified to tackle the subject of tanker development. The book ranges over much more than its title might suggest, including recent attempts to produce an efficient and environmentally-friendly oil carrier.

The author states that the ultimate aim is to develop a commercial ship that will use hydrogen fuel for propulsion instead of fossil fuels. Although early oil carriers are touched upon, the story really begins with the T-2 tanker. This 16,800dwt vessel arose from the need for a fleet of tankers to carry oil for the allies in World War Two. Only the USA had the capacity to produce this fleet and a standard tanker for volume production was needed. The T-2 was part of the US Maritime Commission's emergency programme (T-1, T-2, and T-3). The T-2s included five variations, and 536 were built.

They are described in some detail in the book, including the hull structure and machinery, which was turbo-electric, chosen mainly because of lack of facilities to produce mechanical reduction gearing. There were problems, and *Schenectady* was lost at its fitting-out berth due to brittle fracture. A famous T-2 was *Ohio*, which reached Malta with its precious cargo in spite of suffering severe damage from enemy attack.

With so much of the world's oil coming from the Middle East, closure of the Suez Canal in 1956 and then in 1967, rang warning bells in advanced nations. The latter closure, in particular, led to much larger tankers. Until well into the 1950s, tankers of more than 25,000dwt were rare, but after 1967 the very large crude oil carrier (VLCC) and ultra large (ULCC) classes were developed.

During the late 1960s and early 1970s, Mr Onassis built 16 VLCCs and negotiated the construction of two 500,000dwt tankers in France. Then in 1973, discussions started for the design of a 1,000,000dwt crude oil carrier, equivalent to 62 T-2 tankers.

Ideas for this were developed over a period, and the author devotes a chapter to the proposed ship. It makes very interesting reading, detailing what needs to be considered in the design and operation of a ship so much larger than anything in existence - structure, propulsion, manoeuvrability, squat, available ports, and so on, not to mention the importance of experienced designers and builders. Although technically feasible, the design was not acted on because of the changing economic situation. The largest tanker afloat today is the ULCC *Jahre Viking* at 564,763dwt.

With some 3500 tankers in service it is inevitable that some 'incidents' will occur. The author spends some time debating the major oil spillages and their consequences, both in terms of affect on the environment and the rules governing their design, construction, and operation.

The grounding of the 211,000dwt *Exxon Valdez* in 1989 was a particular landmark, leading as it did to the US Oil Pollution Act of 1990, mandating double hulls on all tankers operating in US waters. The story is more complex than that, of course, and the book discusses the Act and its consequences in some detail, including the arguments for alternative hull designs that would be equally effective in preventing spillage in the event of grounding or collision.

The relative merits of different designs will depend upon the scenario postulated. The stability problems encountered by the early, somewhat rushed, designs of double-hull tankers are mentioned.

Fortunately major oil spillages are not frequent - the book lists 18 in the period 1967 (*Torrey Canyon*) to 2002 (*Prestige*) - and it is pity that the

author does not cover the implications of the much more frequent but lesser spillages and pollution from normal operations. Design changes to deal with the major spillage may not assist in the case of a minor spillage.

Also, the author concentrates on grounding and collision as the stated causes of oil release. As was debated in the book *The Tankship Tromedy* (*The Naval Architect*, May 2006, page 44), these may be the final events that lead to pollution but the real cause may be loss of propulsive power or steering that leads to the grounding. Such underlying causes need to be fully addressed in ship design and operation. That is not to say that they are ignored in the book and, indeed, a chapter is devoted to redundancy in propulsion and steering systems to improve reliability.

Over 50 pages are devoted to the energy-efficient tanker. This makes interesting reading and covers hull form - including bulbs at the bow and stern, coatings, propulsors - including contra-rotating propellers and off-centre propellers, and machinery systems - including diesel engines, fuel cells, nuclear power, and electro-magnetic propulsion.

One chapter deals with the actions and interactions of the classification societies, the International Association of Classification Societies (IACS), the International Maritime Organisation (IMO), flag states, and port states, the various pressures under which they work, and the consequences for their effectiveness. The final chapter considers risk assessment in design and operation, including technical and business risk, together with tolerability of risk.

Much of the discussion in the book is applicable to ships generally and not limited to tankers. As such, it should interest a broad readership. On the down side, it is a pity that the illustrations in the book are all black and white and some are of poor quality. An index would be very useful to enable the reader to quickly access points of detail, of which there are many.

EC Tupper

## Dutch cathodic system aims to protect against corrosion

WITH many years of experience in cathodic (corrosion) protection of steel structures and marine growth prevention for box coolers and sea water intakes, The Netherlands-based company Corrosion & Water-Control is an international supplier in this field. Its core technological products are claimed to be amongst the most economical solutions against corrosion and fouling on the market. In order to expand business, the company has recently established a unit in China.

The company's impressed current-type (ICCP) system provides a vessel with all-round protection, including protection for the propulsion and rudder systems, in fact, all submerged metal parts of a vessel are covered. When using such a system, an indication of a vessel's coating condition will be shown on a touch-screen display. All data can be downloaded to an external computer and transferred via the Internet for checking; system adjustments can also be made using the same procedure via uploading data.

A modular high-frequency power unit ensures a reduction in weight and size, and if for some reason a unit fails, the other units will still operate. Together with the specially-designed ICCP anodes and reference electrodes, the high frequency power unit should ensure a correct degree of protection in any situation. Even if the electrolytic effects of water vary, this system quickly adapts and continues to offer the correct and optimum protection.

Other advantages of this ICCP high frequency power unit include: touch display operation in all main languages; control of 'off potential'; a coating condition indicator; propeller shaft monitoring (along with an alarm function); an automatic system scan; the history of all data in years can be examined; a three-point temperature check of the cabinet (along with an alarm function); and the system can be connected to a ship management system via RS485 and RS232 ports.



ICCP anodes with an integrated rigid di-electric shield and protection plate.

Corrosion & Water-Control has supplied its system to different types of vessels, including container ships, ferries, VLCCs, and product carriers. Customers include Schöller, of Germany; Jan de Nul, of Belgium; AP Möller, of Denmark; and Wagenborg Shipping, of The Netherlands; as well as numerous navies and coast guards. 

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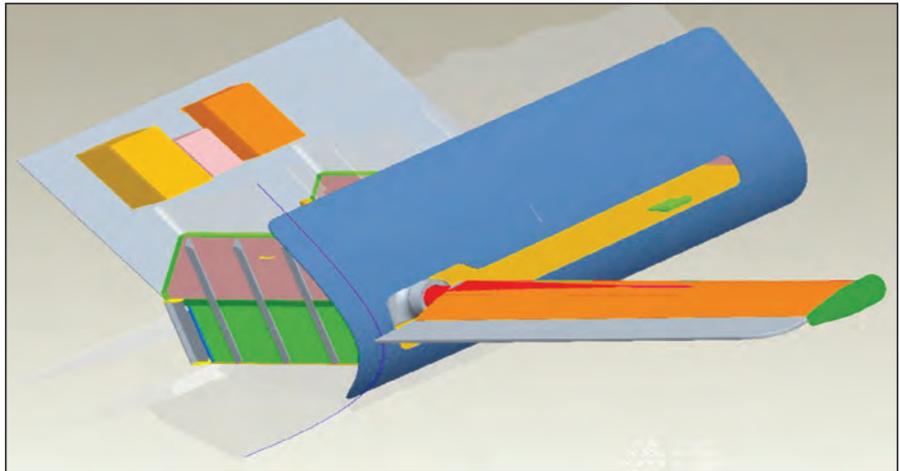
# Stabilisation at rest: a new solution

A NEW market for stabilisation systems has recently emerged for megayachts since they are becoming longer, wider, and more sophisticated. Twenty years ago the largest yachts had lengths of around 50m, now it is becoming common to have vessels reaching between 80m and 170m. Demand for yachts of 32m and above is expected to reach 189 a year in 2010; in 2006, 162 vessels in this range will be completed.

This increase in orders and size is, it is believed, due to a changing customer profile in the market. Whereas in the past owners would start with small yachts and replace them with bigger ones over the course of a number of years, now first-time buyers often purchase large yachts to begin with.

This new owner also expects greater onboard comfort, and those with little at-sea experience are looking for reduced motions whilst a vessel is at rest; in fact, a zero-speed stabilisation system is often a priority for an owner, it has been reported. In the last 10 years these types of stabilisation systems are now fitted on a significant number of 32m-plus size newbuildings.

To serve this new market, Rolls-Royce has, over the past 12 months, adapted its Brown Brothers Aquarius retractable-fin stabiliser design for use on larger yachts. The Aquarius 50 fin chord has had its width increased, creating a 'tadpole' profile, and making an area of up to 5.7m<sup>2</sup>, compared with an original area of 3.5m<sup>2</sup>; in addition, it has had its tilt actuator adapted to increase the maximum fin sweep from 22.5deg to 40deg. No strengthening of the fin shaft, bearings, fin box, or crux box is needed.



The retractable fin on this stabilisation system is similar to having additional bilge keel, and it can extend 200mm-500mm, depending on the vessel type.

A new control and electro-hydraulic arrangement can sense the start of any roll and whilst a yacht is at rest the system tilts the fins at a high angle to generate reaction load to counteract wave motion. When active, the system takes lift forces generated by the ship's forward speed to dampen roll motion. Fins can be completely retracted for safety when passengers are swimming around a vessel, and when manoeuvring in harbours or narrow seaways. Rolls-Royce is believed to be the first company to devise such a 'stabilisation at rest' system using retractable fin stabilisers, and a patent is currently pending.

The new fins, which were tested at MARIN, The Netherlands, are said to be able to reduce yacht roll in wave heights of 0.5m by 80% when the ship is at rest, by 80%-90% when the vessel is underway, and by up to 30% when the fins are in passive mode. Performance on individual yachts is dependent on vessel equipment size.

These fins can also help to save costs, since one pair of Aquarius fins can replace two pairs of low-aspect ratio fins for vessels up to approximately 95m length. The system can also be retrofitted by modifying Aquarius fins, or fitting new ones which can increase hydraulic capacity.

The trailing edge of the fin remains exposed outside the fin box when it is in 'parked' mode. This feature allows owners to have a sleek hull, ensuring that extension of stabilisers while passive does not protrude beyond the bilge keel outreach, which also avoids the risk of grounding and damage.

An Aquarius fin, which ensures stabilisation at rest, being manufactured at Rolls-Royce's Dunfermline, Scotland, plant.

Three orders for these stabilisation systems have been received by Rolls-Royce so far, all from oceAnco, a shipyard in The Netherlands. All three yachts - the first two with yard numbers Y701 and Y702 - are 67.4m long, with a 13.8m beam, a 3.6m draught, a maximum speed of 19knots, an 1850tonne displacement, and a roll period of just over nine seconds (estimated). The trio is set for delivery in December 2006, summer 2007, and 2008 respectively.

Rolls-Royce has been working jointly with oceAnco on the stabilisation-at-rest feature. Two standard Aquarius systems had already been supplied to this Dutch builder, which was in the process of constructing two of the above yachts; after contracts were amended, the new Aquarius systems were installed. Sea trials on the first yacht are taking place in November 2006.

Rolls-Royce is anticipating more interest in the system and is set to introduce a smaller unit, the Aquarius 25 for up to 3.5m<sup>2</sup> and an Aquarius 100 for up to 8m<sup>2</sup>. These stabilisers can also be used in other vessel types such as small ferries and offshore ships, and Rolls-Royce is building two sets for Polish shipbuilder Remontowa for a 900gt passenger vessel ordered by a Danish operator.

The company is aiming to grow this part of its business over the next five years and is working on a new package that would include a complete life-support service, either through long-term service agreements or on an 'as required' basis. This support could last 10 or 20 years, and further investigations are undergoing to assess if there is a market need for this service. The company is also just about to begin investigating non-retractable fins for stabilisation at rest, as well as re-investigating its tank stabilising business.





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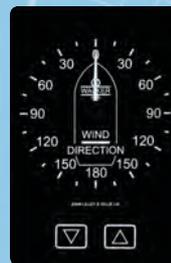
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# Masters or sailors?

Following the SARTOR 3 review (standards and routes to registration) in 1997, the UK Engineering Council - and so the professional institutions - raised the bar for Chartered Engineers. Once, the requirement for Chartered Engineers (the pioneers of engineering, as one engineering council brochure termed them) was for a Bachelors Degree (in Engineering) followed by a minimum of four years on the job training and increasing responsibility. Today, the bar is for a Master's Degree in an engineering-related subject, followed by the same minimum four years on-the-job experience.

**What is in a Master's Degree that raises the bar? Is that extra height valuable to an engineering consultancy? What does a ship design consultancy expect of its graduates and Chartered Engineers? What do we experience when interviewing**

**Masters graduates, and do they progress any faster through our organisation? There appear to be some useful aspects of the Master's Degree but what remains lacking in many graduates is an appreciation of real life engineering. So should we stop making Masters and instead send them to sea?**

**This article\* by J Buckley, from BMT Defence Services Ltd, explores some these questions from the viewpoint of a ship design consultancy that is actively involved in promoting the role of the professional engineer in the maritime industry. Although orientated towards the defence sector, the principles involved apply to all.**

IT is not the author's intention to capture here a comprehensive set of needs that represents the maritime industry, nor even to capture the perspective of different design consultancies, of which the author works for one. The perspective put forward here is one that represents a naval design consultancy with work that spans from early concept and cost assessment studies, through to playing significant roles in frigate, submarine, and aircraft carrier design, and further through to support of in-service ships and submarines, refits, disposal, and development of policy and standards.

The author notes a presentation made by Mr Roger Swann, then chief executive of British Maritime Technology Ltd, to participants of the International Workshop - Teaching Future

Warship Designers, 2004, hosted by UCL [Ref 2]. In this, Mr Swann stated the following attributes required of a graduate:

#### *Essential attributes*

- good grounding in basic naval architecture/engineering principles
- creative and innovative, but also with a feel for viability of solutions
- enthusiastic and self motivated
- literate
- ability to work in multi-disciplinary teams
- understanding of system integration.

#### *Desirable attributes*

- awareness of design and analysis tools
- awareness of procurement process, user requirements, and design cycles
- project management fundamentals
- appreciation of risk and safety management simple understanding of contract law and tort.

The author concurs with the list of essential attributes and the distinction between what has been determined essential and desirable. However, it is noted from many graduate applications and interviews that the essential attributes of a good grounding in basic engineering principles, literacy, and an understanding of system integration are often lacking.

#### **Work of a graduate**

The following is the author's view of some of the attributes required of graduates from the perspective of a design consultancy. For all the grand projects that each company is involved in, a significant proportion of daily work makes use of the basic naval architecture and marine engineering skills. These are the skills that are typically covered within the first or second year (in Scotland, second and third year of the five-year course): stability, strength calculations, and layout.

Unless they have been one of the more proactive or fortunate graduates who found vacation placement work in the marine industry, the whole work scenario may be foreign to them, as they come to grips with:

- getting things right because there is a contract with a customer relying on the result - perhaps for operator guidance or a decision how to proceed - where good project management is as important as good engineering.
- working to a budget of hours; for every hour over budget to complete the task is either a free hour extra from the employee or an hour off the project profit on a fixed-price contract.
- working in a team environment where colleagues have pressures and goals on a different scale to new graduates; the team are not all at the same level and working to the same goal of graduating.
- working in an environment where one is expected to be able to start applying skills to

the task in hand, without the need to revise before hand. As the author remembers one lecturer saying, 'Ask all the questions you like now, however silly they are; for when you start working you will be expected to know.'

Perhaps there will be occasion where more in-depth skills and knowledge are required, that may have been learnt in the third or fourth years (then the reality is that more of one's colleagues may also need to remind themselves).

However, it is expected that the naval architecture graduate understands the basics of stability - intact and damage; can construct a GZ curve; can make sense of stability regulations; can create (once having learnt the software) a stability model, load it, and set up credible damage cases (albeit with the help of some tips on what to look out for).

It is expected that the graduate can undertake some structural hand calculations, even if they need to refer to a copy of Roarke; that even without the experience of design solutions, they can think through the manner of loading and therefore what purpose the structure has to perform.

Perhaps they will take part in an inclining experiment; they should be able to perform the calculation by hand (even if they refer to a text book for a reminder of some equations). They should be able to deal with rake of keel, converting between marks and perpendiculars, keel thickness, effect of trim on tank calibrations, estimating deadweight (and truncating the estimate to a suitable number of decimal places!), and understanding the impact on stability analyses and the setting up of loading conditions in that analysis.

Perhaps they will be involved in a watertight integrity survey; they should be able to record details thoroughly and consistently; to understand the impact on stability assumptions and operator guidance.

Or perhaps they will be fortunate to be involved in an early concept study and have to contribute to production of a design disclosure that deals with everything from stability to propulsion, to operability, to support, to build cost, as well as other factors, for the model that adorns the publicity stand will attract both admirers and critics and potentially a customer who wants to see the reality of a balanced design.

The point above should be repeated: a significant proportion of daily work makes use of the basic naval architecture and marine engineering skills. If other ancillary skills and knowledge are required, then there is opportunity for them to be learnt as part of their initial professional development.

An employer does not want to hear a graduate claim that the basics were not their strong point or that on their course they did not spend much time on that, or a statement that the graduate has not done that since the first year.

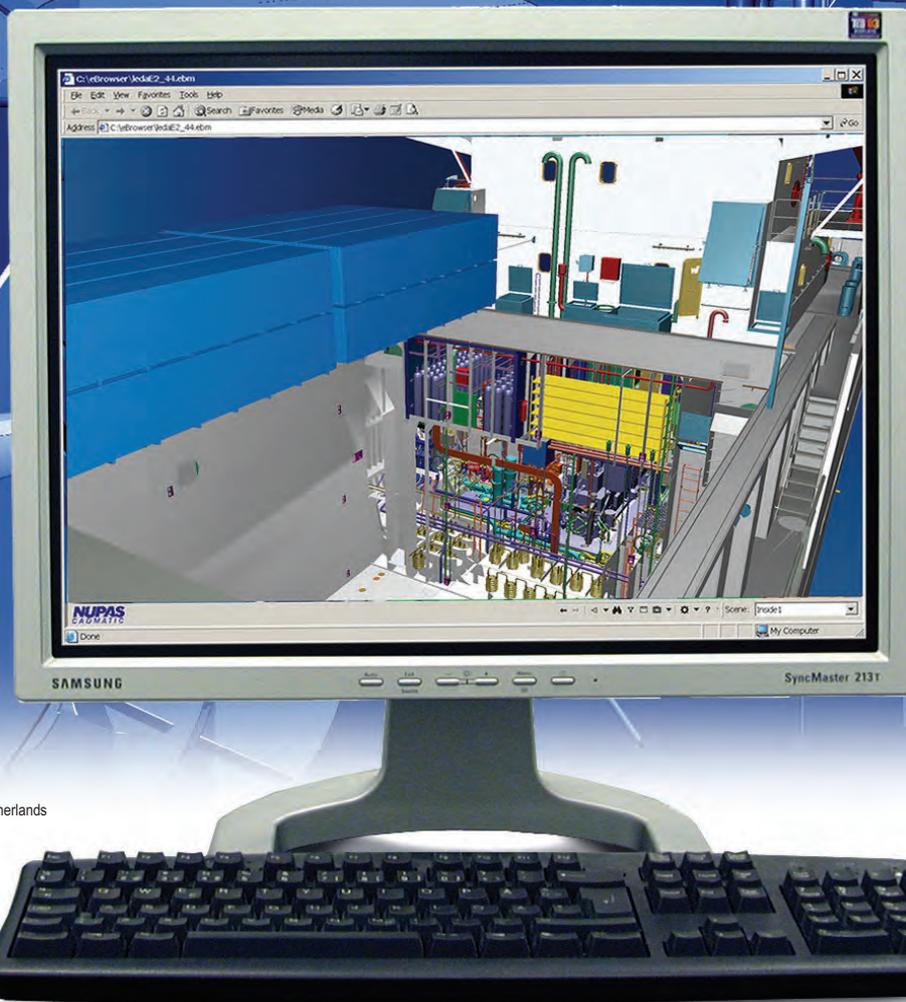
The graduate, whilst it is acknowledged that he or she is still learning, needs to earn his/her keep. The company's aim is to assist them in making a swift transition to employed life, and enabling

\* Extracts from the paper Masters or Sailors?, presented by J Buckley, BMT Defence Services Ltd, at the international conference Education, Training, and Continuing Professional Development of Marine Engineers in the Maritime Industry, organised jointly by The Royal Institution of Naval Architects and The Institute of Marine Engineering, Science and Technology, and held in London on May 23-24, 2006.

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them to gain a broad range of experience in what is a relatively short period of time (the minimum four years to apply for CEng - noting it is not time served!), so that they can be of use in a broad range of applications.

If a graduate has a relative inability to apply the basics, this has the potential to have a significant impact on their usefulness/employability and therefore their opportunity to gain a broad experience and subsequently their progression relative to their peers. In the author's opinion, this gap can be as much as a year within the first four years of employment - but is obviously not the only contributing factor.

### What we experience at interviews

In BMT Defence Services, when interviewing graduates, the company likes to probe their understanding of ship design and support issues. In addition to finding out about them as an individual, we like to set a problem for them to discuss; a problem from a real job that our graduates have been working on.

Sometimes we are impressed by the graduates' fluency in engineering, as they talk us through how they would approach the problem and expand on the issues to be considered. They readily take hold of the pen and paper and guide us through their design.

However, it is not uncommon to be struck by an interviewee not being able to describe the characteristics of a GZ curve, or not having an appreciation of the size of structure on a ship, or not knowing whether a ship's diesel-generator set would be the size of a cupboard, the room, or the building. We do not expect them to know the size of every genset manufactured - these are simply examples to illustrate a point.

It is noted that these startling observations are also true of Bachelor's graduates. However the problem has not been solved now that we interview Master's graduates, at which point the author reminds the reader of the SARTOR 97 aim, to 'ensure that the UK continues to possess a world-class engineering workforce at least as well educated and trained as the very best of international competition'.

There are too many students leaving university without an embedded understanding of the basic engineering principles or an apparent appreciation of the physical nature of the subject they have studied.

It is noted that many of the graduates (recent and CEng) spoken to when writing this paper, were in general agreement, that all courses would benefit students by including regular ship visits and even some sea time. As one graduate stated, it is an extension of learning 'work shop' skills to go and learn 'what does it look like' skills.

### Value of a Master's in engineering

What the author found particularly interesting was that many graduates could not articulate the value of having studied a Masters in engineering. To many, this was just something that was now required of them. Some graduates in the transition years were aware that it would affect in some way their route to CEng, but were not clear what this meant in practice, nor what the route to CEng was anyway.

The following statement about the value of an MEng, from one of our graduates who has had a few solid years experience, extols some of the benefits of the MEng but also captures some of the author's concerns: 'I have come out with a broader understanding of how everything works together, eg, a better understanding of marine engineering. This means that I can more easily work with the naval engineering department. However, I feel that I do not have a full understanding of the basics. I had not produced a set of GZ curves before coming here.'

Perhaps in the long term, one has employed an engineer with a broader outlook. However, in the first four to six years (the typical time to gain chartered status) the employee is predominantly required to gain a thorough practical experience of engineering on day-to-day issues.

Further, the route to Chartered Engineer status encourages a broad base of experience. By the time graduates start to specialise they have probably taken on something entirely different from the specialist subjects studied at university. It has only been a few years since the Master's degree was made the new bar, so it is perhaps a little too early to tell what the long-term benefit is. And if the straight Master's route is to stay, the industry will potentially only have a small range of years in which to compare the progress of graduates from the BEng and MEng courses. However, to date there is no apparent evidence to indicate that Master's graduates are progressing at a faster rate in their long-term usefulness to the company than did Bachelor graduates.

It is more about ability, enthusiasm, aptitude, and application than the number of years spent studying. Of note, this opinion received quite vigorous agreement from most of the graduates spoken to, both BEng and MEng. In some areas, this observation about what makes a difference is even apparent with some of BMT Defence Services' exceptional apprentices, who sometimes snap at the heels of graduates.

Consider the following experience within BMT Defence Services. The company has run a RINA accredited graduate training scheme, with a dozen or so graduates enrolled. In recent years, it has had a mixture of BEng and MEng graduates. Consider two graduates, one BEng and one MEng. They both conduct the same type of work and after approximately four years apply for and obtain CEng. During that four years, the MEng graduate did not make use of any knowledge gained on the MEng course that the BEng graduate did not possess. What benefit to the standing of the CEng has the MEng degree made?

### Implications of an extra year at university

Here are some interesting observations about the effect of a student staying on for an extra Master's year. Perhaps the most striking observation for an employer is that the MEng graduates are another year further away from the core naval architecture subjects that they learnt in the first years; such as what a GZ curve is.

It may sound flippant, but as indicated above, the reality is that for most companies involved in ship design and support, the vast majority of the work relies on a thorough knowledge of the basics of naval architecture or marine engineering, in order to deal with the perhaps sometimes mundane but very real day to day operational issues that require sound engineering judgements. These are the judgements that Chartered Engineers have to make before signing off a certificate for stability, structural strength, or marine propulsion.

For the individual, there is probably an extra year of debt, with significant tuition fees and cost of living for someone who has not yet started to earn anything more than from vacation employment. Only time will tell whether this produces a shift of student interest away from MEng to BEng.

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Also of interest is the emotive conundrum of remuneration expectations. The perspective of some MEng graduates is that they now not only have a degree but a Master's degree but that surely that commands respect and a salary to match. There was mixed reaction by graduates to this. There were some who considered the MEng as just a stepping stone. Though some reflected on their experiences in the Ministry of Defence where they believed that the commitment required for the MSc is generally acknowledged and respected.

It was also considered, by some of the graduates, that having an MEng was necessary to get through a curriculum vitae siff! Further, it was recognised that some employers may now shy away from BEng graduates due to the potentially greater struggle to get employees through their Initial Professional Development and the company's desire to have CEng employees due to their greater selling potential.

However, (in the author's opinion) from the company's perspective, the MEng graduates are still 'green' graduates, possibly with no experience of having applied first-year engineering to a real problem - there is a steep and possibly long learning curve on the route to them earning money for the company.

So, for a company that believes it can offer a broad range of employment experience and increasing levels of challenge and responsibility - to an extent that a BEng graduate will find it within their grasp to obtain recognition as a CEng in a reasonable timescale, a BEng graduate is perhaps an attractive recruitment prospect (all other things being equal). Time will tell as the first BEng graduates who are required to complete a matching section approach this hurdle, whether the BEng or MEng route is the most attractive option for graduate or employer.

#### What should a Master's course address?

Perhaps the Master's degree is required - to maintain the standard of professional education relative to other nations and to provide a broad educational base in maritime engineering. May be the MEng does not go far enough.

As noted earlier, it appears that the objective of an MEng (as opposed to an MSc degree) is to broaden rather than deepen. Perhaps instead it should be to deepen in some of the core subjects. A Master's student who could readily turn their hand to a non-linear finite-element analysis would actually be quite useful. Perhaps the bar is not quite high enough?

It is noted that one aspect of some Master's degrees is a whole ship design project in a group setting. This does appear to have value. Perhaps it is for industry to become more involved in this process, to provide more advice and increase the reality and opportunity to learn from this experience. For it is not so much the specialist subjects that one looks for in a graduate, but one hopes for an understanding of the wide range of issues implicit in whole ship design, issues that can only really be experienced.

A view shared by some graduates is that universities should provide greater emphasis on learning and understanding the core subjects. For example, to maintain the exercise of calculating cross-curves by hand, so understanding what is going on. Too many graduates know how to run

Tribon or Paramarine or other software package, but it is like a black box to them - they are software users but have not understood the underlying physics.

There is a balance required between deepening and broadening, and there will be many views from both industry and academia where that balance is. A question to be answered is whether the current balance is value for money; for the individual or the company.

#### Value of practical experience

There is another side to experience, and that is experience of the real thing. Not the design and paper support of producing operator guidance or refit packages, but the hands on experience of the operation of ships.

Some universities are keen on sandwich courses, which appear to offer students an excellent opportunity to apply what they have

learnt and take back into the learning environment - real life experiences to frame their future learning. Perhaps these placements are at design consultancies or in dockyards.

#### A year at sea

The Master's Degree year could make use of this concept and be used instead to gain operational experience of ships. Perhaps the graduates could spend a year at sea to experience all aspects of the ship operation. As part of this, there is potential to gain vocational qualifications. This concept could be extended further and combined with an investigative project that is conducted on an issue related to the operation of that ship (The Royal Institution of Naval Architects and at least one of its past-presidents has attempted to instil the concept of a year at sea, but generally this request has fallen in stoney ground - Ed).



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This project could itself be supplemented by distance-learning academic study to provide sufficient academic input to this extra year. There are several distance-learning diploma courses on offer that may be suitable for this purpose; such as a Diploma in Marine Surveying, or Diploma in Port Management.

A year's experience of this nature could provide a significant edge for graduates entering a ship design and support consultancy. For, how many times does one hear the inquisitive tones of an operator 'Those delightful designers, why did they design it so?'

The concept of extended sea time has yet to be discussed with ship operators to establish how attractive it would be to them. An additional benefit to the graduate, additional to the obvious invaluable experience of sea time, could be to gain remuneration for the year as opposed to solely debt.

### Half a year at sea

As recognised above, one of the useful aspects of the Master's year is a well run and industry-participation whole ship design, group project. An alternative to a full year at sea may be to combine six months at sea with the associated individual investigative project carried out whilst onboard, followed by the whole ship design, group project on return to the university.

Several graduates considered the idea of a sandwich year at sea in the Master's degree, or a combined six months at sea with the ship design project, attractive.

### Other alternatives

An alternative is to make use of the MTEC modular Master's to bridge the gap between BEng and MEng. With the flexible approach and distance learning, this is more accessible to employers. However there is the question to be answered: who would pay, the student or company? A company would probably not wish to fund an entire MTEC Master's as a matter of course for BEng graduates.

Likewise, the cost of an MSc (typically £10,000 fees, plus time out, so lost earnings, plus T&S) makes them prohibitive for all but big organizations. Even for them there is no way to guarantee return of service. A smarter/cheaper way of allowing an MSc to be taken is long overdue and would be welcomed by industry.

### Conclusions

This article has presented a collection of observations and concerns that have been debated over the past few years. The author did not set out to conduct a thorough study of the content of every naval architecture Master's degree on offer, or to canvass the opinions of a rigorously selected sample of graduates, nor the rigorous analysis of the findings of graduate interviews. However, the points that have been made have often been the subject of debate amongst managers and between graduates, and are points that can be relied on to make emotive discussion topics in the work place.

Some of the concerns raised were in existence prior to the results of SARTOR 97. These are in relation to many graduates' apparent lack of practical understanding of engineering and the

lack of ability to remember and apply the basic principles of engineering at the end of their studies. These issues need to be addressed.

However, the advent of the MEng requirement, post-SARTOR 97, does not appear to have solved this problem. It is not evident that the MEng students address any better the essential attributes proposed by Swann Ref 2]. Further, it is not evident to all of industry whether the MEng is providing value for money in respect of the additional year spent in education, nor of its success in contributing to the SARTOR 97 aim to 'ensure that the UK continues to possess a world-class engineering workforce at least as well educated and trained as the very best of international competition'.

The experience recorded in this paper is that the same problems are experienced with MEng graduates, and there is no evidence to suggest that

MEng graduates create better Chartered Engineers, nor that they progress at a faster rate in their careers than BEng graduates.

It is proposed that if the requirement for an extra year of study is maintained, that consideration should be given to reviewing the purpose and content of that year. It is suggested that of greater benefit to industry would be time spent gaining understanding of the operational issues of the maritime industry through first-hand experience of extended sea time.

Finally, it is noted that industry has a role to play in establishing greater input to academic learning and providing feedback on observed trends, both positive and negative. The industry as a whole will benefit from the input given to students' ship design projects. This was reflected in the Dearing Report as 'More co-operation needed between schools, colleges, universities and employers'. ☺

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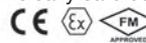
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The JLMD oil recovery system has now been installed onboard a new short-sea tanker which will feed Brittany's islands off France's Atlantic coast. The connectors were fitted by Saint-Nazaire Marine at the Aker Lorient yard (previously Alstom Leroux Naval) in June this year.

The area is ecologically and economically very sensitive, and in spite of the relatively small size of cargo tanks (300tonnes of refined oil products), this owner wanted to limit the risk of spills, even beyond all regulation requirements. This vessel is the seventh to be equipped with a fast oil recovery system (FOR), and is due for delivery in October.

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### Hull stress monitoring system gains orders

A number of new orders have been placed by owners for BMT SeaTech's new touch-screen version of its hull stress monitoring system, SmartStress. Already, a number of major tanker, bulk, and LNG operators have ordered a total of 12 complete systems for new ships. Existing clients are also keen to advance their old software, with 16 touch-screen upgrades to date.

BMT SeaTech, a subsidiary of BMT Ltd, has spent two years, in conjunction with owners, operators, and crew, developing what is claimed to be the only touch-screen system to be approved to the latest rules by the major class societies. For safety-conscious operators, this system should provide improved information, with emphasis on the safe transport, loading, and discharge of goods.

The new software provides real-time stress and motion data, including information on slamming and fatigue throughout the life of the ship. This allows operators and crews to assess the operation of their vessels and should help to prevent the early onset of fatigue damage and overstressing of a hull.

Quintana Management LLC, an international provider of dry bulk marine transportation services, became one of the first ship operators to upgrade its existing system to this technology. In other cases, an operator has placed an order to upgrade 10 vessels; another has already upgraded one ship, with two more complete systems to be delivered by BMT.

IMO recommends the fitting of hull stress monitoring systems onboard all bulkers over 20,000dwt, and since BMT developed the original long-base strain gauge in the 1960s SmartStress is now fitted to more than 120 vessels of various types worldwide.

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### Innovative electric propulsion introduced

After three years of research and development, the Norwegian company Stadt has introduced a new-

generation of electric propulsion system for ships. This new Stascho concept has managed to combine pure sinusoidal electric power, both towards the main switchboard and to the electric motors and other electric consumers - claimed to be at a minimum cost and space occupation.

Sinusoidal waveform on voltage and current ensures that there are no interferences from inverter drives to other sensitive electronic equipment on a ship - such as radars, echosounders, and seismic research instrumentation, as well as no bearing damage, and the absolute minimum of acoustic noise from electric motors and drives. This is said to be unlike other propulsion units, which have systems with a very high degree of electric pollution/noise in their main grid switchboards.

The idea to create unique solutions based on sinusoidal, ie, pure electric power, is an approach that Stadt has developed in close cooperation with the Swedish company NFO Drives AB. The power range offered goes from less than 1kW 220V up to 25,000kW (25MW) and 15kV. Typically four generators, one or two main propellers, side thrusters, and other heavy consumers, such as winches and compressors, can be integrated in the full electric propulsion system by Stadt.

The new Stascho propulsion system, is ideal for smaller vessels, such as seismic ships, and other special offshore vessels due to its compact size, low noise profile, and moderate cost. It also gives benefits regarding pollution from NOx, CO<sub>2</sub>, and soot from the exhaust, and a reduction in oil consumption. The unit is also easily adaptable to combinations of gas and fuel cell power generation onboard a ship. High energy flexibility is another advantage of the full electric Stadt concept, where the available energy can be used for whatever purpose onboard a ship at any time. More details appear elsewhere in this issue, in our Electric Ships feature.

Contact: Stadt AS, 6083 Gjerdsvik, Norway.

Tel: +47 70 02 88 84. Fax: +47 70 02 88 85.

E-mail: [info@stadt.no](mailto:info@stadt.no)

### Maintenance systems for Everard's new tankers

UK-based Marine Software Ltd is supplying marine planned maintenance systems to FT Everard & Sons for that company's new series of coastal products tankers being constructed at Qingshan Shipyard China. *Speciality* is the first of the new 3750dwt vessels to take delivery of the system, after the initial database had been set up.

The software provided by Marine Software is centred on paper-based information from preliminary class listings, general arrangement drawings, and machinery outfit details supplied by the owner. This provided a full structure of maintenance job-cards to cover all class surveys, installed machinery, and safety items. Once all instruction manuals become available, the chief engineer then expanded job instructions during the recent delivery voyage from China.

Once *Speciality* had been delivered, Marine Software then concentrated on the Everard's existing tonnage and began the set-up process

for *Agility*, *Alacrity*, *Asperity*, and *Audacity*. Once completed, most vessels were visited for installation and brief crew training in the time allowed by the vessels turnaround. A series of further training courses have been conducted at Marine Software's dedicated training suite for both onboard and head office staff, which will ensure the software is used at its full potential.

As all remaining newbuildings are sister vessels to *Speciality*, each will be supplied with the same maintenance data and will be adjusted for any installation differences, and of course scheduled from each respective delivery date. Each new vessel will also be supplied with the planned maintenance 'Vibration' module which links to the RCM vibration monitoring system.

Contact: Marine Software, Units 3 & 4,

Aylesham Business Park, Ackholt Road,

Aylesham, Kent CT3 3AJ, UK.

Tel: +44 1304 840009.

Fax: +44 1304 840075.

[www.marinesoftware.co.uk](http://www.marinesoftware.co.uk)

### New factory extension inaugurated

The AC drives manufacturer Vacon has extended its facilities in Vaasa, Finland. Some of the extended parts have been in use since February, and as a consequence, Vacon has employed about 20 new staff members.

The extension cover a floor area of 7100m<sup>2</sup> in total, which is divided into one section, with another section connecting with the old production facilities. Some 3400m<sup>2</sup>, or approximately 50%, of the facilities is reserved for Vacon and the rest is used by DHL, responsible for Vacon's logistics services. The facilities that Vacon leases include production lines, office space, also personnel and storage facilities.

At the end of March 2006, Vacon employed almost 600 people worldwide, of which 161 work in production. Vacon also has a Chinese facility, officially called Vacon Suzhou Drives Co Ltd.

Contact: Jari Koskinen, vice-president,

production, Vacon Group, Finland.

Tel: +358 40 8371 217.

E-mail: [jari.koskinen@vacon.com](mailto:jari.koskinen@vacon.com)

### Electric-drive rolling hatch covers ordered for 12 bulkers

A dozen 207,000dwt vessels will be the first to feature E-Roll rolling hatch covers, developed by MacGregor in cooperation with Universal Shipbuilding, as part of a range of environmentally-friendly electric-drive cargo systems being introduced by MacGregor.

The E-Roll hatch covers will be installed on the 12 bulk carriers being built at Universal Shipbuilding's Tsu works, in Japan, starting in October 2007. MacGregor developed these covers for this new design of double-hull Capesize bulk carriers in cooperation with Universal's technical department. MacGregor has made three patent applications in relation to E-Roll hatch cover system.

This particular ship design uses electrically-driven deck machinery as well as electrically-



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driven hatch covers. This means that no hydraulic oil piping/components are required, eliminating oil leakages on deck.

Each E-Roll side-rolling hatch cover comprises two panels, one on each side, which are opened by a geared electric motor after being raised by electrically powered cylinders. One complete roll-up/roll-down and open/close operation is carried out automatically when the operator pushes a single button, and smooth operation is ensured by inverter and PLC control.

Development work on the electric-drive side-rolling hatch cover started as a three-year project in 2001. Historically, electric-drive hatch covers have progressed from single-pull covers with the wheels lifted by hydraulic cylinders; 'piggy back' covers, again with the wheels lifted by hydraulic cylinders; and sliding covers for tweendecks.

Claimed advantages for electric-drive hatch covers to the shipowner include no pollution by hydraulic oil; no hydraulic oil or piping needed; easy maintenance; the operator's position is not restricted (remote control); energy saving can be made as the covers are not continuously running; all hatch covers can be operated easily; there are no problems with cold weather; and they are easy to monitor.

Contact: Yoshida Yoichi, area sales manager, MacGregor, Japan. Tel: +81 3 5403 1955. Fax: +81 3 5403 1953. E-mail: yoshida.yoichi@macgregor-group.com

### New waste water treatment exceeds regulations

Towards the beginning of this year, specialist in environmental solutions, Evac, of Finland, launched a shipboard waste water treatment system that is said to produce clear effluent that exceeds requirements of all current quality standards, including those set by IMO, Alaska, USCG, and the Navy NIAG. It is a compact and low maintenance system.

This MBR equipment, based on proven membrane bioreactor technology, allows yachts, cruise liners, ferries, naval vessels, and other ships to treat and discharge all waste water generated without threat to health or the environment. The technique is capable of filtering out particles as small as viruses, and its compact footprint means it is suitable for retrofitting, as well as on new ships. MBR is fully automated and does not require monitoring by skilled personnel.

The system works as follows: high-volume grey water streams are mixed with lower volume black water in an equalising tank, to ensure controlled and balanced flow of waste water into the system. This stream then passes through a pre-treatment screening system to remove solids. The stream is then circulated and re-circulated through a membrane bioreactor into that incorporates submerged flat sheet membranes, using bubble air diffusers, until the water is clear. A final stage ultra-violet sterilising process can be incorporated, if required. The final product, as demonstrated in a recent pilot study, is a clear effluent with virtually no suspended solids, a biochemical oxygen demand of less than 3mg/litre.

Contact: Juha Kiukas, Evac Oy, Veinilaaksontie 1, FI 02620 Espoo, Finland. Tel: +359 20 763 0250. Fax: +358 20 763 0222. E-mail: jkiukas@evac.zodiac.com www.evac.com

### Next-generation navigation technology unveiled

Sperry Marine business unit recently presented its next-generation marine navigation technology. This new family of navigation products, to be marketed under the VisionMaster FT label, is a scalable family of solutions designed with an advanced PC-based Ethernet architecture offering upgradeability and built-in redundancy to meet the emerging requirements for shipboard navigation. Using VisionMaster FT, a shipowner can select whatever level of sophistication is needed, from a standard type-approved radar up to a complete integrated bridge system (IBS) with a built-in upgrade path to address future requirements.

The VisionMaster FT technology is also designed to take advantage of value-added services such as electronic chart downloads, automatic weather routing, remote diagnostics, and performance monitoring, as broadband ship-to-shore satellite links become more widely available in coming year. Marine superintendents and other authorised shore-based users will be able to access the ship's systems through Sperry Marine's BridgeLink web-based portal to access ship operational data, view performance data, and remotely monitor the ship's navigation systems and sensors.

VisionMaster FT comprises four basic levels of navigation functionality - radar, chart radar,

electronic chart display and information system (ECDIS), and multi-function workstation. The configurable architecture makes it easy to upgrade from one configuration to the next.

At the apex of the pyramid is TotalWatch, which replaces traditional, stand-alone single-function navigation workstations with a multi-function navigation console similar to that used in aircraft cockpits. With TotalWatch, multiple task-oriented functions are combined into one integrated workstation. The TotalWatch station can display any VisionMaster FT mode, as well as data from other shipboard systems such as machinery monitoring, alarms and even closed-circuit television. A ship's master can create any combination of console displays for any scenario, such as inshore piloting, open-sea navigation, docking, or anchoring.

The VisionMaster FT radar incorporates Sperry Marine's proprietary automatic clutter suppression technology. It facilitates detecting and identifying small, weak targets in the presence of sea or rain clutter, even when sailing near large landmasses, without manually adjusting gain and clutter controls. Available in a wide range of interswitchable X- and S-band automatic radar plotting aid (ARPA) configurations, the VisionMaster FT radar meets all current and projected performance standards for marine radar systems. It uses the same proven BridgeMaster E transceiver and antenna configurations, permitting easy and inexpensive retrofit for existing installations.

Contact: Northrop Grumman Sperry Marine, Charlottesville, Virginia, USA. Tel: +1 434 974-2656. E-mail: sales\_commercial@sperry.ngc.com



This 4280gt, 97.50m research vessel, *Meteor*, owned by the Federal Ministry of Research & Education, Germany, has been equipped with one HRP electrically driven retractable azimuth thruster of the tunnel mode, type 6011 RT. This thruster has a rated power of 1100kW at 1200rev/min and will be useful for manoeuvring operations that the ship may carry out during its operations.

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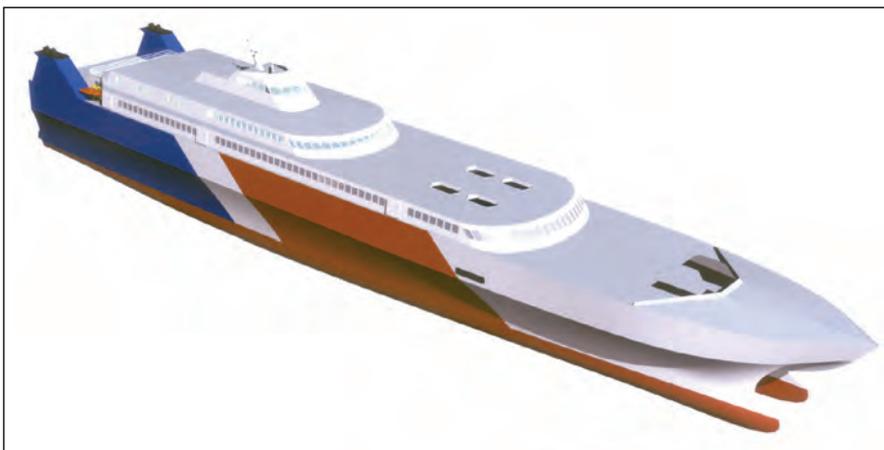
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## SteelCat: a fast catamaran with potential

This large steel-hulled Norwegian design from Brevik Engineering, with a high length/beam ratio, is believed to offer several advantages over competitors. Prospects for both passenger and cargo versions remain optimistic, despite a slack market.

A HIGHLY interesting fast catamaran ferry concept from Norway, which claims to offer benefits over rival concepts, is the SteelCat, created by Brevik Engineering, a company within the Aker Yards group, and based at Brevik, south of Oslo. The SteelCat has already attracted attention from one or two operators - one a well-known company - but so far no orders have been placed, partly due to the current very high level of fuel prices.

The SteelCat, which has been under development for several years and which was discussed with *The Naval Architect* recently during a special visit to Brevik, is generally



An impression of a SteelCat, seen here in its passenger/vehicle version. Note the relatively narrow spacing of the demi-hulls, which have vertical inner surfaces and are straight throughout the ferry's length.

### TECHNICAL PARTICULARS STEELCAT FAST FERRY (FREIGHT VERSION)

Length, oa.....	143.80m
Length, bp.....	135.20m
Breadth, moulded.....	22.00m
Depth, to main deck.....	9.40m
Draught, design.....	3.35m
Speed, service (100% MCR), design draught.....	32.00knots
Speed, service (90% MCR), design draught.....	30.00knots
Payload.....	1080tonnes
Heavy fuel.....	90tonnes
Marine diesel oil.....	16tonnes
Fresh water.....	5tonnes
Lubricating oil.....	5tonnes
Sewage tanks.....	2tonnes
Crew and miscellaneous.....	2tonnes
Deadweight, design draught.....	1200tonnes
Range.....	320nm
Crew (single cabins).....	12
Containers/lorries.....	58 x 18.50tonnes
Classification.....	Det Norske Veritas +1A1, HSLC, R2, Container, E0

### VARIANTS FOR PASSENGER VERSION

Payload.....	665tonnes
Heavy fuel.....	120tonnes
Marine diesel oil.....	15tonnes
Fresh water.....	15tonnes
Sewage tanks.....	15tonnes
Passengers.....	60tonnes
Deadweight.....	900tonnes
Passengers.....	800
Vehicles.....	135 cars plus 31 x 18.5tonne lorries
Crew.....	20
Classification.....	Det Norske Veritas +1A1, HSLC, R2, Car Ferry B, E0

conceived as a simple ship; it comes in passenger/vehicle or ro-ro freight variants and differs from many other commercial catamaran designs in using demi-hulls with their inner face vertical and straight throughout their length.

Brevik calculations anticipate a maximum speed of 36.00knots or 33.00knots at the design waterline draught. The relatively small distance between the two hulls allied to a high length/breadth ratio of 1:7 gives better motions compared with conventional catamarans.

If required, active fins could additionally be installed at the stern but a small centre bow also assists with this aspect. In any case, both versions would have a class society R2 restriction imposed (navigation restricted to within 50miles of a safe refuge). Actual economical service speed is estimated to be around 30knots to 34knots.

During 2003, a major series of model tests was carried out at Marintek, in Trondheim, which, happily, confirmed that Brevik's own calculations and model tests were correct. Just a few refinements were needed, including a slight lengthening of the hulls to reduce outside spray - this proved another positive move, since no spray at all was subsequently recorded.

Further tests on the SteelCat were conducted at the Krylov Shipbuilding Research Institute, in St Petersburg, Russia. Although these resulted in recommendations for minor hull line improvements, they did not give superior performance in the important 30knot-34knot speed range. As a result, Brevik Engineering made a decision to retain its original lines, which offered a lower level of resistance.

Meanwhile, further tests back at Marintek in the seakeeping basin, revealed encouraging handling characteristics in ahead, oblique, and following seas. Originally, Brevik had thought that the hull could cope with 4m significant wave heights but as a result these particular tests, the allowable wave height in following seas was increased to 5m. In practice, this

figure would probably be too severe for both hull and crew to cope with in head seas and at speed.

These particular results will be most attractive for the unnamed operator who had considered ordering a SteelCat ferry to transport fresh fish products from Norway across the North Sea to Eemshaven, in Germany. However, this particular company has temporarily withdrawn from this enterprising plan.

As the name implies, a SteelCat would be constructed from steel - mild steel in many parts, with HT36 high-tensile material in selected areas - and the superstructure would be fabricated from aluminium. Although steel is heavier than aluminium, the small and constant distance between the hulls would result in a weight saving. Frame spacing would be 300mm or 400mm, with 1.50m between web frames. Much skilled welding would, nevertheless, still be needed on an advanced ship of this type.

### Heavy-fuel engines chosen for economy

Brevik Engineering has chosen diesel engines burning heavy fuel as the most economical option for a SteelCat power plant - especially relevant in today's climate of very high fuel prices. First choice is four Wärtsilä 18V or 20V 32-type models (4 x 9000kW is the output needed) but others can be easily accommodated. These would be split over two independent machinery spaces, with the engines arranged in stepped positions. They would drive four waterjets, which could be Wärtsilä Lips size 150 models, and between engines and waterjets will be four reduction gearboxes. Electrical power on the freight variant is proposed to be provided by two 600kW gensets burning marine diesel oil, or larger units of 1200kW on a passenger version, which would in turn be supported by two 1200kW shaft-driven units. In addition, a passenger ferry would be fitted with two retractable bow thrusters, each of 1000kW.

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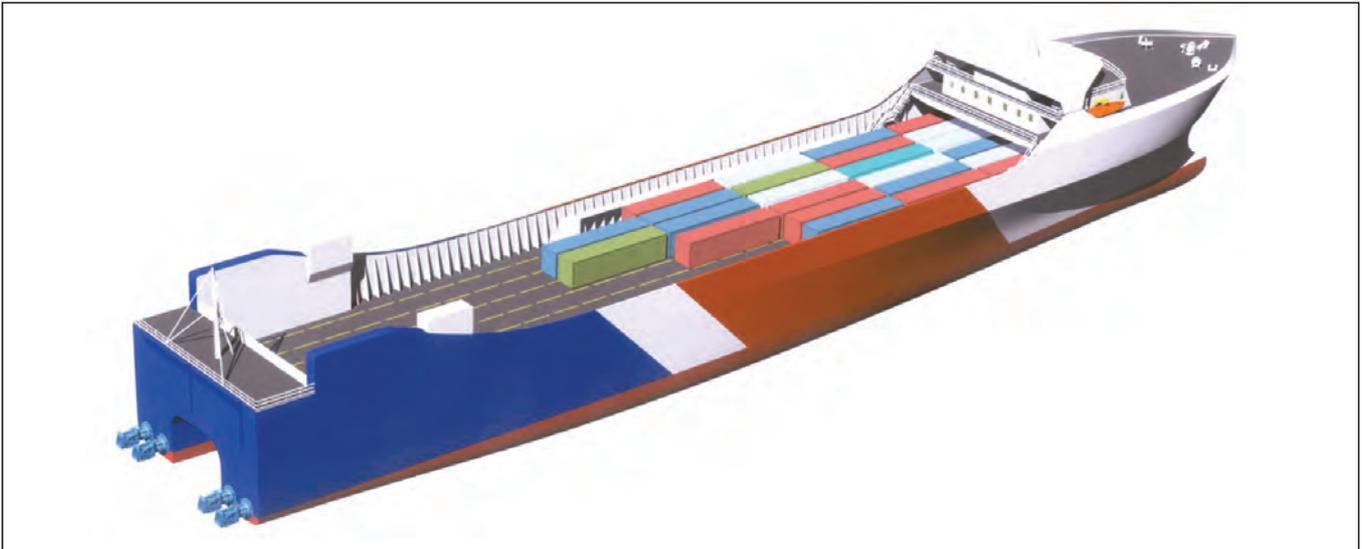
Model	Generating Capacity	Model	Generating Capacity
6EY18(A)L	360 - 750kW	8N280L	2000 - 2200kW
6N21(A)L	600 - 960kW	6N330L	2200 - 2500kW
8N21(A)L	800 - 1270kW	8N330L	2600 - 3300kW
6EY26L	1300 - 1720kW		

Generating capacity varies depending on generator efficiency.



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The freight-variant SteelCat, viewed from the stern, showing the four waterjets and two flush access ramps in the transom.

Only one main ro-ro vehicle/cargo deck is proposed (open in the case of the cargo variant), with access only over the stern via two hinged ramps (5m x 8m); on the freight version, due to the height of the main deck, shore linkspans would be required. The passenger version would have a small mezzanine deck forward to provide extra space for cars, and again, in this version only, the deck would be sloped at the aft end to enable suitable links with shore ramps. Below the main deck would mainly be

void spaces or liquid tanks. Up to 58 trailers or containers could be loaded on a freight ferry, with reefer plugs provided for each one.

Basic lifesaving equipment would comprise davit-launched liferafts and a rescue boat, but more advanced systems such as rescue chutes are specified for the passenger versions.

Prospects for both passenger and cargo versions remain very much alive, Brevik told *The Naval Architect*, despite a slight plateau in the high-speed sector, and routes in southern

Europe and in the Baltic (the steel hull could easily be strengthened against ice) are being considered by various potential customers. A hurdle to be overcome, nevertheless, is finding a yard in the current buoyant shipbuilding climate willing to build a prototype, at a time when contracts for simpler, more assured, vessels are easier to come by. Possible options here are one of the Aker Yards' sites in Romania or Aker Brevik's own berth in Norway. ⚓



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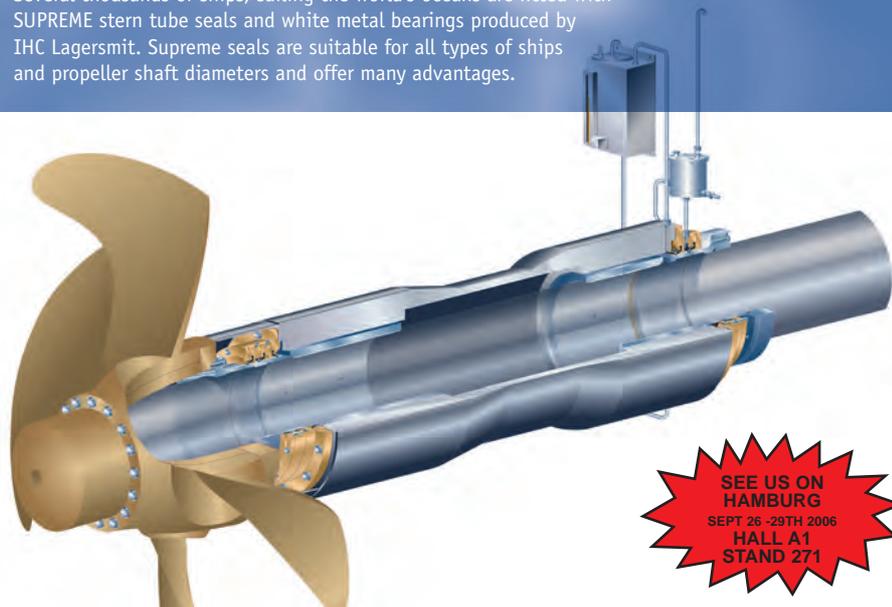
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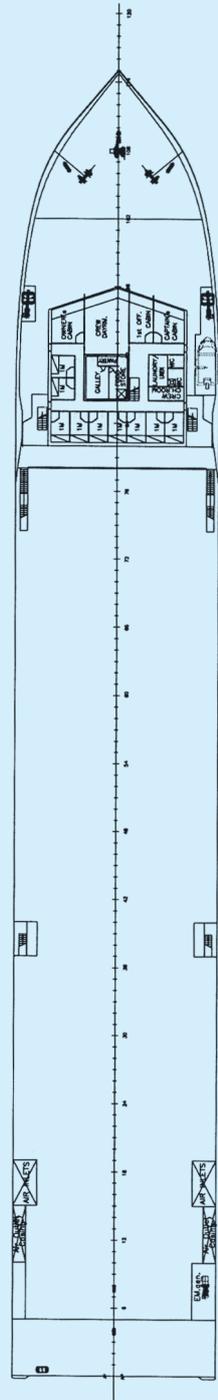
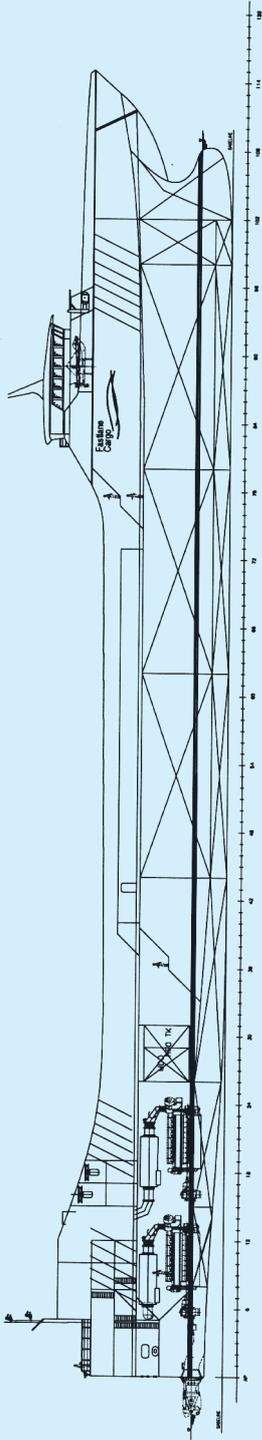


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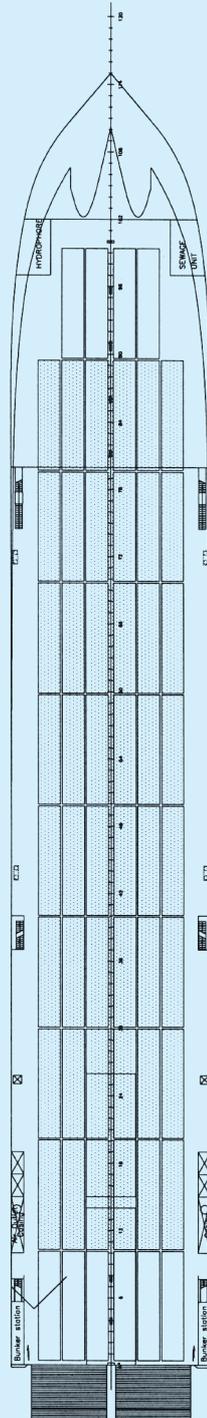
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Outline general arrangement plans of a SteelCat fast ferry, seen here in its freight version.

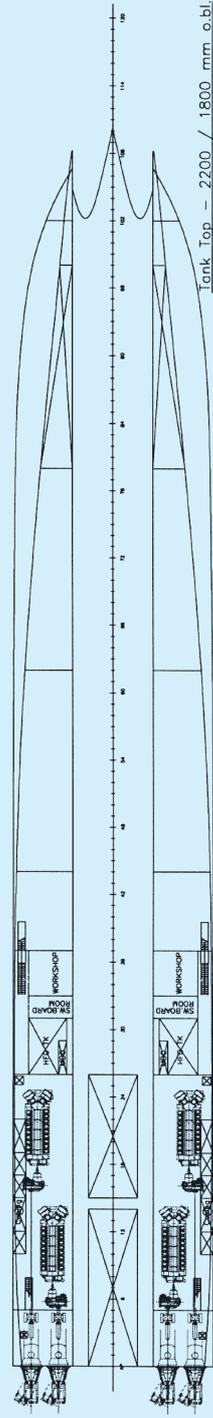


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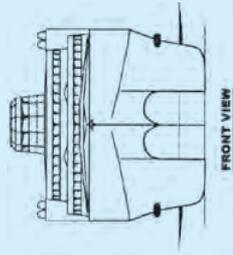
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## Fast ferry incident database to be updated

A CONTRACT has been awarded to UK-based Seaspeed Marine Consulting Ltd for the updating of the UK Maritime and Coastguard Agency (MCA) fast-ferry incident database. Three years ago, Seaspeed updated and analysed this database on behalf of the MCA with a view to investigating buoyancy and stability related incidents.

The results of that study were presented at The Royal Institution of Naval Architects' (RINA) High Speed Craft Conference, in November 2004. It was clear at the time that a much greater range of interesting and useful incident statistics could be extracted. Thus, Seaspeed continued the updating process and has since undertaken more general statistical assessments, such as those presented at FAST 2005 in St Petersburg, and at the RINA conference 'Learning from Marine Incidents III' held in January 2006. Seaspeed now has a contract with the MCA to continue updating the database, primarily to provide background information for the development of the IMO HSC Code of Safety.

The database records specific information for each known HSC incident covering date, vessel identification, and a brief specification, incident type, geographical location, environmental conditions, fatalities and injuries, and a short description of the incident itself. The recorded data has been drawn from a wide range of sources and thus the quantity and quality of data varies between incidents. For each incident, Seaspeed also maintains a paper copy of all available incident reports and descriptions, allowing for more detailed study as required. The database currently covers approximately 1000 incidents.

The incident data relates to fast commercial ferries of any hull configuration, and covers the full range of operational activities from normal commercial operations to sea trials and re-positioning voyages. Whilst considerable effort has been put into populating the database, it is clear that it is not fully comprehensive. It is for this reason that the current ongoing effort to update the database is focused not only on collecting recent incidents but also on increasing the resolution of the database as a whole.

### Incident categories

In order to provide a general overview of the incident data, information has been grouped into six main incident categories, with injuries and fatalities grouped together as equivalent fatalities (e-fatalities). This works on the basis that one e-fatality is equivalent to one fatality, 10 major injuries or 100 minor injuries. Fig 1 presents these statistics. From this analysis some interesting features for each category were found, as follows:

#### Collision

This is defined as a ship striking, or being struck by another ship. It is the most important category for HSC since it accounts for 24% of all recorded incidents and 36% of all e-fatalities. Interestingly many of the most serious collisions were with other fast ferries and nearly half of these were with sisterships on the same route.

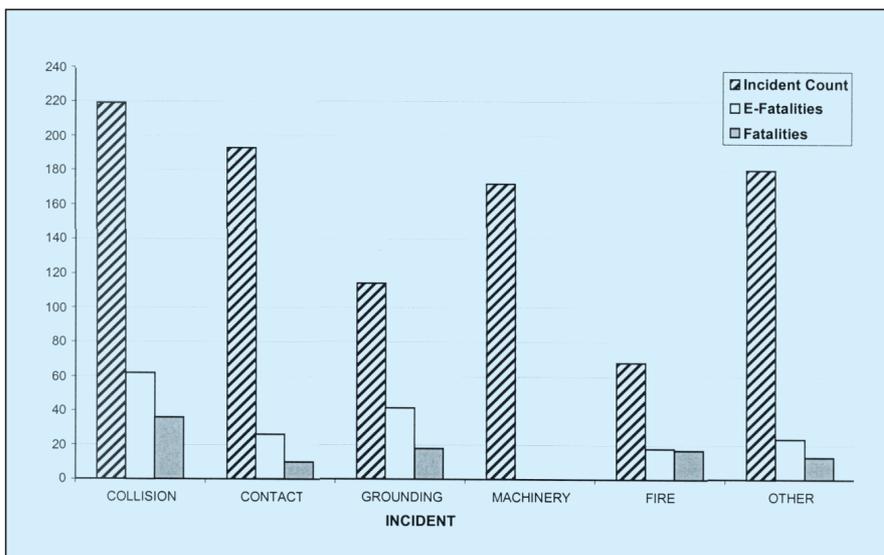


Fig 1. Incident data by incident category (all high-speed craft).

#### Contact

This is defined as a ship striking or being struck by an external object (other than another ship or the sea bottom). This is the second most frequent accident category, accounting for about 20% of all incidents and 15% of all e-fatalities. It is notable that over 65% of contacts occurred when close to their berth and 30% happened at night with another 12% occurring in poor environmental conditions.

#### Grounding and stranding

Grounding is defined as the ship coming to rest on or riding across underwater features or objects but when the ship can be relatively easily freed from the obstruction. Stranding is generally a more serious sub-category where the ship becomes fixed on an underwater feature or object, and cannot be freed.

#### Fire

This is defined as an unwanted or uncontrolled combustion process other than an explosion. A total of 67 fires have been recorded, equivalent to 8% of all incidents but claiming 11% of all e-fatalities.

#### Machinery

Machinery failure is defined as the failure of any equipment, plant, or associated system which significantly restricts (or could restrict) the ship from manoeuvring, being propelled or maintaining stability. This category, which usually dominates accident statistics, accounts for 18% of all recorded incidents with no fatalities or injuries.

#### Others

This covers a wide range of other accident categories such as wave impact, explosion, payload related, hazardous substances, and personnel. It is thought that these types of incidents would only be reported if they were

particularly hazardous and this is borne out by the statistics, with 75% having resulted in damage to the vessel and 32% involving injuries.

### Distribution of incidents by year of occurrence

It has been noted that there has been an increasing number of incidents as the fleet size has grown, up to about 1996, when it appears that the incident rate decreased. It is interesting to note that it was about this time that the ISM and HSC codes were first implemented. Since this refers to year of occurrence rather than year of build, it probably indicates that the operational management improvements associated with these codes have indeed improved operational safety.

### Where next?

To continue to generate useful and informative statistics and trends, the database will be updated each year by Seaspeed. As previously mentioned, the database is probably not as comprehensive as it could be and there is a need for more information to improve its status and in turn increase the validity of any statistics generated.

In order to do this the MCA is asking for relevant maritime authorities, organisations, and individuals within each country that operate fast ferries to contact Mr Stephen Phillips, at Seaspeed Marine Consulting Ltd, [stephen@seaspeed.co.uk](mailto:stephen@seaspeed.co.uk), in order to provide relevant information for the current update process.

Seaspeed has noted that Italy, France, China, Japan, Spain, Turkey, Australia, Malaysia, Singapore, the Philippines, and Greece are particularly low on incidents for their relative fleet sizes, and information from the relevant authorities in these countries would be particularly beneficial, as indeed would information from any interested party. A re-analysis of the revised and updated database will be made public via a technical paper to be presented at RINA. 

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## Engine installation for Austal US-built Hawaii catamaran

CONSTRUCTION of the first of two 107m-long fast catamaran ferries by Austal USA has reached a new stage with the installation ahead of schedule of its four MTU 8000-series diesel engines. Each of the 45tonne 20-cylinder engines fitted to the Austal Auto Express 107 passenger/vehicle ferry, which is destined for operation by Hawaii Superferry, produces 8200kW at 1150rev/min.

Their installation, completed in three weeks, was a first for the Mobile, Alabama, yard of Australian shipbuilder Austal Ltd in terms of engine size and weight. The completion is a major step in building the first Auto Express 107, which is billed as the largest aluminium vessel ever constructed in the USA. Engine fitting took place smoothly even though Hawaii Superferry was forced, early in construction, to alter its choice of engine due to manufacturer supply difficulties.

Hawaii Superferry's first new fast ferry is due for delivery in the first half of 2007. The second ship is scheduled to go into service in the first six months of 2009. The company plans to employ the catamaran ferries, each capable of carrying 866 passengers and up to 282 cars or 342 truck lane-metres plus 65 cars, on a three-hour route connecting Honolulu to Maui and Kauai. The vessels will also sail between the Hawaiian capital and Big Island within four hours.

The concept of a high-speed inter-island ferry link dates back to 2001 when Hawaii's unique dependency on air travel was thrown into sharp focus by America's 9/11 disaster. At the time, no one could travel for four days, fresh food ran short on the islands, and emergency medical evacuation had to be handled by the military. A contract agreement for the two vessels, offering Hawaii's first high-speed vehicle-passenger service, was finally reached with Austal in December 2003.

This Auto Express design is 107.7m long with a 23.8m beam, and has a maximum deadweight capacity of 800dwt. It has a service speed of 37knots and, apart from the four MTU 20V 8000 M70 engines, is equipped with four Kamewa 125 SII waterjets.

Vessel loading is via stern ramps and, for the comfort of passengers when boarding, dry exhaust funnels have been designed to direct main engine exhaust fumes away from the ramps and other passenger areas. The ferry will halve the cost of air on its allotted routes in Hawaii.

Another high-speed vessel under construction at Austal USA's Mobile shipyard is a 127m long trimaran Littoral Combat Ship (LCS) for delivery to the US Navy. Austal designed and will construct the LCS seaframe as a subcontractor to the Navy's main contractor, Bath Iron Works, a General Dynamics company.



One of the four MTU 8000-series diesel engines being installed in the first of the two new Austal 107m-long ferries that are being constructed in the USA, at Mobile, Alabama, for Hawaii Superferry.

Photo: Austal

The LCS, which carries two large helicopters that can be operated in adverse sea conditions because of the ship's stable trimaran design, is based on the 127m-long hull of the Austal prototype *Benchijigua Express*, delivered last year as a fast vehicle-passenger ferry to Spanish ferry operator Fred Olsen SA (*The Naval Architect*, September 2005, page 42).

The benefits of this special hull in commercial use on *Benchijigua Express* are better seakeeping, passenger comfort, and hull efficiency. For naval operators, these features and a beam of 31.6m combine to provide a ship with superior speed (in excess of 40knots), flexibility, shallow draught, payload, and significant aviation capabilities over conventional designs.

The Fred Olsen ferry, which went into service between ports of Spain's Canary Islands in Spring 2005, has just completed its first full year in operation. It operates between Los Cristianos in the south of Tenerife and the

islands of La Gomera and La Palma. The vehicle decks provide for a total of 450 truck lane metres plus 123 cars or just 341 cars.

*Benchijigua Express*, which is capable of carrying 1350 passengers, has a crew of 35. With a beam of 30.4m and hull draught of 4m, the ferry has a maximum deadweight of 1000dwt.

Austal USA recently completed a major expansion project at its Mobile yard, with new construction halls providing a total covered area of 16,500m<sup>2</sup> for shipbuilding, roughly quadrupling the existing facility. The scheme adds two large 41m bays under a common roof for module fabrication/erection and component storage; two additional launch aprons in front of each bay; and combined quay length of 238m and additional overhead cranes able to lift 80tonne modules in each bay. The additional space has been required primarily to accommodate the construction of the US Navy LCS vessels. Ⓢ

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## New-design compact waterjet launched

A NEW type of high-performance waterjet, which has been optimised for fast ships, has recently been launched by Wärtsilä Corp. The LJX offers, in comparison with other waterjets available today, a 25% reduction in mounting-flange diameter, a 10% overall weight reduction, and a 35% increase in cavitation margin.

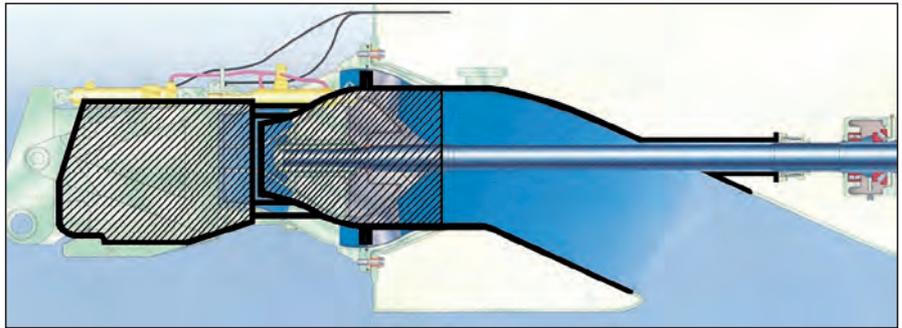
The LJX is being developed to allow an optimum number of waterjets to be chosen for a given propulsion power requirement without requiring an excessive transom width in high-speed vessels. Generally, when selecting waterjets, required power is distributed between multiple waterjet units to create an installation with lower weight, higher efficiency, and lower costs, than when using fewer, larger units. Multiple waterjets have a penalty in increased transom width, which is usually unacceptable in high-speed vessels since transom width is an important vessel design parameter.

In addition, waterjets that are currently available are designed to cover all propulsive requirements for extremely high speeds, up to more than 70knots, and for very high powers on relative small diameters. However, the Wärtsilä LJX cuts out the extreme in hydrodynamic design parameters, and is based on a completely new design to create a more compact unit with heavily increased cavitation margins.

The first Wärtsilä LJX waterjets are being delivered for two Incat 112m high-speed wave-piercing catamarans, order by Japanese customers (see our story elsewhere in this feature). These cats will be delivered in 2007 from Incat's Hobart, Tasmania, shipyard.

With a load-carrying capacity of 1500tonnes, these are believed to be the largest catamarans to be powered by diesel engines. They will each have capacity for more than 800lane metres of trucks and other heavy vehicles, together with 150 cars, or, if trucks are not carried, for more than 400 cars alone. They will also be able to carry up to 1000 passengers.

Capable of speeds greater than 40knots, the vessels will each be equipped with four LJX



The new Wärtsilä LJX waterjet will offer, in comparison with other waterjets available today, a 25% reduction in mounting flange diameter, a 10% overall weight reduction and a 35% increase in cavitation margin.

waterjets having a 1500mm diameter impeller and an inboard layout for steering and reversing hydraulics.

The mechanical design of LJX is similar to the current Lips Jets series with all main parts of the stator and the steering assembly fabricated from stainless steel plates. This approach allows Wärtsilä to achieve minimum weight with maximum design flexibility. It is thus possible to have not only common steering/reversing and booster jets, but also jets for fast crash stop and reversing, jets with nozzle closing devices, and jets with inboard hydraulic systems. The oil-lubricated thrust bearing remains inboard in the jet room with a water-lubricated marine bearing supporting the shaft in the stator bowl.

By employing LJX waterjets, new high-speed vessel designs are a possibility, according to Wärtsilä. As an example, 36MW of propulsive power in a stabilised monohull is typically generated by four diesel engines. Four waterjets are then the logical solution but they rarely fit within the transom width. A typical compromise is the installation of two 9MW wing jets and a single 18MW central jet driven by a complex twin-input/single-output gearbox with two reduction ratios. An alternative of using an 18MW gas turbine

instead of the central two diesel engines is unpopular because of the fuel consumption penalty.

However, four LJX jets of equal size will easily fit in the space normally taken by the three unequal-sized units because of the 25% smaller diameter of the compact Wärtsilä LJX design. The vessel's owner also benefits from greater redundancy and the lower logistics and maintenance costs of the uniform propulsion installation, with all jets and gearboxes being identical and requiring similar parts.

High-speed planing yachts can be built with two wing waterjets and a large, central waterjet. Yet, most of the time, such craft will usually cruise at low speed on their wing jets alone, with the high-powered central jet being shut down. Installing the LJX on the wing propulsion lines will give this type of yacht increased freedom in the choice of cruising speeds, owing to the improved margins for cavitation; these make high acceleration thrust available at low speeds.

LJX units also allow slightly larger wing waterjets to be chosen for even further increases in operating freedom and low-speed efficiency. Even with larger LJX wing waterjets, the compact design gives yacht designers benefits in reduced width and a lower height of the jet flange, freeing up more space aft in the vessel. 

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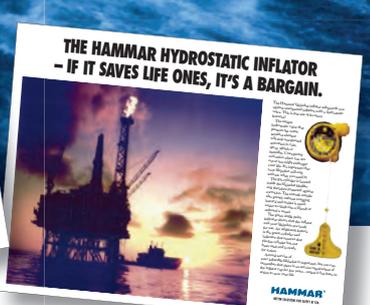
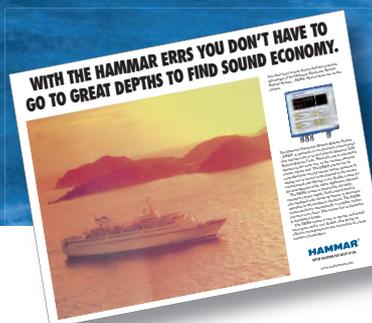
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## Gotlandia II - a new fast ferry from Fincantieri

THE recent completion of the 40knot *Gotlandia II* high-speed monohull ferry by Italian shipbuilder Fincantieri is another sign of the growing significance of marine traffic across the Baltic Sea. Ordered in June 2004 by the Swedish owner Rederi AB Gotland for its subsidiary Destination Gotland AB, the ship was constructed at Fincantieri's Riva Trigoso yard, with fitting out at its Muggiano site before delivery just 14 months from its February 2005 keel-laying.

The 122m-long vessel joins a Destination Gotland fleet of both high-speed and conventional ferries, including the French-built 112.5m monohull high-speed craft *HSC Gotlandia* (constructed in 1999 by the French yard, Alstom Leroux & Lotz) which serves routes between the Swedish mainland and Baltic island of Gotland.

Built and designed according to the IMO code HSC 2000 and classed by Lloyd's Register of Shipping, *Gotlandia II* has a high-tensile steel hull and light-alloy superstructure. She is 16.65m wide and is equipped with four 9000kW diesel engines for propulsion, four steerable and reversing waterjets, and two 350kW HMC 0-4-11 NG bow thrusters.

The fast ferry, whose operating speed is 36knots, has a maximum deadweight of 580dwt, with capacity aboard for 780 passengers, in addition to more than 160 cars and eight buses. She has a 3.3m draught.



*Gotlandia II* joins a fleet which already includes another fast monohull, *HSC Gotlandia*, as well as conventional ferries, some of which also have exceptionally high speeds.

*Gotlandia II* was designed to meet the strict environmental demands of the Swedish Maritime Authority. She is equipped with catalytic converters to reduce the level of pollutants emitted by the diesel engines both at sea and when in port, and with passive control systems for acoustic pollution, which will enable noise levels to be substantially contained at all times.

Growing trade and passenger traffic with the eastern Baltic states reflects the liberalisation of the former Eastern Bloc and marks an acceleration in the revival of maritime traffic across the Baltic. This is reflected in the growth in ro-ro vessels and a swelling fleet of fast-ferries

catering for both cargo and passengers. Another operator, Tallink, from Estonia, helps to epitomise this growth.

It is clear that Rederi AB Gotland has already won a greater share of passenger traffic from air, in spite of today's growing European threat to ferries from low-budget airlines. The latest Gotland ferry order has also boosted Nordic business for Trieste-based Fincantieri, which also has several fast ferries in service in the seas off Italy and the UK. In 2004, the shipbuilder won a contract from Finnish owner Finlines to construct five large ro-pax ferries and, last year, gained an order for a large fast cruise ferry for the Estonian operator AS Tallink Grupp.

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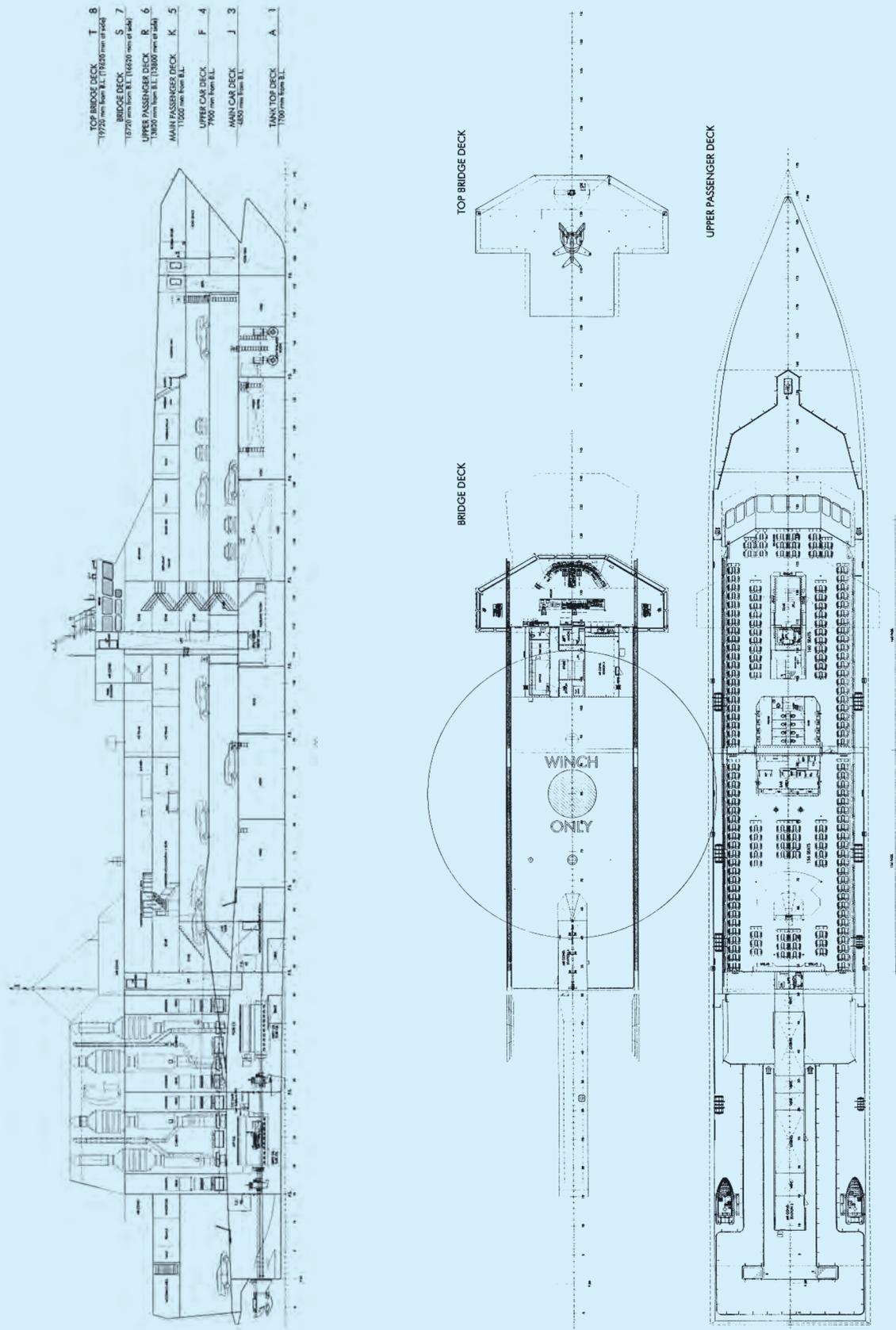
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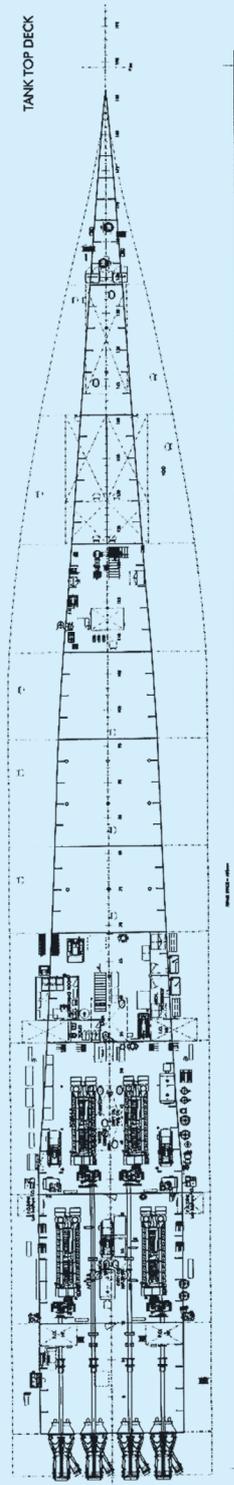
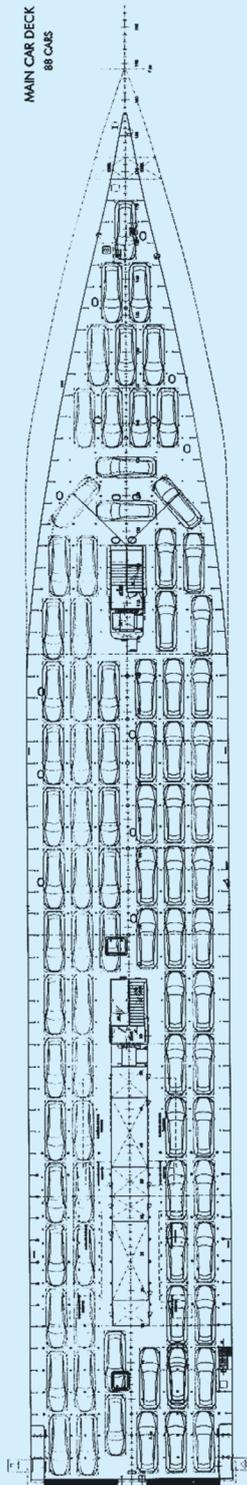
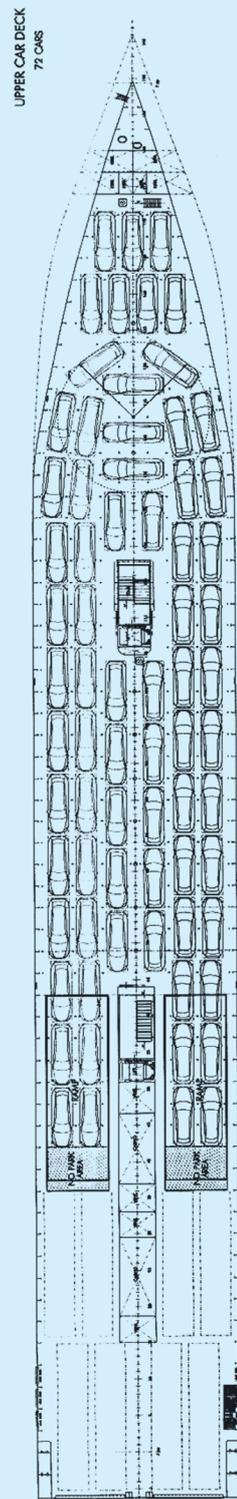
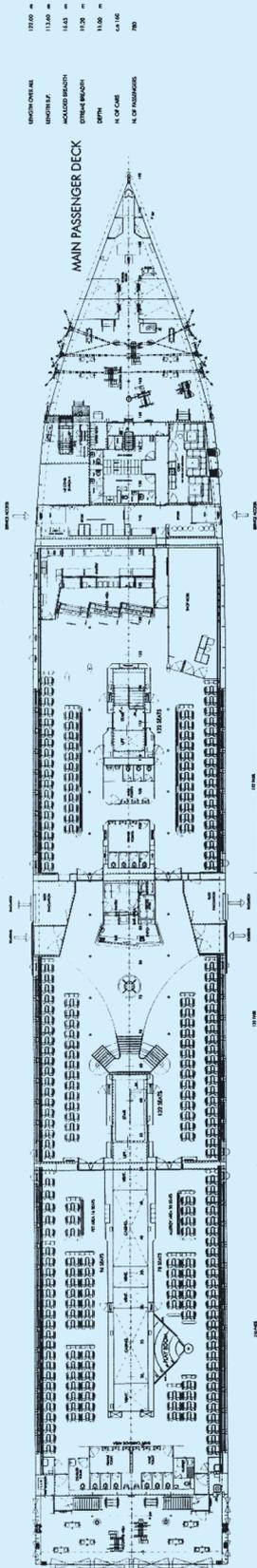
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General arrangement plans of the newly completed high-speed monohull ferry *Gotlandia II*, built by Fincantieri for operation by Destination Gotland.





## Incat contract with Japanese operator

**I**NCAT Australia Pty Ltd, the innovative Tasmanian shipbuilder, has won a breakthrough contract to supply two of its newly-developed 112m-long high-speed catamaran ferries to the Japanese group Libera Corp. The first of the large Evolution One12 vessels, which are scheduled to link the Japanese port cities of Aomori and Hakodate (Honsu to Hokkaido islands), is due to be delivered in June 2007 with the second supplied a year later in mid-2008.

The Evolution One12, created by Revolution Design, can carry 800 passengers, with up to 412 cars, alternatively freight vehicles on 529 truck lane metres plus 286 cars. The ferry, with a maximum 1450dwt, has a moulded beam of 30.50m and a draught of approximately 3.93m.

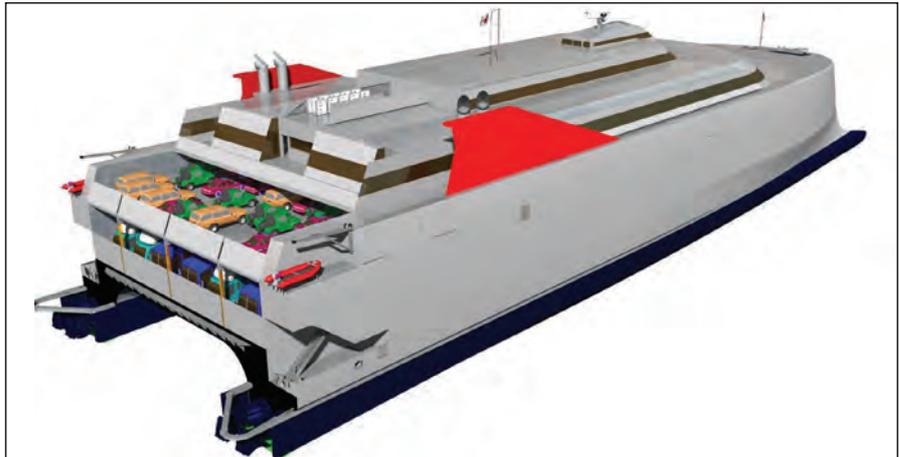
Libera, based in Tokyo, signed a letter of intent to the purchase the fast ferries in January this year, and the contract was confirmed at an official ceremony staged in the Japanese capital at the end of May. The deal is Libera's first with the Australian aluminium ship specialist.

This is a ground-breaking order for Incat, both because it is the first for its wave-piercing catamaran ferries of more than 100m length and because its previous business has been chiefly in outside Asia. Full details of this interesting concept appeared in *The Naval Architect* April 2005, page 6, and work on construction of the prototype was reported in our September 2005 edition, page 54.

'We are particularly pleased by this order for our largest vessel yet since it comes from a new customer in an area where we believe there is enormous potential for Incat high-speed craft. The contract represents a new era for both our companies, with the introduction of large high-speed vessels to our customer's fleet to replace conventional ships, and a new era for Incat, as the concentration of our high-speed ships to date has been in Europe and the Americas', said Incat's chairman, Robert Clifford.

With its top speed of 40knots, the Evolution One12 should halve the time currently taken by Libera's existing conventional vessels, thus improving the service for passengers.

The ferries will be powered by four MAN B&W (Ruston) 20RK280 diesel engines, with each one housed in a separate engine room, allowing for



An impression of the Incat Evolution One12 catamarans that have recently been ordered by the Japanese operator Libera Corp.



Seen here with her portside marine evacuation system chutes and liferafts (supplied by Liferaft Systems Australia) deployed during a test in Hobart, Tasmania, is *Milenium Tres*, the newest catamaran ordered by Acciona Trasmediterranea. The two slide systems shown here each consist of a 17m inclined inflatable slide, with a 100-person self-right liferaft attached. They were deployed simultaneously and were ready for boarding within 50 seconds.

unscheduled maintenance on any one of the four drivelines while the ship is underway on three engines. This new larger wave-piercing catamaran has been three years in development and construction, since Incat found that its existing 98m versions of the ship were just not large enough for high-volume ferry services, mainly in Europe. The 112m model offers greater transport efficiency with the new size, and diesel

engines provide better specific fuel economy by making the vessel 18% more economical on a per-tonne deadweight scale.

Incat was due to deliver another fast ferry, *Milenium Tres*, in August to an existing European customer, Acciona Trasmediterranea SA. This new 98m long wave-piercing catamaran is the fourth such ferry that the Australian shipbuilder has provided for the Spanish operator. 

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## SeaBridge pentamaran project for US coastal service

**L**EADING European ship design consultancy BMT Nigel Gee & Associates is involved in an innovative fast ferry project aimed at helping reduce growing road traffic congestion on US highways. The company, based in Southampton, UK, has just completed the detailed design for a large, high-speed ro-pax pentamaran vessel for the American company SeaBridge USA Inc. This company is planning to establish a fleet of up to 12 fast ro-ro ferries to carry trucks, cars, and passengers between major port cities, initially, along so-far unserved stretches of US East and Gulf coasts.

SeaBridge USA's plan, which it has dubbed 'the most significant... travel option since the aeroplane', is designed to enable long-haul trucking companies to avoid exposing drivers and equipment to frustrating delays and related risks on the country's increasingly congested coastal highways. It should also provide an attractive alternative to millions of motorists faced with clogged roads.

SeaBridge, which holds an exclusive development agreement on BMT Nigel Gee's patented pentamaran design (discussed in several issues of *The Naval Architect*, including April 2004, page 20), has chosen VT Halter as the lead shipyard to construct the ferries which, under US Jones Act regulations, must be built in the USA.

The pentamaran ferry design is configured to offer 2900 lane metres of vehicle space, with capacity for around 173 trailers or 75 trailers and 500 cars. Passenger capacity is flexible, with up to 1800 berths provided, allowing for a maximum of around 1864 and 286 crew.

The SeaBridge pentamaran would be 300m long, with an overall beam, including sponsons, of 45m, a maximum deadweight amounting to 6500dwt and draught of 9.70m. The pentamaran, with a top speed of 42knots at 90%



An impression of BMT Nigel Gee's SeaBridge pentamaran design, which is planned to run a coastal service on the US east coast, to relieve road congestion. A service speed of 40knots is proposed.

MCR and a service speed of 40knots, the ferry is configured for maximum flexibility and so has a diesel-electric propulsion plant allowing for efficient vessel operation at lower speeds.

Each ro-pax ferry is expected to be propelled by MAN B&W or Wärtsilä primary diesel engines (8 x 21,600kW) totalling a massive 172,800kW, and to be fitted with five Lips/Kamewa waterjets and two tunnel bow thrusters.

SeaBridge and BMT Nigel Gee have successfully conducted a detailed structural analysis using loads calculated from a 3D hydrodynamic software package verified by

strain gauged model tests. The structural design has undergone preliminary design appraisal preview by class society Det Norske Veritas.

Although not intending to compete for freight, SeaBridge's aim is to create a long-term competitive advantage in coastal transportation by developing comfortable, high-speed vessels sailing under the SeaBridge flag. This operator is ready to be the first-to-market provider, leading to the possible emergence of a scheduled deepsea, long-distance passenger, and freight service around the extensive coastline the USA. 

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# New approaches to ballast and cargo tank coating

The needs for anticorrosive protection are changing, says J Azevedo, sales and marketing director for the Portuguese company Euronavy SA\*. New performance concerns (eg, TSCF15 and IMO Directives), emergent environmental issues, careful cost analysis, and increased safety worries are creating new trends in the market for anti-corrosive marine coatings. This article describes the new needs and presents a novel humidity-tolerant epoxy technology incorporating the best trends to answer them, as well as introducing important savings for both refurbishment and new construction projects.

THE needs for anticorrosive protection are changing, regardless of the field of application, leading to new trends in both surface preparation and coating type. Environmental pressures, new cost factors, performance needs driven by new aggressive operation conditions, and safety concerns can be answered by some emerging trends, summarised in Fig 1.

These needs (detailed below) and corresponding trends have been recognised, partially or totally, by numerous authors [Refs 4, 7, 8, 9, 10, 11, 15, 16]. Today's changing needs are acutely felt by the shipping industry, maybe more than by any other economic activity. Since the 1990s, increasing attention is being paid to the corrosion of ballast and cargo tanks within the tanker fleet.

The first trigger for this was the *Exxon Valdez* accident off Alaska, in March 1989, followed by *Erika* in 1999, *Castor* (2000) and *Prestige* more recently. Several organisations such as IMO, SOLAS, IACS, and Intertanko reacted to those events [Ref 14], promoting the study of corrosion causes and introducing marked changes in the regulatory environment regarding corrosion assessment and control obligations by the ship owners.

The regulatory changes regarding the use of coatings for corrosion control began with IMO Resolution A798 (1994, guidelines for coating prevention systems in ballast tanks), followed by SOLAS Amendment Chapter II-1 Reg. 3.2 (after July 1 1998, tank and bulk ships should provide hard coatings in ballast tanks). More recently IMO has started preparing Performance Standards for Protective Coatings [Ref 18] are based mostly upon the Tank Structures Cooperative Forum's (TSCF) *Guidelines for Ballast Tank Coatings Systems and Surface Preparation*, published in 2002

\* Extracts from the paper 'A new approach to ballast and cargo tank coating: a solvent-free and humidity-tolerant epoxy system with edge-retentive properties', by J Azevedo, Euronavy, Portugal, presented at The Royal Institution of Naval Architects' international conference Advanced Marine Materials and Coatings, held on February 22-23, 2006 in London.

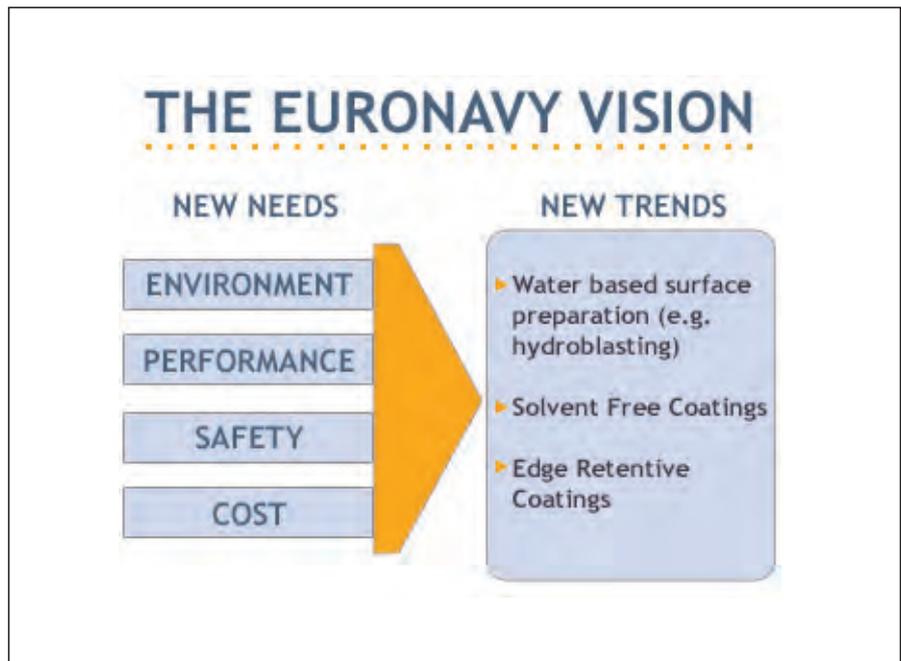


Fig 1. New trends in surface preparation and coating methods driven by changing needs.

[Ref 17]. These are already being widely used for new oil tankers. The European Maritime Safety Agency (EMSA) is also addressing this issue, reporting a number of recommendations in a recent report [Ref 20].

Meanwhile, an important parallel effort driven by the same basic concerns (corrosion problems onboard ships due to poor coating systems performance) was developed by US Naval Sea System Command (NAVSEA) [Refs 7 and 8], resulting in upgraded coating selection and surface preparation procedures. The MIL-PRF Standard 23236C (2003) is the ultimate result of this work [Ref 18], implementing stringent rules for the acceptance of coating systems to be used onboard US Navy ships, specially for ballast tank protection. These rules apply not only to the performance of the coating (evaluated by standard tests) but also to specific features such as edge-retention and volatile organic compound (VOC) content of the coating also health, safety, and environmental compliance of its components.

One can conclude that the problem is identified and the tools to solve it are available. But the solution may be difficult to implement due to the present 'business' environment. The lack of such implementation is particularly felt by the oil tanker owners: the estimated worldwide average annual corrosion cost due to

maintenance, repairs and downtime for oil tankers only, is US\$2353 million, based on 6920 registered tankers as per Joshua [Ref 13].

This equates to an average cost for each ship of US\$200,000/year for corrosion repair and US\$140,000/year due to downtime! Failure to assure long-lasting coating systems for ballast tanks at the new building stage means the owners are facing the prohibitive cost of refurbishment of a ballast tank coating during the service life (costing 3-17 times the cost of coating it at the newbuilding stage).

Eliasson [Ref 15] identifies the traditional antagonistic relationship and conflicting interest between the parties involved (owners, builders, and coating manufacturers) as the main problem making the correct implementation of the right solutions for the corrosion problem difficult. Despite the new rules, one cannot see their reflection in the standard guarantee traditionally given by the shipyard from the delivery date: just one year.

This means that the shipyard does not feel pressured to supply an effective corrosion protection system if its application means extra production costs and delays. The result is that the shipyard claims exorbitant extra costs to supply efficient and TSCF-compliant ballast tank coating systems for 15 or 25 years' service life, and the owner fails to evaluate correctly



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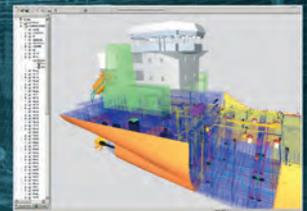
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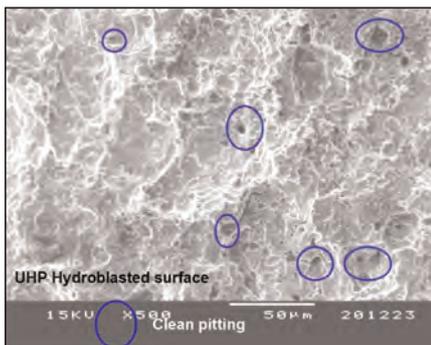


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**Fig 2. A hydroblasted surface without salts and conserving the original profile.**

the gains of such extra costs on future avoidable costs of refurbishment and downtime. He often accepts a standard-priced ship with a sub-standard corrosion protective coating system.

Lodhi [Ref 10] departed from this assessment of the current situation to evaluate further typical cost factors of a new VLCC regarding coating. The average cost of such a new ship increased from US\$100 million in 1995 to US\$130 million in 2005, the total painting cost being steady at 7% of this total (around US\$9 million in 2005).

A huge slice of this painting cost (50%) is for ballast tank coating, divided between material cost (35% = US\$1.59 million) and labour cost (65% = US\$2.96 million). The bad news is the labour costs for blasting and coating, which have doubled from 1995 to 2005. The conclusion is that the cost of the coating application of ballast tanks that the yard is willing to assume (and the owner willing to pay) increased 30% during these last 10 years, but that the man-hours cost increased by 100%, meaning that the total labour resources available for the coating application in ballast tanks decreased by 30% (from 22,700 man-hours in 1995 to 14,800 man-hours in 2005).

The same author goes further, extrapolating for 2007 for the case that shipbuilding expected overcapacity in the near future will depress the VLCC prices down to US\$94 million. Maintaining the same scenario (frozen 3.5% of total costs dedicated to ballast tank corrosion protection), the result will be a further reduction in resources availability, down to 8800 man-hours, 60% less than the resources available for ballast tank coating application in 1995!

The author would like to add two extra factors that are also contributing to poor coating performance after new building: the lack of influence of the ship owner on the coating supplier selection and application control by the shipyard at newbuilding stage. This means that specifications with too many degrees of freedom are being used by yards, who may select materials from a broad spectrum of traditional coating suppliers with 'me-too' products.

To compete in this environment, coating suppliers may be tempted to downgrade product quality to cope with depressed prices or (even worse) to be more tolerant' (more than the coating itself) to surface preparation and other pre-requisites, in order to cut delays, as a means of pleasing the yard and helping future business.

In such a difficult scenario, the solution depends on all parties yielding a little of their interest, by understanding the broad picture and the un-sustainability of the present situation. A fourth party not yet mentioned (classification societies) should also play a more active role in such an evolution.

The intention of this article is not to advise on such desirable moves, but to present an additional contribution from a particular coating system. The coating system presented below can help the adoption of the desirable newbuilding coatings specifications for tanks such as the TSCF ones, for 15 years service life with a lower impact on the costs of surface preparation and application, plus diminished extra delays on the production progress.

This coating system may be used for both ballast and crude cargo tanks at the newbuilding stage, and incorporates all the new above-mentioned trends. Moreover, due to its surface and humidity tolerance features, the system enables owners to choose voyage repairs for ballast tank refurbishment with good durability expectations, thus saving the huge downtime associated if the same job is done during drydocking.

### Changing needs

The needs driving new trends in surface preparation and coating methods can be divided as follows:

- *Performance needs:*
  - longer service lives required
  - attention is given to previous neglected causes of failure as salt level at steel surface or coating thickness at the edges and on welding seams.
- *Cost needs:*
  - emergence of cost-benefit analysis
  - collateral costs as environmental control costs (eg, abrasive disposal), downtime in case of failure and delays are evaluated
  - the cost of the coating itself takes a decreasing slice of overall cost
  - surface preparation costs are taking an increase slice of overall cost.
- *Environmental needs*
  - new regulations regarding VOC content of coatings and abrasive use and waste disposal
  - media and social pressures towards the adoption of 'cleaner' technologies.
- *Safety needs*
  - new regulations regarding health and safety compliance of coatings
  - increased constraints in the use of technologies that introduce additional risk (for equipment and people) within industrial environments.

### Shipping industry changes

The main consequences of the above-mentioned regulatory changes within the ship industry are:

- industry shift from single-hull to double hull tankers
- hard coatings mandatory for ballast tanks (SOLAS Reg. II-1/3.2)
- mandatory coating of crude cargo tanks (bottom and top) is expected to be settled in a near future
- increasingly stringent rules regarding tank condition control (IACS classification). The economic advantage for owners of keeping ballast tanks in GOOD condition (corrosion assessment) is becoming increasingly important (if classified as FAIR or POOR, important restrictions may apply for the vessel's operation and the imposition of increased frequency of inspections will impact downtime costs)
- TSCF guidelines for ballast tank coating: pre-qualification of coating systems, stringent rules for surface preparation (primary and secondary), salt level, film thickness, and stripe coating.

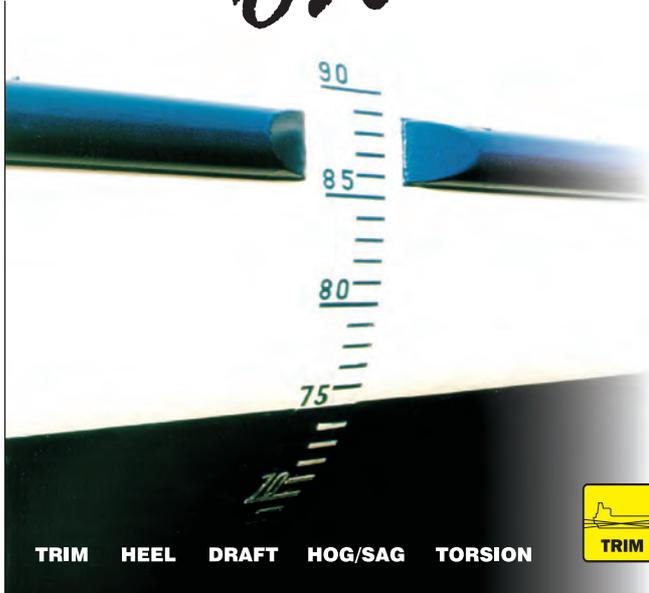
The shift to double hulls and the augmented need for good corrosion control are contributing to an increase in importance of this issue for the owners. The factors are:

- double-hull VLCC tanker ballast-tank areas range from 240,000m<sup>2</sup> to 280,000m<sup>2</sup>. This is around double the ballast tank area on an equivalent size single hull ship.
- for economical and technical reasons, double-hull vessels are built using 80% 90% high-tensile steel, to allow a diminution of the thickness of steel plates. A double-hull ship has only 11% weight increase when compared to an equivalent size single hull. The result of this strategy is that any steel thickness loss is more critical and the steel flexibility is higher. Another effect with consequences for corrosion due to coating failure is the dimensional changes during sailing: thinner steel plates are much more flexible.
- single-hulled tankers' crude oil cargo tanks were not coated in the past. But double-hull cargo tanks are experiencing heavy pitting problems only four-to-five years after delivery. The reason is connected with the 'thermos flask' effect of the double bottom and the flexibility of the steel. Warm crude cargo from Middle East do not cool as quickly as used to happen in single-hull ships, due to the direct contact with colder seawater, only one steel plate away. Now, the void space between acts as insulation that keeps the cargo warm, at optimal temperatures for microbial growth where water is present (in the bottom and in the top of tanks, in this case because of condensation). Microbial induced corrosion (MIC) is playing an important role.

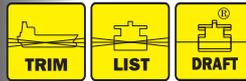
### Emergent trends

Numerous examples of authors presenting their solutions for changing needs can be cited. In

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Fig 3. The edge-retentive performance of ES301 is seen here.



Fig 4. Humidity and surface tolerance: ES301 priming over UHP hydroblasted surface, flash rust M.



Fig 5. High adhesion (pull-off 20MPa, during FPSO conversion works in Singapore).

2000, Thomas and Webb [Ref 7] presented the US Navy's answers to face service life problems in ships, namely through the use of solvent-free edge-retentive coatings. The present version of the US military standard MIL-PRF 23236C [Ref 19], states the performance features required for painting systems to be used in ships and submarines, and represents a demanding challenge and an important upgrade of former performance requests.

Meunier presented (1998) [Ref 16] the SNCF (Société National de Chemin de Fer) opinion of the best way to give economic answers to environmental control needs during steel bridge painting, using ultra-high-pressure (UHP) hydroblasting. Quintela, Silva e Leite [Ref 9], in 2002, presented the Petrobras vision over the needs of environmental preservation while saving costs, through a reformulation of coatings characteristics (low VOC, humidity tolerance) and the use of hydroblasting.

Lodhi (2005) [Ref 10], claims that if the steel surface quality can not be improved at the time of construction due to yard reluctance, the use of a surface + moisture tolerant and edge-retentive coating instead of conventional solvent borne coating is worth the extra cost. Many other references could be shown, in agreement with the conclusions and results of the examples listed above.

In summary, to cope with the new needs, some key new trends on both the coating and surface preparation activities have been observed: the increasing adoption of ultra-high-pressure water jetting (as defined by SSPC SP12 standard) as surface treatment method, the increasing use of low-VOC coatings (eg. solvent-free or ultra-high-solids epoxies) and attempts to increase the edge-retentive properties of the coatings.

### Challenges

Answering the new needs in the way outlined by Fig 1 may lead to new problems. Each option carries advantages but also some drawbacks, which should be correctly identified and solved.

### Hydroblasting

The use of hydroblasting has a number of advantages, namely a lower salt level content on the prepared surfaces, a lower environmental impact, decreased safety risks (compared with abrasive blasting) and fewer

counter-effects on the original surface profile (Fig 2) or on adjacent coated areas. Due to safety concerns, hydroblasting is much more compatible with ongoing industrial activities, when compared with abrasive blasting.

Nevertheless, some drawbacks can be associated with this surface preparation, mainly the dry surface requirements such as the flash rust dilemma and reduced performance of the protection compared with traditional coatings over SA2½ abrasive blast standard [Ref 11].

Conventional coatings are the main adversaries for a larger adoption of this preferable surface preparation technology. There are numerous reports of maintenance jobs using hydroblasting, under high humidity, where the absence of moisture tolerance of the coating can lead to increased waiting times and often to excess flash rust and dangerous salt levels when the surface finally dries.

Reblasting is then necessary, and the cycle may repeat forever. A possible outcome is giving up the job or carrying out the application anyway, therefore crossing the red line, delivering reduced coating performance.

The salt level issue should be looked at carefully. In fact, immediately after hydroblasting, a SC-1 condition (surface free of detectable salts, as per SSPC SP12 standard regarding non-visual contaminants) can be achieved. But under marine conditions, salt contamination of the surface will occur quickly, risking surpassing the SC-2 condition (7micrograms/cm<sup>2</sup> chlorides) after drying. A preferable chloride level below 3micrograms/cm<sup>2</sup> or 4micrograms/cm<sup>2</sup> is much easier to obtain if the coating application is possible a short while after blasting or washing, without need for extensive drying.

### Edge retention

Coatings with increased edge-retentive properties allow a better protection of critical areas, such as welding seams and stiffener edges [Ref 1]. The advantages of such a coating's ability are especially important on ballast tanks and complex land-based steel structures. A typical solvent-based coating, applied on a 90deg edge by airless spray, will experience an after curing dry thickness reduction on the edge, dropping to only 20% to 30%, compared with the adjacent flat surfaces.

A good edge-retentive coating should present a ratio superior to 70% (Fig 3), as per US Navy/NAVSEA requirements for long service



Fig 6. ES301 primer and stripe coat during crude cargo tank hydroblasting and coating job. A two-coat system with 300micron DFT is used for this purpose.



Fig 7. Edge retention is a key feature for the durability of tank protection.

life ballast-tank coatings (20 years) [Refs 7 and 19]. With such coatings, a trade-off is possible between extra performance and stripe coating needs (which can be reduced).

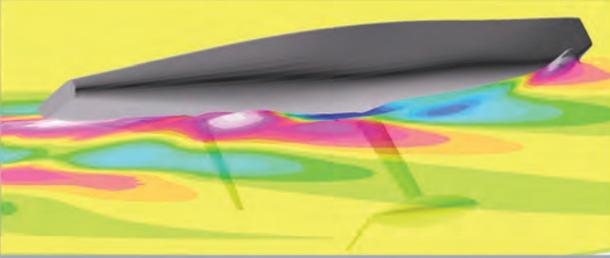
On the newbuilding side, edge grinding is mandatory as per TSCF guidelines and other steel preparation specifications. This costly operation may also be reduced without critical impact on the performance, if an edge-retentive coating system is used. Normally, edge-retentive coatings have very high viscosities, low pot-life, and may cause airless application



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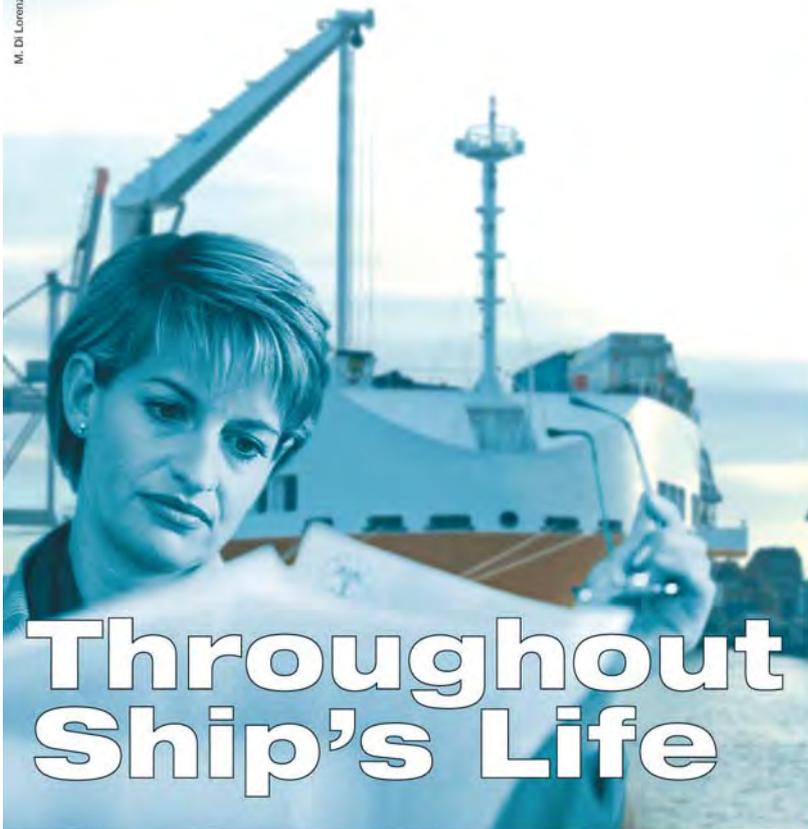
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Salt fog ASTM B117	Rating 10 (0-10, ASTM D1654) after 1000h	(A)
	> 2000h no defects	(B)
Condensation ASTM D4585	Rating 10 (0-10, ASTM D1654) after 1000h	(A)
	> 2000h no defects	(B)
Combined weathering test (NACE TM0184)	4000h no defects	(D)
Adhesion (pull-off, ASTM D4541 or equivalent)	System applied over SA2 ½ or WJ2 standards	
After application and curing	12.0- 24.0MPa	(B)
After 1000h salt fog	9.3 – 10.8MPa (ES301K+ES301S)	(A)
After 700h salt fog	10.0MPa (ES301L+ES301S+PU) NF EN 24624	(C)
After 1000h condensation	11.5 – 13.8MPa (ES301K+ES301S)	(A)
Atmospheric exposure (2.5 years)	Ratings 0-10 accordingly to ASTM D1654 Rust: 10; Blistering: 10; Scribe undercut 0.5mm	(A)
Cathodic disbondment (MIL P24647, ES301K+ES301S)	No defects (90 days, 'pass').	(A)
Choc resistance (falling weight) (NF EN ISO 6272)	6.4 – 8.3J (fall from 65cm to 85cm) (ES301L+301S+PU)	(C)
Fire resistance ASTM E84-01	Rating A (NFPA No 101, evaluating flame spread and smoke liberation)	(E)
Edge-retention (procedure of MIL-PRF 23236 C standard)	% retention 74% - 101%, for edge radius between 0,1 mm and 2.4mm, respectively. (ES301K+ES301S system)	(A)

Table 1. Test results of ES301 system.

- (A): Naval Research Laboratory, Center for Corrosion Science and Engineering, US Navy.  
(B): CENPES/PETROBRAS, Centro de Pesquisas e Desenvolvimento Leopoldo A.M. Mello  
(C): SNCF, Société National de Chemin de Fer (Eurailtest Laboratoire de Vitry)  
(D): DNV Preliminary Report on Type Approval  
(E): NGC Testing Services, Fire Testing Laboratory

ITEM	REQUIREMENT	COMMENTS
<b>PRIMARY SURFACE PREPARATION</b>		
BLASTING	Abrasive, SA2 ½	ISO8501, 4.1-4.6
PROFILE	30 – 75microns	ISO8503-1/3
SOLUBLE SALTS	< 30 mg/m <sup>2</sup> (chlorides)	ISO 8502-9
PRE-CONSTRUCTION PRIMER	EURO-shop PE31, 25 microns	Organic epoxy using the same resin-curing agent system than ES301
<b>SECONDARY SURFACE PREPARATION</b>		
STEEL CONDITION	P1 Grade (one pass edge grinding)	ISO 8501-3
SURFACE PREPARATION	UHP Hydroblasting to WJ2 on damaged areas. Moderate flash-rust level accepted. HP washing (> 700bar) of other areas with intact shop primer.	SSPC SP12 / SSPC Vis4
SOLUBLE SALTS	< 30 mg/m <sup>2</sup> (chlorides)	ISO 8502-9 (NOTE : using water as secondary surface preparation means that the salt level is more easily achieved)
DUST	'1'	ISO 8502-3
ABRASIVE INCLUSIONS	None	Using water as secondary surface preparation means that this control is not needed any more.
<b>COATING</b>		
1st coat	ES301K62 (red oxide colour, with luminescent additive as option)	150 microns DFT
Stripe coat	ES301S brush applied	150 microns DFT
2nd coat	ES301S00 (light colour)	150 microns DFT

problems. These drawbacks may imply the need for plural-airless equipment to apply the product.

### Solvent-free epoxies

Epoxies are one of the chemical families of coatings more adaptable to solvent-free formulations (meaning ultra-high solids with VOC ranging from 0g/litre to 150 g/litre). Solvent-free epoxies are environmentally preferable (reduced VOC emissions). A number of technical advantages when compared with solvent-based epoxies are generally observed. Solvent-free epoxies reduce the problems arising from solvent retention in applied coating films, are more tolerant to over-thickness situations, allow a reduction in the number of coats of the coating system, present better cohesive and tensile strength resistances, and better appearance (glossy surface, which is easier to clean).

Today's typical solvent-free epoxies on the market also have some drawbacks: reduced pot life and extremely high viscosities are the main ones affecting easy application. Solvent-free epoxies tend to be applied with excess thickness, given application difficulties, with negative impact on costs (paint consumption) and curing. A majority of solvent-free epoxies on the market are not surface-tolerant and are dew-point restricted, thus making the option for hydroblasting problematic.

### Interesting new trends

The ideal solution to answer the new needs, in order to avoid the above drawbacks of the individual approaches, would be a coating system incorporating all the new trends. This system should be solvent-free, tar-free, tolerant to humidity and to surface preparation/flash rust, user-friendly (pot-life, viscosity, curing profile) and have good performance (allowing long life protection over hydroblasted surfaces, similar or superior to that achieved using traditional technologies over abrasive blasted SA2½ surfaces).

Moreover, it should present good edge-retention properties and be formulated without any dangerous or undesirable components such as heavy metals, chromates, or zinc. Euronavy has developed a solvent-free epoxy technology that combines all these aspects.

### Possible solution: the ES301 coating system

At the beginning of the 1990s Euronavy created what is claimed as the first version of a novel epoxy system (branded ES301). This combines a majority of the new trends (including the solvent-free and humidity tolerance features). The system was further optimised during the decade and as been used by respected customers such as the US Navy, SNCF, Petrobras, Transpetro, and National Iranian Tanker Co - just some of the companies and organisations that were more aware of the need for change.

Table 2. ES301 system specification for 15 years service life as per 'adapted' TSCF15 guidelines.

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ITEM	ES301 System	Typical TCSF 15 approach	Observations and references	OUTPUT OF CHOOSING ES301
Shop Primer	May use the organic epoxy PE31 shop primer	Zinc ethyl silicate	Using PE31 means cost savings (shop primer cost per sq.m.) and lower failure risk (inorganic zinc is very sensitive to application).  The conjugation PE31/ES301 is already being used in several conversion and new building projects.	PRODUCT COST SAVINGS SAFER PRODUCT APPLICATION
Secondary surface preparation	Allow UHP hydroblasting	Demands SA2 on all areas (SA2 ½ damaged spots)	PE31 shop primed surfaces can be over coated with tolerant ES301 system without the need of removing it by abrasive blasting. EURONAVY procedure accepts UHP WJ2 (SSPC SP12) on damaged spots and intact areas preparation by HP water jetting (> 700 bar). This option is possible due to the humidity and surface tolerance features of ES301, and has been used in several shipyards in Singapore and Brazil.	HUGE SAVINGS ON 2 <sup>nd</sup> SURFACE PREPARATION COST  SAVE WASTE DISPOSAL COSTS (abrasive) ENVIRONMENTALLY FRIENDLIER EASIER SALT LEVEL CONTROL
Steel preparation (edges)	Accepting P1 (one pass grinding)	Demands P2 grade (three pass grinding)	ES301 system is approved by MIL-PRF 23236C from US Navy as Type VII (no solvent added) and by classes 7 (ballast tanks), 17 (bilges) e 15b (no dew-point restricted, may be applied over wet bare steel). This approval means that the Edge Retention Ratio is >70% with a 1mm radius edge: P1 is quite enough to assure good thickness over edges and welding seams.	SAVING TIME & COST SPENT FOR EDGE GRINDING
Stripe coats	One stripe coat, between the two coats, is enough to assure edge thickness.	Two stripe coats mandatory for two-coat systems.	ES301 advantage is a result of the edge-retentive behaviour (approved by MIL-PRF 23236C). Among the few systems with such approval, ES301 was accepted with minimum 300 microns DFT (as TSCF15 requirements). All others have to be applied to a minimum 350 microns DFT. Moreover, among the 23236C Type VII approved systems, ES301 is the only one tolerant to humidity (Class 15b).	COST SAVINGS ON MAN POWER
Painting	Without dew-point restrictions.  Low-VOC, friendly pot-life	Dew-point restrictions.	MIL-PRF 23236C Class 15b approval means that ES301 may be applied over wet surfaces without dew-point restrictions. As solvent-free product (Type VII of MIL 23236C, no-solvent added, VOC <150g/litre), can be considered environmentally friendlier and with higher performance	NO DELAYS DUE TO HUMIDITY CONSTRAINTS  SAVES DEHUMIDIFICATION COSTS
Durability	20 years as per US Navy PPIs	15 years	ES301 system is specified by US Navy /NAVSEA for ballast tanks as 20 years service life system. Petrobras chose ES301 system for 25 years drydock-less offshore projects.	SUPERIOR PERFORMANCE

Table 3. Advantages and justification of the ES301 approach to TSCF15 guidelines.

The edge-retentive feature was added in 2000 and the result (ES301S version) was presented by M Paiva and J Martins during the SSPC 2000 Conference [Ref 1]. The main features of this product family and the respective system characteristics are presented below.

The system is now being increasingly used, namely for offshore equipment (maintenance, FPSO conversions and newbuilding), the marine industry (mostly for ballast and cargo tank protection, both for newbuilding and refurbishment in drydock or voyage repairs), industrial sites, and steel bridges.

#### Product features

- modified epoxy, polyamine cured
- solvent free
- tolerant to damp surfaces
- no dew point restrictions

- tolerance to adherent iron oxides
- good compatibility with old coatings or shop primer.
- strong adhesion to steel (> 12MPa pull-off).
- chemical interaction with steel, oxides and moisture
- Steel profile is not a critical factor.
- User-friendly pot-life (up to 3 hours at 25°C, depending on version)
- applicable by brush, roller or airless (60:1)
- 'edge retentive' version (ES301 S) available.

#### System characteristics

- surface preparation standards: hydroblasting to SSPC SP12 WJ2 (WJ2-M visual standard as per SSPC Vis4 - NACE No 7, medium flash rust); SSPC SP10/ISO 8501, SA2½, SSPC SP2/SP3/SP11.

- typical dry film thickness per coat: 100-150 microns
- same product type for priming/intermediate/finish
- if extra ultra-violet resistance is required, the system may include a classic polyurethane topcoat
- two- or three-coat systems, ranging from 200microns to 450microns total dry film thickness (DFT), depending on the areas to be protected, corrosiveness and service life target
- No need for dehumidification in enclosed spaces such as tanks and voids.

The use of the novel system itself allows extended protection, as can be seen in the accompanying illustration. The high adhesion values, solvent-free feature without application drawbacks, and edge-retention abilities are the basis of this superior performance. As an example, the US Navy/Navsea [Ref 21] expects a service life of 20 years for ballast tanks coated with this system, over SSPC SP10/ISO 8501 SA2½ abrasive blasting, with a total DFT (two coats) of 10mil-14mil (250microns-350 microns), with one stripe coat only.

#### Results

The system has been used by a number of respected customers over the last years. Significant track record can now be shown as result of customer-based certification or approval processes and inspections during service life. The system is approved by NAVSEA/US Navy, and is qualified per MIL-PRF-23236C standard [Ref 19]. Under this standard, ES301 is qualified as Type VII, Classes 7 (seawater ballast tanks), 15b (can be applied over wet surfaces prepared to bare metal) and 17 (bilges). The qualification as Type VII means that ES301 is recognized as 'a formulation with no solvent added, VOC <150 g/litre, absence of pigments that are hazardous or create hazardous waste above trace levels and the dry coating is not a hazardous waste under USEPA regulations'. Up to now (December 2005), the ES301 system is the only one being approved for 15b class (tolerance to humidity).

Petrobras, the Brazilian oil company, approved ES301 system as main coating system for offshore newbuilding or conversion projects. Transpetro, the Petrobras-owned oil tanker company, is also using ES301 system for both ballast tanks and crude tanks refurbishment, normally over UHP hydroblasting.

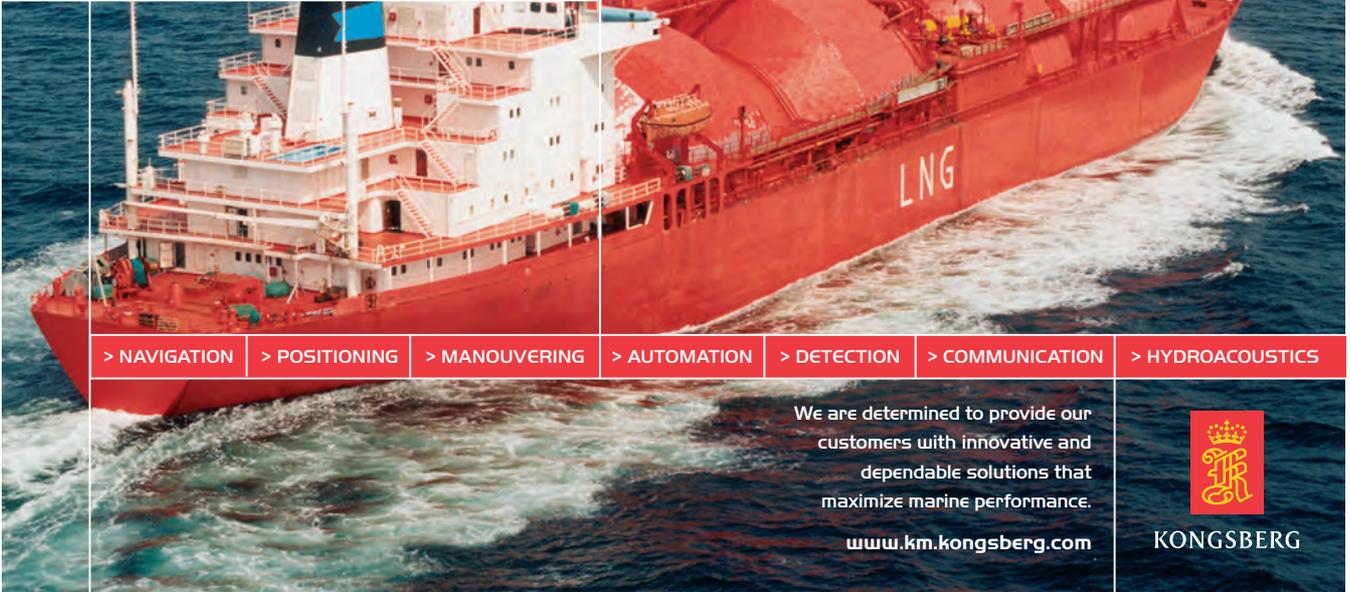
Regarding health and safety, other relevant features should be mentioned. ES301 system is found suitable for safe use by the Navy Environmental Health Centre (NEHC) as per MIL-PRF 23236C rules [Ref 19] (meaning absence of heavy metals or other hazardous pigments above trace levels). On the safety side, ES301 two-coat systems were tested at independent NGC Labs (fire testing laboratory). The flame spread index of ES301 systems ranged from 15 to 20 (0-100 scale) and the smoke developed index from 300 to 450. Accordingly, the ES301 systems was rated Class A (the most demanding) as per National Fire Protection Agency (NFPA) standard No 101, meaning a coating with a good resistance to flame spread and limited smoke development while burning.

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The increasing adoption of the ES301 system is driving developments towards added capabilities, given the extension of its use on new ships. One of these added capabilities is the certified compatibility of the system with welding operations. A primer coat of 75microns of ES301 was certified as having no influence on the welding process (SGS Cert. 1201/10202).

Another recent additional feature is the possibility of supplying ES301 for tank coating with ultra-violet-sensitive pigmentation to allow dark-light inspection.

An important complement to the system is an organic epoxy shop-primer (branded PE31) using the same resin-curing agent system as ES301. This shop primer is Type Approved by DNV (certificate No K2751) as compatible with welding. The combination of PE31 + ES301 is being used for some years now at off-shore new building and conversion projects, using UHP hydroblasting (damaged spots) and HP (700bar) washing of sound shop primed surfaces as secondary surface preparation. The durability is similar to that of ES301 system applied directly to bare steel, given the ES301 surface and humidity tolerance abilities, the full compatibility of the resin types and the consequent very high adhesion of complete PE31+ES301 full system over steel.

#### Using ES301 to cope with TSCF guidelines

ES301 coating system joins performance and tolerance in a unique way. The specific features of this system may now be well perceived by the market and can be proved by the numerous success cases within the marine market (for maintenance and new ships) and by extensive approval and test report data. How can both owners and shipyards use these features to meet emergent rules for tank coating in an economic and successful way? This document presents the first tentative answer: a draft specification for a typical 15 years' service life using TSCF15 guidelines as departure point and adding some additional options to fully utilise the ES301 system potential.

It is the author's opinion that the data presented above gives enough indication about ES301 ability to be applied cost-effectively, with important savings regarding steel (edge grinding) and secondary surface preparation, without affecting the 15 years service life targeted by TSCF guidelines. This ability is possible thanks to the added surface and humidity tolerance and edge-retentive features that enabled the MIL-PRF 23236C approval.

Table 2 presents a suggestion about how a specification for 15 years' service life, following basic TSCF15 requirements, may be adapted, to include more economic and less time consuming secondary surface preparation, edge grinding and stripe coats when selecting ES301 as coating system, together with PE31 organic shop-primer.

Table 3 details the differences, justifies the adoption of alternative methods with the specific ES301 features and summarises the advantages of each adaptation made, compared with typical TSCF15 procedures when using conventional products.

#### Conclusions

Shipowners' and shipyards' perception of the value of top quality tank coatings for long service

life is changing. The perceived added value of such coatings, compared with traditional non-tolerant solvent-based solutions, is increasing. If such a coating system, together with the performance-added value, can be applied with reduced impact on the cost of steel and surface preparation and application delays, it may constitute a reasonable 'agreement opportunity' for both owners and yards interested in answering the current challenges and avoid the potential dangers of conflicting interests.

Despite the focus of this article on coating specifications for tanks at the newbuilding stage, a straightforward additional conclusion should be highlighted: the high-performance plus tolerance features joined together in ES301 is also helping the adoption of this coating system as cost and performance effective tool for ballast and cargo tank refurbishment.

The advantages are especially significant for drydocking repairs using hydroblasting or for voyage repair when a fair extension of service life of the ship (>10 years) is targeted. This particular field of ES301 application, including data from the biggest ever voyage repair ballast tank refurbishment project (being carried out since 2003 using this system) may contribute for a separate article to be published in the future.

A final mention should be made regarding the cost of a solvent-free, edge-retentive, and surface-plus-moisture-tolerant system as ES301. Looking at the specific case of a 300 microns system for 15 years service on ballast tanks, such system (material cost only) will cost about 10 US\$/m<sup>2</sup>. A conventional good quality solvent-borne modified epoxy system for the same application costs approximately 6US\$/m<sup>2</sup> [Ref 10]. Taking into consideration the prohibitive cost (as explained above) of coping with TSCF Guidelines using a conventional coating system (extra edge grinding, secondary surface preparation to SA2, extra stripe coat and the correspondent additional delays), the gap of 4US\$/m<sup>2</sup> may look quite attractive if it allows the adoption of the 'modified' TSCF15 specification as shown in Table 2. The other option is not to cope with TSCF guidelines or other reliable specification to assure 15 years service life. In this case, the expected result in terms of coating repair and downtime costs during the ship's service life is incomparably higher than a mere 4US\$/m<sup>2</sup> on the capital expenditure at newbuilding stage.

#### Acknowledgements

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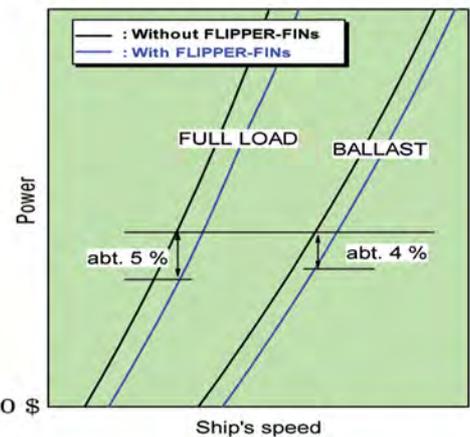
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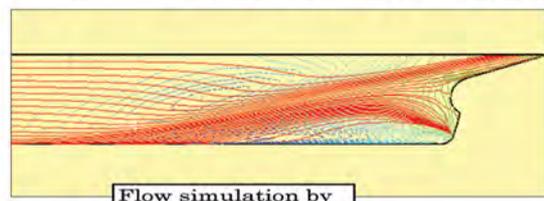
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Flow simulation by

# The making of the numerical towing tank

Numerical simulation of fluid flow around ships and marine structures has a long tradition in naval architecture, dating back to the 19th century, with some of the rather clerical and classical methods still in use today. Now however, advances in computer technologies alongside improved algorithms and extended theoretical basis over the past two decades have accelerated developments to such an extent that the ultimate dream of a complete 'numerical towing tank' or 'virtual basin' is within reach today. This topic is discussed here by Jochen Marzi, from HSVA, and Dracos Vassalos, of the Universities of Glasgow and Strathclyde.

RESPONDING to an invitation by the European Commission in the 6th Framework Programme, a group of leading Computational Fluid Dynamics (CFD) developers and service providers joined forces in 2005 to submit a successful proposal for an integrated project aiming at the development of a virtual basin. During a four-year period (2005-2008) this integrated project called 'Virtual Tank Utility in Europe' (VIRTUE) will develop new and improve existing software tools to deliver a complete toolset for marine hydrodynamic, encompassing resistance, propulsion, seakeeping, manoeuvring, and cavitation prediction; all integrated in an IT platform to target hydrodynamically optimised ship hulls using multi-criteria, multi-objective optimisation.

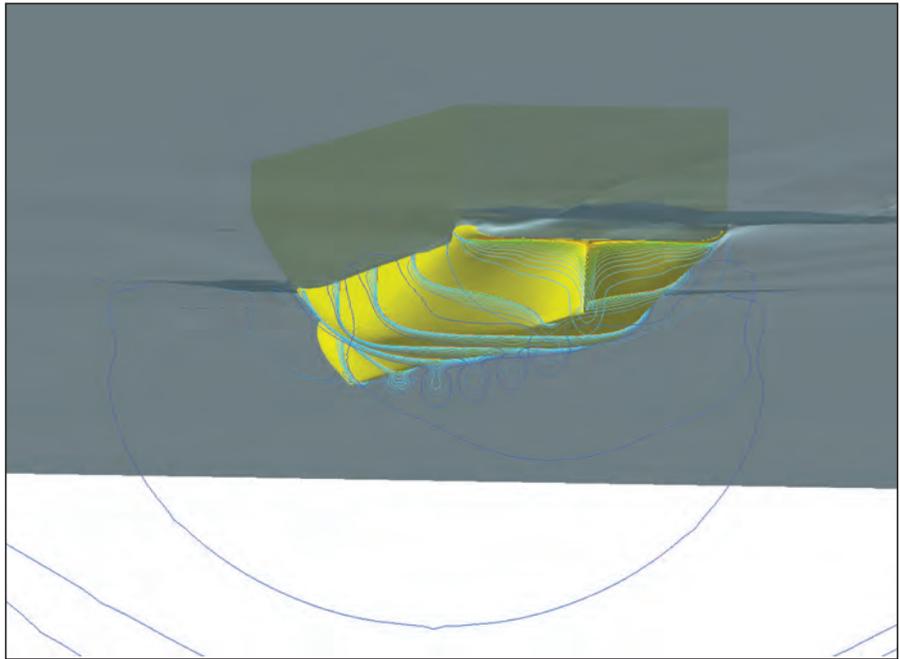
The overall project volume of €16.5 million provides the basis for this ambitious endeavour. Having successfully met the first year's objectives and milestones, the project is gathering momentum, bracing itself for the challenges lying ahead. Developments will lead to a series of successive prototypes at different levels of refinement which will be presented in a series of conferences and workshops in the following year.

## Accuracy, speed, and integration

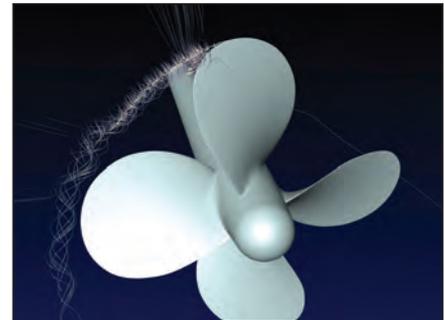
Fluid flow predictions for ships and marine structures are often significantly more complex than those for other vehicles. Sailing on a random free surface and undergoing large unsteady dynamic motions poses a significant number of extra requirements to the methods applied.

In the past, researchers associated with academia and model basins have developed numerous dedicated computational methods with particular applications in mind. This allows simpler potential flow-based methods, for example, for wave resistance, propeller flow or seakeeping predictions as well as for more recent dedicated viscous flow/RANSE type of methods.

Although these methods are extremely useful tools in their own right, the majority of them lack the level of accuracy which would allow the replacement of traditional model testing, which is still the measure to compare with. This holds particular significance in the crucial case of resistance prediction, the key issue for hydrodynamic performance optimisation, with accuracy being the prime source of uncertainty for



Development of the boundary layer (axial velocity profiles) on a fast ferry - RANSE prediction with free surface.



RANSE prediction of the viscous flow around a propeller: visualisation of hub vortex (left), tip vortex roll-up (right).

the efficient determination of propulsive power for a new ship. Previous European research, such as in the MARNET - CFD network has clearly identified accuracy issues as being the prime obstacles for a routine application of CFD methods in ship design.

The large variety of numerical methods developed for dedicated applications poses, in turn, another problem when targeting an integrated approach to complete product, ie, ship, simulation and optimisation during the design stage.

Different (data) requirements, numerical approaches, and implementation issues very often do not allow for easy exchange of data and hence for the interplay of numerical methods and the collaboration of partner design teams, the latter amplified by the fact that use of most of these tools is laborious and time consuming, a level of time that is not available when knowledge is needed most at concept development stage, thus necessitating the development of computational means to render speed of predictions manageable.

Moreover, today's requirements for lifecycle considerations during product design are a

necessity. This in turn calls for a more integrated product development and design covering all pertinent aspects of ship hydrodynamic behaviour. Therefore, in order to maintain its competitive edge, the European shipbuilding industry must be supplied with accurate, fast, and integrated analysis tools, applicable over the full duration of the ship design process and capable of covering all relevant aspects of hydrodynamic design analysis in a holistic manner.

## Approach and objectives

In view of the problem areas described above, the team has carefully shaped a project plan to meet the inherent requirements of improved computational accuracy and speed/integration for future CFD analysis tools. The work performed in the project addresses all relevant aspects and will deliver better and more accurate CFD results, and close the 'quality gap' between today's CFD and experimental analysis. The aim is to provide these results in a shorter time with the experimental analysis being enhanced through a thorough integration of currently largely disparate methods into a common platform. The



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project's developments will thus influence production costs mainly by providing reliable data for evaluation of new designs in affordable time.

The work programme has been subdivided into five areas or work packages, each one either providing improved services in one of the classical fields of marine hydrodynamics as well as integrating pertinent tools into a common IT platform. This is done to ensure a visible front end to CFD tools which will facilitate a holistic analysis of hydrodynamic behaviour leading to optimal hull forms.

VIRTUE integrates services from four different virtual tanks dealt with in different work packages, namely, the virtual towing tank; the virtual seakeeping tank; the virtual manoeuvring tank; the virtual cavitation tank/tunnel; the fifth work package, the Integration IT Platform, provides all prerequisites for a multi-criteria, multi-objective optimisation based on common standards for data provision/exchange and presentation of results.

This ambitious programme naturally demands a level of effort that can only be expended by a large team of experts. This large-scale international collaboration brings together 22 European partners including the leading model basins in Europe, academia, software providers, and marine consultants. VIRTUE will not only greatly improve quality and accuracy of general purpose and specific CFD methods and tools, but also integrate a wide range of today's disparate numerical analysis methods in a virtual environment simulating complete ship behaviour



Computed streamlines on a container ship hull from a free-surface RANSE prediction.

at sea, and providing an important complement to real test basins in the provision of marine hydrodynamic services.

#### Shaping the future of maritime CFD

VIRTUE is expected to continue until the end of 2008. During the life of the development project a number of demonstration prototypes will be developed and made available to the wider public. It is predicted that the virtual basin will eventually include more refined RANSE-based CFD predictions methods which will be fully integrated to deliver a holistic analysis of hydrodynamic behaviour.

The virtual basin will facilitate and nurture the routine use of CFD to assist and to replace physical model tests on ship design. In this respect the full potential of the virtual basin system will be vast, and its exploitation of fundamental importance to all involved. Concepts for the use and application of the virtual basin and results

obtained in the project are presently under discussion and will be presented in the near future. VIRTUE will held a number of public workshops in the second half of the project, presenting results and announcing further developments.

Meeting its objectives, VIRTUE, it is claimed, will contribute to a significant increase in productivity and competitiveness of the European shipbuilding and ship design industry, and will boost the range and quality of services offered by European hydrodynamics providers, as well as the R&D capacity of the sector. Modern integrated tools will allow complete analysis and optimisation of hydrodynamic performance of new ships, leading to unrivalled product quality at further reduced lead times. More information can be found on the project website at [www.virtual-basin.org](http://www.virtual-basin.org)

*All computations: HSVA. Visualisations by Zuse Institut, Berlin.*

## 2006 RINA LLOYDS REGISTER SHIP SAFETY AWARDS

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*Entries close 1st January 2007*

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Entries may be submitted directly by individuals or teams from universities and industry from any country, and may cover design, construction, research, equipment or operations. Entries are judged on originality, quality of design, feasibility of production and contribution to ship safety.

Members who are aware of recent work by a university, company or organisation which has or could lead to an improvement in safety at sea are invited to nominate them for one of the Awards, giving brief details of the achievement. The nominated university, company or organisation will then be invited to submit an entry.

There are separate categories for universities and industry. An Award of £1500 is made in each of the categories and will be presented at the 2007 RINA Annual Dinner.

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# New ferry engine contracts won

IN the first quarter of this year, Wärtsilä Corp was awarded a contract for the main and auxiliary engines for two new high-speed ro-ro passenger ferries being built at Aker Yards' Rauma shipyard, Finland, for the Norwegian ferry company Color Line (discussed in our February 2006 issue, page 11). These ferries will form major transport links between Norway and Denmark. Wärtsilä's engines are already in service on other recent Color Line vessels, including *Color Fantasy*, built at Aker Yards in Turku, Finland (our February 2005 edition, page 14).

For each of the new ferries, four nine-cylinder Wärtsilä 46 main engines with a combined maximum continuous power of 38,400kW will be supplied, together with four six-cylinder Wärtsilä 32 auxiliary engines of 12,000kW combined maximum power. The auxiliary engines will be equipped with common-rail fuel injection to ensure lower exhaust emissions, and operation without visible smoke.

Installation of the engines will incorporate special measures to ensure compliance with the noise and vibration limits set by the Comfort Class notation of Det Norske Veritas. *Color Fantasy* and her sister (currently under construction) also comply with this notation.

Wärtsilä will also deliver a CBM (condition-based maintenance) system covering both main and auxiliary engines. This is a system to support preventive maintenance and fault avoidance by monitoring engine condition, analysing trends, and diagnosing faults.

Color Line will operate the two fast ferries on its Superspeed service across the Skagerrak on two routes. The first vessel is due to enter service on the Kristiansand-Hirtshals route in December 2007, and the second in April 2008 on the Larvik-Hirtshals service.



Color Line's new high-speed ro-ro passenger ferries will be equipped with Wärtsilä main and auxiliary engines, installed to comply with the DNV Comfort Class notation for controlled noise and vibration levels.

The 33,500gt ferries will have a length of 211.30m and a breadth of 25.8m. They will each carry up to 1900 passengers and have some 2000 lane metres on the ro-ro decks for all types of vehicles and cargo. A service speed of up to 27 knots will reduce the crossing times between Kristiansand and Hirtshals to three hours and 15 minutes, and between Larvik and Hirtshals to three hours and 45 minutes. The ferries have been designed for an efficient turnaround in ports, which should take no more than 45 minutes.

### Power for new Tallink ferry

Wärtsilä has also been awarded a repeat order for main and auxiliary engines on a fourth new cruise ferry for the Estonian ferry company Tallink Grupp AS. The ferry will be built at Aker Finnyards's Helsinki site, with delivery expected in the summer of 2008. The engines are expected to give the newbuilding a compact, low-weight machinery plant with economic fuel consumption.

Wärtsilä will deliver the complete outfit of main and auxiliary engines on this ship, that is four 16-cylinder Wärtsilä 32 main engines with a combined power of 24,000kW, two Wärtsilä

twin-input/single-output reduction gears, and three six-cylinder Wärtsilä Vasa 32 auxiliary engines totalling 7380kW.

Wärtsilä has already delivered the machinery for three sister Tallink ferries, *Romantika*, *Victoria I*, and *Galaxy*. The newbuilding will be fairly similar to these sisters. It will be 212m long and 29m wide, with accommodation for 2800 passengers together with a large ro-ro capacity for vehicles, road trailers, Mafi trailers, cars, and coaches. Passenger accommodation will include 927 cabins, several restaurants and bars, as well as a 450-seat conference centre. The principal difference with this ferry from her sisters is that she has a greater service speed of 24.5 knots.

Wärtsilä will also deliver the basic design of the engine-room together with the workshop documentation for this ferry, owing to a change in the main engine type (Wärtsilä 32 with a higher output). Previous vessels in the class are each equipped with four 16-cylinder Wärtsilä Vasa 32 main engines in Vee-form configuration and three six-cylinder Wärtsilä Vasa 32LN type auxiliary generating sets.

Although the Wärtsilä engines were selected mainly as a repeat of the three previous ships, the change in engine type gives the required increased power to comply with the requested increased cruising speed, in a compact machinery plant of minimum weight. ⚓

Wärtsilä will deliver the complete outfit of main and auxiliary engines also main reduction gearboxes for Tallink's fourth new cruise-ferry.



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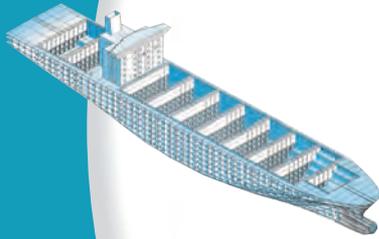
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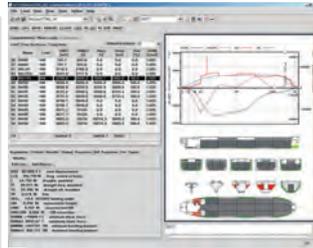
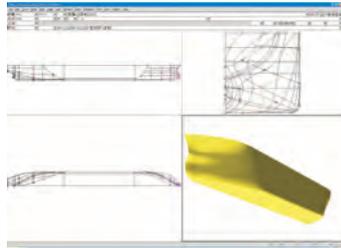
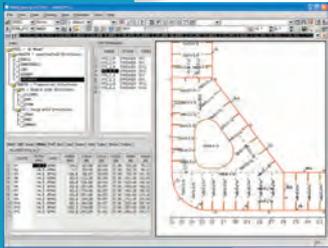


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# Welding automation to assist yard production

FOR shipyards, maintaining a competitive edge requires efficient production, and improvements in cost-effectiveness often call for an increase in automation. The Pema Vision robot welding portal (VRWP), from Finnish company Pemamek, claims a high arc time ratio (more than 80%) and a high utility ratio (100%), and can help to raise the productivity of panel production lines. A typical portal consists of a robot welding gantry with three external robot axes, a six-axis welding robot, associated equipment, and a patented vision system that is based on robot programming.

Vision programming is an online programming method that features a short programming time with a programming ratio 1/30 or more, and usually there are no off-line programming problems. The systems can be supported by qualified welders, and the programme has a high utility ratio due to the fact that it is working with a real workpiece, not a model. In addition, other programming methods may be applied to the robot welding process, and macro and off-line programming systems are available for shipyard production applications.

The first Pemamek robot gantry of this kind has been operational at Aker Finnyards' Turku site, in Finland, since the summer of 2002, and the results have reportedly been a success. According to this shipbuilding group, during the first years in operation the robot has welded with an arc time ratio over 80% and with a utility ratio close to 100%. The yard has since purchased other equipment, including a complete bulkhead line with two more robot gantries, each with two welding robots, as well other robotised applications.

The Pema Vision robot system can be used in the welding of subassembly ship sections or stiffeners for large flat panels, for example. Conventional off-line programming of robots is replaced in the new concept by a vision system that identifies the required workpiece using a high-resolution digital camera. All the welding operator has to do is approve the movement tracks and welding programmes proposed by the computer, and leave the robots to do the work. The operation of this new technology's online system takes place on the spot, and the programming is said to be quick and uncomplicated.

Deliveries of Pemamek machine vision welding portals have been made to other shipyards in Finland and other European countries, including Italy and Croatia. New orders have been confirmed in Spain, and several others are currently under negotiation.

## Vertical welding system

Apart from robot processes, Pemamek can offer other possible automated solutions. In the production of ship hull structures such as double bottoms and bulkhead sections, vertical welding is a time- and labour-consuming process that often takes place in difficult and unpleasant conditions. To ease and speed up these operations, the Pema



Pemamek's Vision robot welding portal claims a high arc time ratio (over 80%) and a 100% utility ratio.

vertical welding system, assembled on a movable portal, is specially designed for efficient vertical seam welding in ship sections.

Its main features include simultaneous welding of four vertical seams; reportedly user-friendly operation by PLC-programming; powered adjustment of platform height and position; four MIG welding torches supported by a slewing ring, with a powered rotation of  $\pm 45^\circ$ ; freely programmable oscillation system for different throat thicknesses; an automatic, programmable jump over horizontal stiffeners; accurate positioning above cross-sections by a laser crossbeam system; and effective fume extraction system for each torch.

This Pema design normally includes four water-cooled ESAB 500A power sources with wire feeder systems. Utilising the oscillation system and flux-cored wires, such an arrangement can weld up to 7mm throat thicknesses with a single run, and larger throat thicknesses with multi runs. Welding speed varies between 10m<sup>3</sup>/min and 35m<sup>3</sup>/min depending on the amount of oscillation.

Pay-back calculations indicate that a Pema vertical welding layout can replace eight to 12 welders' work input, and the investment pay-back time is shorter than a year.

In hull sections such double bottoms and bulkhead sections, vertical welding is both time and man power consuming process. Usually this is carried out by a large number of manual welders using semi-automatic MIG welding equipment.

Currently, yards such as Aker Ostsee (Warnow site) and Kvaerner Philadelphia are already working with this equipment. In addition, several projects are under discussions to ease shipyard problems. With this new arrangement, time and money can be saved, and welders can concentrate on more demanding jobs.

Pemamek can also design and supply various shipbuilding automated production lines. These include: tube, plate, and profile prefabrication systems; flat-panel production lines; double-bottom production lines; sub-assembly production lines (micro, bulkhead); curved-section panel lines; robot panel lines or production cells for welding and cutting; production data collection; and logistic control software solutions. 

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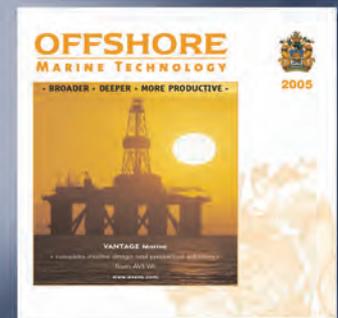
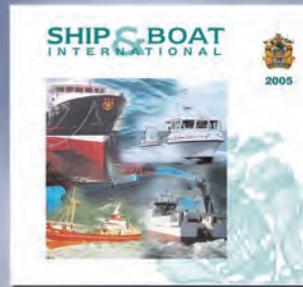
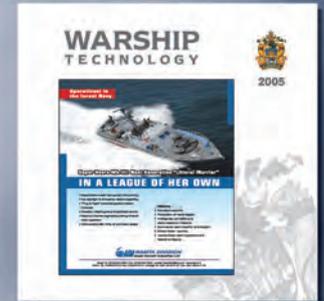
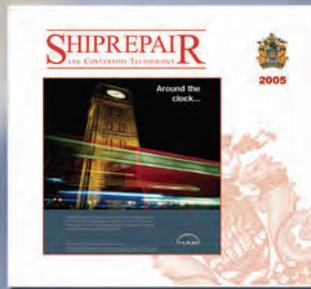
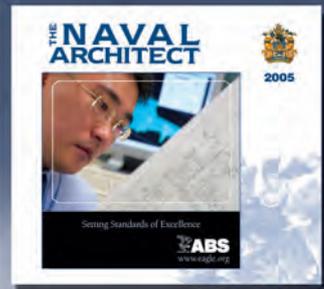
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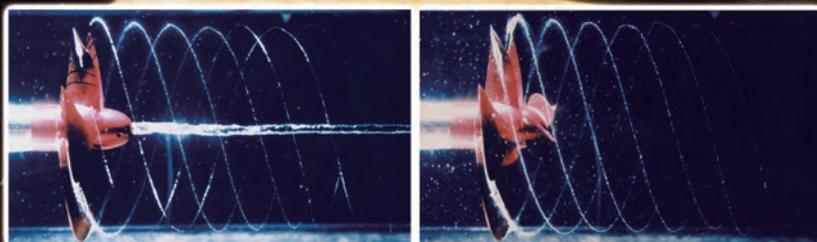
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# Stern hull forms might contribute to deck container losses

MUCH interest is refocusing on the issue of deck container losses. In recent months, around 400-500 containers are believed to have disappeared overboard in 20 separate incidents, and initial investigations seemed to show that all the ships involved were using fully automatic twistlocks, featuring a single-latch design, for box securing. In the past, losses of, and damage to deck containers has most often been attributed to the feature known as parametric rolling.

Following these latest incidents, it was at first thought that under certain conditions and combined with ISO container tolerances, these twistlocks do not always lock satisfactorily. Class society Germanischer Lloyd (probably the leading society for container ship design and construction) has recommended that stevedores check visually that all four locks are positively closed - an operation that may be difficult and costly to implement.

As a result of all this, one of the market leaders in such equipment, MacGregor (through its Conver division in Germany) decided to withdraw all its ALC-2 and ALC-2/1 products - although none of these are believed to have been involved in the incidents. The company has initiated a global plan to switch to semi-automatic twistlocks. At the same time, MacGregor is designing a new generation of fully automatic twistlock; this is expected to be ready towards the end of this year.

Despite all this action, new theories are now being promoted, following a thorough investigation by Germanischer Lloyd. This reveals that losses can be sustained by ships of all sizes, but examinations have centred on ships which lost boxes from their stern areas in the Bay of Biscay, during moderate to poor weather conditions (Beaufort Force 8-9 and 10m-high waves).

A reconstruction has shown that factors such as loose and overstretched securing equipment, damaged and broken-off floor twistlocks, and enlarged ISO hole areas in the corner fittings can have as much influence as inaccuracies in container construction, degree of wear on corner fittings for older boxes, and correct lashing



One possible aid to avoiding overboard losses of containers could be a tall lashing bridge at the transom, as seen here earlier this year on a new OOCL liner at Samsung, in Korea. Several operators already specify such a feature.

procedures. Still to be checked are the weight of individual containers, cargo inside, and their positions in stacks plotted against the approved stowage plan.

It is hoped to reconstruct any errors that may have occurred, and to make suggestions for improved operations, as well as to determine which piece of equipment failed first. Interestingly, laboratory tests on fully automated twistlocks showed that they all passed their load threshold value and a simultaneous material load. As a result of these tests, Germanischer Lloyd will not retract approval for any of its approved make of twistlocks.

Of interest to naval architects will be the apparent fact that the ships which lost containers in the Bay of Biscay had a flat stern shape, optimised for maximum box stowage. This is a fairly common feature on container vessels but

is one which, when stern slamming occurs, can trigger vertical accelerations, says Germanischer Lloyd. More information is to be gathered on this phenomenon. It appears surprising, considering the number of container ships which probably have this type of stern, that any problems have not come to light previously.

Using collected wave data from those voyages, the development of sea conditions will be modelled by Germanischer Lloyd, and transient pressure distribution calculated in a finite-element model. Computational fluid dynamics (CFD) will be employed to gather pressure details around the air/water threshold. In addition to all this, long-term measurements are to be made on an 8400TEU container liner, at least through the winter of 2006/07, to gather more details about stern slamming. ⚓

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## Furniture and panels from Faro

DUTCH manufacturer Faro Marine Products has developed a complete range of wooden furniture, especially designed for installation onboard ships. Several naval vessels, also commercial ships and offshore platforms have already been equipped. Generally, the company uses plywood covered with a layer of Formica laminate but other materials such as solid wood or medium-density fibreboard can be used if requested. Well-known European brands of hardware are fitted.

Extra features are included for marine use, such as reversible rims on tables, and extra hinges on large cupboard doors. Faro designers are currently working on a new line of modern furniture suitable for ferries and other ships.

The company can additionally supply a range of wall and ceiling panels for ships. These include tongue-and-groove or clip type sandwich panels, suitable for areas requiring a B-30 fire rating as a free-standing partition. Other designs include a tongue-and-groove design with a B-15 rating for use as a free-standing partition, or as a A-30 panel when used in combination with a steel bulkhead (lining board exposed to fire hazard). A third alternative is an interlocking ceiling sandwich panel for a B-15 fire rating, or A-30 when used in combination with a steel deckhead.

All these products are lined on both sides by 0.6mm thick galvanized steel sheet. Each design can be supplied as a Faro-engineered modular panel system or in standard sizes and profiles to suit individual shipbuilders' needs.



Examples of Faro Marine Products' cabin furniture and panelling systems.

## Customised circular mill for Hyundai

STRATEGIC provider of on-site machining tools and custom solutions, Climax Portable Machine Tools Inc, of the USA, has announced a cooperative agreement with Hyundai Heavy Industries Co, Korea. In this agreement, Climax will develop a custom-designed circular mill, based on the Climax PM6000 portable milling machine, to be used for a new ship construction project.

Climax will train machinists at Hyundai Heavy Industries in the capabilities of the new milling machine. Climax is scheduled to complete the on-site training and commissioning during October 2006.

Hyundai Heavy Industries chose the Climax solution over other machine options because, it says, its machine specifications meet higher tolerances and milling capabilities in a relatively short time. This circular mill was delivered to Hyundai Heavy Industries in July 2006 and Hyundai reportedly plans to place

additional tool orders with Climax for other construction and repair work in the shipbuilding industry.

The customised circular mill utilises the X-Axis bed and spindle assembly of the PM6000 portable mill, mounted to a precision ground rotary table. Custom engineering included modifications that allow this machine to face-mill in a diameter range of 2m to 5m. The circular mill offers a flatness tolerance within 0.05mm, which will enable operators to accurately mill a base ring diameter. It also features an ID mounting range from 2m to 2.3m.

The Climax machine is counterweighted and capable of milling horizontally, vertically, or in any position in between. This flexibility gives the machine the versatility to be adapted to other milling projects in the future. Hyundai Heavy Industries plans to use this custom tool for a base ring application onboard a ship during primary construction and scheduled maintenance tasks.

## New energy-saving bow for bulk carrier

JAPANESE yard Universal Shipbuilding Corp has developed a new bow shape named Leadge-Bow, which can be applied to bluff-form hulls such as bulk carriers or tankers for increasing propulsive performance in waves. Leadge-Bow has been termed such through a combination of the words 'Leading' and 'Edge'. Leadge-Bow is based on the Ax-Bow, first developed by Universal in 2000.

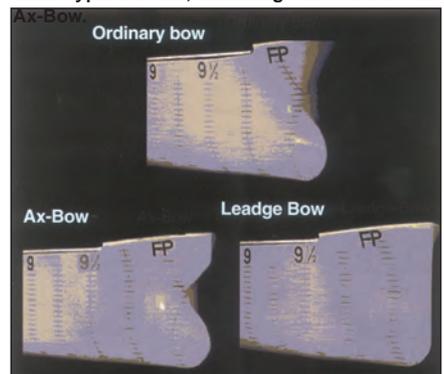
This bow shape is expected to decrease the required power in waves by 4%-5% in comparison with a conventional bow. The first ship to utilise this new bow is an 81,000dwt bulk carrier to be constructed at the Maizuru Shipyard.

The first Ax-Bow was applied to the 172,000dwt Capesize bulker *Kohyohsan*, built in 2001 for Mitsui OSK Lines (*Significant Ships of 2001*). Records of this ship have shown the required horsepower has been reduced by 3%-4%, and has shown good performance in sea conditions; the vessel won Ship of the Year in 2001, awarded by The Japanese Society of Naval Architects and Ocean Engineers.

Since 2001, many ships with the Ax-Bow have been built. Although this bow has demonstrated good performance, changes have been made to improve performance in waves, resulting in the Leadge-Bow. Through a study of bows, Universal Shipbuilding has improved hull performance in waves by straightening and sharpening the bow edge between the Ax-Bow above the waterline and the bulbous bow below the waterline, which eliminates the bulbous bow in the side view. In model tests, this bow shape has been confirmed as giving the same wave-making resistance in still water as a conventional hull with bulbous bow, although the bulbous bow has conventionally been considered to reduce wave making resistance in still water.

This means that Leadge-Bow shows the same performance in still water as conventional ships with bulbous bows. In waves, on the other hand, Leadge-Bow can reduce the required horse power in waves by 4%-5% compared with conventional ships, whose reduction rate is also more than that with an Ax-Bow. A parent for Leadge-Bow was applied for on 2002.

The shape of a Leadge-Bow compared with other typical bows, including Universal's own



## Desalination specialist acquired

DESIGNER and manufacturer of marine and offshore fluid handling systems, Hamworthy, has acquired Serck Como GmbH, a market leader in desalination plants for cruise ships. Hamworthy agreed to pay €7.85 million for Serck, which is a privately owned company based in Geesthacht, near Hamburg, Germany, with 80 employees located in a modern manufacturing facility. The company has been renamed Hamworthy Serck Como GmbH and will become part of Hamworthy's water systems division.

Serck Como's sales in totalled €17.6 million in 2005, of which 70% was marine related. The company is experiencing significant growth, especially in the cruise sector: its July 2006 orderbook stood at €28.5 million, of which cruise ships accounted for €20.9 million.

The cruise ship order book includes deliveries of desalination plant for customers including Norwegian Cruise Line, AIDA Cruises, Carnival Cruise Lines, Costa Crociere, Princess Cruises, Celebrity Cruises, MSC Cruises, P&O Cruises, Royal Caribbean Cruise Line, Holland America Line, and Cunard. Overall, Serck Como has over 80% of the current newbuild order book including, most recently, an order from Aker for what will be the world's largest cruise ship. Recent cruise ship deliveries that feature Serck Como desalination plant include *Costa Concordia* and *MSC Musica*.

Cruise ship desalination plant comprises one or more 'multi-stage flash' (MSF) evaporators. Steam, engine jacket water or a combination of



Three 700tonne/day Serck Como multi-stage flash (MSF) evaporators for a cruise ship.

these can be used for heating. The capacities of these tailor-made evaporators range from 150tonnes/day to 1000tonnes/day, with steady production at sea water temperatures between 2°C and 32°C, while the capacity of a standard single-stage unit typically installed on tankers

and bulk carriers ranges from 6tonnes/day to 70tonnes/day. A potable water treatment unit according to WHO standards can be supplied as an option, and the range of single-stage and multi-stage evaporators is approved by all the main classification societies.




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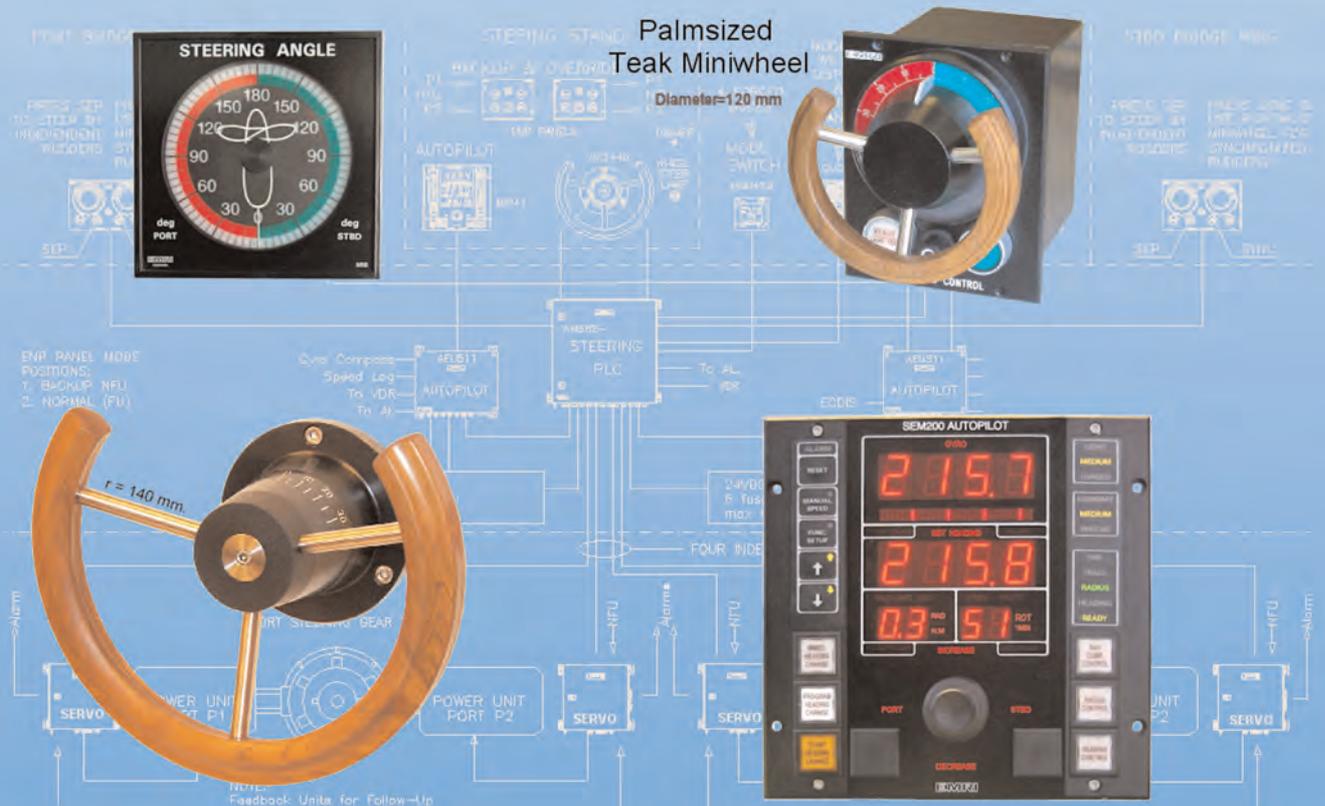
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# Evaluating the design of passenger and crew accommodation in ships

**Post-occupancy-evaluation (POE) methods developed for evaluating buildings in use could also be used to evaluate and inform the design of passenger and crew accommodation on ships. Like the designers of buildings, the designers of accommodation on ships rely heavily on experience and tradition. They have few opportunities to test spaces and fittings as prototypes in use before committing to final construction. They also have little opportunity to know the expectations of users - passengers and crew - and to be able to balance those expectations with the requirements of maintenance staff and ship owners, or with engineering and physical environmental constraints.**

**Post-occupancy evaluation has been developed and used in architecture during the last 20 years, as a participatory technique enabling designers to optimise the expectations of all interest groups associated with a building. It is a process of negotiation which informs the fine-tuning or re-fit of an existing building, and provides a sound database about users' expectations for the design of new buildings.**

**It has been used on a very wide range of building applications, and has also been successfully used to focus on specific accommodation issues such as direction finding, safety, and means of egress, as well as issues of style, comfort, and interior presentation. Post-occupancy evaluation could assist ship designers, shipyards, and ship owners to improve user satisfaction and effect economies in the fit-out design of vessels of all kinds. The concept is here reviewed by D A Joiner, chair in design at Massey University, New Zealand.\***

**METHODS** used by architects and property managers for evaluating buildings and spaces in use, are proposed as being suitable for evaluating the design of passenger and crew accommodation on ships. Post occupancy evaluation (POE), a participatory evaluation method whereby those who have an interest in a facility evaluate that facility, in the facility has been found to provide valuable information for

management of buildings, adaptations to existing buildings and for briefing and design of new buildings.

During the last 20 years, they have become an integrated and sought-after service provided by architectural design practices in a number of parts of the world. Briefly, they account for the expectations of building owners, makers, managers, and users, and have been found to lead to increased levels of satisfaction by all parties, as well as optimum use of resources and, in many cases, considerable cost savings.

This proposal to use post occupancy evaluation methods in the marine industry, assumes that ships, like other transport vehicles and conveyances that people get into, form part of our human spatial environment. They could be considered perhaps, as a specialised subgroup of the buildings people occupy and experience spatially, in a continuum which includes urban public spaces, schools, offices, shops, factories, hotels, hospitals, and houses.

In each of these kinds of buildings, as in ships, the users have reasons for being there, and have expectations about the kinds of activities the spaces in them will support. In effect, ships are special kinds of buildings for special purposes, and with rather particular requirements for protecting people and their belongings from physical environmental elements. In relation to this proposal the important thing that buildings and ships have in common, is spaces for people to live and work in.

## Reasons for evaluating

Another thing that buildings and ships have in common is that they are designed, built, owned, and used by different groups of people who have different and sometimes conflicting expectations about what the accommodation should provide. The approach presented here, to evaluate the design of passenger and crew accommodation in existing ships in use, is intended to provide a basis for reconciling those differences in expectations, and to optimise the design for each group.

In architecture, we have found that understanding differences in expectations leads to improved levels of user satisfaction, enables more adventurous design approaches, and can often result in cost savings. I expect the same would apply to ship accommodation.

As with buildings, ships are built to order to designs and specifications. They are built by a main contractor, but also include thousands of components and systems supplied by others. They take months or years to make, and once finished, users and owners have to accept them as they are. Furthermore, from the day of hand-over, they require ongoing maintenance which in itself establishes particular patterns of commitment and use.

Buildings and ships may be used for several years before they are modified. Unlike the

processes for design and manufacture of mass produced products, there are few opportunities to prototype and test complete buildings and ships in use before finally committing to production. Knowledge about what works, what customers and users like, and what is perhaps not so successful, has to be accumulated and passed on from one project to another.

In architecture, there are a number of reasons why this does not always happen very well, and tradition and expediency become the basis for decision-making in design. In the preface to his book on architectural knowledge, Duffy describes how user research and user feed back enables the benefits of design invention to be demonstrated to clients and users. With better knowledge about how buildings are used and what users expect from them, the design of accommodation can be advanced and enhanced. Duffy identifies two special characteristics of architectural knowledge.

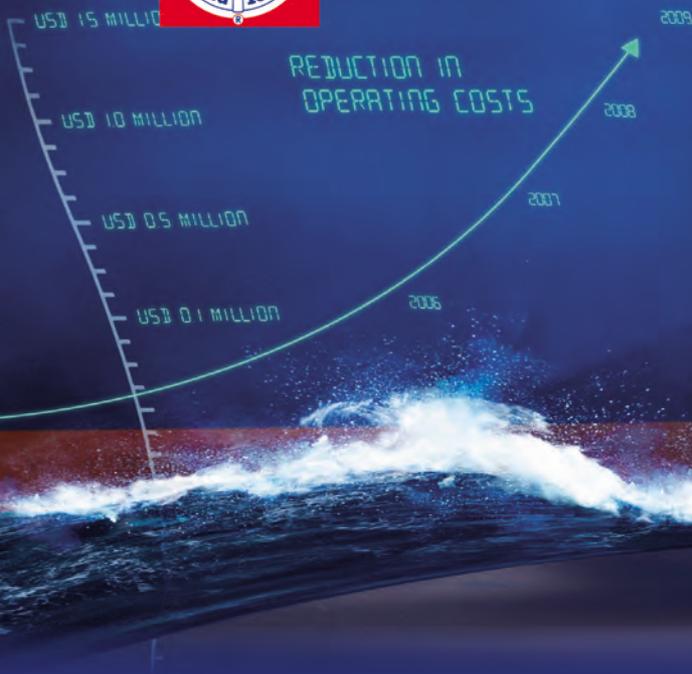
The first is that it is usually combinatory and complex - linking understanding of user requirements to the capacity of buildings to accommodate those requirements. Linking what has been done in the past with predictions of what ought to be done better in the future. Linking practicality with artistic judgement. Linking many disparate elements, because buildings are such large, complex, and value-laden objects.

The second characteristic is that architectural knowledge is usually concerned with the deontic rather than the descriptive - with things as they ought to be rather than things as they are. I imagine that knowledge about accommodation on ships also has these two special characteristics. It is the linking and deontic characteristics of knowledge that we have sought to enhance with post occupancy evaluation methods.

Because of our conventions and ways of going about designing and making buildings and ships, many of the opportunities for developing linking information are lost at the outset. We would expect that in the ordering and commissioning of new vessels, the owner's, and possibly the operator's expectations would be conveyed to the designers. But it is unlikely, expect perhaps in the case of superyachts and sporting vessels, that the designers will have any contact with those who crew a ship, manager passenger services, or indeed ride on it as passengers. The users of ships seldom if ever communicate with the designers and builders.

Kernohan *et al* describe the different and distinct cultures of building providers and users, and further identify three types of users - occupants, visitors, and owners. Owners are users, although they may not be occupants, because they purchase, select, or lease buildings in order to make money from them, or in the case of public facilities, to fulfil some kind of public service.

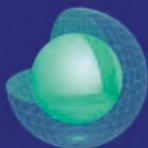
\*This paper was first presented at The Royal Institution of Naval Architects' International Symposium on Marine Design, held in La Spezia, Italy, April 12-13, 2006.



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The different cultures of building users and providers, and the user subgroups of occupants, visitors and owners, can be identified in relation to ships and indeed all kinds of transport vessels. Providers would include makers, naval architects, designers, engineers, and shipbuilding companies. They would also include traders, the agencies that buy and sell or lease vessels, maritime finance companies and the like. Providers would also include maintainers, for example, shipyards which carry out maintenance work, or contract cleaning services for ferries.

In relation to buildings, Kernohan *et al* concluded that the two cultures of providers and users are divided by supply and demand. These two cultures hold different values, they rarely make contact and often conflict. It would seem that this is also the case in relation to ships, where the expectations of users, passengers, and crew, might be quite different from those of the providers - the ship builders and owners.

Users and providers are alike in that they derive some advantage from their connection with the ship, but are different in the nature of that advantage. Owners, as providers for example, will want to maximise profit and efficiency and return on investment in the vessel. Crew, as users will regard the vessel as their place of work, and possibly residence, and will have expectations relating to their personal and collective safety, comfort, and support for effectively carrying out their professional duties. Passengers as users, will be expecting the best qualities of space, comfort and service in relation to the fares they have paid and their reasons for being on the vessel.

Fundamental aspects of crew and passenger safety and well-being are the subject of international regulations and agreements. However many of the characteristics of a vessel which affect its comfortable, safe, and efficient operation to meet the expectations of both users and providers, will be of a qualitative and subtle nature over and above basic requirements for human health and safety, and will probably also have little to do

with cost. In a general sense, the concepts of user and user needs in buildings and ships are simple. However, all facilities are used by more than one group of users (even the family house and the family power boat have more than one user, and if visitors and friends are taken into account the list of users becomes quite large and diverse).

Schools have teachers and students; courthouses have judges, public, lawyers, and accused. On ships there are passengers and crew. There may be several classes of passengers (relating fares to accommodation standards) and there will almost certainly be classes of crew - officers, seamen, cooks, and stewards. All of these have social and cultural groupings that are distinctive, and expectations that are probably not aligned. The problem is that buildings do not normally satisfy the differing interests of the various users and providers.

Kernohan *et al* point out that buildings usually satisfy one or the other group preferentially, and often the supply side dominates, because people on the supply side are accustomed to making decisions about what is built in their day-to-day work. They know how they want things to be, and they have to hand the resources and expertise to bring that about. Users do not usually have that advantage, and so are destined to accept things as they are.

The same probably applies to ships. Other than to avoid using it, passengers have no say in how the accommodation on a ship is configured, and similarly crew will have to accept things as they find them, unless they have strong support and feedback opportunities through their employers to their ship owners and providers. Without such feedback opportunities, it is hard for people who design accommodation on ships to know whether what they design is as good as it could be, or any good at all from the point of view of the users.

In ships, there is also an engineering dominance, which further weights the supply side. This is common in most transport vehicles, where power plant, machinery, and

drive chains for example, which are important if the vehicle is to get anywhere, dominate the layout, configuration and shape of the vehicle. Perhaps extreme examples of this can be seen in the compromises to crew accommodation in submarines and space craft.

Passengers can spend an hour or two on a sightseeing ferry which has been built with poor sightseeing visibility, but the arrangement of seats is subjugated to the layout of the machinery, which means that seated passengers cannot see very much, and the seats are uncomfortable anyway. It is unlikely that any of the thousands of passengers who have used this ship have told the operators, the ship's pilot, or, even less likely, the boat builders. They probably think that is just the way boats are, because the have to have an engine in the middle, make a noise, stay afloat, and there are safety considerations and life rafts to be stowed. They have accepted the traditions of ship design.

There are, of course, long traditions in the navy and merchant navy, and indeed extensive and ancient cultures to do with seafaring and ships, to which many of the exigencies and spatial deprivations of shipboard life are totally acceptable. There is a close relationship in the navy between accommodation, rank and status, and pride in seamanship, and weaponry, which can render these issues unquestionable.

In this respect it is noteworthy that the armed forces have been among the first enthusiastic promoters of the participatory building evaluation techniques which are described later in this article.

It is also probably true, that many people are attracted to spending time on boats and ships, partly because of the particular kind of accommodation they provide. For some passengers, there is romance and excitement associated with travelling in ships and experiencing the special kinds of accommodation and spatial arrangements which they perceive as being a necessary and important aspect of being at sea.



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Maritime safety regulations, employment unions, operator company agreements and the like will also influence accommodation on ships. But if they are similar to their land-based equivalents in building and architecture, they too will be steeped in tradition. Much of what they recommend will no doubt be short on knowledge about what people think and do in spaces. Extreme examples of this were demonstrated in Jonathan Sime's studies of people's behaviour in emergency situations.

He found that despite adequate provisions in terms of regulations, people died in building fires because of social and behavioural factors. They were slow or reluctant to respond to alarms, and tried to leave buildings by the way they had come in rather than by the fire escapes. No matter what is provided, if it is not perceived as relevant or safe by the users, it will not be used.

To find out about user satisfaction, and what people are expecting from their environments, post occupancy evaluation was developed. The methods, which are simple, are based on knowledge about the social and cultural aspects of people's behaviour in spaces.

### **Behaviour in accommodation**

In order to find out about what people and think about and want from accommodation, we need to understand about people's perceptions and behaviours in relation to the spaces and objects, vehicles, ships and accommodation that they use. There are many codes of practice, standards and regulations relating to human accommodation in buildings, ships, aircraft, and all kinds of vehicles and conveyances.

Some of these are applicable internationally, and some apply with specific jurisdictions or countries. The intentions of most are clearly to minimise the risk of injury to users of the accommodation to which they apply - to make it safer to use, more convenient to use, or more comfortable. During the last century, there has been a lot of science and technology applied to improving environmental conditions in all kinds of accommodation, particularly in workplaces (driven by trade unions, ie, social influence). They relate to air quality, hygiene, human waste disposal, lighting, access, stairs and lifts, fire protection, emergency evacuation facilities, crash testing, seatbelts, airbags, and so on.

Most of these things have made a big difference to the habitability of our accommodation, comfort and safety. But they can only do this if they are used or applied as the designers and legislators intended - and this is frequently not the case, so they do not work. Handrails on companionways only prevent falling if people hold onto them. Seatbelts in cars only reduce injury if people wear them.

Air conditioning makes jumbo jet travel around the world possible, but energy-saving constraints applied by airline owners and operators make them also very effective ways of spreading disease around the world, too.

Each physical refinement is only made effective through corresponding social and cultural action. Hawthorne's studies were among the first to show that there is not a direct relationship of a stimulus-response kind between peoples' behaviour and their physical environments, and they suggested that the relationship is more complex. From studies involving changes in office lighting levels, increases in the productivity of office workers were seen to be related more closely to perceived attention from senior management than to improvements in physical working conditions. In other words, they were responding to a perceived social situation rather than to changes in their physical environment as such.

The studies by Rapoport and Watson in the early 1970s have drawn attention to the cultural variability in environmental standards, most of which bear little relationship to what people do, or how they are able to perform. There are many examples of people being able to work in physical conditions which would be intolerable to others, and much of these differences can be explained by socially and culturally based expectations. For example, most people would find it difficult to think clearly, reason, and calculate among the distractions and clutter of a ship's engine room, but marine engineers expect to do this all the time.

From the work of Terence Lee and others, we know that people have mental maps or schemata of their environments which are based on their social experiences and expectations. Our activities can be seen to be more closely related to our mental maps than to the physical attributes of our accommodation. Our expectations about our accommodation, and our activities and our behaviours are socially and culturally defined. Boat drills on passenger ships are a good example of attempts to re-programme socio/spatial schemata in order to prevent in emergencies, the kinds of fatal behaviours reported by Sime in relation to building fires.

It is important to recognise that accommodation and facilities people use do not cause behaviour, but are passive, and either permit or prevent us from carrying out activities which we want to undertake for socially and culturally defined reasons. The mechanic does not top up the oil cups on the bearings because they are there. The naval rating does not stand at the ship's wheel because it is there. They do those things because they have socially and culturally defined roles relating to getting the ship from one place to another, and those aspects of their facilities and accommodation enable them to carry out those roles.

Aspects of the design and locations of those facilities will make those roles easier or more pleasurable however, and may provide opportunities for new things to be done. Constance Perin has said that behaviour originates with the person and that the person endows the environment with various kinds of stimulus properties. Meaning taken from the environment depends on the person's intentions towards it. From studies that have

been done so far, we have been able to propose a general model of environment behaviour relationships which we have used in design education and practice. The key feature of the model is that it demonstrates how people are involved a continuous process of negotiation between the things they want to do, and the opportunities provided by their accommodation.

### **Negotiating accommodation**

Ellis and Joiner have described the complex relationship between what we do, the socially and culturally based expectations we have, and the physical constraints and opportunities provided by accommodation and resources. Our ability to negotiate within these relationships will affect how we feel about our accommodation.

For designers and providers to have a better understanding of how to make better accommodation, it is important for them to have access to the negotiation process. Daish and Joiner have described an approach to architectural practice based on the shared experience of owners, users, and designers, and it is this concept of sharing experiences that participatory post-occupancy evaluation methods build upon.

Post-occupancy evaluation is proposed here as a way of developing knowledge for improving existing vessels and improving accommodation in new ones. To do this, we must not only look at the accommodations themselves, but we have to enter into the negotiations which users/owners/regulators have with each other vis a vis the accommodation. A really positive outcome of this approach is that it can open up new ways of thinking about ships, accommodation.

### **Putting it into practice**

Post-occupancy evaluation is simply a way of bringing together people who have an interest in accommodation so they can share their experiences and negotiate with each other about what could be done to make it better. The process we use for POE brings participant interest groups together in the accommodation to be evaluated. The participants are the accommodation evaluators.

Stated simply, the process involves walking through the accommodation with interest groups, noting how they describe it, how they talk about how they use it, the good and the bad points, and how they think it could be better. In the walk through, the evaluators are negotiating their ideas and perceptions with what they see, and with each other.

Following the walk-through, the interest groups further negotiate their findings and recommendations with each other in an evaluation meeting. Participant groups represent the different interests in the accommodation. For instance, an interest group evaluating crew accommodation on a navy patrol boat, would be the naval ratings and NCOs.

Another interest group might be the master and officers, who also have accommodation on the ship, and who have responsibility for the ratings and for maintaining the social



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structure and protocols under which they all work. Other interest groups for this patrol boat would include maintenance staff, navy purchasing and policy staff, and possibly designers and builders of the ship .

POE evaluation is facilitated by facilitators who do not evaluate. Managers are normally not concerned with the evaluation, although they may be represented in a participant group. Their role is administrative and supportive. They may initiate, approve and authorise an evaluation, and they have responsibility for ensuring there is action on the outcomes, and for the ongoing management of the action.

#### **POE methods**

There are several well-documented post-occupancy evaluation methods which are used by a variety of government, commercial and private organisations in the design and management of their buildings. The common attributes of the effective methods are that they are participatory, in that they provide a forum for providers and users to directly negotiate their ideas; they take place within the accommodation being evaluated, and have a walk through component; and they require the participants in their various interest groups to be the evaluators.

The evaluations most frequently conducted by the author include the three core events of the generic process described by Kernohan *et*

*al.* An introductory meeting of the facilitators and the participant groups to explain the evaluation process, and the procedures of the touring interview and review meeting.

Touring interviews, when each participant group walks through the building with the facilitators. They visit places relevant to their interests and to topics raised at the introductory meeting. The touring interview is primarily for the members of a group to discuss and reflect on their views of the facility. A review meeting where the essential negotiation event of the process takes place. Topics raised from the touring interview are discussed, and formed by consensus into participant group recommendations for action.

#### **POE applications**

The generic post-occupancy evaluation method has been used in a wide variety of applications of various size and complexity. A number of organisations with multiple facilities have used it to inform their decision-making on design of new accommodation as well as the management of their existing facilities. For a large trading bank, post-occupancy evaluations of retail branches were conducted as an integral part of their nationwide programme introducing new public facilities and services. A retail store chain has used post-occupancy evaluation for similar purposes, and for fine tuning its facilities and customer services.

Public agencies, including the Department of Justice, police, and the armed services, use post-occupancy evaluation to provide an accumulating database to inform their provision of new facilities (from court houses to army barracks) and to inform their maintenance, facilities management and accommodation upgrading programmes. For organisations such as these, where an ongoing commitment can be made to maintaining a post-occupancy evaluation database, the benefits, both physical and organisational are far reaching. It seems possible that shipping fleet operators and shipyards would benefit from this approach.

Post occupancy evaluation is also used for focus studies of particular aspects of accommodation. Way finding in large buildings with public access, such as museums, airports, and hospitals, is a particular problem to which imaginative design approaches have been applied. Post-occupancy evaluation has been used successfully in New Zealand government facilities to discover the kinds of physical and mental cues people rely upon to locate themselves in large buildings. Other examples of focus studies include the layouts of machine rooms and workshops, and detailed studies of various kinds of workstations. The detailed design of plant, services, and equipment on ships could also benefit from focus study approaches such as these.



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Post-occupancy evaluation methods have also been adapted for use in participatory design projects of the kind developed by Sanoff where prospective users are involved in the design of new accommodation. Evaluation and design using a range of interest groups could conceivably new and inspirational approaches to the design of ships of all kinds.

A number of people who have facilitated post-occupancy evaluations have remarked that people are willing to give time and commitment to discussing the physical environments they use. The benefits from post-occupancy evaluations are usually both physical and social, and many participants describe the immediate benefits they feel from having had an opportunity to share their views and experiences with others and to reach a better understanding of the accommodation they use. Physical benefits usually include changes to existing buildings and/or to the designs of new buildings. Social benefits include organisational and attitudinal changes resulting from evaluations, and in some instances, these were all that was necessary to bring about improvements in workplaces.

#### Conclusions

This article is speculative, in so far as it does not report evaluations of passenger and crew accommodation on ships, but rather

proposes that post-occupancy evaluation methods which have been developed for architectural practice could also be used in marine design. Over 30 years of international research into people's behavioural and emotional responses to physical environments, have resulted in alternative approaches to designing and managing buildings so that they better suit their users. One of the more important applications of this research has been through the development of post-occupancy evaluation methods.

In addition to continually improved codes and practices for physical conditions in buildings, post-occupancy evaluation has become integrated in architectural services and building management to bridge the distance between providers and users and enable effective negotiation of design quality.

When post-occupancy evaluation is used routinely and regularly by building providers, it enables them to quickly establish a comprehensive and valuable database about the aspects of their buildings that are appreciated by users, and those that are less than satisfactory. It also provides them with large amounts of anecdotal information which can help them to better understand the preferences of the various social and cultural groups who occupy their buildings.

In the provision and management of ships, as with buildings, there appear to be few opportunities for communication between providers and users. Like buildings, ships are often large complex single entities, including hundreds of sub-systems and technologies from a variety of sources. They may take months or years to build, and, like buildings, are subject to large amounts of legislation, tradition, and established practice. Except perhaps in the case of small mass produced craft, ships are not subject to the mediation of the marketplace and individual customer choice, which bridges the gap between providers of consumer products and their users.

Walk-through participatory post-occupancy evaluation is proposed for improving the design of passenger and crew accommodation on ships. In architectural applications it is found to give good information on which to base design and modification decisions. Just as important, it provides interest groups with a good understanding of the opportunities and constraints in a particular building project. It has been found to open up opportunities which did not previously exist, and which enhance usability and enjoyment of facilities and save money and resources. There is every reason to believe that it will bring these advantages to the design and management of ships. 

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## MARS ERP system for VT

VT Shipbuilding, based at Portsmouth, in the UK, has purchased a MARS enterprise resource planning (ERP) system from the Danish company Logimatic AS. This is expected to be a major benefit to the yard's new state-of-the-art complex (discussed in *The Naval Architect* July/August 2003, page 45). VT Shipbuilding (formerly Vosper Thornycroft) began searching for a new ERP solution in order to maintain its leading position, primarily as a constructor of warships, but also including smaller paramilitary types and RNLI lifeboats, built at its Halmatic site.

The process of selecting the right system was not an easy task; the company was seeking a new system that would be suitable for the future, because its old one was neither productive nor efficient enough. Selection was a time-consuming task but was eventually narrowed to two candidates. MARS was chosen largely because it is shipyard-specific.

MARS is a vertical ERP solution and consists of four major applications:

- MARS\*Material (material management)
- MARS\*Production (production management)
- MARS\*Planning (resource planning and control)
- MARS\*Tendering (cost estimation).

MARS is designed to develop comprehensive functionality, to provide more flexibility, and to

VT Shipbuilding's new MARS enterprise resource planning (ERP) software is expected to make the yard much more efficient and proactive in the construction of ships, such as the new Type 45 destroyers, a section of one of which is seen here in the company's new covered hall at Portsmouth. The Type 45 class is said to be groundbreaking in that ships are being built in different locations, in association with BAE Systems.

help shipyards reach their full potential in planning, executing, and controlling projects in a competitive market. The suite's cross-functional architecture comprises its set of four powerful applications designed for streamlining, simplifying, and handling the complex and critical processes found in most yards.

A modular approach allows customers to start with a few modules and gradually increase the scope by adding new functions or modules as business, or perhaps the complexity of new projects, increases.

Compared with more conventional ERP solutions, MARS is claimed to offer vertical functionality for shipyards worldwide, which no other available solution is said to be able to match. Furthermore, MARS was developed in close cooperation with several leading shipyards around the world, so that a number of best-practice processes could be incorporated. Today, the MARS system is implemented in more than 50



shipyards of various types worldwide, including those handling newbuildings; repairs, conversions, and overhauls; outfitting; and offshore work.

### Experiences with MARS

The MARS system went live at VT Shipbuilding in November 2005, without causing any mentionable difficulties. However, information systems director, Colin Beames, acknowledges that the eight-month implementation period has been a very challenging time schedule. Nevertheless, even though MARS is still quite new, VT Shipbuilding can already recognise some achievements, enabling the yard to be more proactive. 

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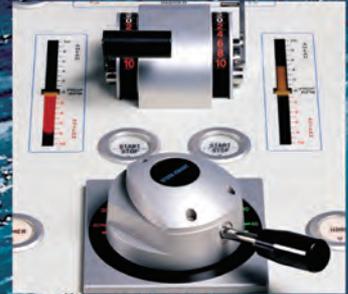
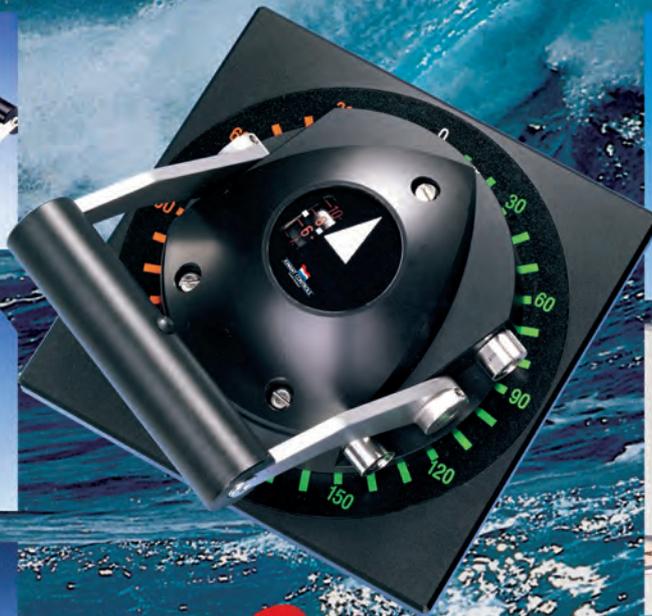
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# Safety role of the naval architect

The professional naval architect often has more to worry about with regard to safety than do many others. In addition to the traditional science of hydrodynamics, structures and powering, naval architects have commonly taken a lead in co-ordinating the overall design and integrating the work of many other disciplines to deliver a ship to time and cost. In modern parlance this is the role of the project manager. As well as a designer, either individually or in a team, elsewhere the naval architect may be a consultant, surveyor or regulator providing expert oversight, policy and advice. In each position the responsibility for safety will vary according to the job description.

THE Royal Institution of Naval Architects commissioned a document, *Guidance on the Safety Role of the Naval Architect*, to inform and provide guidance to members on available methods and the application of safety management. This was published in 2002 and a PDF version of the guidance documents can be downloaded from the Institution's website ([www.rina.org.uk/showarticle.pl?id=6348&n=230](http://www.rina.org.uk/showarticle.pl?id=6348&n=230)). The following article is an abstract from this document, which is currently under review by the Institution's Safety Committee. Readers' thoughts and comments on the documents and the issues it raises would be most welcome.

Naval architects must obey the law of the countries where they are employed and recognise the laws and standards of countries where ships may visit or be used. Although there are many legal variations and complexities to be found, most countries have enacted similar maritime safety legislation in two areas, namely:

- minimum standards for the design, construction and operation of ships
- laws providing protection to the users of equipment during construction, maintenance and operation of vessels.

## National legislation

National shipping laws lay down the minimum design, construction and seaworthiness requirements for the registration of ships within the country and embody recommendations, codes of practice and conventions agreed at IMO. In some cases statutes demand higher safety standards than is agreed by IMO convention. It is usual for national authorities to delegate the monitoring and approval of these regulations (all or in part) to ship classification societies.

Other regulations provide for the well-being of those working in or around a ship whilst building. There may be an extension of essentially land-based safety law to cover activities in territorial waters (such as loading and discharging cargo), or whilst undergoing maintenance and repair.

## Consumer protection

In addition, many countries have legislation providing protection to the consumer. The general aim is to ensure that products are 'fit-for-purpose'

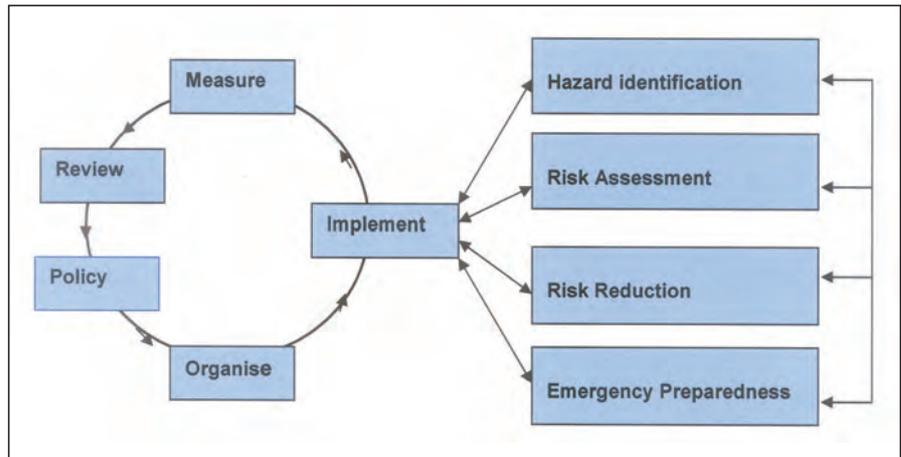


Fig 1. The iterative process of safety management.

and that all contributors to an evolution are made guilty of a fault unless there is sufficient evidence to prove otherwise. Those who observe malpractice and take no action become accessories.

## Offshore

Offshore installations have their own national and international regulations, several of which are similar or derived from merchant shipping regulations. The operator is often required to produce and maintain a safety case by the licensing authority. The safety case defines the company's design, construction and operating philosophies and policies against which performance can be measured.

## Naval vessels

Naval vessels are not generally subject to international regulations such as SOLAS and MARPOL, but most defence forces require their vessels to be designed, built and operated to standards equivalent to those required under civil legislation wherever practicable. Where a safety assessment is required, account will be made of the increased risk of military operations balanced against the need to take reasonable care of the safety of people, equipment and the environment.

## Personal liability

Most employers will vicariously protect their employees in the event of civil claims for compensation in the event of loss. However, in some countries, employers cannot relieve employees of responsibility in regard to the results of his or her criminal negligence or other offence. Self-employed naval architects should obtain professional indemnity cover to safeguard themselves from civil claims for compensation. They should familiarise themselves with national safety legislation and liability insurance in the countries in which they are working. Other obligations arise through contracts, or through the operation of vessels without due diligence, or inadequate levels of competence.

The scope of the above laws should not be underestimated. They presume an adequate degree of competence in those responsible and supporting evidence that they have kept

themselves up to date in their profession by being fully informed of new developments and aware of the centres of expertise available to them.

## What is safety?

Everyone has some understanding of the term safety but its interpretation can vary widely. A survey by Professor C Kuo suggests that in company with others, many naval architects tend to believe that safety is concerned with 'technical issues' and is achieved by compliance with rules and regulations. Lessons from many major disasters however, suggest this is not the whole picture. Mr Justice Sheen attributed significant blame for the *Herald of Free Enterprise* capsizing to poor management, while Lord Cullen's report on the *Piper Alpha* disaster identified major deficiencies in management and operating procedures and the inadequacies of relying wholly on a formal regulatory approach. The Cullen Report was significant in recommending a goal-setting methodology rather than prescriptive approach and led to the introduction of the Offshore Safety Case Regulations.

The achievement of adequate safety may be considered to depend on a combination of three elements: effective technology, the contribution of human factors and good management.

## Goal-setting methodology

Prescriptive regulations are best for routine situations and well-established practices. They provide a datum based on experience and a means of steadily improving baseline safety standards. They are also a convenient reference against which statutory authorities can measure the compliance of operators. However it is difficult to keep rules up to date with developing technology and impracticable to write a rule for every eventuality.

In order to achieve more effective safety assurance, designers and ship operators should look beyond the minimum requirements of the statutory safety certificate, and adopt a goal-setting methodology to take account of all conceivable hazards. The goal-setting methodology is based on finding answers to five basic questions:



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- what can go wrong? (hazard identification)
- what are the chances & effects of this? (risk assessment)
- how can we reduce this? (risk reduction)
- what will we do if an accident occurs? (safety management).

### Safety management

The process of safety management should be holistic, commenced at the first concept of design, iterative (Fig 1) and continued throughout the life of the vessel. As time passes, new hazards that arise from changes and modifications (both material and procedural) must be continuously reassessed, and the baseline safety justification and management system reviewed to assure that safety is maintained within acceptable limits.

### Safety case

In many countries, the offshore oil and gas, nuclear, process, chemical, defence and railway transportation industries know this methodology as the Safety Case concept. Although particular requirements differ between industries, a Safety Case essentially consists of:

- system / process or equipment description
- safety management system or plan
- risk assessment
- emergency / contingency planning
- supporting documentation.

### Human factors

Mankind has a propensity to take risks, weighing the benefits to be gained against the perceived dangers. Cultural background, knowledge and experience continuously influence this behaviour. Behaviour is also subject to the physical limitations and frailties of the human body, errors of judgement and action, bravado and malevolence. Poor design will contribute to accident causation not only by miscalculation leading, for example, to failure of the ship's structure, but also because sometimes insufficient attention is given to the key role played by the crew. Since accidents are mostly initiated either directly or indirectly by people, safety is inextricably linked to human attitudes, behaviour, decisions, actions and errors.

Statistics on marine accident claims recorded by P&I Clubs suggest that human error is responsible directly for 60% of accidents and indirectly for a further 30%. Thus addressing engineering alone will not resolve all safety risks.

### As-low-as-reasonably-practicable (ALARP) principle

ALARP is the main test applied by safety authorities such as the UK Health & Safety Executive, and seeks to determine that:

- it has been demonstrated that all reasonably practicable risk control measures have been taken
- further action is grossly disproportionate (in cost or disruption) to the amount of risk reduction
- current industry practice risk control measures are also to be in place.

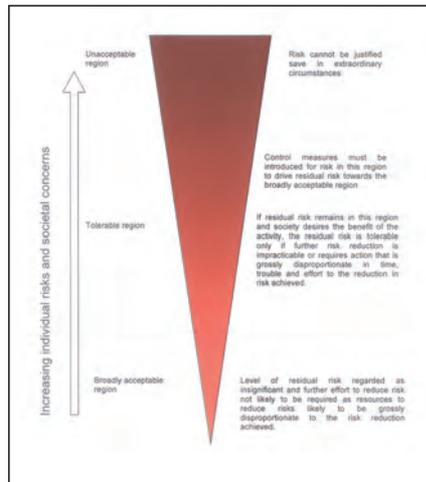


Fig 2. Criteria for the tolerability of risk (UK HSE Reducing Risks, Protecting People, 2001).

ALARP is not yet embodied generally into maritime legislation. However the IMO has accepted a risk-based methodology known as Formal Safety Assessment (FSA) as part of the future rule-making process.

### Regulatory approach

Methods and standards of ship construction have evolved over time and the regulations that govern those standards have always attempted to keep pace with innovation. It is inevitable that innovation will lead regulation and regulators will continue to try to encompass new designs, materials and manufacturing methods within existing regulatory frameworks. It is also inevitable that the process of regulation becomes a bargaining process between regulators and ship owners.

Industry is happy for the regulator to prescribe regulations provided they are not too burdensome. If the regulator tries to impose more onerous standards they may be resisted on the basis that there is no evidence of any greater risk. If a disaster occurs it is not unusual for a corporate spokesman to say that the operation complied with every regulatory standard and it was the regulator's fault for not requiring higher standards. This relationship is known as the 'compliance culture' where ship operators seek to absolve themselves of responsibility by blindly following prescriptive requirements.

### Ships are different?

Ideally, shipping would follow the same path as did the nuclear industry after the Windscale disaster, the chemical industry after Flixborough and Bhopal and the oil industry after *Piper Alpha*. Those industries adopted the use of risk assessments in a safety case regime where the operator took responsibility for managing the risks of his plant and demonstrating its safety to the regulator.

Regrettably, this is unlikely to happen in the shipping industry without a major change in culture, because of its devolved management structures, mobile assets, the existence of flags of convenience and the traditional reliance on class society rules and surveys.

World-wide, where some ship owners, classification societies and flag states have been shown to evade their responsibilities it has become necessary for nations to seek positive

assurance that the ships visiting their ports do not impose a risk to safety and the local environment. Thus Port State Control Inspections are carried out by the national regulatory authorities to check upon the validity of charts and the working condition of navigation equipment, safety equipment, hull and machinery. From July 1 2002 for all categories of SOLAS ships, evidence of a documented and working safety management system was also required.

### Role of IMO

The standards against which ships are inspected are derived from International Conventions (such as the Safety of Life at Sea Convention and the International Convention on Load Lines) adopted at IMO and implemented into national legislation. Member states of IMO are entitled to interpret the requirements of Conventions but are required to inform the IMO Secretariat of any exemptions they grant. It is the policy of responsible maritime administrations to give exemptions from the prescriptive requirements of Conventions by establishing equivalent levels of safety.

### International Safety Management (ISM) Code

The ISM Code was adopted in November 1993 by means of IMO Assembly Resolution A.741 (18). This states, 'The most important means of preventing maritime casualties and pollution of the sea from ships is to design, construct, equip and maintain ships and to operate them with properly trained crews in compliance with international conventions and standards relating to maritime safety and pollution control.'

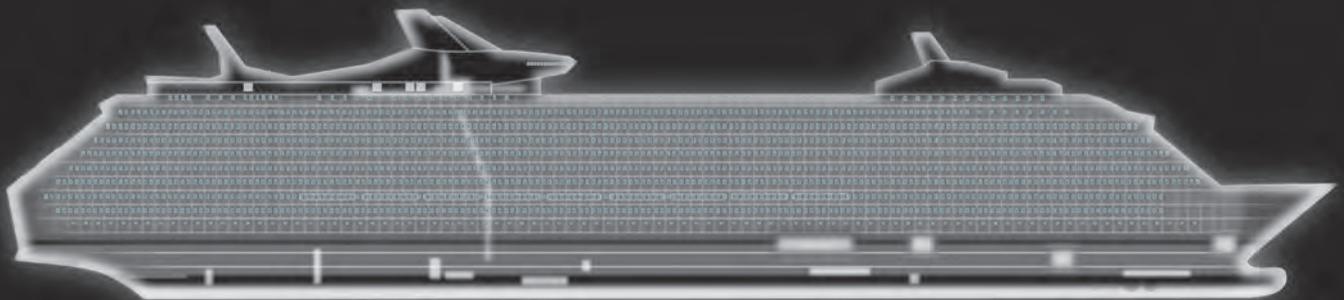
The ISM Code was introduced chiefly as a response to the *Herald of Free Enterprise* disaster. It was determined that a management system which assumed that a system (the bow door) was safe unless someone reported that it was unsafe was inherently flawed. Also the ISM Code recognised that the age-old assumption that a ship's master held responsibility for everything on his ship was no longer strictly true. The responsibilities of management ashore who control maintenance budgets, crew contracts and charters often have a greater influence on safety and seaworthiness than a master employed by a manning agency. This poses crucial questions of what should those standards be, and what areas of concern should be covered in the conventions. FSA aims to provide rational answers to these questions.

### Formal safety assessment

The risk approach is increasingly recognised as a rational basis for the management of safety in the shipping industry, but it is has not yet been possible to legislate for universal ship safety cases. IMO has recognised FSA as the basis for developing future regulations. Its purpose is to assess and develop safety and environmental protection regulations that are appropriate to the

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risks involved and aimed at preventing accidents from occurring in a cost effective manner rather than mitigating their effect after they have happened.

The adoption of FSA is intended to improve maritime safety that will improve efficiency and therefore provide additional benefits to the industry in the long term. The FSA process comprises five steps as follows:

1. identification and ranking of hazards
2. quantified assessment of the risks associated with those hazards
3. consideration of alternative regulatory options for managing the risks
4. cost-benefit assessment of alternative risk management options
5. recommendations for regulatory decision making.

### Qualitative risk assessment

It is increasingly recognised that risk is not easily measured. The 1992 Royal Society Report on *'Risk: analysis perception and management'* could not reconcile the different opinions of physical scientists, some of whom suggested that risk obeys the formal laws of statistical theory, and social scientists who favour the theory of subjective risk which varies depending on individual perception.

The UK Interdepartmental Liaison Group on Risk Assessment in 1996 reported that subjective or 'qualitative' risk perception would usually conflict with the objective view of the scientist. A more coherent and consistent approach, better cross-use of available data and a common criteria for comparing risks (both real and perceived) was called for.

### Risk - actual or perceived?

Unfortunately for the physical scientist, accident data is frequently unreliable in accurately recording the past, and poor at predicting the future. The problem is essentially one of change. Technology is constantly advancing with new materials, methods of manufacture, improved reliability and performance, and society continuously modifies its amusements, economies, politics and philosophies. As time moves on, risk arises in new environments out of situations never quite the same as before. Furthermore the very process of collecting data tends to alert those people at risk (and their managers) with the result that both the perception of risk and behaviour will be modified.

Risk perception varies according to one's viewpoint. For example, in a US survey, college students feared nuclear power more than any other risk, whereas safety experts rated it only 20th out of 30 listed alternatives.

For the risk analyst, violent death is a convenient metric. It is accurately recorded and as a consequence of an accident it is unambiguous. However the incidence of accidental death is often very low.

Collecting injury and near-miss information will yield a mass of data but is liable to give misleading results because of variations in categorisation and reporting. Also only a fraction of what happens is ever recorded. So what approach can be taken to allow for variables in quantification, so as to demonstrate that risk is as low as reasonably practicable?

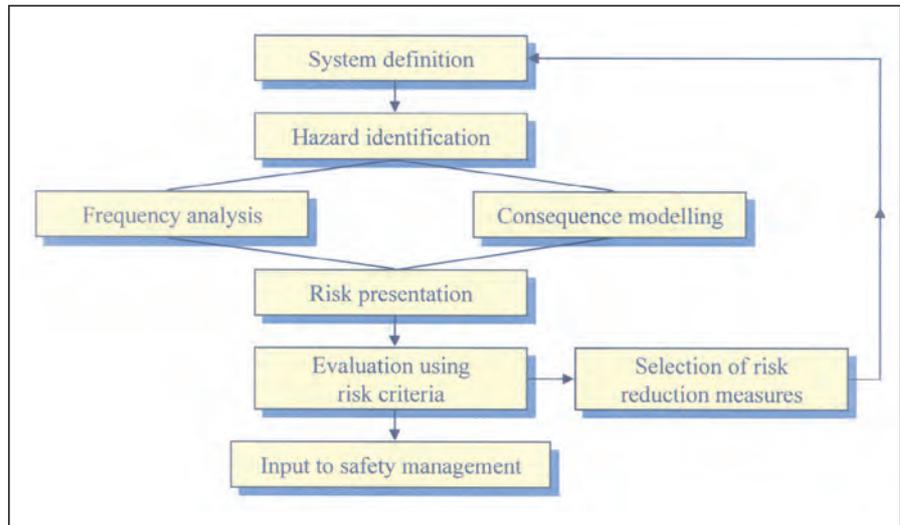


Fig 3. General structure of a QRA study.

### Hazard identification

Before starting to consider risk an attempt must be made to identify all potential hazards. The process (often called HAZID) uses a variety of techniques eg:

- FMEA (failure modes and effects analysis)
- HAZOP (hazard and operability study)
- SWIFT (structured what-if technique)
- judgement.

### FMEA/FMECA

In recent times, the team approach has gained favour over more individualistic techniques such as Failure Modes and Consequences Analysis (FMEA) or Failure Modes Effects and Consequence Analysis (FMECA). FMEA/FMECA is well suited to reliability studies in electrical and mechanical systems but is less easily adapted to deal with human error.

### HAZOP

The most commonly used technique today is Hazard and Operability Study (HAZOP), which was developed in the mid-1960s for the process industry but is readily adapted for marine systems. It can be used for simple engineering systems but is also appropriate for large complex operations where a preliminary overview may be necessary. HAZOP needs a team, ideally about five or six people, prepared to spend enough time together in preparation (which may require visiting the ship or facility), data collection and by a process of reasoning must identify as many potential hazards as they can. The team needs a facilitator (leader) practised in the technique and a good mix of stakeholder representatives. Types of hazard that should be considered are:

- historical events
- inherent design, system and material hazards
- accidents inferred from the above
- simple combinations of events
- complex combinations not previously experienced
- recognised hazards, with designed-in countermeasures
- conceivable but previously unknown/unprepared for hazards.

HAZOP uses guide words systematically to test the result of deviations from intended procedure or operations. This is a 'brain-storming' process that defines the boundaries to a system and asks 'what can go wrong?'. The following basic guide words are applied to each element of the system (with typical meanings applicable to a marine engineering system):

- NO eg, no flow, no vent
- MORE eg, more speed/temperature
- LESS eg, less pressure/power
- AS WELL AS quantitative eg, contamination
- PART OF qualitative eg, less additive
- REVERSE eg, reverse flow from design intent
- OTHER THAN different from design intent eg, product delivered to the wrong tank.

HAZOP works well for human operations with slight modification of the guide-words that are then applied to 'actions', 'sequence', 'time' and 'information'. The process of HAZOP is thorough but laborious until the team is practised.

### SWIFT

An alternative is Structured What-if Technique (SWIFT) that uses checklists constructed specifically for the system and tests for hazards resulting from deviations from normal. As its name suggests, SWIFT will generate answers more quickly than HAZOP but is less thorough in looking at the detail. The SWIFT technique is also a brain-storming team activity allowing discussion of regulations, requirements and past experience. As an example, the following SWIFT checklist headings could be used in an analysis of passenger ship operations: ie, wind, sea state/current/tide, visibility, trim, draught, human error, and equipment failure.

This checklist can be applied to assess each stage of the operation.

Both HAZOP and SWIFT will generate a large number of potential hazards. The Hazard Log should serve as a means of recording decisions, actions and status of each identified hazard through to its resolution. It will provide an audit

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trail and at future safety reviews allows development of previously closed out actions where some change in procedure or equipment fit may have occurred. The next stage is to consider risk i.e. the combination of the frequency and severity of these hazards.

### Risk assessment/ranking

A qualitative ranking of both frequency and severity of each hazard is deduced by consensus. These can be amalgamated in matrix form (see Table 1) where the risk categories are:

- A = intolerable
- B = undesirable and shall only be accepted when risk reduction is impracticable
- C = tolerable with the endorsement of the project safety review committee
- D = tolerable subject to normal project review.

### Delphi technique

The Delphi technique offers a pragmatic approach to the difficulty of defining both the categories used in the frequency/severity indices and obtaining agreement on the tolerability ratings. The Hazard Identification team may use this technique to reach agreement between different subjective views of the team members.

To aid understanding of the terms used in the qualitative assessment it is sometimes helpful to add a numeric scale. Thus for severity of consequence we may use a financial measure, eg:

Negligible	<£10,000
Marginal	£10,000 - £100,000
Critical	£100,000 - £1 million
Catastrophic	>£1 million.

### Consequence analysis

Whereas frequency is deduced either from data or by debate, the consequences of an accident can be analysed by modelling with the results fed into the group HAZID and incorporated into the risk matrix. Consequence Analysis is used to define design accident thresholds for emergency systems such as control or communication equipment, firewalls or sprinkler systems that have to survive and continue to operate in severe conditions. The process may be iterated - design tools specified at concept stage may have to be revised as a result of risk assessment and the subsequent cost benefit analysis.

To survive a major ship accident the integrity of the hull to resist flooding will be a primary objective. Subsequently, stability after damage and finally the ability for those on board to make a successful evacuation and/or the assistance of rescue forces must be assessed.

Damage to property and the environment may be considered depending on the type of ship, its cargo and the severity of the incident. An example for assessing whole ship safety could be to analyse the (separate or combined) consequences of collision, grounding, flooding and fire. Generic data is input where this is available, to construct a mathematical model using, for example, a probabilistic distribution of the location and extent of damage from which possible evacuation options can then be developed.

To explain the qualitative terms used in the risk matrix for frequency, events per year can be shown as follows:

FREQUENCY	ACCIDENT SEVERITY			
	Catastrophic	Critical	Marginal	Negligible
Frequent	A	A	A	B
Probable	A	A	B	C
Occasional	A	B	C	C
Remote	B	C	C	D
Improbable	C	C	D	D
Incredible	C	D	D	D

Table 1. Frequency versus accident severity.

Incredible	<10-6
Improbable	10-4 - 10-6
Remote	10-2 - 10-4
Occasional	10-1 - 10-2
Probable	1 - 10-1
Frequent	>1

The terms and definitions given above, including the numbers of frequency and severity bands and allocation of risk categories are typical but must be confirmed as appropriate to the application. It will however be rarely possible to verify these figures with any precision and therefore their use is for comparison purposes only.

### Quantitative risk assessment

Quantitative risk assessment (QRA) is the term most often used to describe the use of statistical or more properly 'quantitative' methods applied in safety management. It can be defined as a systematic analysis of the risks from a hazardous activity, evaluating their significance, in order to provide input to a decision-making process. Fig 3 shows the general structure of a Quality Risk Assessment Study.

### Application of QRA

QRA is underpinned by statistical analysis of previous accidents but is necessarily more than this, since statistics about past events provide only limited guidance about the future. QRA provides a structured framework for combining statistics with theoretical models and expert judgements.

QRA may be appropriate in the following circumstances:

- where it is specified by regulations or by company procedures - eg, in the offshore industry
- where good safety management requires a detailed, systematic analysis of risks, to understand the significance of different hazards
- where there is the potential for infrequent, but severe accidents - these are difficult to address by judgement alone and quantitative analysis may give useful help - eg, in the nuclear industry
- where risks are to be assessed against numerical acceptability targets
- where risk reduction measures are to be evaluated using cost-benefit analysis - eg, as in the IMO guidelines for FSA
- where there is sufficient statistical data to provide a basis for the assessment.

### Results from QRA

QRA provides measures of risk to people, property, business and to the environment. These

can be in various formats, dependant on the nature of the risk eg, simple single-figure measures, risk contour maps, and frequency-consequence (FN) curves. In combination with cost-benefit analysis, QRA can provide measures of cost-effectiveness for benefit decisions such as net-present values, and implied cost of averting fatalities, such as net present values of benefits, and implied costs of averting fatalities.

### Strengths and weaknesses of QRA

QRA is arguably the most sophisticated technique available to predict the risk of accidents and give guidance on appropriate means to minimise them. In combination with cost-benefit analysis, it is able to give consistent guidance on the difficult balance between economics and safety. The quantitative approach also helps with understanding and communicating risk issues.

However, while it uses scientific methods and verifiable data, QRA is a rather immature and highly judgmental technique and its results have a large degree of uncertainty. In unskilled hands QRA may be dangerously misleading.

Despite its limitations, QRA has proved to be useful in many applications. However, it should not be the only input to decision-making about safety, as other techniques based on experience and judgement may be appropriate as well. A survey of UK offshore operators in 1993 found that 14 out of 15 felt that QRA had improved their understanding of risks and was helping to improve safety on their installations.

### Effective safety assurance by good management

#### Decision making

So far the assessment and ranking of risk has been considered. The final stage involves hard decisions where the proposed safety improvements may be difficult and the cost to implement considerable. The principle of As Low As Reasonably Practicable (ALARP) shows that tolerable risk is not a simple pass/fail test. The risk matrix will highlight the areas where work should be done to reduce the risk further. The owners of each risk must be satisfied that safety arguments, criteria and decisions are sound and documented so as to provide an audit trail. Peer review and the use of independent safety assessment/audit are also valuable in giving strength to decisions and actions, particularly if later challenged.

#### Cost benefit analysis

It is inevitable that the management of risk will cost money and the monetarisation of risk absorbs great effort by risk analysts who will use cost benefit to justify the measures proposed. Cost benefit analysis (CBA) is not well suited to

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environmental risk where putting a value in the loss of nature assets such as a green valley for the construction of a by-pass poses great difficulty and disagreement between developers and protesters. It is also difficult, sometimes distasteful to attempt to value life.

'Expressing the same value in the conventional and more convenient way (although misleading if used carelessly) the value of a statistical life to be used in cost benefit of risk changes would be £2million-£3 million.' The Royal Society's 1992 report on risk.

Incidentally, £2 million-£3 million works out to be the current average UK settlement for loss of life. Some companies use higher figures for Value of Life and increasingly it is recognised that serious disability can attract even higher compensation awards than are routinely paid for death. In other parts of the world compensation pay-outs for accidental death will produce different values of life. Generally in the developed western world, with a sophisticated legal system, court settlements are substantial and continuously increasing.

Total loss control, that is the summation of consequential cost of an accident - human, asset, environmental and political, offset against the up-front capital expenditure of a proposed safety measure - is increasingly suggested. But those who have to foot the bill may take some convincing that the risks identified and the consequential costs of accidents are realistic. In the case of large projects the solution could be to prioritise and develop time-at-risk arguments to spread the work over an acceptable time-span. The justification must be made openly and the

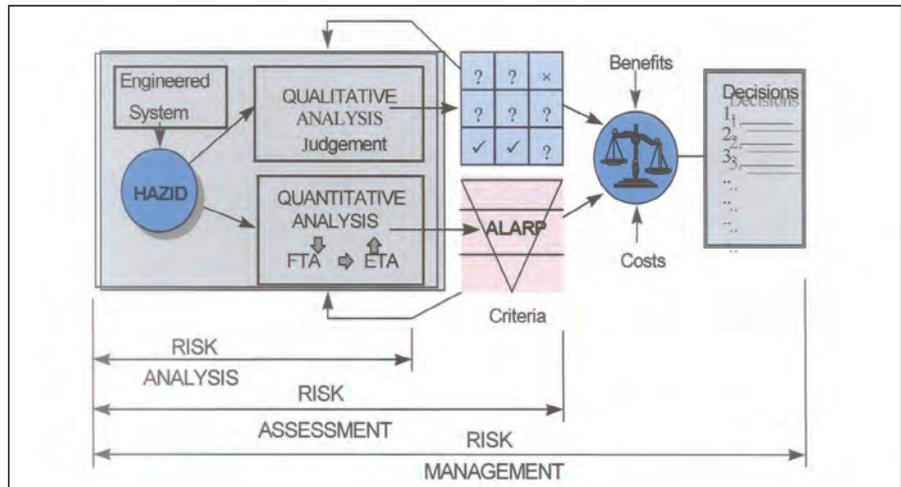


Fig 4. Risk management and its component processes summarised. Source: Det Norske Veritas.

logic defensible when challenged or in the case of a subsequent accident occurring before the safety measures have been carried out.

#### Risk criteria

Where the risk analyst has carried out a numerical risk estimate, it is often necessary to present the argument in qualitative terms. Risk criteria are used to translate a quantitative measure (eg, E-7 per year) into value judgements (eg, negligible risk). These can be set against other value judgements (such as 'environmentally friendly' or 'desirable employment prospects') in a decision-making process and are often presented in this form to the public to sell products or justify actions.

Words such as 'acceptable, tolerable, and justified' are sometimes interchanged. A tolerable risk usually means a residual risk that remains after all reasonably practicable efforts have been made to eliminate or reduce it. It is accepted with some reluctance. The justification is the argument in support of the concluding position. It should satisfy those involved in the activity, the statutory authorities and others including the public.

There are no universal risk criteria. This is a social and political judgement that can be guided but not entirely defined by expert evidence or advice. A few sectors of industry (such as nuclear power) have specified numeric targets but for most other industries the safety regulators offer only broad guidance.

## Terminal installation milestone reached

THE 10,000th Fleet terminal was activated earlier this year by the global mobile satellite communications company, Inmarsat. This milestone was reached when the AND Group installed a Fleet 77 terminal on *Morning Midas*, a car carrier.

This vessel, which has also been equipped with an Inmarsat C unit, will use the voice and 64kbps data capabilities of Fleet 77 for a range of corporate and crew communications, including fax, e-mail, Internet access, and crew calling.

Launched back in 2002, F77 is the flagship service in the Fleet range, and provides ISDN and packet data connectivity to support ship management applications, online chart updates and weather information, vessel telemetry, e-mail, and other data communications. In 2005, Inmarsat unveiled an enhanced F77 service that offered a dedicated 128kbps channel.

Other Fleet services include F55, which uses a smaller antenna for global voice and 64kbps data in the spotbeams; and Fleet F33 which offers global voice and enhanced 9.6kbps data, accessed in the spotbeams through a compact antenna.

#### Advanced global satellite coverage

Meanwhile, it is now claimed that Inmarsat's next-generation satellite system - the Inmarsat-4 (I-4) series - covers 85% of the world's total landmass. The first two of three I-4 satellites are now in commercial operation in Inmarsat's

Indian and Atlantic Ocean regions, with coverage extending across North and South America, Europe, Africa, Asia, and the Far East. The fourth-generation I-4 spacecraft are said to be among the largest commercial communications satellites ever launched.

They replace their highly successful predecessors - the Inmarsat-2 and Inmarsat-3 spacecraft - as the foundations of Inmarsat's new broadband global area network (BGAN) services. They can deliver simultaneous voice and data at speeds of approximately half a megabit/second.

Each I-4 offers greater call capacity than all five I-3s put together; 60 times more power than any one of its predecessors; 12 times greater efficiency in its use of radio spectrum; 16 times the capacity; and 25 times the receiver sensitivity.

The I-4 spacecraft have been built largely in the UK; the bus in Astrium's factory in Stevenage; and the payload in Portsmouth. The two halves were then joined together in Toulouse, France, along with the US-built antenna, and German-built solar arrays. The Inmarsat-4s, like their predecessors, are equipped with a single global beam that covers up to one-third of the Earth's surface, apart from the poles.

Each satellite also generates 19 wide spotbeams that provide continuous coverage across the same region for Inmarsat's existing high-end services, including Fleet F77 128kbps, Fleet F55

and F33, and maritime mini-M. New to the I-4s are an additional 228 narrow spot-beams, designed to form the backbone of Inmarsat's broadband services, including the BGAN, which was launched at the end of 2005. BGAN delivers Internet and intranet content and solutions, video-on-demand, videoconferencing, fax, e-mail, phone and LAN access at speeds of up to 492kbps. Together the first two I-4s serve about 98% of the global population.

The satellites are controlled from a satellite control centre (SCC) at Inmarsat headquarters, in London, which is responsible for keeping the satellites in position and for ensuring the onboard systems are fully functional at all times.

Data on the status of the Inmarsat satellites is supplied to the SCC by four tracking, telemetry and control (TT&C) stations located in Italy, China, and Canada (two). There are also back-up stations in Norway and New Zealand.

A call from an Inmarsat mobile terminal goes directly to the satellite overhead, which routes it back down to a gateway on the ground called a land earth station (LES). From there the call is passed into the public phone network.

With the launch of BGAN, two new gateways, or satellite access stations (SASs), have been introduced, both of which are owned by Inmarsat. The first, in The Netherlands, is operated by Inmarsat partner Stratos/Xantix, and the other, in Italy, by another partner, Telespazio.



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**March 12-14, 2007: International conference on advancements in marine structures**, Glasgow, UK. Contact:

MARSTRUCT - Network of Excellence on Marine Structures, Professor P K Das, Dept of Naval Architecture and Marine Engineering, Universities of Glasgow and Strathclyde, Henry Dyer Building, 100 Montrose Street, Glasgow G4 0LZ, UK.

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**March 27-29, 2007: Ocean Business 2007, exhibition and demonstrations**, Southampton, UK. Contact: Versha Carter, Intelligent Exhibitions Ltd. Tel: +44 1453 839228. E-mail: Versha.carter@intelligentexhibitions.com www.oceanbusiness2007.com

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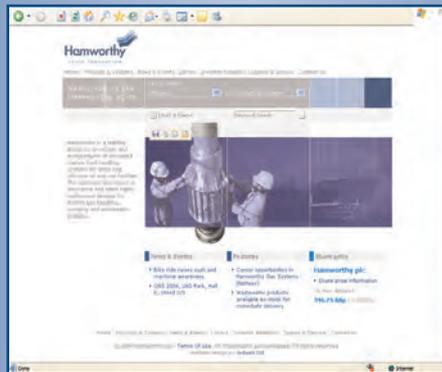
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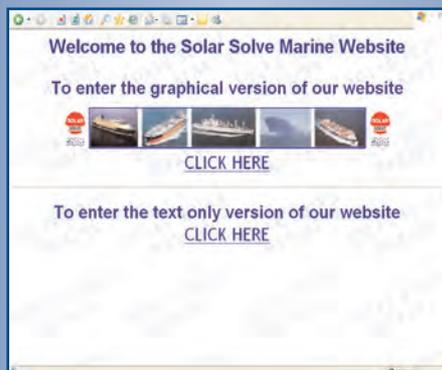
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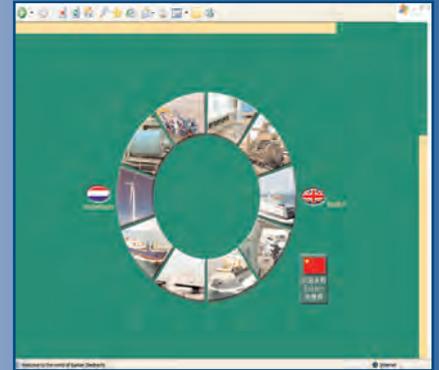
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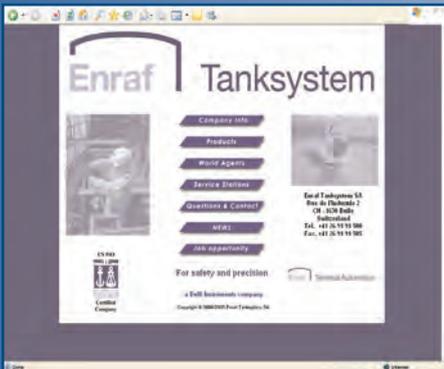
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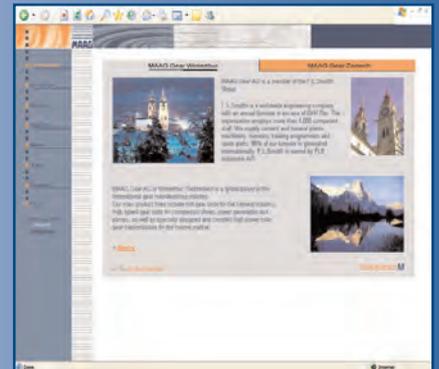
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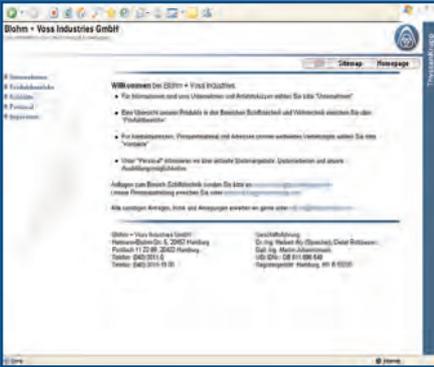
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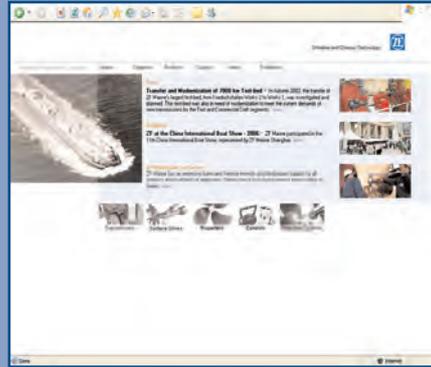
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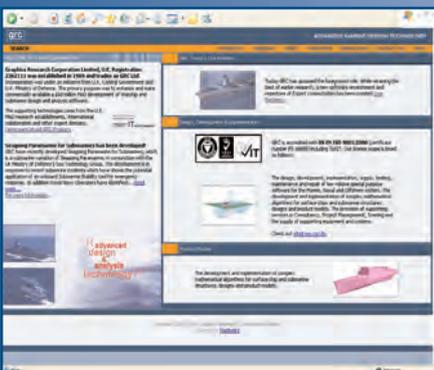
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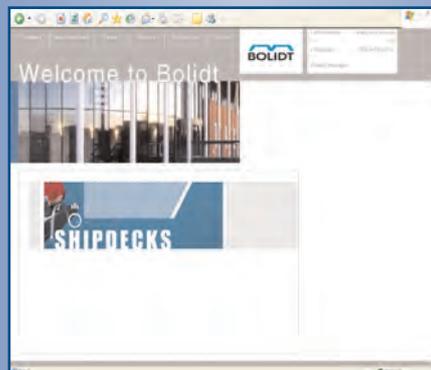
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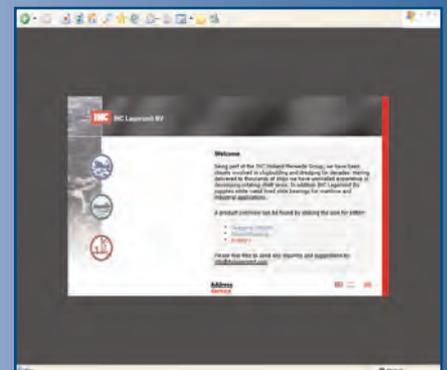
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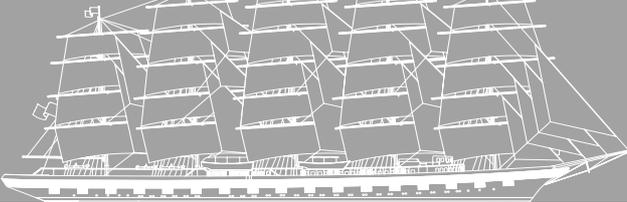


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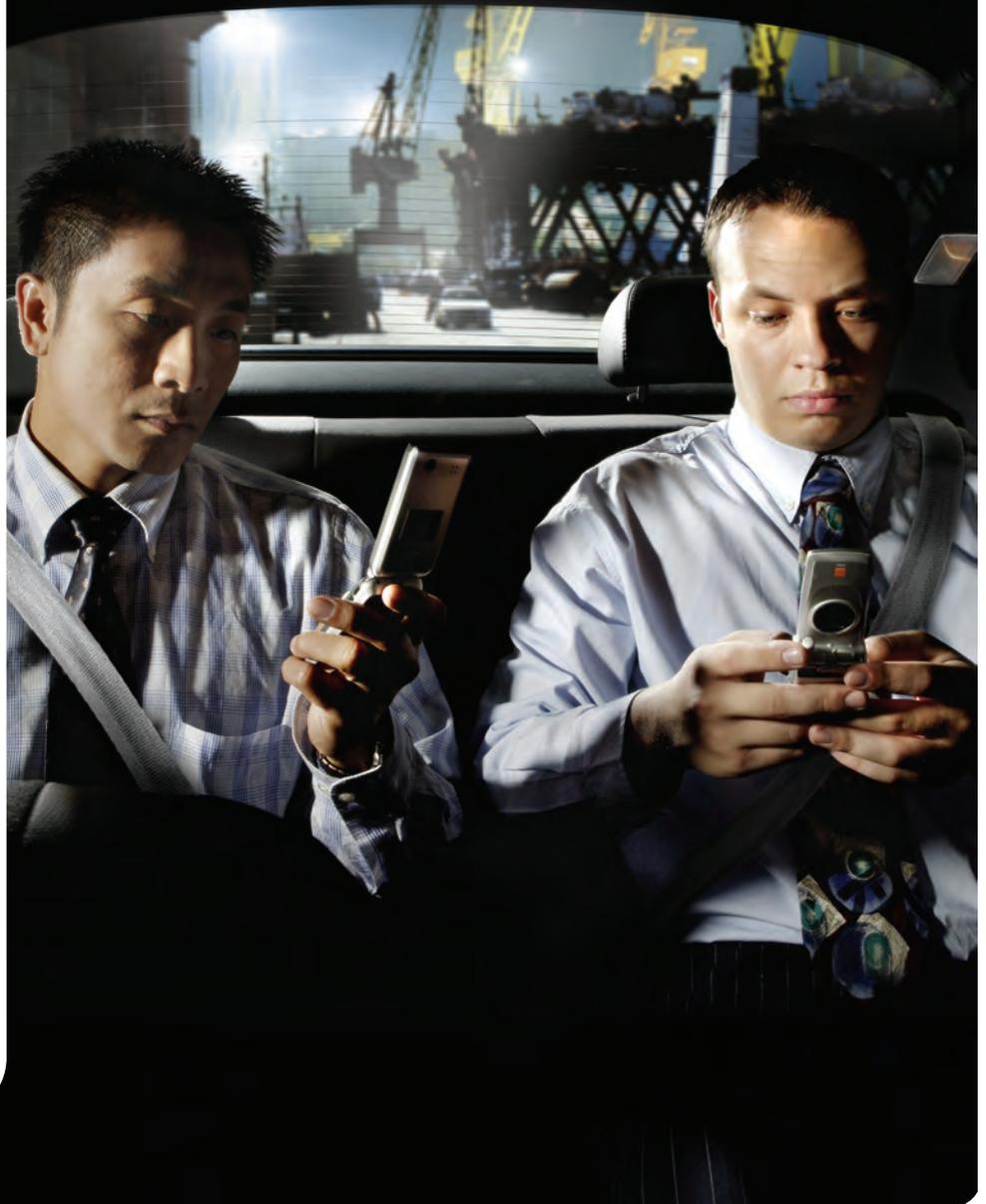
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