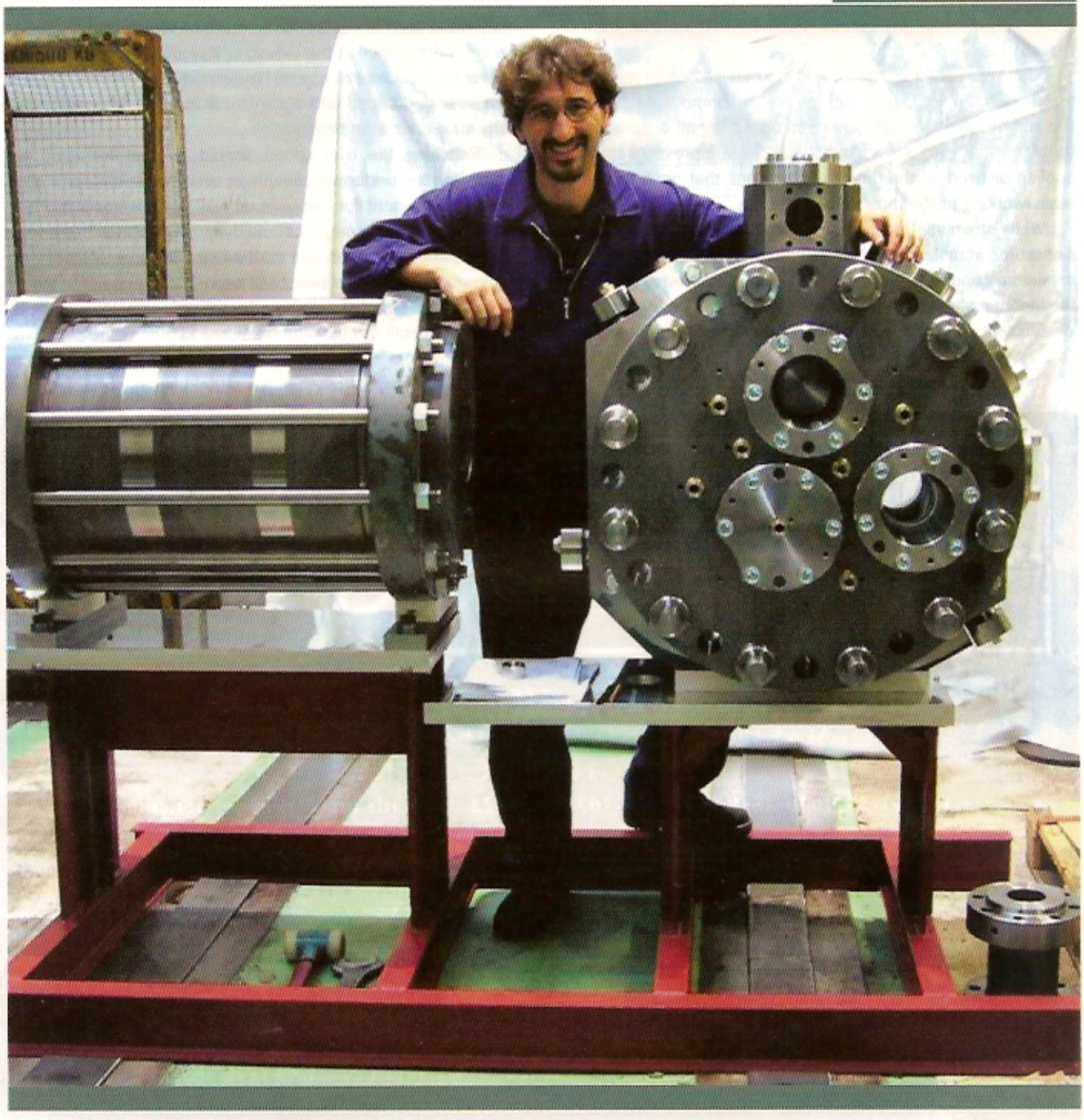
Intertwined targets

David Tinsley investigates the environmental and efficiency drivers underpinning current R&D



Certain countries, Germany in particular, have long displayed a propensity and capability for more commercially attuned engineering research, in line with a culture and a framework that stimulates technological research and innovation as an integral part of ensuring market competitiveness.

The most successful producers and designers in the marine field have maintained R&D budgets through the ups and downs of the market, cognisant of the long-term impact of such endeavours on competitive position.

The proportion of turnover ploughed back by a company into R&D is, of course, a fundamental measure of commitment. However, the ultimate effectiveness of the investment, irrespective of scale, is a factor of focus, project structure and planning, and the channels and timescales for converting research into working systems, products and technical concepts.

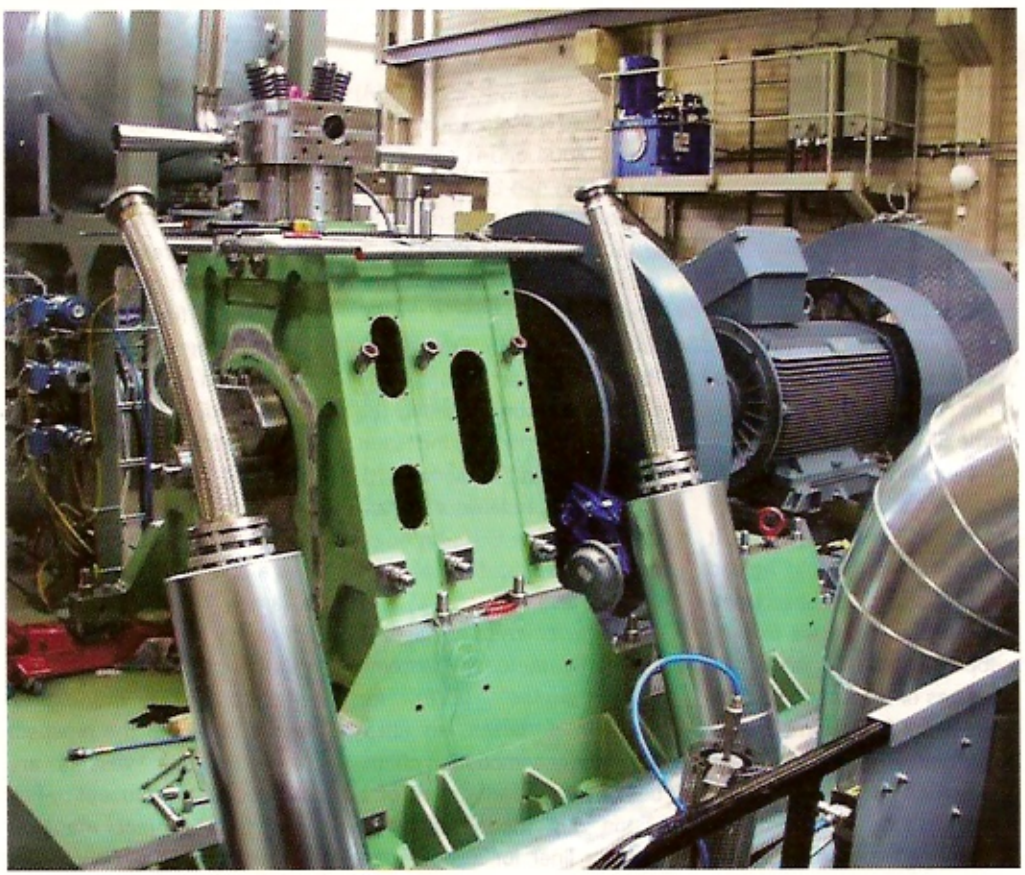
Although some quarters of the industry remain sceptical as to the value of committing public funds to technological research, there is no doubt that the various European and national programmes have become more pragmatic as regards both topics and goals.

Certainly, the European Commission's policy regarding publicly sponsored research of fostering collaboration on a very wide scale, seeks to bring more and more organisations into the fold and broaden the potential benefits of such work. This implies the need for the most prudent project management and co-ordination so as to ensure the efficient functioning of large studies.

The Framework Programme (FP) is the EU's main instrument for funding research and development and the current Sixth Framework Programme runs to the end of 2006. FPs have been implemented since 1984 and cover a period of five years, with the last year of one FP and the first year of the following FP overlapping.

By contrast, it has been proposed that the forthcoming Seventh Framework Programme should run for seven years, becoming fully operational on 1 January 2007 and expiring in 2013. New elements will be the emphasis on research themes rather than research 'instruments', and a focus on developing research that meets the needs of European industry through the work of Technology Platforms and new Joint Technology Initiatives.

■ **Achievements of the Hercules integrated project, aimed at raising marine engine performance through technological innovation, include an ultra-large spray combustion chamber design (left) and an 'extreme value engine' (below)**



Quantifying pollution

A large-scale, long-term integrated project to determine the amounts of atmospheric pollution from shipping, land transport, and aviation was launched last year under the acronym QUANTIFY, with EC funding until 2010 under the Sixth Framework programme.

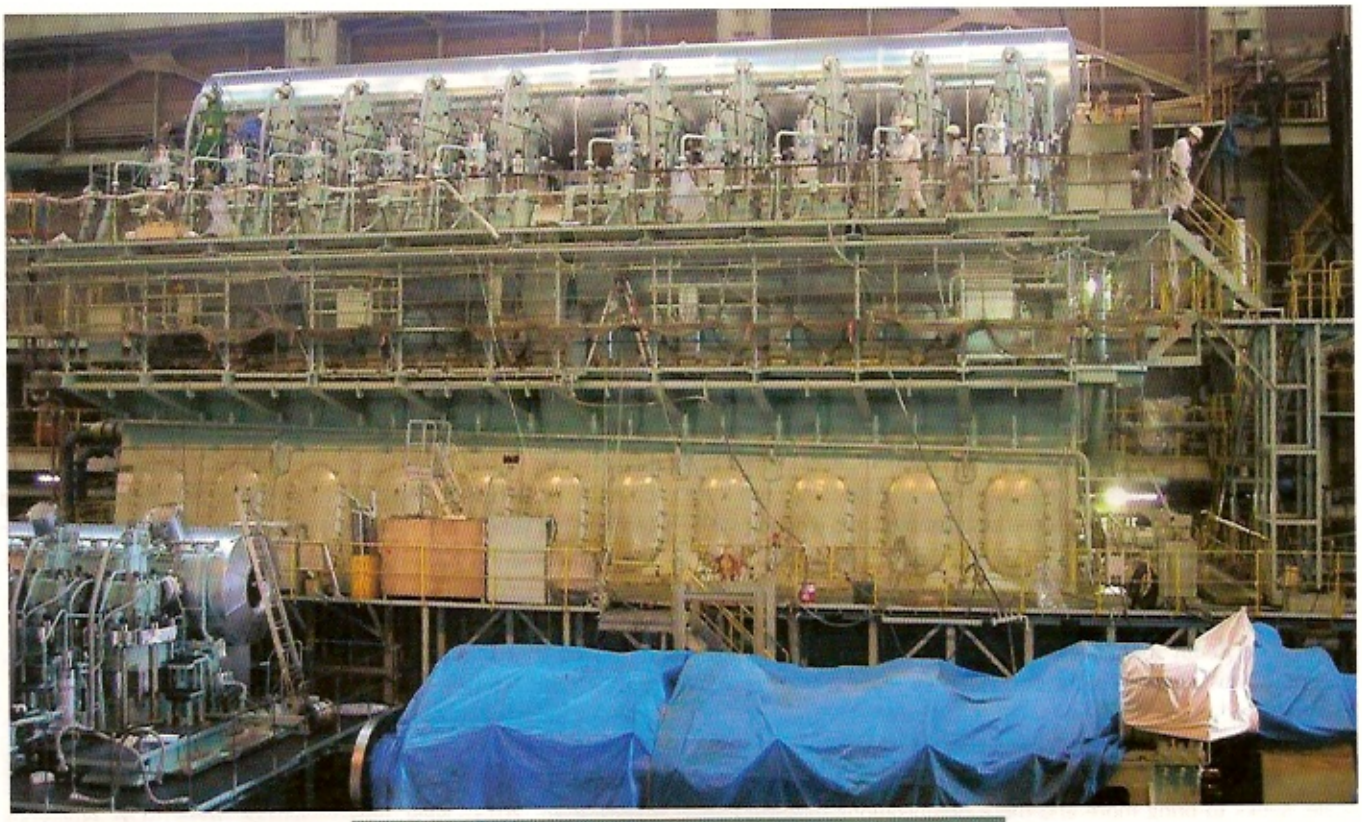
QUANTIFY involves 35 participants and four associated members from 16 European countries and the USA, who are tasked with quantifying the climatic impact of transport with regard both to the present situation and in future scenarios.

The study will examine long-lived greenhouse gases such as carbon dioxide (CO_2) and nitrous oxide (NOx), emissions of ozone precursors and particles, and ship stack emissions and aircraft contrails (vapour trails). A key objective includes the provision of forecasts and other advice relevant to industry and to policymakers.

Co-ordination of the project is being undertaken by the Institut für Physik der Atmosphäre at the Deutsches Zentrum für Luft- und Raumfahrt (DLR). At a presentation during the official start of the QUANTIFY project, the DLR co-ordinators provided statistics from earlier studies indicating that annual emissions from shipping are at an extremely high level.

Although well below those of road traffic, total emissions of CO_2 from shipping are higher than those from aviation, while NOx emissions from shipping are far in excess of those from aviation and a fairly close second to those from road transport. Emissions of sulphur dioxide (SO_2) from shipping are considerably higher than from road traffic, while SO_2 from aviation is at a comparatively very low level.

Shipping is also responsible for most of the particulate matter (PM) emissions attrib-



■ One focus of the Hercules project has been bypass arrangements for exhaust gas on large two-stroke diesels

utable to transport activity.

The 35 participants in the project are mainly technical institutes, universities and research organisations, and include Det Norske Veritas (DNV). Among the four associate members is the Rolls-Royce group, with its extensive interests in aero engines and ships' equipment, and also the UK Department of Trade & Industry.

Improving performance

Building on the work being carried out under the auspices of the Hercules integrated project, a huge, collaborative endeavour aimed at raising marine engine performance through technological innovation, MAN Diesel (the erstwhile MAN B&W Diesel) and Wärtsilä Corporation have proposed a follow-on Hercules-B study of greater duration and financial depth. Bold goals as to reduced engine emissions and improved fuel efficiency are central to Hercules in both its present and envisaged guise.

Like the current project, which has EU and Swiss government funding, Hercules-B is seen as a co-operative study to involve a broad spectrum of technical bodies, institutes and companies. The remit would be to raise the efficiency of marine diesel propulsion systems to above the 60% mark, with resulting improvements in unit fuel consumption and CO_2 and other emissions.

To put this aim into perspective, the highest thermal efficiency rating for modern marine diesels to date is about 50%. To give the ultimate target still greater weight in an environmental context, it is estimated that an improvement of just 1% in thermal efficiency across the industry would reduce annual emissions of CO_2 from ships by some 5Mt per year.

Hercules-B is planned to run over a four-year period with a targeted budget of €60M. It is expected to be fully agreed in 2007, and to be subsequently proposed for partial funding support by the EC under the auspices of the future Seventh Framework Programme.

Whether or not Brussels will agree to such sponsorship remains to be seen, although it is hoped that the EC will recognise the potential significance of Hercules-B towards achieving reductions in CO_2 and other emissions, and the importance of the joint involvement of the two pre-eminent designers and licensors in the global marine engine market.

The current Hercules (A) integrated project started in March 2004 and is scheduled to finish in mid-2007. It has an overall project budget of €33.3M, and €17.8M of this is being publicly funded, to the tune of €15.0M from the EC under the Sixth Framework Programme provisions and with €2.8M contributed by the Swiss government (Bundesamt für Bildung und Wissenschaft). The present endeavour is managed by Uleme EEIG, an Augsburg-based subsidiary of MAN and Wärtsilä.

Achievements highlighted so far relate to an 'extreme value engine' (EVE) for research purposes, an ultra-large spray combustion chamber design, development of a piston ring friction tester, a cylinder liner for a 'hot'-operating engine, and exhaust gas bypass arrangements for large two-stroke diesels.

Under Hercules-B, a number of Technology Demonstrator engines would be prepared, and certain new technologies developed through the project would be validated on board newbuild vessels.

Fuel cells

Meanwhile, a full-scale demonstrator of a marine power plant based on fuel cells is planned for 2008 by north European partners in a pan-industry research undertaking known as FellowSHIP, backed by funding from the Eureka programme. The pilot application will be as a ship-board auxiliary.

Integrated hybrid systems suitable for both main and auxiliary power are a key objective of FellowSHIP, which has a budget of €18.75M and a largely Nordic involvement. Efficiency gains of up to 50% relative to today's diesel engines and environmental merits that offer the prospect of 'ultra-clean' vessels are claimed for the concept by FellowSHIP's project manager Tomas Tronstad of DNV.

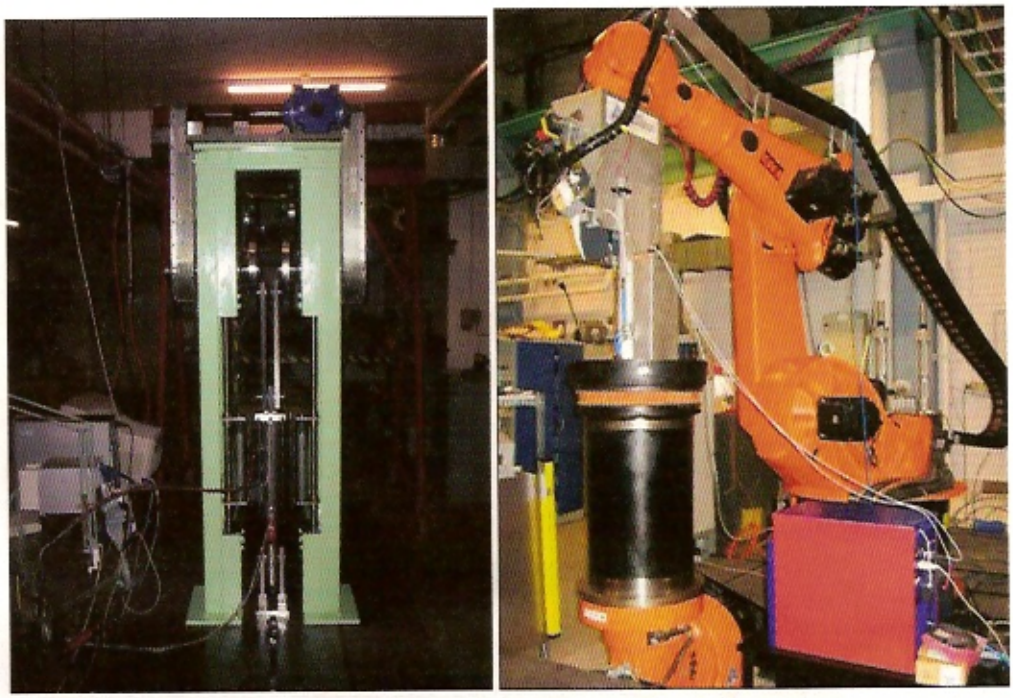
Led by DNV, the FellowSHIP initiative includes Eidesvik Offshore, MTU CFC Solutions of Germany, Wärtsilä Automation Norway and Norwegian ship design consultancy Vik-Sandvik. The opening phase also involved Wallenius Marine of Sweden and Wärtsilä Corporation, which has been pursuing fuel cell technology development for distributed power generation markets on land and sea.

Freedom from the NOx, SOx and particulate emissions of internal combustion engines, plus high thermal efficiency and quiet, vibration-free running are characteristics of fuel cells that could benefit the marine sector, given growing environmental controls and rising expectations as to shipboard habitability and passenger comfort.

The potential benefits offered by fuel cell technology are greatest when operation is on high purity hydrogen and oxygen, and when the heat and water produced from the energy conversion reaction can be utilised. Although there will be a CO_2 content to the exhaust if carbon-containing fuels such as natural gas are used in FC plant, this will be reduced by as much as 50% relative to diesel engines run on bunker fuel.

Besides the advantages springing from the inherently silent running properties, FC systems promise simpler designs and reduced maintenance requirements due to fewer moving parts and their modular nature.

FellowSHIP has been launched as a three-year project, tasked with developing and testing marine and offshore power solutions using molten carbonate fuel cells (MCFC) and solid oxide fuel cells (SOFC). The sponsorship by Eureka, the network for European collaboration in R&D, offering a complementary approach to the EC's Framework Programme, is of added significance because Eureka is regarded as having a stronger leaning towards market orientated research.



■ A piston ring friction tester (left) and a cylinder liner for a 'hot'-operating engine (right) have both been developed as part of the Hercules project

In addition to its project management role, DNV's responsibilities under FellowSHIP embrace safety and reliability issues and environmental analysis. DNV was also entrusted with providing an information flow from two earlier EU-sponsored marine fuel cell research projects, FCSHIP and NEW-H-SHIP, as well as several EU projects on hydrogen, namely HYSAFE, HYWAYS and EIHP (European integrated hydrogen project).

In the FCSHIP study, DNV participated in the safety module, working together with three other European-headquartered classification societies to develop basic safety requirements for fuel cells in ships.

Hydrogen options

A proposal has been made for a large-scale, integrated project to demonstrate the feasibility of operating hydrogen-fuelled vessels. It envisages the construction of three 'demonstrators' of different types in three participant countries. Entitled *Demonstration of hydrogen-fuelled ships*, with the project acronym H2 TO SEA, the project would provide the marine equivalent of major initiatives taken in Europe to showcase the benefits and viability of hydrogen fuel in applications to public bus transport.

H2 TO SEA has been proposed under the auspices of the Sixth Framework Programme, and might potentially have EC funding in the range of €10-15M. Earlier this year it appeared that organisations and companies from Iceland, Norway, the Faroe Islands, France and Germany had signalled their intention to join the research consortium, but that further participants were being sought, as a much larger grouping is required for an EU integrated project.

The existing consortium is open to further participants from, in particular, the shipyard, certification and safety, fuel cell and hydrogen engine conversion sectors. It is understood that two boat builders in the Faroe Islands may join H2 TO SEA.

The three demonstrators would be a Norwegian local ferry, an Icelandic fishing vessel and a Faroese fishing boat. Conversion or construction of the vessels would be undertaken in different shipyards, and the focal point for each would be a hydrogen fuel system.

The Norwegian demonstrator would be an existing ferry converted to run on hydrogen, using a fuel cell and incorporating an onboard fuel reformer. The Icelandic fishing vessel may be powered by either a fuel cell or an internal combustion engine, and the final decision will be influenced by the conclusions of the NEW-H-SHIP project. The Faroese contribution will be a fishing craft of under 30ft length, powered by an internal combustion engine but equipped for onboard hydrogen supply using wind energy.

Speed trials

A three-year initiative to establish transparent and accurate methods for newbuild speed and power trials has been completed during 2006 by an industry group with an exceptionally large representation by shipowning companies.

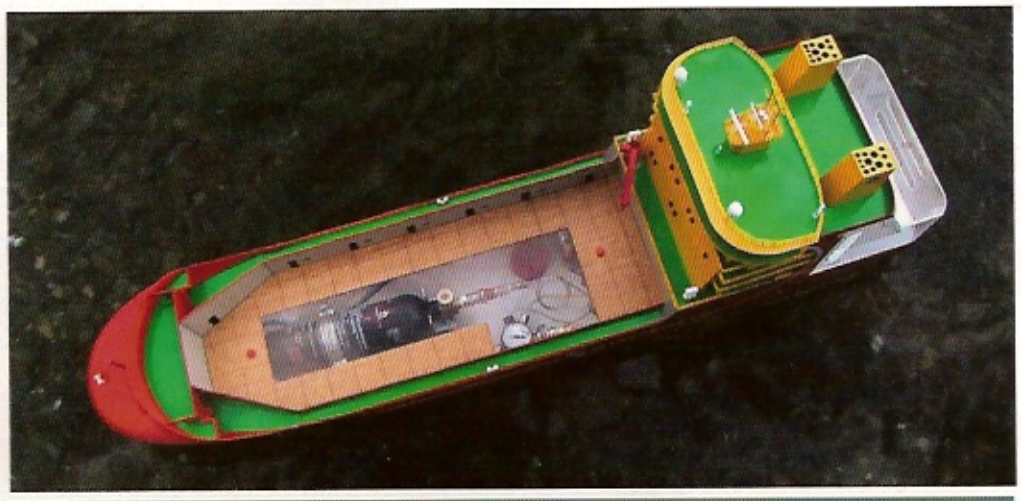
Known as the Sea Trial Analysis (STA) joint industry project, the research project was co-ordinated by the Dutch maritime institute MARIN and

encompassed at least 10 owners and operators, as well as five South Korean shipbuilders and Japan's Sumitomo Heavy Industries.

Historically, analysis of shipbuilders' speed trials uses established corrections to allow for deviation between the conditions during the trial and those defined in the contract. However, recent unsatisfactory experiences of several shipowners have spurred reconsideration of the corrections, as some have not been revised since their introduction 30-40 years ago.

STA started with case studies to investigate the results of trials by various analytical methods as the basis for developing recommended practice for trial procedures and measurements. Subsequently, the project group formulated analysis methods and software specific to the type of ship involved. Evaluation was made of the results of some 20 previous sea trials, made available by participating shipowners. Trial procedures and measurement techniques are specified in detail in the recommended practice guidelines. New correction methods for waves and wind effect were developed.

The project included trials on selected ships constructed in Korea. These were conducted in accordance with the new practice guidelines and analysed using the new software. One of the demonstration trials concerned the 8600 TEU containership *Colombo Express*, built by Hyundai for Hapag-Lloyd. Shaft power and speed were measured, as well as the incident wave and wind conditions.



■ The FellowSHIP scale model (1:84) of the offshore supply vessel is operated remotely and powered by hudrogen and proton exchange membrane (PEM) fuel cells

Innovative new test models of podded propulsors have been developed by MARIN as a result of studies carried out in conjunction with the Eindhoven University of Technology. The move was prompted by a wish to improve accuracy and flexibility in undertaking research and tests on pod design and performance, by introducing models incorporating integral electric motors, as employed in the actual propulsors. Hitherto, such investigations have been based on models powered by an external electric motor and mechanical right-angle drive.

Two different pod model versions have been created, comprising a small scale, basic type best suited to manoeuvring and seakeeping experiments and a large scale, more complex variant conceived for detailed propulsion studies and dynamic measurements.

The new modelling approach is claimed to obviate the drawbacks associated with the conventional arrangements used hitherto by obviating the need for bevel drive gears, which impose geometric restrictions for certain pod shapes and also introduce vibration. In addition, the mechanical drive system restricts modelling freedom since the angle between the propeller shaft and rotational axis is fixed at 90deg.

Propeller analysis

Ten Norwegian-based manufacturers of propellers, in collaboration with DNV, research institute Marintek, and the National Technical University of Norway, are involved in a three-year joint industry R&D programme. The initiative is known as the Propeller Forum (or Propellkameratene) and has the aim of

■ The solid oxide fuel cell (SOFC) unit projected by Wärtsilä, a partner in the FellowSHIP project for which the pilot application will be a shipboard auxiliary

1. Fuel cell stacks
2. Air pre-heater
3. Fuel processor
4. Process gas heater
5. Fuel pre-heater
6. Catalytic burner
7. Air blower
8. System control and power conversion
9. Purge gas
10. Water management

developing new and more efficient tools of design and analysis and to improve the efficiency of design and production processes used by the companies involved.

The national goal is to secure Norway's long-term technical competitiveness in this field. To this end, the programme is receiving financial support from the Research Council of Norway and Innovasjon Norge.

Norwegian-based producers of propellers, thrusters and rudders are a mixture of small- and medium-sized enterprises and large international companies, notably Rolls-Royce Marine and Wärtsilä Propulsion. They are all keystones of industry in their respective regional locations of Norway.

It is anticipated that the improved products and installations that will ensue from the results of the programme will achieve reductions in fuel consumption by up to 10-15%, with a corresponding reduction in emissions. □

Renewable fuel research

A research consortium co-ordinated by Wärtsilä is to receive a €1M grant from the European Union to develop the use of fuel cells consuming methanol to provide electrical power to marine vessels. The project is entitled *Validation of a Renewable Methanol Based Auxiliary Power System for Commercial Vessels* (METHAPU) and its entire cost is €1.9M.

The main purpose of the project is to develop and validate technology based on renewable fuel on board a cargo vessel involved in international trade. A further important aim is to lay the technical groundwork to support the introduction of the necessary regulations to allow the use of methanol as a marine fuel.

The specific components of the technology to be validated are methanol fuel bunkering, distribution, storage and a solid oxide fuel cell system that consumes methanol. The consortium includes leading players in the fields of fuel cell system integration, sustainable shipping, classification and environmental assessment, including Lloyd's Register, Wallenius Marine, University of Genoa and Det Norske Veritas.

The consortium's research will deal with the solid oxide fuel cell (SOFC) unit of 250kW and the focus is on marine application issues, as well as the unit's safety and reliability. For marine validation purposes a smaller 20kW unit will be installed on board a Wallenius Marine car carrier. The 20kW unit will be factory-tested, laboratory-tested and approved before installation.

The installation, likewise, will be approved before the unit and its carrying vessel begin to sail on world trade routes. A lifecycle assessment and an operational safety assessment will be made. The results of the validation run and the tests will contribute to the second and final part of the research – the marine compatibility of the 250kW unit, its safety and reliability.

The project will take two-and-a-half years, one year of which is dedicated to the application's validation. The regulations and technical requirements for using methanol as a marine fuel will pave the way for the commercial use of methanol-consuming fuel cells on board commercial vessels.

This research project also serves as a springboard for future research related to sustainability.

According to Erkko Fontell, General Manager, Fuel Cells, at Wärtsilä: 'This is an interesting option for reducing ship emissions when harbouring.' □