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REVIEW
NORWEGIAN MARINE TECHNOLOGY RESEARCH INSTITUTE

Shipping in Cold Climate Regions

2 - May - 2007

Contents:

Growing oil and gas activity in the Arctic regions of Norway and Russia will increase shipping traffic in these harsh environments. This increase will come from field development and maintenance of subsea installations as well as exports of larger volumes of oil and gas. There will also be more cruise traffic in the far north and possibly an increase in exports of metals/ore. It is also expected that a growing amount of oil and gas will be carried from Northwest Russia and Northern Norway to the west coast of the USA. The shortest sailing distance for such voyages involves passing close to Iceland and through the region of roughest wave conditions in the world.

MARINTEK is currently involved in several projects and pilot studies which focus on the safety of shipping in rough weather in the Arctic.

Arctic Emergency Operations

This is a three-year project supported by the Research Council of Norway. MARINTEK is project co-ordinator on behalf of the Ship Manoeuvring Simulator in Trondheim. Project partners come from the maritime cluster and oil companies. In addition to Norwegian companies the project has participants from France, Germany, Japan and the Russian Federation. Topics covered by the project include:

- Drifting of disabled and damaged tankers
- Best practice for emergency towing operations
- Emergency lightering under harsh weather conditions
- Emergency operations for disabled tankers in ice-infested waters
- Collision scenario for a bulk carrier and cruise vessel in Arctic waters.

As part of the project, new training courses will be developed, tested and made commercially available by the Ship Manoeuvring Simulator. In order to improve the simulation models the project includes field tests of the manoeuvring performance of a Norwegian coast guard vessel in calm water and waves. One of the project partners, the Norwegian Coastal Administration is making the results of field tests of emergency towing operations available to the project. These results, in combination with operational experience of tug operators, will be used to develop a set of guidelines for functional specifications for emergency towing vessels designed for harsh weather operations in cold climate regions. The project has already held three open international workshops on emergency towing operations. The next one is planned to take place in Trondheim in late September 2007.

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Preparing the towing connection for "Belokamenka".

SINTEF

Shipping in Cold ....

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Ship-to-ship transfer of LNG in cold climates

This is another R&D project initiated by BW Gas and MARINTEK. The focus is on safe ship-to-ship transfer of LNG in open waters in cold climates. It is assumed that this could be a possible scenario for an LNG transport chain that would employ short-distance ice-strengthened LNG vessels for the first leg of an export route from North-west Russia to the east coast of USA and Canada. Other partners in this project are Rolls-Royce Marine, Framo Engineering and DNV. The project is financially supported by the Research Council of Norway under the MAROFF programme.

Emergency response to disabled vessels in arctic waters

A number of recent situations have involved disabled vessels drifting in harsh weather conditions in European and US waters. These incidents demonstrate that current methods, vessels and emergency towing competence all need to be improved. With financial support from the EU's Northern Periphery Programme and the Norwegian Barents Sea Secretariat, MARINTEK is co-ordinating a pilot project on sea safety and emergency response facilities for vessels in voyages between Northern Norway/North-west Russia and the east coast of the USA/Canada. This passage passes through an area with the harshest wave conditions in the world, south west of Iceland. The need for emergency response/ towing vessels to assist disabled vessels on this passage thus ought to be studied. Partners in the pilot project include Vardø ProMor, the Icelandic Maritime Administration and the Central Marine Research and Design Institute (CNIIMF) in St. Petersburg. The partners are collecting traffic information for the regions concerned and comparing existing contingency plans and material along the route.

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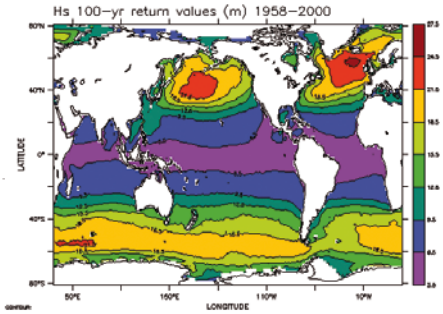

Extreme wave conditions southwest of Iceland (from the KNMI/ERA-40 Wave Atlas).

FLAGSHIP

European Framework for Safe, Efficient and Environmentally-Friendly Ship Operations

European ships are already a very safe, environmentally friendly and efficient means of transport. However, constantly developing technology provides new potential for further improvements. A new research and development project called "FLAGSHIP" is now being launched by a group of leading European ship-owners and operators, system manufacturers, shipyards, class societies, universities and research institutions. The purpose of the project is to develop and test the use of new technology in a variety of on-board and shore-side systems that have an impact on safety, the environment and efficiency.

In the area of "Technical operations", the project emphasises early detection of problems, efficient diagnosis and timely repair, as well as long-term efficiency and savings by optimised monitoring and maintenance.

The focus in the area of "Nautical operation and support" is on improved working conditions for the ship's officers as well as on improved ship-operating efficiency. The latter includes environmental issues as well as cargo handling and stowage.

The third project area is "Emergency management", and focuses in particular on more highly integrated emergency management in highly critical situations such as fires and hull damage. The research includes better prognostic tools as well as improved coordination between the emergency teams on board and on shore.

In addition to these main three areas, the project also incorporates support actions in the areas of ICT infrastructure, health, safety and human impact, as well as support for standardisation and liaison with legislative bodies.

The project will run for four years, have a total budget of € 19.4 million and is partly funded by the European Commission's Directorate-General for Research. FLAGSHIP is run by a European consortium of 49 partners, under the coordination of the European Community Shipowners' Associations (ECSA) in Brussels. British Maritime Technology (BMT) and MARINTEK will support ECSA in project management.

The overall vision of FLAGSHIP is to create the mechanism whereby the expertise of all parties can be brought together in real time, independently of their location, and given the required information (in the right format, at the right time and incorporating the highest level of knowledge) in order to better manage all the questions which confront a ship operator: these include issues relating to the vessel itself and its equipment (e.g. hull monitoring, equipment diagnostics, maintenance planning), its day-to-day operation (e.g. navigation, cargo, rule compliance) as well as emergencies and other exceptional situations (collision, fire, etc.).

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The cruise ship industry emphasizes safe and environmentally friendly operations. (Photo: RCCL)

Ship-to-Shore Reporting

For several years, MARINTEK has been working on the use of XML (eXtensible Markup Language) in various applications of ship-to-shore reporting. XML is the "lingua franca" of modern distributed computing and enjoys immense popularity as the message format for electronic exchange of documents over Internet. This article offers an overview of the state of the art in this area as well as some possible future scenarios.

Port calls require extensive reporting from the ship.

Port clearance

More than 25 documents have to be sent from the ship, or the ship's agent, in conjunction with a port call. Although the agent handles much of the reporting, a significant amount of work still has to be done by the ship's master. Today, much of the master's reporting is done via plain e-mail or fax, but electronic messaging is an option in some ports.

UN/EDIFACT is currently the officially proposed document standard for electronic clearance of ships. This format is fairly costly to install and maintain, and is mainly used in large ports. However, XML is rapidly gaining popularity, and the US Coast Guard and the European Maritime Safety Agency (EMSA) have adopted XML as their mandatory electronic document standard. Several port state authorities have also adopted XML for some of their reporting needs; for example, XML can be used in Hong Kong, Finland and Norway.

Currently, no common standard exists for XML-based ship reporting. Traditionally, UN/CEFACT has handled trade-related electronic data interchange standards. There is an initiative under way for new XML-based messaging standards to be developed and implemented , but it is expected that these will be general multi-modal and mainly cargo-related document formats. Thus, there is still a need for standards to cover the more general reporting requirements for ships calling in foreign ports.

To address this problem, MARINTEK has helped to launch a new work item in ISO TC8/SC10 to develop a new international standard. The standard will contain a unified set of data elements that can be used in electronic reports. It is hoped that this standard can form the basis for a more unified approach to ship/port reporting in the future. The first draft from the committee is expected in the late summer of 2007.

Technical reporting

MARINTEK has also been developing a new concept for monitoring ship performance and technical condition. This concept is called TOCC: Technical Operations Competence Centre. The basic idea is that the ship sends electronic engine reports to an automatic analysis system on shore. This system performs a general technical condition and performance analysis and returns a short status and deviation report to the ship and/or the marine superintendent. If necessary, additional information or assistance can be obtained by contacting experts in the centre.

The message format used in TOCC is XML and the data-handling infrastructure is basically identical to the systems proposed for electronic port clearance. Currently, the engine reports are filled in manually, but it should be fairly easy to automate parts of this procedure. The XML file formats can easily be aligned with the upcoming ISO standard.

Reports to charterers and owners

A third project is the development of technical solutions for automatic reporting from the ship to the charterer and owner. These reports are partly used for charter-party performance analysis and partly for voyage monitoring. The latter aspect is covered by noon reports and pre-arrival notices to ports and channel authorities. The performance analysis is done automatically by a tool similar to that used in TOCC. In principle, this tool can be used by both owner and charterer to compare performance claims and to monitor the voyage. This project also uses XML as the electronic message format. The data types and messages will be based on the proposed ISO standard.

In the first deployment of the system, the ship-side reporting system will be a relatively simple tool based on a spreadsheet workbook that is capable of receiving and sending XML messages via electronic mail.

Future developments

XML has been proposed and used in a wide range of applications, from mandatory ship reporting to ordering and paying for cargo transport services. In the maritime transport area, it is quite clear that this technology has great potential as it is easy to develop and has low deployment costs.

In the three projects briefly described above, the focus is on regular reporting from the ship. It follows that the tools and protocols developed in these projects can form the basis of a more general-purpose ship operations platform that can integrate these functions as well as other related functions, e.g. in the area of technical operation, crew and transport management. It will also be feasible to integrate other systems such as automatic ship reporting through the mandatory AIS and LRIT services or voluntary services such as AMVER.

More automated systems can significantly reduce work load as well as improve the efficiency of operations. Developing international standards for ship reporting has the potential of significantly lowering the cost of automated systems both on board and in the shore offices. This is obviously a long-term goal, but the positive effects of standardisation are very visible today in the World Wide Web, where the first specification was published as long ago as 1990. On this note, it is worth pointing out that XML is a true child of the World Wide Web and also represents an important component of its future.

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High-Speed Craft – an Alternative Means of Environmentally Friendly Passenger Transport?

A general trend in major cities is the rapid growth of population, which means that thousands of people enter the city centre and leave later on the same day. Large cities often lie close to the sea, fjords or waterways. Today, most passenger transport is by train, underground, bus and car. Train and underground transport is usually efficient and clean, but this cannot be said of travel by bus or car. Transport by high-speed craft is a better solution in terms of time, pollution and flexibility.

The situation today

A normal situation with cars and buses is that hours are spent on congested roads, which in turn leads to more pollution and stress for everyone. For cars parking availability and related costs in the city centre are also a problem. For cities close to larger fjords and the sea, another problem is that buses and cars have to make crossings by ferries, meaning that journeys are divided into three or more stages, and that the landside infrastructure requires not only roads but also ferry terminals.

A new generation of high-speed craft

In order to be competitive in the passenger transportation market, new solutions will have to be developed; solutions that produce less pollution and offer more flexibility for passengers, better transport chain logistics and shorter travel times and less stress for passengers.

New types of craft are under development in Norway, with a focus on several areas:

- Layout of craft, passenger and cargo arrangement, side-, bow-, and stern loading.
- Machinery solutions; diesel, gas- and fuel cells
- Materials and building methods
- Efficiency in transport, propulsion, steering and manoeuvring

Craft arrangement

To be competitive with cars and buses, the craft will have to offer the following features:

- Passenger seating and facilities that are better than buses offer
- A cargo deck where bicycles, motorcycles, ATVs and baggage can be stored
- A stern ramp capable of loading and unloading motorcycles and ATVs
- A side or bow ramp at least capable of rapid loading and unloading passengers, possibly also cargo.

Machinery

Most of today's high-speed craft are diesel driven, usually in combination with a propeller or a waterjet propulsion system. In the course of time, the diesel engines could be reduced to an emergency system, i.e. a "take me home" system in the event of main engine failure.

On a shorter time-scale, pollution from diesel engines will be greatly reduced. Catalyser concepts are being developed for marine engines, sea-water cooling and exhaust gas scrubbing systems have been developed, as well as noise reduction systems. Passenger transport by high-speed craft will become much more competitive with car or bus transport when new systems like these come into widespread use.

A small-scale LNG distribution system has already been established in Norway. Three important car ferry routes are now being operated by gas-fuelled ferries in Stavanger, Bergen and the Molde district. The reduction in emissions compared to conventional ferry traffic is considerable. In the course of a few years, gas engines will also be developed for high-speed passenger craft, either using technology similar to that in use in the gas-fuelled ferries, or similar to the gas engines used in buses today.

For shorter routes, on which the engines are in continuous operation, the fuel cells that are currently being developed may turn out to be a very good and clean alternative to today's engines.

Materials and building methods

Assuming modern, optimised hull design, the key factor in transport efficiency and emissions is the weight of the craft. Weight saving in every aspect is important, hull structure, engine, superstructure, interior

NGA cat operating in New York. *Courtesy BMT Nigel Gee.*

BrAa cat operating in Stavanger. *Courtesy Br. Aa.*

Oma Catamaran Tedno, Bergen Norway. *Courtesy Oma Baatbyggeri/Tide.*

At harbour (Stavanger). *Courtesy Br. Aa/Rødne AS*

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Today's Offshore Vessels

In the course of the past few years, offshore vessels have become larger, and have incorporated more innovative solutions in terms of operation, dynamic positioning and transit. These developments are largely due to the market for more flexible vessels capable of operating with higher loads under more demanding conditions. There is every reason to believe that the trend will continue in the future.

To cope with future operational requirements, various combinations of moonpool configurations have been developed, together with more flexible crane systems. Innovative propulsion systems are also being introduced. Vessels are becoming more and more flexible, offering short response times in dealing with operations all over the world.

MARINTEK runs a number of commercial research programmes based on developing and verifying solutions for its customers. The comprehensive use of CFD, traditional calm-water testing, numerical seakeeping calculations and seakeeping tests in MARINTEK'S ocean basin in various seastates and conditions enables us to determine the operational limits and behaviour of concepts under a wide range of conditions. Decisions are typically made on the basis of analyses that combine numerical and experimental results. Results include vessel behaviour in waves, speed loss in waves, slamming analysis, wave drift forces and current and wind forces on the hull, as well as thrust reduction in a seaway. Equipment suppliers also use our results in the process of designing and manufacturing deck equipment.

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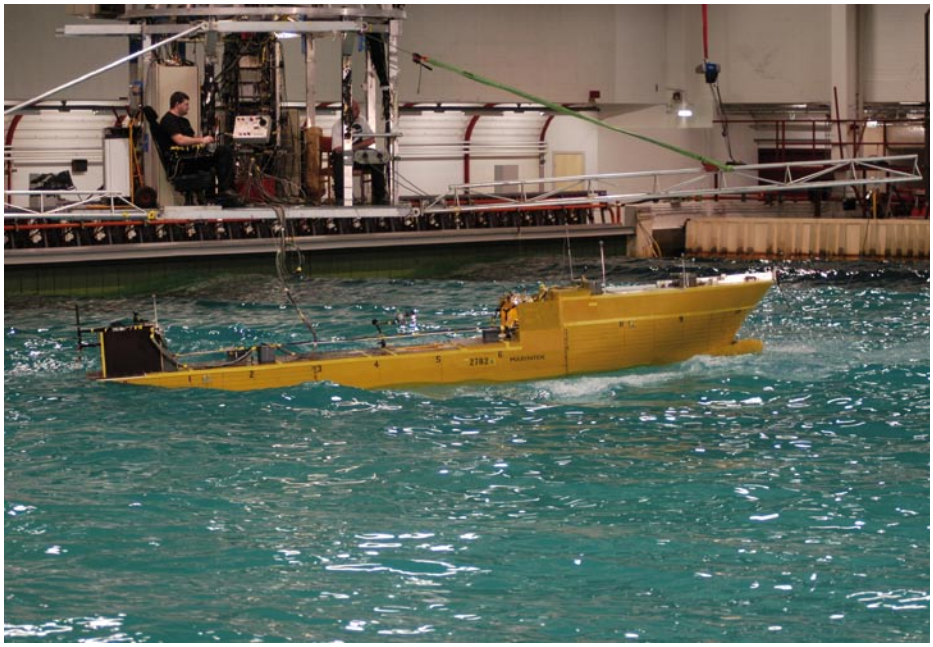

Testing of offshore vessel with forward speed in bow quartering seas in MARINTEK'S ocean basin. The hull-model is completely free in all degrees of freedom. During testing, the gondola follows the model closely with a bundle of cable transferring control and measuring signals.

High Speed Craft …

Cont. from page 4

and equipment weights must be reduced to well below current levels.

New materials and methods have already been adopted in high-speed craft construction. Besides being more cost-effective, the new materials reduce weight and offer better hull stiffness and a longer lifetime. The reduction in emissions is directly proportional to the reduction in weight.

Transport efficiency

The transport efficiency of high speed craft is also dependent on optimum propulsive efficiency and good steering and low-speed manoeuvring characteristics. In Norway, years of development efforts on propeller/hull systems and interaction have resulted in very good overall performance. Waterjet and surface-piercing propeller solutions will be developed in a similar fashion in the near future.

New steering systems such as interceptors, fin–flap systems will replace rudders and water-jet steering nozzles. The gain here is that more of the available thrust is used for forward speed, and less for steering power.

Bow ramp of BrAa cat in operation. Courtesy Br. Aa

In low-speed mode, today's high-speed craft tend to have poor manoeuvring characteristics. This is due to the fact that such craft are not designed to have good crabbing qualities, as the main focus is on the forward speed condition. In order to meet future requirements for low-speed manoeuvring and safe operation in harbour, new solutions such as fin-flap systems, rudders and retractable/swing-up thrusters will be introduced.

Passenger transport by sea is a good alternative to land transport. The "road" is ready-made and has no maintenance costs, and putting clean, efficient craft on it will help to save the environment.

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Interfacing Commercial Dynamic Positioning Systems to Ocean Basin Test System

As part of an ongoing Institutional Strategic project supported by the Research Council of Norway, new tools for studies of complex dynamic positioning (DP) operations have been developed and implemented in the Ocean Basin. The tools are integrated into the new LabBridge system. The overall goal of the system is to provide a standardized interface between commercial control systems and MARINTEK's software/simulators and laboratory instrumentation using NMEA communication.

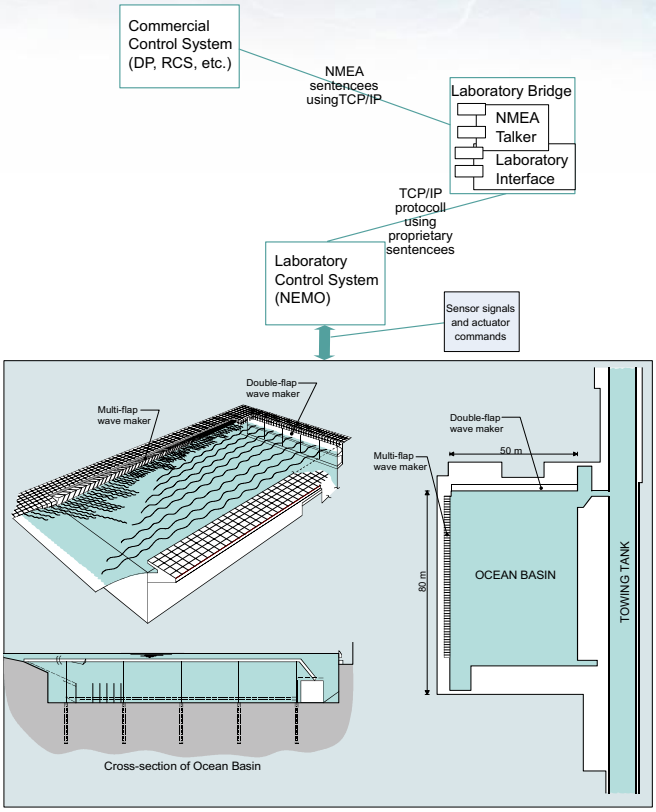

Figure 1. Data flow for new DP test system.

Figure 1 shows the logical flow of data between a commercial control system, LabBridge and the laboratory control and data acquisition system (NEMO). The underlying idea of the LabBridge application is to equalise data between model scale and full scale, and to provide and receive data via a standardized NMEA protocol. It is always assumed that the control system always operates in full-scale, but accelerated in time due to Froude scaling where the time acceleration factor is equal to the square root of the model scale. The time difference between model and full scale is taken care of by a powerful CPU. The NEMO system handles the low-level sensor and actuator communication. It receives set points and commands from LabBridge, and sends sensor feedback to LabBridge. The LabBridge application has been realized using existing software from MARINTEK's vessel simulator and library of associated tools.

An important feature of this system is that the commercial company testing their DP system does not have to disclose proprietary routines and algorithms since the DP system is treated as a black box.

The first application of the system took place in spring 2006. A Teekay Aframax tanker was tested for operations on the Halten Bank field in the Norwegian Sea. The photo (Figure 2) from the test shows the tanker on DP in ballast condition in various combinations of wind, waves and current.

A standard Kongsberg DP system was configured and parameterized as is normally done in full scale. All sensor and measured actuator signals from the laboratory system were fed to the Kongsberg DP system which returned the commanded actuator signals.

Prior to the model tests the DP system was used as a black box together with a MARINTEK vessel simulator for testing and tuning of the DP controller and the signal processing. An important advantage of both these simulations and model tests is the possibility to efficiently study a wide range of wind, wave and current conditions. In addition various failure situations can easily be tested and analysed at low costs.

The Kongsberg experts participating in the model tests appreciated the consistency between the results from the model test and experienced DP system behaviour on-board.

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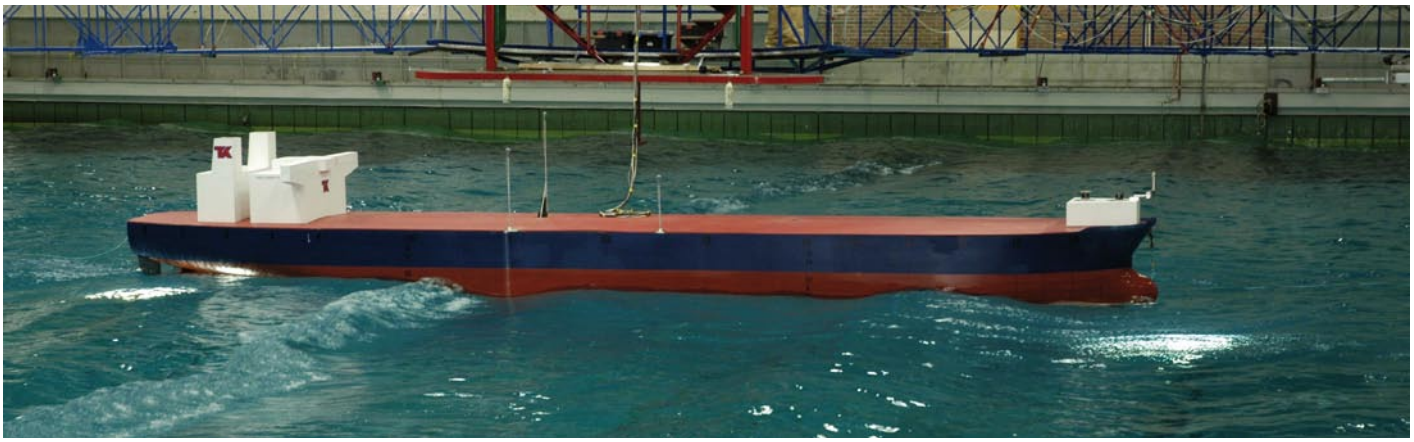

Figure 2. DP testing of new Teekay shuttle tanker.

Powering and Steering of Thrusters and Fluctuations in Their Propeller Blade Loads

MARINTEK has carried out wide-ranging series of model tests with open and ducted thrusters in order to develop a basis for mathematical modelling of the hydrodynamic behaviour of thrusters in design and off-design conditions.

Figure 1. Force measurements on a single propeller blade (grey blade).

"Propeller Forum" is a research programme supported by the Research Council of Norway and Innovation Norway. MARINTEK plays a central role in the Forum. Other participants are DNV and NTNU, in addition to the Norwegian propeller manufacturers Brunvoll, Finnøy, Heimdal, Helseth, Nogva, Rolls-Royce, Scana, Servogear, West Mekan and Wärtsilä.

The operation of propulsion and steering units in extreme off-design conditions introduces new challenges, particularly in connection with complex marine operations. In this regard, novel experiments have been carried out at MARINTEK on different types of thrusters, with emphasis on propeller blade loads and extreme oblique conditions. These experiments have provided large amounts of unique data which will improve our understanding of the physics involved and provide the basis for semi-empirical prediction tools.

A novel propeller blade dynamometer capable of measuring forces and moments in all six degrees of freedom was developed at MARINTEK in close cooperation with NTNU. The instrument is miniaturised, and can be fitted into the propeller boss. In order to avoid electrical noise, a wireless transmission system was developed to transfer the data from the blade dynamometer to the data acquisition system (Figure 1).

Model tests were performed with open and ducted thrusters at different propeller pitch settings (positive and negative) and different headings (propulsor angles). Tests were run at positive and negative advance speeds. Propeller thrust and torque as well as the longitudinal and transverse forces and steering moment of the thrusters were measured (Figure 2). Longitudinal and transverse forces on the duct were also measured in ducted thrusters.

The blade dynamometer supplies measurements of forces and moments on single blades, including valuable data on blade spindle moment (Figure 3) and blade thrust (Figure 4).

These measurements are in many respects unique and have been performed for the first time on such a large scale. The data will help propeller manufacturers to design improved propulsion units which can better meet the challenges of higher loadings and harsher operating conditions. The data are also valid to a certain extent for podded propulsion units, while blade loading measurements are useful input to the whole propeller manufacturing industry. Spindle moment data in particular are invaluable for controllable pitch units.

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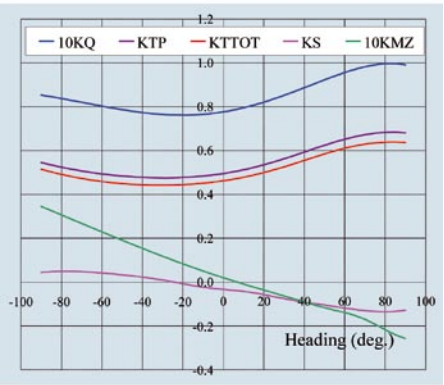


Figure 2. Coefficients of propeller thrust KTP & torque KQ, total thrust KTTOT, thruster side force KS and thruster steering moment KMZ versus heading angle for a pushing thruster.

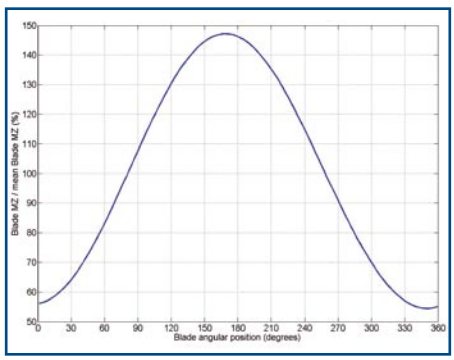


Figure 3. Variations in blade spindle moment during one revolution of propeller of a pulling thruster.

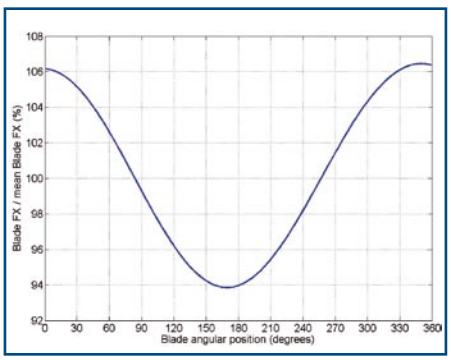
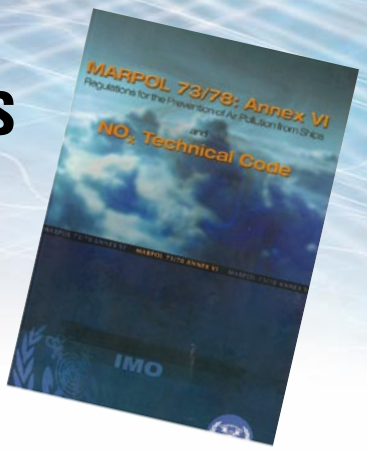


Figure 4. Variations in blade thrust during one revolution of propeller of a pulling thruster.

Reducing Air Emissions from Ships



Marine diesel engines are among the most fuel-efficient combustion engines available, and shipping is more energy-efficient than any alternative means of transportation. However, international shipping is a significant source of atmospheric pollution and is also a source of greenhouse gases, among which CO_2 is the primary source of concern.

The contributions to total global emissions from shipping are roughly indicated within the following ranges:

- CO_2 2-4%
- NOx 10-20%
- SOx 4-8%

Driven by the growth in world trade, emissions from ships are increasing rapidly. The relative contribution from shipping is also increasing since emissions from land-based sources are falling or at least growing at a slower pace. This is illustrated by Figure 1, which shows SOx emissions in European waters compared with land-based emissions.

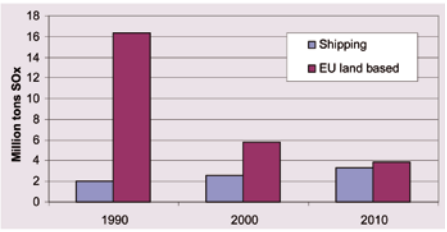


Figure 1. Sulphur emissions in Europe (Source: EU Commission)

Similar trends can be observed for NOx and particulate matter (PM). Prognoses suggest that unless action is taken, emissions from international shipping in Europe will exceed those of all EU land-based sources by 2020.

This development puts pressure on the shipping industry to reduce emissions. New technology is needed to meet these demands. Generally speaking, new legislation tends to be needed to implement new technology. In many cases legislation is also needed to develop new technology; however legislators need to know that targets set out in directives, rules and conventions are achievable, enforceable and cost-effective.

MARINTEK works with industry to test and develop emission reduction technology and with legislators to develop regulations. This unique position makes MARINTEK an important contributor to rulemaking processes.

Reduction of emissions to the atmosphere from ships will require significant development in terms of:

- Better engines
- Cleaner fuels
- Exhaust gas cleaning
- Increased energy efficiency

Better engines

Compared to its land-based counterparts, emission legislation for ship engines has not been very demanding. This is about to change, as the IMO is currently revising its regulations for the prevention of Air Pollution from Ships. MARINTEK is heavily involved in this process, drawing on decades of experience of emissions measurements and engine upgrading.

Cleaner fuels

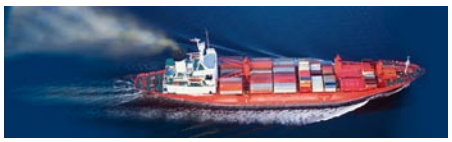
Energy forecasts indicate that fossil fuels will continue to be the dominant source of energy for the next 30 years. This will probably also be the case for shipping. However, fossil fuels utilised in ships need to be cleaner than the residual fuels in use today. One obvious candidate is natural gas, a technology that MARINTEK has been developing and promoting for several years.

Exhaust gas cleaning

Technology exists for reducing NOx and SOx from ship diesel exhaust gas. This includes Selective Catalytic Reduction (SCR) for NOx, and open- and closed-loop scrubbing for SOx. Analysis and performance measurements have shown that emission reduction can be very good, but that certain prerequisites must be satisfied to achieve these reduction levels. Legislators must be aware of these limitations when tailoring regulations. Other technologies which have been tested by MARINTEK include intake air humidification (HAM), water injection, water emulsification and steam injection.

In-field measurement of exhaust gas SCR cleaning efficiency.

Increased energy efficiency



Increased energy efficiency will reduce emissions to the atmosphere from vessels. To achieve more efficient operation, MARINTEK is working not only on improving the efficiency of hull and propeller design, but also on ship operation. This includes human-factor issues, knowledge management, training, and culture-building on one hand, and technology decision support, energy management and direct energy-saving measures on the other.

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This article is an excerpt of paper presented at 25th CIMAC World Congress, May 2007.

Emissions of Particulate Matter from Ships

Particulate matter (PM) is known to be extremely harmful to human health. Special concerns are related to cardiopulmonary disease, respiratory symptoms and poor lung function.

PM emissions from ships are closely related to fuel sulphur content, and the strong drive to reduce sulphur emissions from ships in ports in both the EU and the USA is primarily due to a desire to reduce emissions of particulate matter in these areas, not SOx.

PM emissions from ships are not regulated at present. An important reason for this is the complexity of measuring such emissions, and also of achieving reductions with the marine fuels in current use. While reducing sulphur content may provide significant reductions in PM, this is unlikely to be sufficient on its own. More research is needed to develop the technology and design the legislation necessary to reduce PM emissions.

LNG as Fuel for Ships in Short Sea Shipping

Cleaner fuels are an important instrument for reducing emissions from ships. Natural gas is the cleanest fossil fuel available, and it enables a combustion process resulting in very low NOx emission. The main challenge is to find sufficient space for storing the natural gas. LNG offers the highest energy density, however, it leads to reduced operating range and makes LNG first of all an environmentally friendly alternative fuel for ships in short sea operation.

LNG as fuel

LNG contains virtually no sulphur, hence SOx emissions from natural gas engines are neglectable. The LNG burns very cleanly and results in very little particle emissions. LNG contains more hydrogen and less carbon than diesel fuels, hence CO2 emissions are reduced. Unfortunately, increased emissions of methane (CH4) reduce the net effect to about 15% reduction of CO2 equivalents. Typical emission values from a lean burn gas engine is shown in Figure 1.

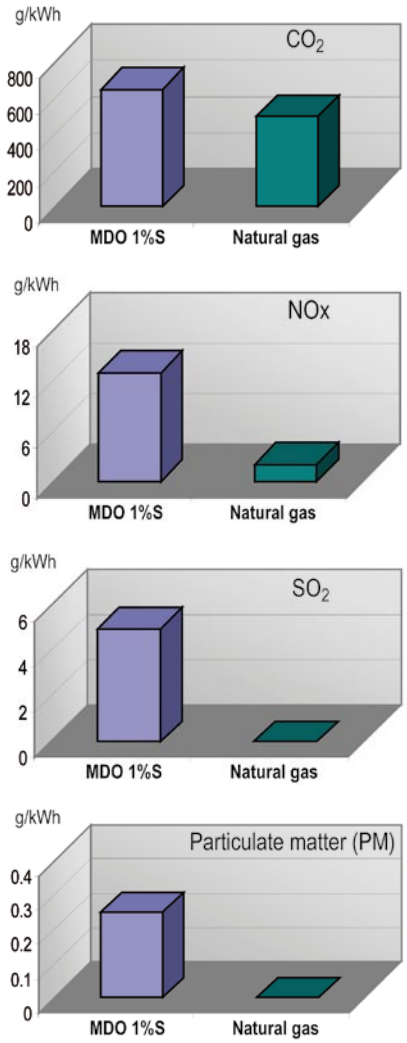

Figure 1. Comparison of emissions with operation on natural gas and MDO.

Figure 3. RoRo concept with LNG as fuel.

Marine gas engines

Marine gas engines burn a lean (A/F ~ 2.2) premixed charge which is ignited either by a spark plug (lean burn gas engine) a micro pilot diesel flame (micro pilot dual fuel engine).

To optimise gas fuelled ships for low fuel consumption mechanical drive is a necessity. Both the micro pilot dual fuel and the lean burn gas engine concepts can be operated at variable speed and mechanical drive, however the engines have to be developed or adapted for this type of operation.

Figure 2 shows specific fuel consumption for the same gas engine at constant and variable speed (propeller load). For constant speed the power is after generator and for variable speed at the shaft. The data is based on tests performed on a Rolls-Royce lean burn gas engine.

Note the difference in the specific fuel consumption characteristics compared to the diesel process. For a lean burn gas engine the lowest fuel consumption will be at highest load.

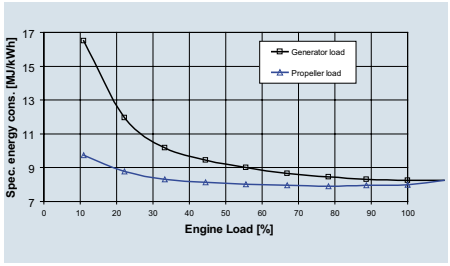

Figure 2. Specific fuel consumption for a lean burn gas engine.

R&D program for gas fuelled ships

Together with Norwegian ship operators (Seatrans and Color Line) MARINTEK is in charge of a research project, BigLNG, which is developing LNG propulsion concepts for two types of ships, freight ship (RoRo) and passenger ferries (RoPax). The purpose of the project is to develop the concepts and consider commercial viability. If the designs are found to be economically non-viable, the project aims to identify what developments should be necessary to achieve commercial viability.

The operation routes considered is fixed transport route in the Baltic Sea (RoRo) and ferries between Norway and Denmark.

Gas engine concepts considered are both lean burn and micro pilot dual fuel gas engines. For the RoRo concept there is an option for pure gas operation. In the case of the RoPax concept the power demand will be too large for existing pure gas engines, leaving dual fuel as the only option.
One of the main challenges for these concepts is to find sufficient space for the LNG storage. So far vacuum isolated pressure storage LNG tanks have been the chosen solution, based on two main arguments:

1. Pressurised LNG storage tanks allow the LNG to be supplied to the engines at correct pressure (typically 5 bars) without pumps. Since there are no moving parts the fuel supply has high reliability. The pressurised tank also has the ability to accumulate boil off gas by accepting pressure build up.
2. The outer shell acts as a secondary barrier in the case of leakage of LNG. The barrier also provides safety regarding external loads, collision and heat from external fire.

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VISIONS - a European Maritime "Think Tank" for greater Innovation

The spring of 2005 saw the establishment of European maritime collaboration in the form of a non-commercial network of European shipbuilding industries, maritime universities and leading research institutes. The network organises annual creative process meetings at which visionary ideas and concepts for vessels and floating structures are developed and validated. Taking market and society scenarios for the coming five to fifteen years as its point of departure, VISIONS is a "think-tank" for product ideas which could become reality in the medium to long term.

Will we see radically new transport solutions in the future?

Idea contest

MARINTEK is leading efforts to develop scenarios that describe market and society requirements in five market segments; intermodal transport in deep sea shipping, short-sea shipping, inland waterways, cruise traffic and large floating structures.

The scenarios are being used as a starting point for an annual contest for students at European universities. In October 2006, the winners of the first contest received their awards during the opening session of the Maritime Industry Forum in Oslo in the presence of more than 300 delegates. A second round is under way, and the market scenarios for a third round will be developed in 2007.

Scenario planning

Scenario planning complements more traditional forecasting efforts by challenging their underlying assumptions. By developing and exploring scenarios we are seeking out trends, events or driving forces capable of leading to a future radically different from the current situation. In this way, we are able to adopt a pro-active role by asking questions such as "what would we do if such and such happens?", rather than leaning back and asking questions such as "what will happen to us?"

Scenarios are defined as structurally different stories about how the future might develop. Scenarios may be interpreted as alternative images of the future, each with a corresponding story-line describing how the scenario emerges in a cause-effect way from the situation today. Unlike traditional forecasting techniques based on historical data, scenarios acknowledge that the future is uncertain and that it is impossible to predict it. By developing scenarios, companies aim to treat uncertainty in a structured way in order to improve their understanding of the forces and mechanisms that drive changes in the business environment.

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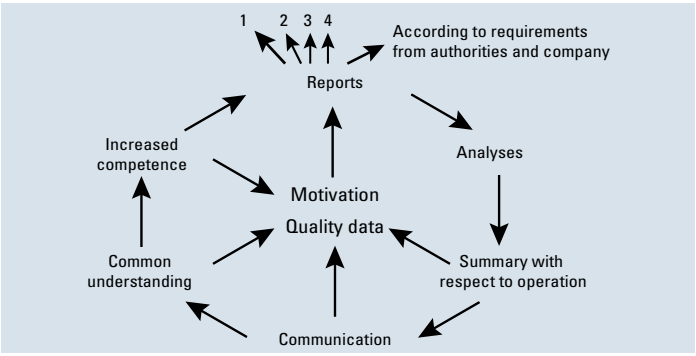
Ship-to-Shore Reporting and Feedback

This project is a co-operative venture between shipowners Odfjell and the Grieg Shipping Group. The project is based on the assumption that safer, more environmentally friendly, more efficient and cost-effective operation of ships can be obtained through a company-specific environmental and technical reporting system. Furthermore, it is assumed that emphasising understanding of how the data collected are used will increase quality and the motivation to report. It is also assumed that the results of the analyses can be used more directly in on-board operations.



Elements of a continuous improvement process.

The project will emphasize feedback, communication and openness as a means of improving understanding of other organizational units in the company, on board and ashore.

The main objective of the project is to increase the value of the reported technical and environmental data for both the crew and the shore offices of the shipping company. This will require better knowledge of reporting requirements and practices. The project will utilise the following methods and tools:

- Map the working day of the ship's officers, focusing on the extensive reporting and documentation requirements involved
- Improve on-board practices in the area

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Fleet Management and Vessel Performance Analysis of large LNG Logistics Operations - Scheduling and Optimization

MARINTEK is developing a new version of the decision-support system, TurboRouter, for scheduling and optimization of one of the largest LNG distribution operations in the world. Our clients are two leading LNG producers who will supply LNG to the global market through a fleet of nearly 80 large LNG vessels. Their supply chain is based on an extremely tight shipping operation which requires close process integration of several departments and external parties. Our clients maintain full commercial and operational control over most of the vessels and keep a very tight follow-up of technical management.

The key elements of the project are:

- Mapping existing operations
- Planning for scalability
- Software implementation
- Optimizing the utilization of vessels and trading patterns
- Production of annual production plans
- Operational optimization.

Due to the untraditional lay-out of their export facilities, with limited storage facilities, scheduling and optimizing of the shipping operation have become very critical elements both of long-term planning and of the operational mode. TurboRouter has therefore become the operation's central DSS - as is reflected in production capacity planning, hydrocarbon accounting and in the berthing and harbour control system, with which TurboRouter has been closely integrated.

View of a multi-train LNG plant.

With close integration with MARINTEK's own Sopran software, a vessel performance system and a third party fleet management system, we have delivered a unique operational tool for the world's largest gas fleet.

The project will be finalised and the systems implemented in 2007. A new business process model has been partly completed and a number of improvement areas have already been identified.

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Ship-to-Shore Reporting …

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of ship-to-shore reporting.

- Reduce amount of reporting forms to a reasonable number.
- Increase quality of reported data through goal-oriented training.
- Improve feedback from shore to ship about reported data.
- Improve the technical, financial and environmental operation of the fleet.

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LNG as Fuel for Ships …

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The negative aspect of this storage system is the need of space onboard the ship. At the same energy content, LNG has a volume 1.8 larger than diesel oil. However, the bulky pressure storage tank consumes space and the actual volume requirement is in the range three times that of diesel oil. Figure 3 Illustrates one solution for the LNG storage on a RoRo ship.

Shipping will face stricter limits for emissions especially in short sea operation. Cleaner fuels will be necessary to meet these restrictions. Natural gas will solve all the requirements regarding reduction of harmful emissions and is the best candidate to make genuine environmentally friendly shipping.

Analysis shows a great potential for LNG fuelled ships to be economical viable in the near future, and LNG as fuel for short sea shipping will be reality within 5 – 10 years.

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Key Performance Indicators in Shipping

- Establishing an international standard for measuring performance in ship operation

The shipping industry is subject to changes in requirements and expectations from the public, employees, customers, governments and other stakeholders. There is a drive towards more visibility and transparency in operations. "Everyone" requires access to information that previously was regarded as being non-public.

Shipping is too often in focus for the wrong reasons (accidents, pollution, substandard personnel practices, etc.), and is not given due credit for the important role it plays as the backbone of the world's transport infrastructure. Interaction and communication with the whole range of stakeholders need to be improved.

Intermanager and a group of 20 leading shipping companies realise that pro-activity is essential to meet these challenges and engaged MARINTEK as main research partner in a project with the objective of establishing an international standard for measuring performance in ship operation. The project is partly funded by the Research Council of Norway.

Current situation

Analysis of current practice regarding performance reporting confirms that there is little standardisation. Different stakeholders have KPIs with the same name, but with different definitions and metrics. Other KPIs are identical with respect to definitions and metrics, but with different names. This situation naturally opens up for confusions and comparison of performance between companies is difficult.

The analysis has also identified eight different focus areas for KPIs used today. These are; Technical, Environmental, Crew management, Crew safety, Cargo, Reputation, Statutory requirements and Financial. However, more areas of focus are likely to be developed.

New reporting requirements are emerging, especially regarding environmental issues and Corporate Social Responsibility (CSR). Society requires transparent documentation of the ecological footprint of a company's operation and whether it focuses on sustainable development.

Increased transparency

The most important areas in which transparency is required are quality, safety and environmental performance.
The project aims to develop a framework for measuring and reporting operational performance. The framework will consist of unambiguous KPI definitions and metrics in a hierarchical structure. Measurable indicators will be aggregated to a level that is meaningful for stakeholders without a technical/maritime background.

Increased transparency in shipping.

Enhanced governance

An industry standard for performance reporting could facilitate performance improvement processes like benchmarking, and contribute to the further development and standardization of "best practice". Being proactive and developing a reporting framework means that the industry itself sets the course and will better be able to influence the requirements that will come from the regulatory institutions. The European Commission's European Maritime Policy Green Paper from 2006 states; "The adoption of CSR strategies and the disclosure of performance in relation to announced goals represent an alternative to regulation."

Standard quality reporting to different stakeholders.

Future regulatory developments

The Shipping KPI initiative will contribute to improving the effectiveness of the ISM Code, and other process oriented quality standards, and support a new regulatory regime of setting minimum operational standards.

The final deliverable of the project is expected to be a "Shipping KPI Report Card". The report card will comprise five to ten Shipping Performance Indexes. Each index will summarise/aggregate KPI information in order to meet performance-reporting requirements from the main shipping industry stakeholders.

Sharper focus on environmental issues in shipping

There is an increasing focus on environmental issues, and this is also an important part of the project. At the time being, the project has identified three environmental KPIs;

- Operational emissions
  - Any emissions resulting from normal ship operation
- Incident-related spills
  - Any kind of spill resulting from incidents/accidents (bunker, lube oil, hydraulic oil, chemicals, solids, gas/-vapour)
- Ballast water handling
  - Handling of ballast water before, during and after the voyage, in accordance with local regulations.

Each of these has a set of underlying indicators with unambiguous measurable definitions, which in a close cooperation with customers and other customers will set the standard for performance reporting in the future.

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