

DMINNEWS

2007



ENERGY AND EMISSIONS

Industrial Processes

Danish Centre for Maritime Technology

Hydro- and Aerodynamics

Simulation and IT

Training, Ports and Human Factors

Energy and Emissions

By Stig Sand, Vice President

In this edition of DMI News we have chosen to illustrate our considerable engagement in the energy industry and our highly relevant services pertaining to reduction of amongst other CO₂, NO_x, and SO_x. The reasons for choosing these themes are several.

First of all, we wish to illustrate to potential customers in the energy market that our services are on the cutting edge, addressing international top priorities, being constantly developed and under one roof with a view to one-stop-shopping.

Secondly, we wish to show that our services are placed in the context of a coherent national knowledge infrastructure founded on Denmark's strong global position as regards energy and emissions.

A recent indication of the latter is the decision that Denmark will host the UN climate summit in 2009. The goal of the summit is to reach a new global agreement on CO₂ reductions after 2012, when the Kyoto Protocol expires. Denmark enjoys international recognition because we have succeeded in decoupling economic growth and energy consumption. In addition, we have rather ambitious commitments with regard to reduction of emissions. Finally, wind energy and energy efficiency are well known strongholds of Denmark.

FORCE Technology is placed in the infrastructure of a Danish energy industry which has tripled its export during the last 10 years. Since 1999 the growth rate has been more than doubled that of the gross national export of goods. The global demand for

the actual figure proves to be just in the vicinity of this, investments will be astronomical and the demands will grow exponentially. We expect that our broad spectrum of advanced services and our position in the strong Danish energy industry will be seen as attractive assets by the global customer. In line with these considerations, we have now established ourselves in Beijing, China, as well.

Increasing international attention is being paid to CO₂ emissions, SO_x, and NO_x from ships. These issues are also addressed in this news magazine. We have shown that FORCE Technology is prepared for the challenge through development and application of specialized knowledge transferred from other domains to the maritime. This cross fertilization rests on our vast experience from five decades in the maritime business and the considerable experience from serving the (land based) industry as mentioned above.

Stig Sand



efficient and environment friendly energy technology is increasing – hence our emphasis in this news magazine on the issues energy and emissions.

The UN panel of experts, IPCC, has stated that 3% of the global GNP should be allocated to reduction of green house gasses (GHG). If

As usual, we also report on topics outside the themes above and on new exiting achievements obtained in close cooperation with or inspired by our customers. I hope you will enjoy the reading.. ■

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PROFILE: Industrial Processes

The department provides consultancy services relating to design and optimisation of industrial processes, and has clients in almost all parts of the industry such as the power industry, the process industry, the food and pharmaceutical industry, and the general manufacturing industry. The department is dedicated to providing optimum solutions to all clients and to add measurable values to the clients' various processes.

Examples of our services are:

- improved process capacity
- minimum consumption of energy and other resources
- stable and optimum process and product quality
- minimum environmental loads

Working closely together with the clients' activities can be focused at several types of processes.

Examples are:

- logistical processes
- chemical and combustion process
- thermo-dynamical processes
- fluid flow processes

Depending on the specific challenges of the specific problem of the client, the department for industrial processes can utilise a wide range of competences and technologies, such as:

- design of model-based control and monitoring systems
- fluid and thermo-dynamical analysis of process equipment using CFD and experiments
- CFD analysis and optimisation of biomass and waste-fired furnaces
- design and fluid dynamical optimisation of flue-gas cleaning equipment
- consultancy on optimum thermal conversion of fuels
- evaluation of manufacturing logistics
- robot design, programming and testing

PROFILE OF:

Carsten Hein Westergaard

M.Sc.Eng., Ph.D.
Sales manager



Carsten joined FORCE Technology in 2006 as Sales Manager for industrial processes. He holds a Ph.D. in theoretical turbulence and optical measurements and has almost 15 years of broad industrial background. His industrial experiences span from oil industry, wind turbines manufacturing to development of high tech optics, lasers and image processing for fluid mechanical research at university level.

Training Simulator Optimising Waste Operation Plant

By Gitte Videcrantz, Project Manager, Industrial Processes

At waste incineration plants the final responsibility for the economy and efficiency is with fewer and fewer people as the competition is growing. An increasingly important area is the access to well-educated operators with the ability to run the plant efficient and safe for the benefit of economy and environment.

Through education and ongoing training by the use of training simulators the operators are given a strengthened basis to overview, understand and analyze the immediate operating situation and ensure an optimal operation, prevent malfunction and avoid accidents by proper action. Furthermore, extreme and infrequent operation situations can be trained in a simulator without any risk for people, plant, environment or economy.

The PC based training simulator gives an understanding of how the incineration of waste takes place and how different types of waste and the variations of composition

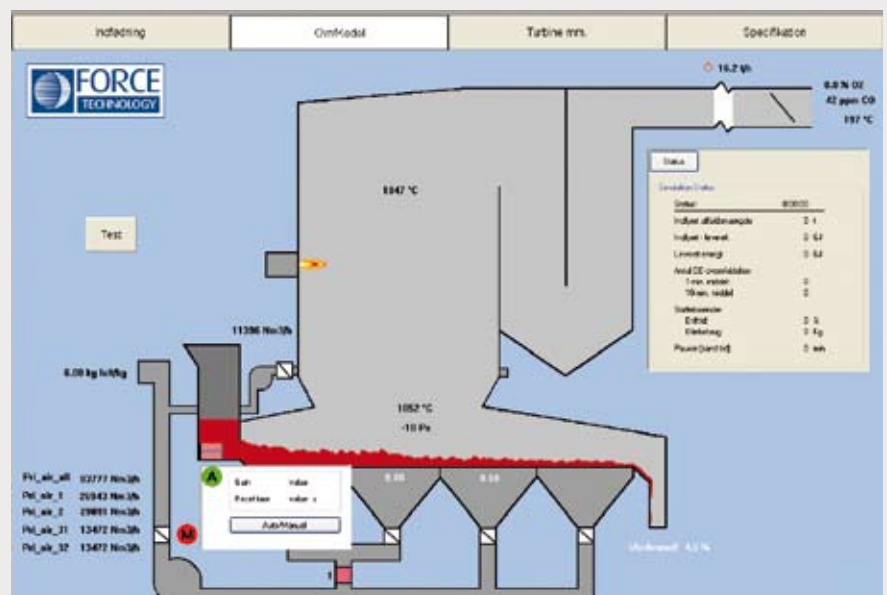
influence the combustion conditions. The simulator features a realistic model of the waste feeding, which focus on the impact on the combustion caused by disturbances from the feeding system.

FORCE Technology's waste incineration simulator consists of:

- realistic model of the feeding system
- general dynamic combustion model based on mass and energy balances
- control system
- reporting system
- boiler model illustrating the steam production's dependence of the combustion process

Training simulators are an efficient and educational tool for teaching in the correlation and dynamic in complicated technical systems like waste incineration plants.

By the use of training simulators an interactive, varied, inspiring and engaging training can be implemented by the educator. ■



In FORCE Technology's training simulator the condition of the process is shown at schematic process displays – here the air supply system, the oven, and the secondary combustion chamber.

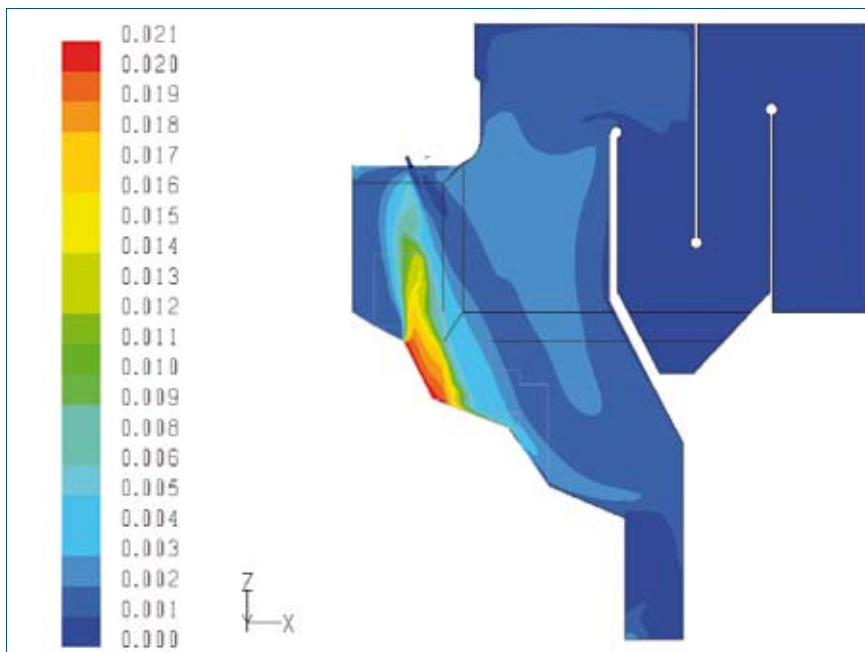
Detailed CFD Simulation of CO in Combustion Processes

By Carsten Hein Westergaard, Sales Manager, Industrial Processes

FORCE Technology has made important progress in detailed mapping of the CO concentration in combustion processes with Computational Fluid Dynamics (CFD). With the new in-house developed model it was possible to accurately predict the CO levels in a full-scale waste-to-energy combustion plant.

The new calculation method, developed by FORCE Technology was applied and met the need of the client to certify their waste-to-energy plant against new cleaner environmental standards. The technical requirements for these new standards are to elevate the temperature to 850°C (or higher) of the entire flue gas during two seconds, after the last stage of injection of combustion air. The operating condition for the plant and the temperature elevation has to be the point of being mostly unfavorable.

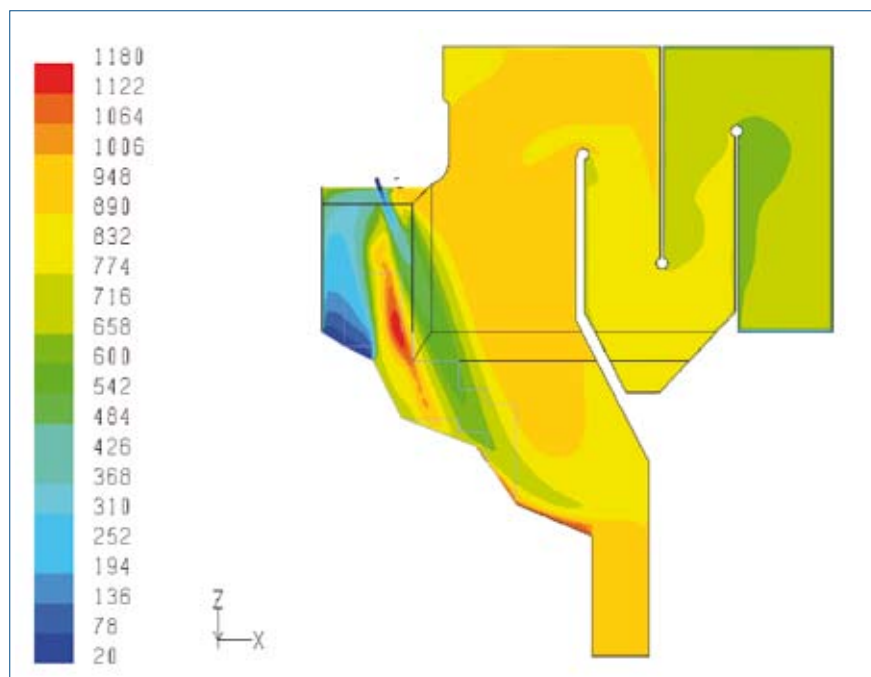
To perform such test on a full scale plant and document the achievements to details would require extended periods of measurement campaign, including complete shutdowns. Needless to say this is quite costly. Therefore, the client was looking



Temperature distribution inside the waste-to-energy plant degree-C.

for alternative solutions. The client asked FORCE Technology to support them with flow calculations, temperature distributi-

ons and CO level predictions which could be used to certify the plant with the Danish Environmental Protection Agency (EPA).



Concentration of CO computed with FORCE Technology's improved CO model.

FORCE Technology applied our improved method for CO into our CFD program, and computed the flow, the temperatures, and the CO levels inside the furnace. This gave detailed information on the conditions in the furnace and how the combustion process progressed. With this information a new position for temperature monitoring could be identified while ensuring an optimal monitoring of the entire plant. Comparing the measurements with the computations, the final result was satisfactory to the EPA, and the client saved a costly measurement campaign.

The excellent agreement between the measurements and the computations for the CO levels in the flue gas was quite satisfactory and the key to success in this project. Further, it could be elaborated that the successful prediction of the CO levels is also a key parameter in optimizing and understanding the combustion process locally inside the furnace; something on which there is an increased focus these years, both in legislation and in research ■

Technology and Market Support in the Wood Pellet Market

By Jonas Dahl, Project Manager, Industrial Processes

The use of wood pellets as a renewable fuel has gained increasing interest in Denmark as well as the rest of Europe. The consumption of wood pellets in Europe is escalating with an increasing speed every year. As a result, the demand for pellets is so high that local production of pellets is no longer keeping up with the demand and has to start relying on import from other countries. Accordingly, wood pellets have increasingly become important merchandise in international trading. Countries like Russia and even USA with high abundance of wood and wood waste, not yet using the resources themselves, are given the opportunity of exporting these resources.

FORCE Technology provides potential investors in this business with consulting services with respect to market intelligence, such as information on prices and quality demands of pellets. Further, we carry out full feasibility studies of starting new productions anywhere in the world for exporting pellets to Denmark and the European market.

Detailed insight providing unique data

As an example of our activities within this area, FORCE Technology conducted a market survey for a North American customer reviewing the European wood pellet market with respect to current prices, qualities, consumptions and also contacts to potential customers. Thereby the customer got a detailed insight in the European pellet market and unique data, enabling him to make thorough decisions on future investments for his business. By participating in several EC-projects (www.pelletcentre.info) and international conferences, FORCE Technology has a unique network and access to independent data about the pellet market – data which is otherwise hard to receive.

One step further with detailed feasibility studies

In other cases FORCE Technology has gone one step further and combined our knowledge of the market with our knowledge of necessary technology and conducted detailed feasibility studies of the erection of pellet production plants. These studies have mainly been done for Russian customers and in close cooperation with our office in St. Petersburg. An example of

such investigation is the feasibility study of erecting a pellet plant in the Zaostrovye, Lomonosovsky district in Russia. The customer was a local investor with contacts in the Russian wood processing industry and in need for assistance in evaluating the technical and economical feasibility of erecting a pellet plant.

The feasibility study showed that a plant producing about 30,000 tonnes of pellets/year (4 tonnes/h) would require a total investment cost of about 1.5 mio. € (except work on buildings transport and custom clearance for machinery). At the pellet prices of 2005 this would result in a pay-back time of the investment within 3 years.

Documentations and suggestions

In addition to full economical and technical description of the pellet plant, the customers were also provided with a list of potential customers for his pellets and documentation for tenders for the equipment of the plant. We also provided the customer with suggestions on how to organise the work and logistics at the plant in order to be able to produce high quality pellets fulfilling the market requirement. ■



From waste wood to high value bio fuels.

Measurements of Particle Emissions from DONG Energy's Main Power Plants

By Lars Peter Johansen, Product Manager, Industrial Processes

The majority of Denmark's electrical supply comes from the DONG Energy power plants which also deliver the majority of the district heating for private housing and companies. The energy comes from coal, gas, wood, straw, and heavy fuel oil, either in a pure form or as combined fuel product, typical: coal/straw, fuel oil/wood and wood/straw combinations.

The total emission of particles SO₂ and NO_x from boilers larger than 50MW is subject to regulation according to the Danish Environmental Agency regulation No. 808. Throughout the last 10 to 15 years research and larger investigations of various population groups have shown a very high correlation between particle emissions and typical diseases when it comes to the finer sizes of particles. As a consequence of these studies it is expected that particle emission standards in the future will focus on the smaller sizes. These particles which are of the order 0.1 micrometer are only produced in combustion processes. In nature they can be forest fires or volcanic eruptions. From human made pollution these particles are produced by power plants, industry and combustion engines. The latter source is found throughout the transport sector, among these the maritime industry.

Normally it is the total particle emission which is measured for regulatory purposes, but recently Bo Sander from DONG Energy asked FORCE Technology to perform a full analysis through onsite measurements with an impact cascade analyzer. 7 sites were analyzed and the particle emission was divided into sized groups in order to relate these to the fuels used at the particular site.

FORCE Technology performed the onsite measurement and made the full analysis of the particles. The measurement and analysis are relevant for many other industrial and maritime processes. ■



Smoke or particle emissions during harbour manoeuvre.



Manual measurements of particulate emissions are often carried out in stacks/chimneys, with limited space to handle the needed 2-4m long probes.

FORCE Technology Aids the Green Olympics

By Stig Arve Jepsen, Product Manager, Industrial Processes

The Chinese environmental engineering company Tsinghua Tongfang selected FORCE Technology to perform calculations and measurements optimizing performance of a NO_x-removal unit on a Beijing power plant. This task was solved using CFD and scale flow modelling, combining the latest computer technology with 18 years of experience to supply drawings that the client utilized to meet legislation requirements.

The Beijing 2008 Olympic Games are denominated as the Green Olympics. One method to meet this aim of being the "Green" Olympics is to decrease smog around the capital city by reducing NO_x emission from coal fired power plants. Coal is the preferred energy source in China due to vast local resources. It is therefore cost efficient to build new power plants and modernize existing plants. This results in China's power sector allegedly being the fastest growing industry in the World.

NO_x cleaning process

Using Selective Catalytic Reduction (SCR) technology the power plants typically cut 80-90% of the NO_x emission. The basics of an SCR unit are to add ammonia injection/mixing and a reactor with DeNO_x catalyst to the flue gas ducts between the economiser and the air preheater. The key success criteria for this process is to achieve good flow and ammonia distribution, low pressure drop and insignificant ash deposition, which is done by using flow modelling in the design of an SCR unit.



Full scale SCR unit constructed at power plant.

The Shijingshan power plant is located in the north western suburbs of Beijing, hereby supplying power and heat for the Olympic City and adding to local air pollution. The engineering company Tsinghua Tongfang Environment Co., Ltd. is supplying SCR units for the 4 x 200 MW boiler units. They selected FORCE Technology as flow model supplier to complete this job in May 2007.

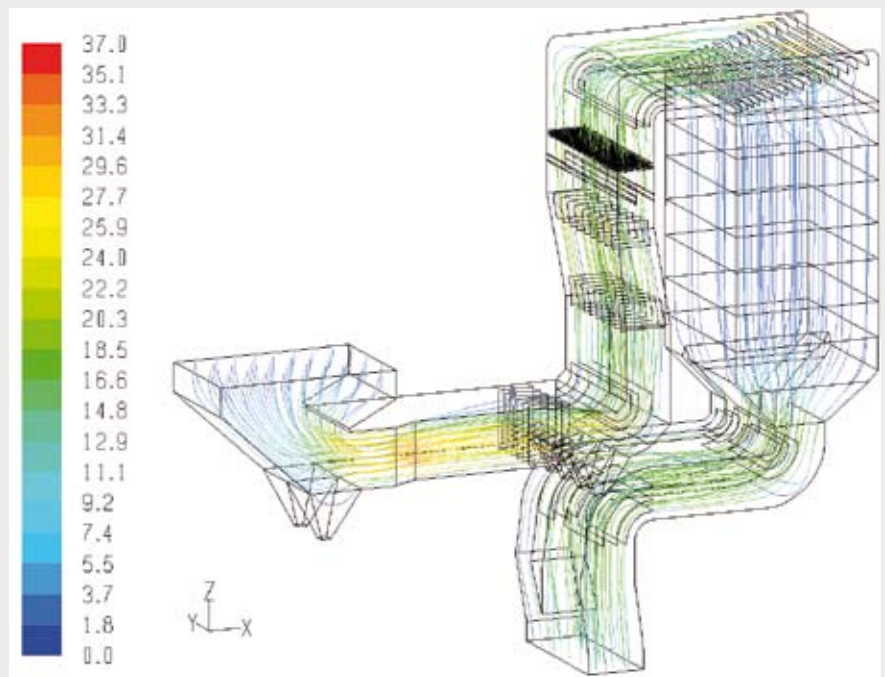
FORCE responsibility

The scope of work comprised both Computational Fluid Dynamics (CFD) and a physical scale model to modify and optimize the SCR design. The flue gas ducts and reactor from the economizer outlet to the air pre-heater inlet were built as a 3-dimensional mesh to be calculated in Fluent CFD application. Required flow conditioning devices and duct modifications were designed and calculated through many iterations leading to a solution that met the required criteria in the best possible way.

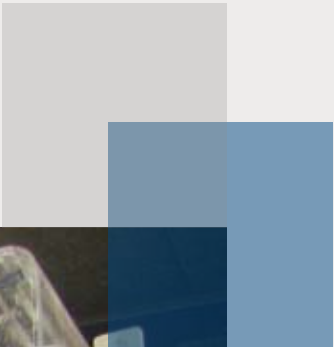
Simultaneously the scale model was built and commissioned in FORCE Technology's own workshop. The static mixer was manufactured in the Rapid Prototype Technology 3-D printer. The use of the in-house 3-D printer technology allows details as small as 16 micrometers to be included, emulating typical full-scale details down to 1/4th millimetre (1/100 inch) where required.

All results from CFD were used in the scale model so that the results from both modelling methods could be compared for verification. Modifications were optimized using a combination of CFD and scale modelling to ensure efficient task solving. Using 18 years of flow modelling experience of SCR units this project was submitted to the client with results meeting the requirements and according to the time schedule.

Tsinghua Tongfang Environment Co., Ltd. is currently completing the construction of these SCR units to be in operation before the summer of 2008. ■



Pathline plot from CFD showing general flue gas velocity through system.



Scale flow model, dimensions 1.8 x 4.2 x 4.6 meters, excluding adjacent equipment.

About Tsinghua Tongfang Environment Co., Ltd.:

This Beijing company with 250 employees has a leading position in the environmental protection field in China. Besides NOx removal their main businesses include solid waste integrated treatment, flue gas dust purification, flue gas desulphurization and coal ash integrated reuse. The major share holder is Tongfang Co., Ltd. that is listed on the Shanghai Stock Exchange.

Fuel Savings and Environmental Impact on a Container Ship

By Carsten Hein Westergaard, Sales Manager, Industrial Processes

More focus on environmental impact and reduction of greenhouse gasses require higher performance. Every detail counts in finding improvements that move towards those goals; but who would believe there are significant improvements to be found in the micrometer sized surface features of marine anti-fouling coating covering the surface of a 300 meter long ocean going container ship?

Hempel A/S recently asked FORCE Technology to find the economical and environmental impact of their newest Hempasil silicone

hydraulic smooth plates showed that the performance of the rig could hold measurement errors as small as 0.3% at 15 knot's speed. In addition to the excellent result, the design of the test was such that the hydraulic smooth plates compared well with classical theory found in textbooks.

Hempel A/S specially manufactured plates emulating a ship surface in three different conditions corresponding: a new build surface and two different levels of rough surfaces emulating different levels of corrosion due to time in service. Each of these types was coated with either the new

2% and 11%, which adds up to over \$2 million per year for a large vessel. In terms of environmental impact this amounts to the equivalent of the emission from 5000 family cars per year.

All the results were consistent to the benefit of the new coating type, which has a smooth and wet appearance in water, similar to that found in nature. Can we possibly conclude that future ships will eventually sail in the sea with skin as smooth as dolphins, saving the environment of hundreds of thousands of tonnes of fuel annually? ■



The testing rig was developed with particular focus on simple but high mechanical accuracy and the capacity to test many panels with different types of fouling control coatings.



A few panels ready to be tested. The panels were ordinary metal plates prepared with undercoatings emulating real life surfaces before being coated.

based anti-fouling coating and to compare it to the performance of a conventional self polishing surface coating (SPC). The test had to be realistic, it had to be easy to compare multiple types of coatings applied in multiple types of conditions, and most importantly - the results should be comparable to a full-scale ship performance in a realistic way. Not an easy task taking into consideration that the expectations were to identify and document force differences of the order 1%.

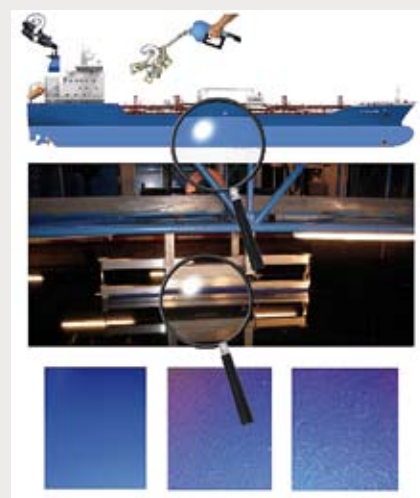
Accurate test rig

To solve the task, FORCE Technology engineered a dedicated test rig to be attached onto our towing carriage in our 220 meter long towing tank. The rig was to carry specially designed test plates emulating ship surfaces. Initial tests with uncoated

Hempasil or the conventional SPC coating. With confidence from the preliminary testing, differences from 1% to 5% could be found consistently between the two coating types depending on the emulated surface condition.

Impact on real ships

Applying know-how within hydrodynamics and turbulence, the results were finally transferred to full-scale performance through computations of the performance of various ship types, including realistic shapes, wave resistance, and the skin friction originating from the difference in surface texture and coating. The power reductions, fuel savings, and reduction of environmental impact were computed, presenting realistic expectation to real performance improvement. The results showed fuel saving between



Enlargement of three different types under coatings emulating different types of realistic surface conditions to be compared.

Investigation of the Layout of a Resistor Exhaust System

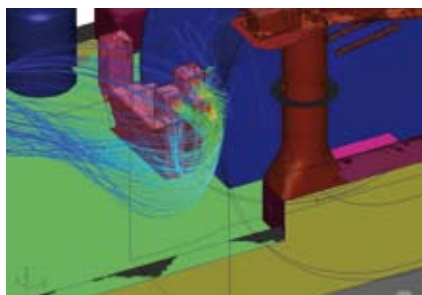
By Thomas Ingvorsen, Project Manager, Industrial Processes

Merwede Shipyard requested FORCE Technology to perform a flow investigation of the hot exhaust air from a brake cooling system on a pipelay vessel, in order to assess the temperature on the ship deck in the near field of the exhaust. The investigation was carried out by the Department for Industrial Processes at FORCE Technology.

Three air cooled resistors are installed on board a deep sea pipe laying vessel to “destroy” energy coming out of the brakes when the crane and pipelay abandonment system lower loads to the seabed. The hot air from these resistors is let out through three exhausts above the ship deck.

The objective of the investigation was to document and optionally optimize the proposed layout of the resistor exhaust system and the impact of hot exhaust air on the direct environment on the ship deck. The main focus of the investigation has been on the impact of the high temperature exhaust air on the operation of a 400 tonnes crane on port side and a 40 tonnes crane on starboard side.

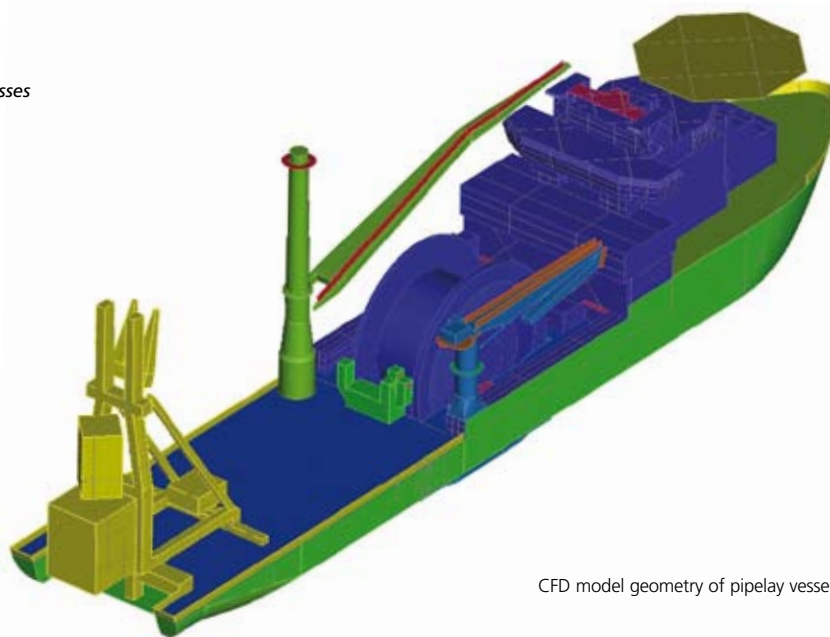
The investigation was based on application of Computational Fluid Dynamics (CFD), since this method provides a very detailed



Stream traces from the exhausts coloured by temperature.

and quantifiable insight into the resolved flow and temperature field. Based on 3D CAD drawings from Merwede Shipyard a geometrical model of the pipe laying vessel was constructed. The model included the whole ship with the general arrangement on the ship deck and all necessary details influencing the flow from the resistor exhausts.

The wind climate was also taken into account as the simulations were performed



CFD model geometry of pipelay vessel.

with the typical prevailing wind speed and with flow from different wind directions.

Conclusions

On the basis of the numerical flow simulations the impact of the hot exhaust air on the surrounding environment on the ship deck has been assessed and the temperature rise in the operational area of the cranes has been predicted. The investigation has been carried out using the commercial available CFD-code Fluent.

The CFD simulation has provided Merwede with an excellent background for evaluating the specific layout of the exhaust system. Further, it has been an efficient basis for identifying possible design improvements.

The Company

Merwede Shipyard's business policy is to respond to the needs of ship owners who require vessels of innovative concept and modern engineering, built to a 'one-off' order or limited series. A distinguished track record and reputation for constructing numerous highly distinctive designs is a confirmation of the versatility of Merwede Shipyard. In the offshore market Merwede Shipyard focuses on large custom-build specialised sub sea construction vessels. Next to the offshore market Merwede Shipyard is active in the Cruise & Ferry-, the Naval-, and the Special Ships market. Merwede has its premises in Hardinxveld-Giessendam east of Rotterdam in the Netherlands and employs approximately 450 permanent staff and workers. Merwede Shipyard is part of the IHC Holland Merwede group of companies.



Subsea 7 Seven Oceans - Deepwater rigid pipelay vessel built at Merwede Shipyard.

Heading for Sustainable Energy Supplies

By Gitte Videcrantz, Project Manager, Industrial Processes

The Russian county, Kirov, will strengthen the use of biomass in the future energy supply. FORCE Technology takes part in the project aimed at converting the polluting poultry manure into an environmental success in both Kirov and Denmark.

Kirovskaya oblast – or Kirov county in English – is approx. four times the size of Denmark and has a population of 1.6 mio. From the hills in Kirov you have a beautiful view of far-reaching plains with dense forests of conifers and birches. The forests dominate this area 900 kilometres east of Moscow.

And then there is poultry. The chicken farms. A resource for Kirov which may also become a resource for Denmark. In collaboration with FORCE Technology, Kirov Khleb Holding is examining how the chicken droppings can be used as a biomass fuel and thus reduce emission of Methane into the atmosphere. Moreover, it will save the Russians from fossil fuel expenses, and it will reduce CO2 emissions. Denmark is then able to buy the CO2 quota that the Russians has reduced, which will be for the benefit of the Danish community. According to the Kyoto Protocol for the reduction of CO2 emissions, if Denmark helps, for instance, Russia to reduce its

CO2 emissions, Denmark will be entitled to purchase that quota. This may assist Denmark in meeting its promise to reduce CO2 emissions.

The restructuring

“We have been conducting various projects in Russia for some years – also projects about CO2 quotas – together with the Danish EPA, among others. Moreover, we have intensified collaboration with Danish companies operating in Russia and, naturally, with the Russian authorities and public bodies. Through our close contact with the Russian business sector, we have now become partners in a project



Chicken farm in Kirov.

aimed at transforming the manure from 10 mio. chickens into biomass fuel. Kirov county is in the midst of an energy supply restructuring process where biomass plays a growing role. FORCE Technology thus takes part in projects where boilers at heating installations have been converted from coal and oil to natural gas and biomass. Now it is about starting a process where the poultry farms actively contribute to energy supplies and to reduce CO2 emissions," says Marina Matveeva, Director of FORCE Technology's Russian subsidiary in Saint Petersburg.

The Russian subsidiary has a large network in energy and process optimisation, biomass and waste incineration and can look back over many years of engagement in Russia with FORCE Technology's Danish environment and energy professionals.

Problematic gas

At present the poultry manure is not used at an optimum. Much of it is used as fertilisers in the fields, and that is a problem since it is degassing. The gas is Methane – a powerful greenhouse gas – like CO2

but with 21 times more effect and it is released directly into the atmosphere.

"The poultry manure can be used in biogas plants and since the biomass is CO2 neutral, it provides an environmental and financial gain to the Russians. According to our calculations 55,000 tonnes of CO2 can be saved in 2008. By comparison, we emit approx. 10 tonnes of CO2 per year per Dane. The savings in Kirov will thus correspond to the amount emitted in one year from e.g. Assens, Maribo or Rudkøbing," say Project Managers Gitte Videcrantz and Lars Peter Johansen, FORCE Technology, who are in charge of the technical documentation for the project in Kirov.

Further potential

Before the Russians can put their saved CO2 quotas for sale, a calculation of the size of the reduction's potential in the project has to be made. A 5-year estimate must be made and FORCE Technology will be in charge of it.

"Currently we have negotiations with the consortium in Kirov to optimise the project

by establishing biomass plants which may also use waste from other productions. Annexed to the poultry farms are also cattle farms, a chicken abattoir and baking factories that all will be able to deliver biomass for the heat or power plant or buy the energy produced. And on top of that we have the forests," says Marina Matveeva.

Several regions in Russia have shown interest in similar projects on implementation of sustainable energy supplies. There is no doubt in Marina Matveeva's mind that the biomass energy will spread in the large country with the many resources.

"There is a market for linking the Russian need for energy conversion to expertise in biomass energy right from analysis level to counselling about which techniques should be used to supply of the technology. FORCE Technology can contribute with a lot of know-how in that respect, but will also act as a sub-contractor to Danish companies who want to become engaged in the Russian biomass energy sector," says Marina Matveeva. ■



Poultry manure can be used in biogas plants providing a financial and environmental gain to the Russians as it is CO2 neutral.

PROFILE OF:

Thomas Eefsen
M.Sc., Naval Architect
Senior Project Manager



Thomas Eefsen is a naval architect (M.Sc.) from the Danish Technical University, DTU. He has worked for FORCE Technology in Lyngby since 1999. Today he works as Senior Project Manager in the Department for Hydro and Aerodynamics. Over the years Thomas has built a large network within the international maritime business and has obtained broad experience within BtB sales and marketing. Long-time project management has given him a significant knowledge within ship-technical problems and their solutions through hydrodynamic model testing as well as numerical (CFD) methods.

Your can contact Thomas by email: tef@force.dk

PROFILE OF:

Kjeld Roar Jensen
B.Sc., Naval Architect,
Marine Engineer
Senior Project Manager



Kjeld Roar Jensen has previously been working in the Technical Organisation in A. P. Møller – Mærsk. During his 17 years in the shipping company, Kjeld has built a solid knowledge of ship operation, performance optimization, on-board systems, maintenance, diesel engine analyses, etc. Over the past 12 years he has had a management responsibility in the shipping company. Kjeld is a marine engineer and naval architect (B.Sc.) supplemented with an MBA in Technology Management. Today Kjeld works as Senior Project Manager in the Department for Hydro- and Aerodynamics.

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PROFILE: Danish Centre for Maritime Technology

Danish Centre for Maritime Technology – DCMT – is now well under way. A total of six Research & Development projects have been initiated within the focus areas of safety, environment and efficiency. All projects will provide valuable results in the coming years to the benefit of “The Blue Denmark”.

Danish Centre for Maritime Technology (DCMT) was established in 2006 in co-operation between the Technical University of Denmark (DTU-MEK) and FORCE Technology. The centre is funded by the Danish Maritime Foundation with DKK 25 millions over a five years’ period.

The objective of the centre is to promote and develop Danish know-how within maritime technology through increased research,

development and innovation in the maritime industry. Further, it is DCMT’s purpose to raise interest in the maritime engineering degrees to ensure an inflow of competent and innovative engineers to “The Blue Denmark”.

DCMT is acting as a catalyst between the academic world and the maritime business both to improve the knowledge-flow from DTU to the business, but also to ensure that the research activities are considered relevant for the business. In that respect a number of research activities have been initiated at DTU which fall within the three focus areas: Safety, Environment and Efficient Operations.

The Centre is managed by Senior Project Managers Thomas Eefsen and Kjeld Roar Jensen. ■

SeaTrend Monitoring Hull and Propeller Fouling

By Kjeld Roar Jensen, Senior Manager, Danish Centre for Maritime Technology

Shipowners’ increased focus on fuel consumption and emissions of green house gases has highly increased the interest of the SeaTrend project, which has been initiated under DCMT. With the SeaTrend system shipowners will have a continuous performance evaluation of the hull and propeller conditions, enabling the technical operators to maintain the anti-fouling system in a good condition.

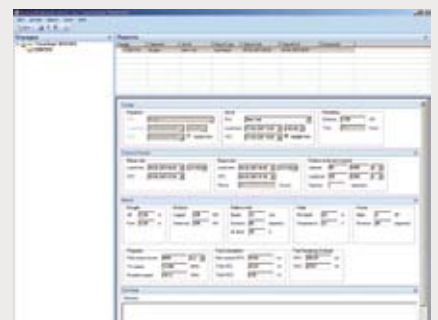
The condition of the anti-fouling system and the condition of the propeller is highly important for the propulsive performance of a ship. Even small degradation of the anti-fouling system or fouling of the propeller blades may be responsible for reduced propulsive performance. Therefore, in order to maintain a good performance of the ship, a professional tool for continuous monitoring of the hydrodynamic performance is of

high importance for the shipowners.

To meet the requirements of the shipowners, FORCE Technology is now developing a professional tool for online and instant monitoring of ship and propeller performance. Based on regular observations onboard the ship the degradation of the hull and propeller performance is monitored over time. The system is based on a user-friendly application onboard the ship for input of daily observations. All data is transferred to a central server for data processing and analysis, and the performance of the ship is displayed to the fleet manager on a dedicated web-site.

The first version of the SeaTrend system is to be installed on a number of ships already in September 2007.

The development of the SeaTrend system is managed by Kjeld Roar Jensen. ■



Onboard data reporting application.



Significant speed loss as a result of fouling. ■

Maritime Innovation with Air Lubrication

By Thomas Eefsen, Senior Project Manager, Hydro- and Aerodynamics

For decades designers and inventors have puzzled with the idea of reducing skin friction drag by air lubrication or air-bubbles. A lot of different ideas and projects have been proposed, but no designs have proven to be very successful. With the patented Air Cavity System (ACS) of DK-Group, fuel savings of 10-15% of a conventional Aframax tanker have been shown in model scale. And now DK-Group goes full scale with tests of the ACS technology on an 80m Multi Purpose Vessel.

The patented Air Cavity System improves the fuel efficiency of ships by reducing the frictional resistance of the hull surface. This is achieved by replacing the flat-bottom surface of the vessel's hull with a patented Air Cavity System consisting of special recessed cavities in the hull bottom. The air cavity system is ideally suited for large tankers, since this type of ships have a large flat bottom and the frictional resistance relative to the wave resistance is high.

Since 2004 DK-Group has undertaken a comprehensive model test programme for a 234m Aframax tanker and a 316m VLCC. In both cases the cavity has been optimised for maximum performance in both calm water and in waves. Model tests have been made with an 8m scale model of the tankers with and without air cavity in order to measure the gain in resistance and propulsive power.

One of the main challenges of the ACS-technology has been to maintain the 'air-bubble' in the air cavity when at speed and when in a seaway. In order to solve this problem, a large test series has been carried out with different sizes and geometries of the cavity. Tests have been performed in both calm water and in waves.

The large R&D programme has shown that for a tanker with the most effective ACS design a reduction of the resistance of 10-15% could be expected. But since extrapolation of ACS technology is not included in the industry practise of extrapolation of model test results

to full-scale, DK-Group has decided to test and document the effect of ACS technology on a real ship. For this purpose an 83m Multi Purpose Vessel has been purchased and will be modified with ACS Technology after a comprehensive sea trial scheme has been conducted for the reference vessel.

The sea trials of the ACS Demonstrator will probably be the largest model test to date, and the project will clearly show the effect of ACS Technology on commercial vessels. The results of the sea trials are expected in the end of 2007.



Photo of 83m ACS Demonstrator.

Hull Optimisation of DIAMOND 34 Bulk Carrier

By Thomas Eefsen, Senior Project Manager, Hydro- and Aerodynamics

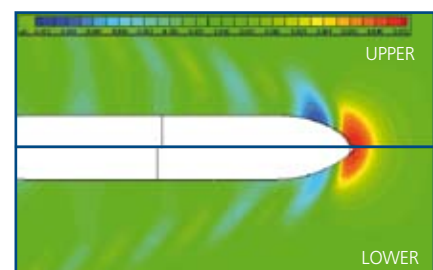
Recently Grontmij Carl Bro A/S presented their new DIAMOND 34 design. The vessel is a 34,000 DWT Double Hull Bulk Carrier with high standards as regards safety, environment, and operational efficiency. One of the primary design drivers was high performance and low emissions, and therefore FORCE Technology was consulted for optimisation of the hull lines. The hull lines were developed using numerous iterations of CFD calculations, and the resulting hull lines had maximum payload with minimum propulsion power.

The project is a very illustrative example of how it by extensive use of CFD programs is possible to optimise the hull lines of ships. For many years it has been normal practice by FORCE Technology always to undertake SHIPFLOW potential flow calculations prior to model tests. In this way the client is ensured a very time and cost effective evaluation of the performance of the hull lines before model

manufacturing is started. In the case of the DIAMOND 34 project the hull lines were optimised in very close co-operation between the experienced naval architects of Grontmij I Carl Bro and FORCE Technology. Based on the results of the SHIPFLOW CFD calculations and an intense dialogue as regards the general arrangement of the ship and the target values for the hydrostatics, the hull lines were optimised for optimum performance in a seaway.

Compared to the initial hull lines the total resistance of the ship was reduced by approximately 2%, which in the years to come will save the ship-owner for approximately USD 50,000 in bunker costs per year. On top of this, the environment is saved for approximately 500 tonnes of CO₂ per year.

Additionally, the flow in the aftship was calculated and optimised using the CHAPMAN viscous flow programme, which is part of the successful SHIPFLOW package developed



CFD calculations of wave pattern for original hull lines (upper) and optimised hull lines (lower).

and provided by Flowtech in Gothenburg. The programme has shown to be very effective for evaluation of the ship wake, and therefore CHAPMAN calculations are now included as a standard when evaluating single screw vessels at FORCE Technology. In case of the DIAMOND 34 project the aftship and the propeller boss were optimised for good flow conditions, which were later documented by 3D-wake measurements.

Advanced CFD Codes for Ship and Propeller Design

By Thomas Eefsen, Senior Project Manager, Danish Centre for Maritime Technology

With the aim of enhancing the applicability of the most advanced CFD codes for ship hulls and propellers, DCMT has now initiated a Joint Industry Project between MAN Diesel A/S (Propeller Equipment, Frederikshavn), Technical University of Denmark (DTU) and FORCE Technology. The project will focus on using RANS based CFD codes for computations of the hydrodynamics of ships with a working propeller.

The Joint Industry Project will focus on the application of highly advanced RANSE CFD codes for solving complex hydrodynamic problems on ships, including ships with a working propeller. FORCE Technology's experience within using CFD for optimisation of ship hull forms is broad, while MAN Diesel has used CFD for development of efficient nozzle and blade designs. By joining together in the project, both parties will benefit from their mutual experience and highly complex hydrodynamic problems will be solved. On top of the validation of CFD codes, DTU will join the project with a Ph.D.



From kick-off meeting. Left to right, standing: Claus Daniel Simonsen, Robert Flemming Mikkelsen (DTU-MEK), Poul Andersen (DTU-MEK). Left to right, seated: Kjeld Roar Jensen (FORCE Technology), Thomas Eefsen (FORCE Technology), Rasmus Mandrup Jeppesen (MAN Diesel).

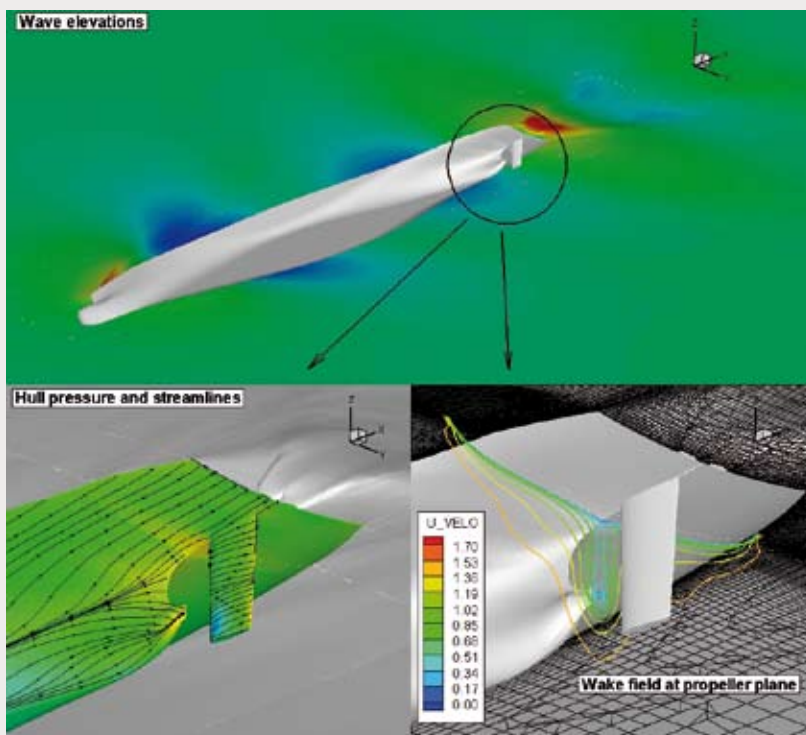


Illustration of RANS based CFD calculation for a container vessel.

student, who will study blade cavitation and transition using the highly recognised CFD code EllipSys, which has been developed by DTU in cooperation with Risø National Laboratory.

The aim of the project is to validate the modern RANSE CFD codes as regards hull and propeller flow. By using the modern RANSE CFD codes, both MAN Diesel and FORCE Technology expect to be able to optimise even further the flow around the hull and the flow to the propeller. It is therefore expected that the CFD codes will prove to be a very valuable supplement to the optimisation of hull lines and propellers. Furthermore, the research, to be undertaken by DTU, is expected to be very valuable for further development of cavitation models for RANSE CFD codes.

The project starts in September 2007, and will run for approximately one year. ■

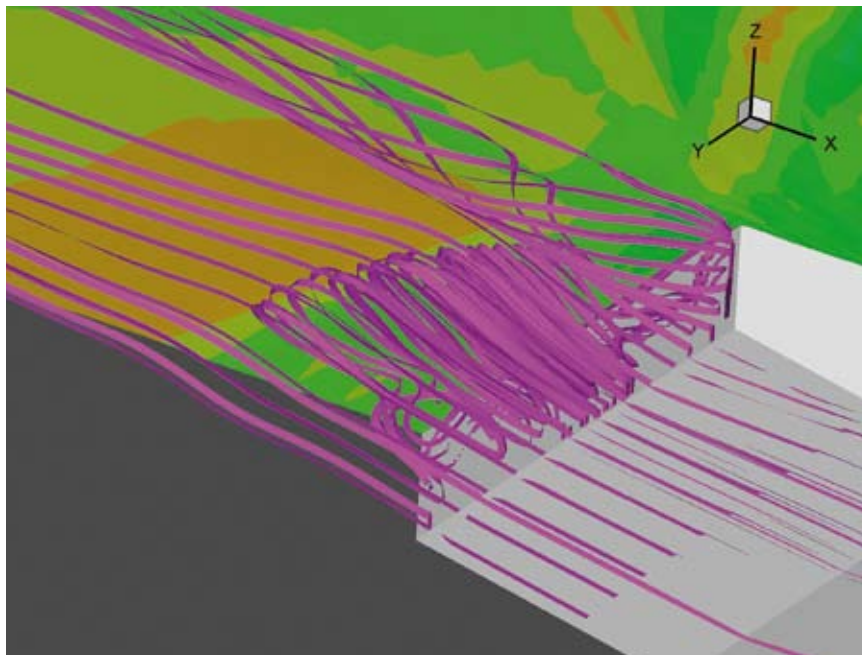
The Numerical Towing Tank is Now Getting Closer

By Thomas Eefsen, Senior Project Manager, Hydro- and Aerodynamics

FORCE Technology has for many years been dedicated to optimising hull lines and improving propulsion efficiency. In this way ship-owners benefit from reduced costs for propulsion. Further, emissions are kept at a minimum. FORCE Technology has a broad experience within using SHIPFLOW for optimisation of hull lines, but now our services also include highly complex RANS based CFD computations using STAR-CCM+ and COMET developed by CD-Adapco.

Based on our broad experience within both potential flow based CFD and RANS CFD computations, FORCE Technology now also offers calculations with STAR-CCM+ and COMET. We have been engaged in application and validation of RANS CFD codes for ten years, and since 2000 we have conducted potential flow CFD calculations for more than 300 projects. From this experience we see a large potential in expanding our services with RANS calculations. With the highly advanced and recognised CFD packages we have already solved a number of complex projects for our clients.

As a recent example we have been working on a project with a Service Jack (a barge



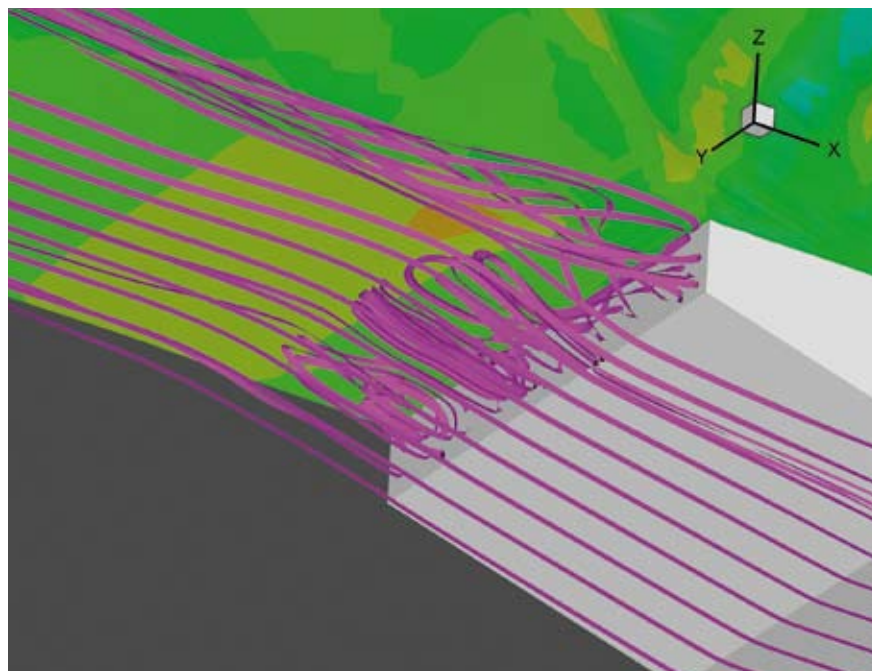
RANS based CFD calculations of original hull lines. The calculations show a large base drag and strong flow separation behind the transom.

type jack up vessel) for Master Marine AS in Norway in order to improve the towing resistance of the vessel. Within the project, calculations were first made for the existing

design and the results were used to evaluate the flow around the hull. Next the aftship was modified based on the findings of the flow evaluation and with attention to the design constraints given by the client. The net result was an approximately 18% lower resistance. Compared to the potential flow calculations, which have been widely used for many years, the new advanced CFD programs provide a detailed visualization of the flow along the hull, including vortices and regions with flow separation in the aftship.

With the new CFD tools we are improving our highly recognised consultancy within CFD calculations for evaluation and optimisation of ship hydrodynamics. Also the CFD calculations have shown to be very effective in investigating and solving hydrodynamic problems. The calculations are suitable for both new-building and conversion projects, and in most cases the calculations combined with our consultancy will result in better performance.

If you want to know how CFD calculations can be applied to your project, please contact Senior Project Manager Thomas Eefsen (tef@force.dk).



Optimised hull lines with significantly lower resistance and reduced vortex formation. The hull lines were optimised with special attention to the client's restrictions.

PROFILE: Simulation and IT

The Simulation and IT department is offering ship-handling simulators, ranging from full-mission to desktop solutions. Depending on customer requirements and specifications, we offer ship-handling simulators using the latest and most sophisticated customer-off-the-shelf technology and simulation software developed in-house.

The cornerstone in creating an optical, realistic and professional simulation comes from the realism of the mathematical ship model DEN-Mark1. FORCE Technology has decades of experience within hydro- and aerodynamics and is known as one of the world's leading experts when it comes to generating mathematical ship models. The department also works with on-board decision support systems for voyage planning, heavy weather navigation, performance optimisation, and ship stability.

PROFILE OF:

Cathrine M. Steenberg
M.Sc. Eng, Ph.D.
Head of Department



Cathrine joined FORCE Technology in 2001 with a background as hydraulic engineer and a Ph.D. in wave hydrodynamics. Over the years Cathrine has worked as Project Manager for the Training, Ports & Human Factors Department on a large number of port evaluation studies worldwide covering services such as grounding studies, mooring studies, fast-time simulations and real-time simulations. Furthermore, Cathrine has been involved in a number of development projects, where especially the development of the tug simulator has been in focus the last couple of years. The experience gained as a user of ship-handling simulators will be useful as Cathrine has taken over the position as Head of Department, Simulations and IT just recently.

You can contact Cathrine by email
cms@force.dk

Cooperation Agreement between Voith Turbo Schneider Propulsion and FORCE Technology

By Aage Damsgaard, Technical Vice President, Division for Maritime Industry

In March 2007 Voith Turbo, Germany and FORCE Technology signed a formal cooperation agreement. It is an agreement between two companies with an ideal match in business areas, in addition to the two companies both being highly motivated to push state-of-the-art further forward. Voith Turbo values the capabilities of the SimFlex Navigator product and not least FORCE Technology's recent advanced development of tug features, which proves ideal for Voith Turbo's further product development. Likewise, it is important for FORCE Technology to add the renowned company (Voith Turbo) to the list of very demanding and professional in-house users of the SimFlex product.

Voith Turbo is the developer and supplier of the unique Voith Schneider Propulsion system, which is being extensively used for

propulsion of a large variety of ships worldwide. The Voith Schneider Propulsion unit is characterized by its ability to create a continuously varying thrust force and direction, which makes it particularly suitable for ships requiring very high manoeuvrability, e.g. the Voith Water Tractor tug design. Even though the Voith Schneider Propulsion unit is a unique invention Voith Turbo has very much focus on constant development of the units, both to offer larger size units and to increase energy efficiency even further.

During recent years FORCE Technology has put much effort into developing the tug simulator based on the SimFlex Navigator bridge simulator system. This development has included the establishment of a mathematical model of a Voith Water Tractor, which accurately performs all the relevant tug operations in the simulator, including direct and indirect towing, pushing, pulling



Dirk Jürgens, Head of R & D, Voith Turbo, and Cathrine M. Steenberg, Head of Department, Simulation and IT, confirm the cooperation agreement.

and fast position change. It has only been possible to achieve this accuracy by performing extensive model tank tests and integrating full-scale and numerical data provided by Voith Turbo into the model. Voith rates the SimFlex Navigator Voith Water Tractor model to be best of its kind.

This excellent performance of the Voith Water Tractor in the simulator has caused Voith Turbo to purchase a SimFlex Navigator simulator to be used both for the continued development of the Voith Schneider Propulsion unit and for the demonstration of the capabilities of the Voith Water Tractor and other ships equipped with Voith Schneider Propulsion units to potential customers. Due to the mutual interests of Voith Turbo and FORCE Technology in continuing this development, the two parties have entered into said cooperation agreement. Under this agreement the parties shall continue to assist each other in the development of the Voith Schneider Propulsion units, the simulator model of these units and ships equipped with the units, in order to establish SimFlex Navigator as the leading ship manoeuvre simulator in the market, especially for vessels equipped with Voith propulsion and Voith manoeuvring systems.



Voith tug simulator setup.

The SimFlex Navigator simulator system installed at Voith Turbo in April, 2007, includes a tug simulator, an assisted ship simulator, and an operator station, all connected in a network. The system was demonstrated at the Voith Turbo agent's conference early May and attracted considerable interest, as

one of the objectives of the Cooperation Agreement is that Voith Turbo will make use of its sales organisation to strengthen FORCE Technology's position in the simulator market. A number of prospective contracts have already been identified through these channels.



Captain Le Chevalier at the helm of the VSP tug.

PROFILE: Training, Ports and Human Factors

The services are based on flexible simulators where real equipment and instruments can easily be integrated to the simulators, by experienced instructors and naval architects and on very accurate ship and engine models.

Training (deck, engine, navy, pilots, offshore):

- ship handling
- crew resource management
- emergency response
- tow out, offshore structures
- tug handling
- plant familiarisation
- watch-keeping
- radar/arpa
- combined deck and engine room
- tailor-made / combined courses
- train-the-trainers

Industry:

- human factor management
- design and tailor-making of courses.

Ports:

- grounding studies
- mooring studies
- fast-time simulations
- QuickSim, part-task simulator validation
- full-mission validation – operational

Guidelines:

- design validation
- port evaluation for on-site evaluation of modifications to layout.

Human factor management:

- human factor audit
- procedure analysis and optimisation
- design analysis and optimisation
- near miss/accident reporting and analysis
- human factor training programs

PROFILE OF:

Niels Arndal

M.Sc., Naval Architect
Senior Project Manager



Niels has been working with marine simulation for 18 years. He is an IPMA certified Project Manager and has been involved in a very large amount of port studies over the years for ports world wide. The projects include large projects involving the new full mission tug simulation system. Niels is also chairman of the database development committee and is responsible for the production of port models.

You can contact Niels by email nia@force.dk

Development of Tool for Assessing Safe Manning of Ships

By Carl Thue Rabjerg, Senior Instructor, Training, Ports and Human Factors, and Aage Damsgaard, Technical Vice President, Division for Maritime Industry

In November 2006 representatives from FORCE Technology and Risø National Laboratory sailed on board the product tanker TORM ISMINI to collect data for the development of a tool for assessing safe manning. The voyage was part of the first phase in a pioneering project funded by the Danish Maritime Fund.

Staff cost is a competition factor

The shipping industry is in tough international competition in which even little margins count. Operational expenses for fuel, port charges, etc., are the same for all ship-owners operating in the same markets. However, staffing expenses are very different from country to country, and they are the only larger expenses which are variable. Therefore, these expenses have become a vital competition parameter and thus, the need for optimising the staffing has become very important.

Scale vs. goal-based manning

According to international regulations all ships must be safely manned and the minimum staffing for each ship is described in a Minimum Safe Manning Document, which is an official document. The ship is only allowed to sail if the minimum staffing is fulfilled. A ship's staffing can be determined either by the scale manning principle or by the goal-based principle. The first is determined by regulation, which

merely stipulates the manning in consideration of type and size of ship. Goal-based manning evaluates the specific conditions on each ship individually under consideration of the functions, which need to be performed safely without violating any rules and regulations.

Simulation of work load

The discussion about how to determine manning in relation to safety, rest hours, etc. is an issue, which is presently being debated in international fora. There is a great need for a tool which can provide an objective basis as well as documentation to assess whether a ship is safely staffed. The tool must be able to evaluate in a dynamic way all the ship's functions and the interaction between staff and functions. FORCE Technology has started the development of such a tool in cooperation with Risø National Laboratories and the Danish Maritime Authority, with funding provided by the Danish Maritime Fund.

The tool selected for the assessment is a so-called Discrete-Event Simulation tool by which an incoming flow of tasks (described by a list of attributes) are solved by the resources available on board. The flow of tasks depends on the state of the ship, whether it is in port, departing, under sea voyage or arriving to port. Tasks may be scheduled or unscheduled, normal and abnormal, and some tasks may be performed at the same time by the same resource. The tool assesses the load on a given crew with given qualifications for tasks occurring on a given ship in a specified operational cycle.

Extensive data collection

A crucial element of the modelling is the definition of the tasks. In the exploratory first phase of the project this was done in cooperation with the Danish shipowner TORM using their product tanker TORM ISMINI as a test case. The data collection for task definition started with a thorough and systematic review of the ship's Quality Management System (QMS). Review of this together with TORM personnel ashore resulted in an initial list of some 60 tasks, which needed to be defined in detail during studies onboard on a Trans-Atlantic voyage. The attributes for each task include the following:



Navigator on duty.

- task description
- qualifications required to perform the task, including number of resources
- duration (triangular frequency distribution given by minimum, mean and maximum duration)
- priority and scheduling (latest start, latest end)
- effect of weather, qualifications, fatigue, etc. on duration
- location for performing the task

Studies onboard were conducted by Captain Carl Thue Rabjerg, Senior Instructor at FORCE Technology and Dr. Steen Weber, Senior Researcher at Risø National Laboratories, and included:

- conducting interviews with crew members
- monitoring work
- comparing procedures and actual actions

- comparing rules and actual actions
- determining working tasks in relation to extent, frequency and qualifications
- cross checking the collected data
- systematizing and collection of data
- follow-up interviews with crew members to clarify insufficient or ambiguous data

This resulted in a final list of 78 tasks to be handled by the simulation model in its final version for this ship. For demonstration purpose in order to illustrate the viability of the tool it was set up for all the functions performed by the deck officers and the operating cycle was described from the historical data for the ship from the ship's logbook.

Great potential

The model has subsequently been demonstrated for stakeholders from the Danish

maritime sector who all agree that the tool has great potential. Not only does it solve the task of assessing the work load and evaluating compliance with regulations, e.g. rest rules. It also enables the user to assess the effect of changing personnel qualifications (e.g. dual officers), the effect of changing automation, instrumentation and physical arrangement onboard, and the effect of re-distributing paperwork between the ship and the land office. It is therefore the intention to continue work into the next phase where a complete model shall be set up and a user-friendly user-interface shall be implemented.

It is strongly believed that the tool will serve its purpose and objectively support the Danish practice of goal-based determination of minimum safe manning. ■



Work at the chart table.

Human Factors Course for Investigators at The Danish National Railway Agency

By Helle Boelsmand Bak, R.N., Master of Education, and Thomas Koester, Psychologist, M.Sc. Psychology, Training, Ports and Human Factors

When the pilot of a passenger aircraft checks the instruments before take-off, when the captain on a ship's bridge navigates at sea and when the surgeon takes a time-out prior to an operation, they all do it because they are trained in Human Factors. They are aware of the fact that the Human Factor may cause a safety-critical incident, which at worst could be fatal for the safety of the passengers, the crew or the patient. It is not safe to rely on the memory alone, and therefore they make use of checklists when a safety-critical action is to take place. For many years FORCE Technology has trained professionals in Human Factors and our strategy is to disseminate the knowledge about Human Factors to other domains, in which safety is an issue.

The Danish National Railway Agency

The railway is one of the safest modes of transportation. Compared to car accidents and personal injury on the roads it is much safer to go by railway. Nevertheless, the Danish National Railway Agency focuses on safety within a large range of technical and organizational areas, among these a thorough Human Factors and accident investigation training for their supervisors.

FORCE Technology has successfully carried out Human Factors and Accident Investigation courses for a total of 21 persons from the Danish National Railway Agency. Twenty one persons, who come from such diverse parts of the Danish National Railway Agency's organisation as Facility & Renovation, Technical Operation, Traffic Safety, Traffic Management DSB S-tog (City Train), Traffic Management Remote Train, and Traffic Management the Great Belt. The courses were carried out in recognition that focus on safety must be present in all parts of the organisation. All competencies are needed in order to prevent accidents from happening. Further, it is important to involve knowledge from different fields when there is a need of finding the cause of the accident or incident.

Human Factors

During the course the participants received a thorough introduction to Human Factors. Human Factors originate from psychology and the knowledge of how people think and act. The Human Factors field is developed from e.g. aviation, nuclear power, and the shipping industry – areas which are tradition-

ally known for focusing on safety, as lack of safety can have fatal consequences. Human Factors are also used within railway safety, e.g. in England, where the Centre for Rail Human Factors has existed since 1998.

"My expectations of the course were among others to broaden my knowledge of human factors and thereby get some tools and methods to work with. My expectations were fully fulfilled. Prior to the course I mainly focused on finding the human and technical mistakes and did not always look at the causes behind – at least not systematically."

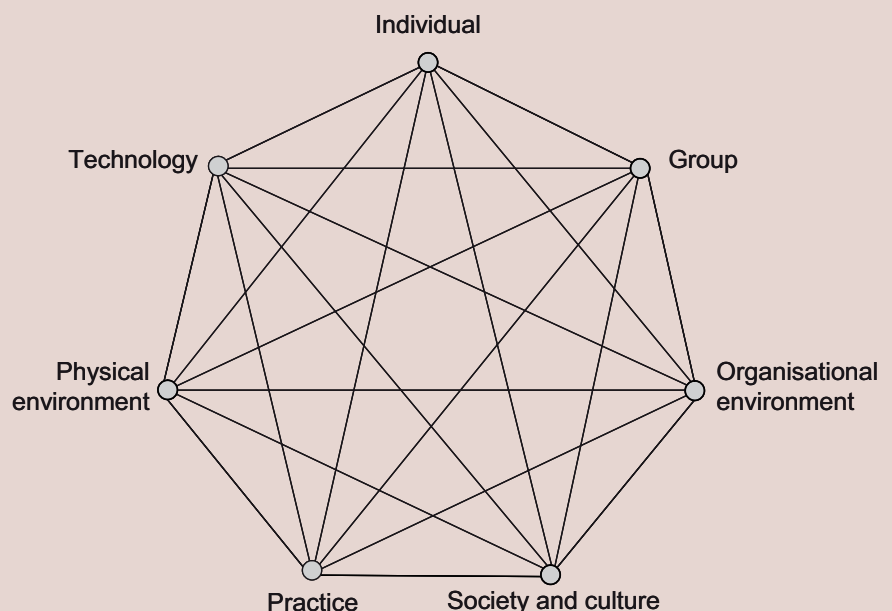
Traffic inspector John Dahl Nielsen, The Danish National Railway Agency

Human Factors specialists at FORCE Technology have on the basis of among other things Edwards and Hawkin's SHELL-model developed a model for the interaction between the elements which forms part of the Human Factors field, called the

socio-technical system. The system can be employed when investigating and improving the interactions taking place in the socio-technical network. For instance, it turns out that accidents are often caused by a breakdown in this set of interactions or by a malfunctioning interaction between two or more of the elements.

"We received a good and exciting insight into the importance of the interaction between people, technology, procedures, organisation, and working environment by investigating safety-related incidents. The result shows that often there are more causes behind an accident. If the company makes use of the results of such a thorough investigation it will often result in improvements which the entire company can benefit from, including better education, procedures, organisation of work and not least help in preventing accidents and incidents from recurring."

Traffic inspector John Dahl Nielsen, The Danish National Railway Agency



The socio-technical system

Hawkins, F.H. (1987). Human Factors in Flight. Aldershot, UK: Gower Technical Press Ltd..

Edwards, E. (1972). Man and machine: Systems for Safety. Proceedings of British Airline Pilots Associations Technical Symposium, London: British Airline Pilots Associations, pp 21-36.

Koester, Thomas: Terminology Work in Maritime Human Factors. Situations and Socio-technical systems. Ph.D. Dissertation, January 2007.

Methods for detection of accidents

During the course the participants receive a thorough theoretical and practical knowledge of how to collect and analyse evidence from the scene of accident. The course covers the entire investigation process and the participants are trained in employing the methods for collecting and analysing data, communication and interview technique. Finally the objective of and the method for report writing is presented and discussed. The methods are trained by means of cases from the participants' own domain. This is a learning method which is the source of useful reflections and discussions.

Building networks

The course is a 5-day residential course, during which the participants stay at FORCE Technology's guesthouse. One of the advantages of carrying out the course as a residential course is the fact that the participants in this way get the possibility of

building a network within the organization. The network is activated by investigating accidents as the individual inspector cannot possess detailed knowledge of all aspects. In addition a common reflection over the operation and systematic structure in the accident investigation process can create synergies.

"As a bonus experience, "landlubbers" like us were allowed to control the two frigates used for simulator sailing and training of mariners at DMI. This was an incredibly exciting experience which was a good lecture in cooperation and communication, as well."

*Traffic inspector John Dahl Nielsen,
The Danish National Railway Agency*

Knowledge of the domain

Prior to the course the inspectors participated in a comprehensive introductory process at The Danish National Railway Agency to col-

lect knowledge of the domain. The process was arranged in a way that ensured that the instructors obtained a solid knowledge of the work at The Danish National Railway Agency, from the work in the control unit and at the DSB S-tog (City Train), to the examination in the safety regulations on the free rail. The process also provided knowledge of the technical terms used within the domain. This again provided an insight into the corporate culture and into the language spoken within The Danish National Railway Agency.

"The course was tailor-made to the railway and prior to the course the instructors had carried out a very extensive research, e.g. by visiting a range of working places at The Danish National Railway Agency. The material used during the course was therefore related to the railway and during the course we were able to test our new knowledge on known material."

*Traffic inspector John Dahl Nielsen,
The Danish National Railway Agency*



Interaction between human, technology, and organisation is important to maintain a high level of safety.



Safety for those moving about the rail line.

It was nice to work with a new view on accidents and human beings, and I have learned that there is always another underlying cause behind the incident. Axel O. Petersen, Traffic Management, DSB S-tog (City Train)

Human Factors and accident investigation in The Danish National Railway Agency context

The theory about human factors was illustrated by means of cases from the Accident Investigation Board Denmark (Havarikommissionen) and The Railway Inspectorate (Jernbanetilsynet).

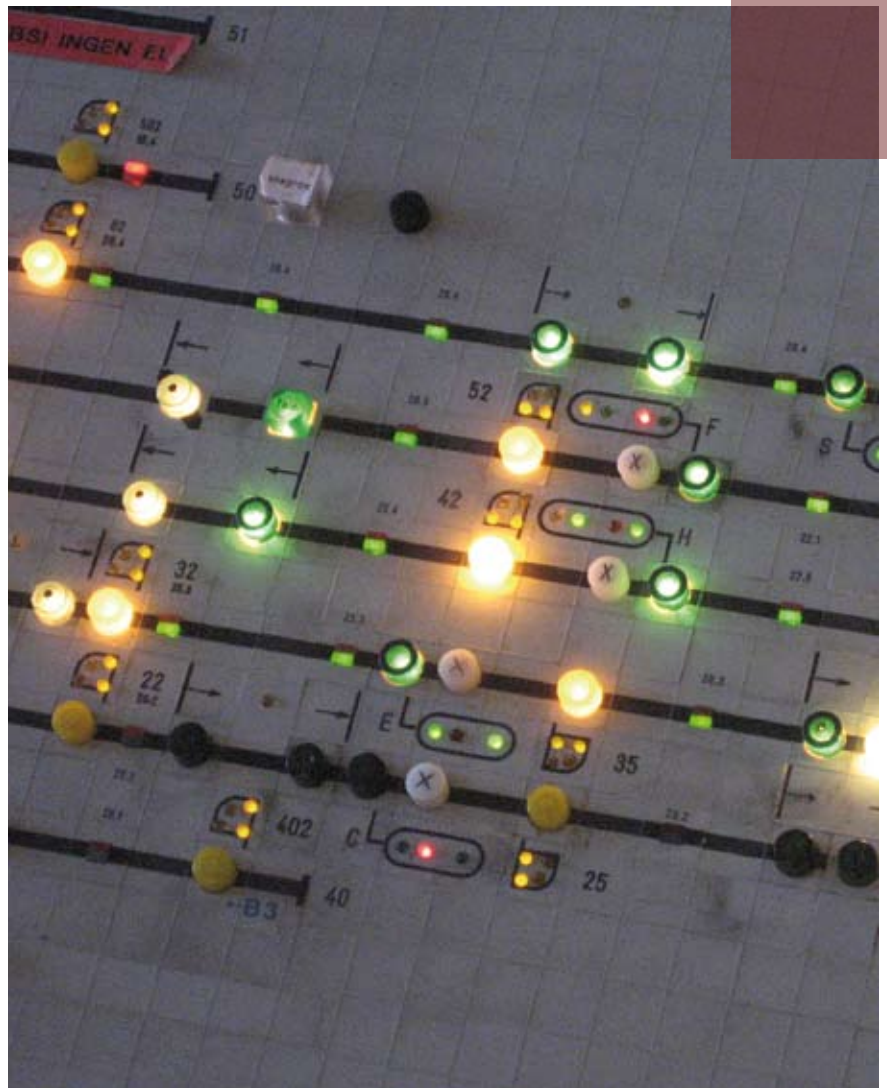
It was very useful that it was not only about our own domain. Parallels from other domains were drawn and in that way it was made visible that principles and the causes behind can be similar. Axel O. Petersen, Traffic Management, DSB S-tog (City Train)

The participants had the opportunity of working with the theory from earlier accidents and near-miss incident, which made the course relevant. From working with the theory in relation to the cases, the participants obtained an understanding of which human factors elements had come into play in the actual case. Interview technique, communication and collection of data in connection with an accident or near-miss incident were examined and as part of the course an interview exercise was included. I would like to emphasize the instructors' immense knowledge within human factors, as well as the fact that they were well informed as to the conditions and terminology used within The Danish National Railway Agency. Axel O. Petersen, Traffic Management, DSB S-tog (City Train).

"I recommend other organisations within the railway sector to let their investigators participate in this course, as I believe that the outcome fully exceeds the costs connected to the course."
Traffic inspector John Dahl Nielsen,
The Danish National Railway Agency

Two participants carried out the interview as a role play, while the rest of the participants supervised the interview from another room. All the participants then watched the interview while the instructor stopped the recorded interview at passages of special interest. The participants had the

opportunity of discussing what went wrong and give their suggestions to how the situation may have developed. This working method provided exiting information on the difficulties and barriers an interviewer must handle in a real situation, and shows the participants that it pays off to practise interviews to sense your own barriers. ■



A successful interaction between human and technology is contingent upon a user-friendly design.

FORCE Technology Completes Marine Safety Simulation Study in Canada

By Peter Krogsgaard Sørensen, Head of Department, Training, Ports and Human Factors

FORCE Technology has recently completed a comprehensive full-mission bridge simulation for the Enbridge Gateway Pipelines project. FORCE Technology was the successful winner of an international tender issued by Enbridge Gateway Pipelines Inc. The project's objective was to confirm that Very Large Crude Carriers (VLCC) can safely and efficiently navigate through the Douglas passage along the north west coast of British Columbia, Canada.

"Enbridge takes marine safety very seriously and chose FORCE Technology for this important work due to their experience and advanced technological expertise in marine simulations," says Cynthia Hansen, Director, Operations Services with Enbridge.

The studies are part of the Enbridge Gateway Pipelines project covering environmental, engineering and land field work in relation to the transportation of petroleum by pipeline between Alberta and Kitimat, British Columbia with related movements by sea.

The study awarded to FORCE Technology included an initial fast-time simulation to identify all safety sensitive areas that were then further studied through real-time full-mission simulations. For the latter, the FORCE Technology's advanced tug simulator system was used to provide accurate input to maneuvering strategies, and to confirm the best navigation option and contingencies along the proposed routes. The tug simulation system was composed of four interactive simulators where tug masters operated advanced fully modeled tugs, while B.C. Coast Pilots operated the vessels.

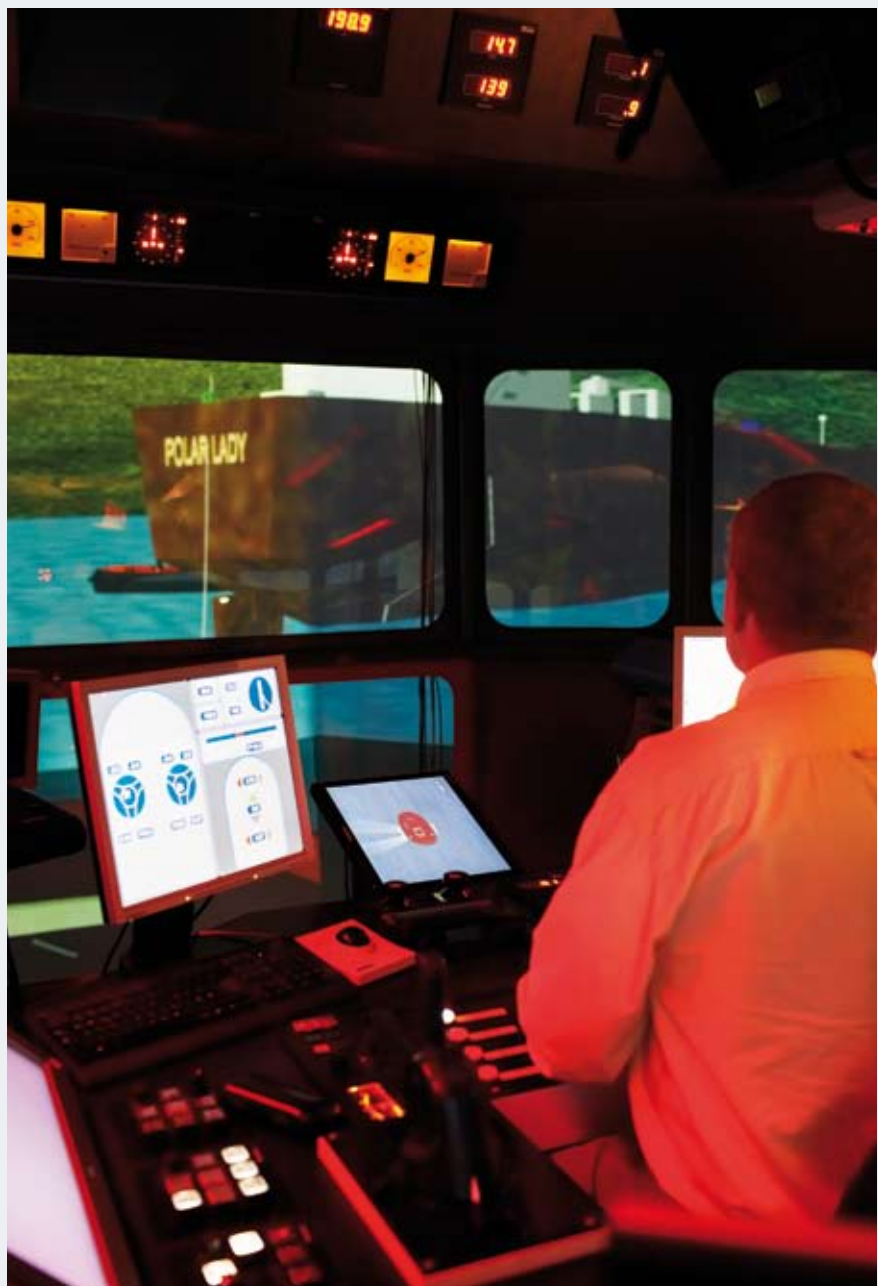
The results of the study will be used to establish operational procedures, and as input to an extensive training program for B.C. Coast Pilots and Tug Masters, who will be involved in the operation in the future. The project is currently scheduled for completion in the 2012 to 2014 timeframe subject to the completion of satisfactory shipping agreements and subsequent regulatory approval.

"For operations in coastal areas, the need for accuracy, predictability and reliability is vital in order to ensure that the right deci-

sions are made and the right strategies are chosen. With more than 45 years of experience and a constant strive to produce the most accurate models in combination with the development of a state-of-the-art full-mission tug facility, we can provide a sound basis for each decision-making process" says Peter Sørensen, FORCE Technology.

Last year FORCE Technology carried out a record breaking 35 port studies. "Ports

and engineering companies are increasingly becoming aware of our capability to provide valid results based on sound engineering principles and extensive experience with maritime operations. Our staff has a unique cross-disciplinary composition. Naval architects, coastal engineers, programmers and experienced mariners have been working closely together for many years to provide valuable results", continues Peter Sørensen. ■



New Approach to Better Assess Real Safety and Performance Levels while Sailing

By Guillermo G. Garay, Senior Instructor, Training, Ports & Human Factors, FORCE Technology, and Frank E. Lee, Director Training, ConocoPhillips Marine

The shipping industry is expanding exponentially: 80 million Americans per year use U.S. flagged vessels, 90% of the U.S. population is served by domestic shipping, 97% of the UK's trade by weight arrives or leaves by sea. There are around 50,000 merchant ships trading internationally, transporting a range of cargos. The world shipping fleet is registered in over 150 nations, and manned by over one million seafarers (BIMCO et al., 2004).

The shipping industry has a good safety record, however maritime incidents have a high potential for catastrophes. The first major oil spill in the English Channel in 1967 (tanker Torrey Canyon), provided a good picture for this environment of high pressure and acute time demands. To save 6 hours, the captain took a more direct route through the Scilly isles to arrive at Milford Haven in time to make the high tide. By missing this tide-window his ship would be forced to wait at anchor for five days before being able to enter the bay. Oil in the tanks was shifted in order to let the ship rise two inches to avoid a potential grounding. But then the unexpected happened; while passing through the Scilly isles, the vessel came across a fishing boat and was unable to turn quickly enough and the ship ran aground, contaminating a total area of about 300 km along the South-western coastline of England.

Valuable tool to access safety and performance

This article describes a brand new approach utilized to better assess the current safety and performance levels on board ships. Instead of trying to identify gaps in safety and performance by analyzing the outcomes of undesired events, this new method integrates Crew and Bridge Resource Management (CRM and BRM) training in full-mission simulators, on-the-job observations, training, coaching, mentoring, integrated with senior officer simulator-based BRM assessment. CRM training involves both deck and engineering officers of all ranks completing a standard simulator based course together. BRM involves only deck officers of all ranks training together.

BRM assessment includes two Masters and two Chief Officers together in a simulator being assessed on their utilization of BRM

principles. For US-Flagged Polar Tanker officers the training and assessment programs were conducted at the Maritime Institute of Technology & Graduate Studies (MITAGS) in Baltimore. Whilst for Foreign-Flagged officers it was conducted at Force Technology in Copenhagen Denmark. The overall concept (assessment protocols and communication log program) was developed by FORCE Technology. Each officer serves two simulations as Captain conning the team and the other simulation in support roles on the team. The assessment protocol includes customized scales to measure expected skills, and a unique communications log completed by a trained psychologist observer present on the bridge of the simulator. This log quantifies the amount and flow of communications for each team member, whether their focus is on the distant past, near past, present, near future or distant future of the simulation exercise, the type of communication (command, observation, question, or chatting), type of response (confirmation, answer, acknowledgement, muttering, or no answer) and is used during the debriefing. It has been observed that it tends to be a trend that low focus on the future decreases readiness and increases risk of surprises and critical situations. Mid-course feedback sessions with the lead instructor and psychologist provide each individual with the feedback necessary to improve over the remainder of the week. The valuable and accurate information obtained can therefore be utilized more efficiently in areas such as individual self-improvement, dedicated training, updating or making operating procedures more applicable or understandable, identifying hazards and local trends, etc.

The coach-observer (C-O) on board ships plays both an active and a passive role in order to assess quite accurately the so-called "non-technical or soft skills"; i.e.: how to properly manage fatigue, work pressure, stress; how to enhance communication abilities; how to best manage the impact of environmental factors on daily operations; how to improve socializing; how to motivate and get motivated; how to handle hidden fears and anxieties; how to overcome or reduce power distance; how to regain or enhance synergy; how to implement real team working and cooperation on board; etc. To our knowledge, this integrated three stage assessment has never been under-

taken within the maritime industry before. This activity provides the company with an in-depth knowledge that will permit tailoring training focused on identified needs and gaps, and makes it much easier to bench-mark and assess results afterwards. At the same time, this method will permit gathering a more accurate picture (by external observer) of real skills utilized on board.

The Socio-Technical Network

Many factors play a significant role in the error-inducing character of the system in shipping. The Socio-Technical Network model provides a very good insight into this, when addressing the relevant role a specific subject plays in incidents and accidents.

It is well accepted in Marine Accident Investigation that "the number one factor causing maritime accidents is human error". This is a rather simplistic explanation and its ambiguity leaves no room for the implementation of very specific actions and tools to ensure that repetition hardly ever will occur. Instead, the Division for Maritime Industry at FORCE Technology has recently developed a



Captain and QAO exchanging viewpoints on the bridge.

new concept that permits a more realistic view of human performance and failure, namely the "Socio-Technical Network". This new view states that it is the failure in the cooperation between the components in the integrated system where humans, the technology, the organization, procedures and the working environment, where accidents' root causes have to be searched for. It is more correct to talk about a functionality breakdown in the socio-technical system than about human, organizational, or technical mistakes. All the information obtained is properly processed and fed back to front line operators. Personal information is not fed back to Head Quarters because the focus is put on enhancing safety and

performance on board by working with human factors. Management will only learn about those issues that can only be solved with the support and authority of the top management.

The traditional way of studying human factors in the maritime work domain is by analysing accident reports, or, better, by analysing accidents in-depth. This traditional approach also has disadvantages, since it does not cover the human factors which did not lead to the reported accidents or near misses. Sometimes the human factor can be seen as a significant ingredient in an incident that is never reported at all.

Another issue is that the human factor may also prevent accidents and near misses. Human behaviour is therefore not only the cause behind a problem. It can also be the solution to the problem. This allows a better method to place confidence upon the system functioning as intended to prevent upset conditions or casualties. Therefore, it would be useful to find, discuss, and develop new empirical approaches for the collection of knowledge about the contribution of human factors to and the impact on the overall safety on board a vessel. We may say that this new activity significantly contributes to it.

Retrospective analysis of accidents

One of the best established methods for collection of knowledge about human factors in the maritime work domain is the retrospective analysis of accidents. A large number of tools have been developed. They have demonstrated their usefulness in this work but the new approach offers a constellation of new opportunities as the C-O gets the real view of the safety climate on board the specific platform. The C-O thus has a unique opportunity to evaluate the safety climate on board a specific ship. The safety climate is a snapshot of selected aspects of an organization's safety culture at a particular point in time. An important relationship between safety climate and performance exists, indicating that a robust measure of safety climate could be used as a predictive safety performance indicator. Here the mediating variables between the safety climate and the safety performance are the crewmembers' level of knowledge, skill, and motivation. The components of the safety performance, the C-O measures

are the safety task performance and safety contextual performance.

Situations with poor communication abilities, misunderstandings between the pilot and the master or the officer on watch, aggressive autocratic management styles, reluctance to question a senior officer's decision, lack of practical use of the CRM principles, wrong interpretation of the teamwork concept, and the impacts of different management styles in performance and safety, can best be observed and analyzed as well as scenarios can be improved by using this new method.

Ecological validity

This method has been implemented on board the ConocoPhillips tank vessels (US Flagged Polar Tankers, Norwegian Flagged Shuttle tanker, and Marshall and Liberian Flagged Aframax Tankers staffed by Spanish officers and Honduran crew) for a bit more than a year now. This method of assessment has ecological validity as it is carried out in the real operating environment, providing a unique insight into inter-departmental differences when comparing engineers to deck crewmembers.

This combination of observations, coaching-mentoring, training and assessment on the spot has already proved beneficial to crewmembers and the company. Radical changes have been noticed in the form of better dialogue and communication among crewmembers, better at anticipating and preventing conflicts, better at delegating both assignments and responsibility, better at reducing, trapping or mitigating errors and their consequences. A ship is only as safe as the way it is operated and the company does not operate the ship - crewmembers do.

Time, effort and money spent on health and safety is an investment, not a cost and this new type of activity on board is an integral part of it. It helps us ensuring that we protect the people, the assets, the environment and the reputation of ConocoPhillips.

The C-O takes this message across all ships in the fleet and his presence is interpreted as a very strong signal of how important all aspects concerning human factors have become for top-management ashore. ■



Communication Bosun-Bridge, making anchors ready.

Architectural Boomerang over the Seine

By Søren Vestergaard Larsen, Senior Project Manager, Hydro- and Aerodynamics

FORCE Technology's wind tests are approved for spectacular bridge over the river Seine in Paris.

The river Seine winds its way calmly through the heart of the city of cities. Toward the west near Boulogne-Billancourt, it cuts a large curve in its course. In this curve is the small crescent-formed island, Ile Seguin, which at the moment is the centre of a large development taking place in the area from where there is a view of the city's 100-year-old architectural landmark: The Eiffel Tower.

Soon, Ile Seguin will be the location for another spectacular architectural landmark: The boomerang shaped pedestrian bridge, Passerelle de Sèvres, which will connect the island to the river bank and provide access to the cultural and scientific institutions, which will take possession of the area.

One arm of the boomerang forms the 80m main span across the Seine while the other forms the approach ramp on the Sèvres bank. The suspension bridge will look impressive and contribute to giving the old industrial area new wind beneath its wings.

The wind plays a part

The wind factor has been taken very seriously by both designers and architects.

Not only must the bridge be stable in strong winds, it must also have the correct aerodynamic design so that pedestrians experience the bridge as safe and reliable. Aesthetics and technology have to complement each other. This is a task in which FORCE Technology has been deeply involved.

In 2006, FORCE Technology was contacted by the British engineering consultant, Flint & Neill Partnership, who are consultants for the owner. They wanted to test the bridge's design and performance in relation to various wind conditions. An exciting and interesting task as the bridge's asymmetrical form contains many complex, technical challenges. FORCE Technology has very modern test facilities at our disposal and in the course of a relatively short time, we were able to deliver the requested data on which the architects and designers could base the further work on the bridge's final design.



View of the foot bridge's deck.

Thorough test

The designers in FORCE Technology's model workshop created a true model of the boomerang-shaped bridge deck in the scale ratio 1:20. The tests were then conducted in one of the company's three wind tunnels. FORCE Technology used about one-and-a-half months to conduct the thorough tests, which provided the designers with important data about how the bridge reacts when the wind force increases. ■

"FORCE Technology was amongst the companies that were qualified to conduct the wind tunnel tests. We have previously worked together with FORCE Technology and we know that the company has a good professional reputation in international circles. Since the economy was also advantageous, we chose FORCE Technology. They have also lived up to the good reputation as far as professional competence and collaboration are concerned. As a design company, we naturally place great importance on design and technological innovation comprising an integral whole. FORCE Technology has contributed to the documentation that Passerelle de Sèvres lives up to our ambitions", says Ian Firth and Chris Barker from the British company Flint & Neill Partnership.



Illustration of the Passerelle de Sèvres crossing the Seine.

Towing Carriage & Wind Tunnel Upgrade

By Christian Schack, Head of Department, Hydro- and Aerodynamics

In order to upgrade its capability FORCE Technology has made major investments in the in-house facility.

Our towing carriage has been through a major upgrade including a new power and control system (new AC-motors, AC controllers, and power transmission). The result is a carriage that can accelerate faster and operate very accurately with a speed from 0 m/s up to 14 m/s. At the same time the carriage's computers, main cabling, and communication systems have been replaced. Currently we are upgrading our photo and video systems to the latest standards. The final upgraded carriage will result in an even more streamlined service for our clients.

In our wind tunnels we have upgraded the power generation and control in our high speed wind tunnel. This will allow

for faster and easier control of the wind speed. The wind tunnel can operate with speeds up to 80 m/s.

Currently we are expanding our capacity and capability of our wide boundary layer wind tunnel. By introducing a removable truncation, very large turntable, and automated traversing system we can expand the wind tunnel's usability and thereby ensure a fast turnaround on all our wind tunnel projects (including buildings, bridges, ships, and offshore platforms).

The design of the truncation in our wind tunnel has been evaluated and optimized by our in-house viscous flow CFD expertise ensuring the best possible flow quality in the upgrade wind tunnel. Once the upgrade has been finalized we will revert with further details on the capability of the wind tunnel. ■

PROFILE: Hydro- and Aerodynamics

The consultancy within hydro- and aerodynamics is supported by advanced testing facilities (model basins and wind tunnels), several in-house developed numerical design tools combined with state-of-the-art commercial CFD codes in order to assist our customers in the development of their projects. The department has been entrusted with hydro- and aerodynamic consultancy for numerous prestigious projects. Customers are leading shipyards, ship owners, oil companies, consultants, and civil engineering contractors.

FORCE Technology's consultancy services include:

- hull lines development, and review
- stability calculations and analysis
- resistance and propulsion
- propeller design and cavitation tests
- damage stability tests (Stockholm tests)
- manoeuvring tests (captive or free sailing)
- seakeeping tests on ship and offshore structures
- VIV tests on risers and offshore platforms
- station keeping tests (DP)
- wind forces on ships, offshore platforms, buildings and bridges
- wind comfort around buildings, cruise vessels and other passenger vessels
- wind environment investigations.

Facilities:

- large towing tank and shallow water basin
- wind tunnels – high speed, boundary and wide (full bridge models and terrain models)
- NAPA hull design system
- AUTOCAD and CATIA CAD/CAM systems
- NC milling machine for hull and propeller models
- rapid prototyping for bridges, buildings and appendages
- CFD codes – COMET and SHIPFLOW.



FORCE Technology towing carriage.



PROFILE OF:

Anton Minchev
Chief Naval Architect

Anton Minchev started working at FORCE Technology in 1999. He has previously worked at BSHC in Bulgaria and at Keppel FELS in Singapore. His profound know-how covers a very broad field of hydrodynamics. Today his main work includes hull form optimisation, ship propulsion and ship seakeeping evaluations. As a part of his work Anton is a member of the ITTC Propulsion Committee.

You can contact Anton by email ami@force.dk.

Rapid Design

By Christian Schack, Head of Department, Hydro- and Aerodynamics

FORCE Technology has implemented a new in-house rapid prototype printer for production of components on ships, offshore platforms, buildings, and bridges to be used for tests in wind tunnels and towing tanks.

With our new 3D rapid prototype printer, we can produce very complex model details extremely accurately. Based on a 3D CAD drawing, the printer makes a 3 dimensional print, just like an office ink-jet printer; except it is in 3D. In each pass, the printer head deposits a fine layer of plastic with the thickness of 16 micron.

The objects can be printed to almost any complexity; even with several moveable components inside each other, for example flap rudders, ducts, etc. Furthermore, it is possible to include complex geometrical details normally ignored.

It is fast and accurate, so just imagine how this opens a portal for improving experimental possibilities: Fast generation of geometrical variants allows the client to tests more variants and thereby faster obtain an optimized solution.

The 3D printer can create 16 micron details. By material choice different struc-

tural properties can be modelled from soft rubber to hard nylon materials. This allows the designer to design parts which previously were very expensive and difficult to model.

Individual objects can be 500 x 400 x 200 mm of size or they can be made even larger when assembling parts.

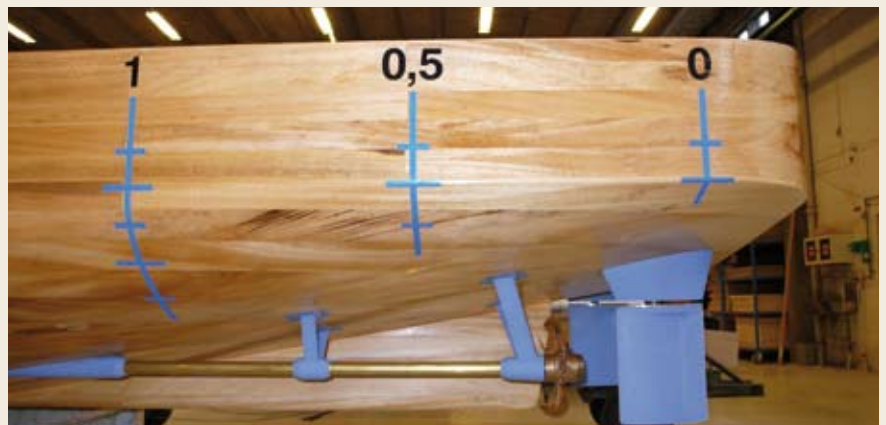
During the last months we have upgraded our 3D design tool to support designs for our workshop with large CNC controlled milling machine and our 3D printer. Today we use and support the following 3D

design tools:

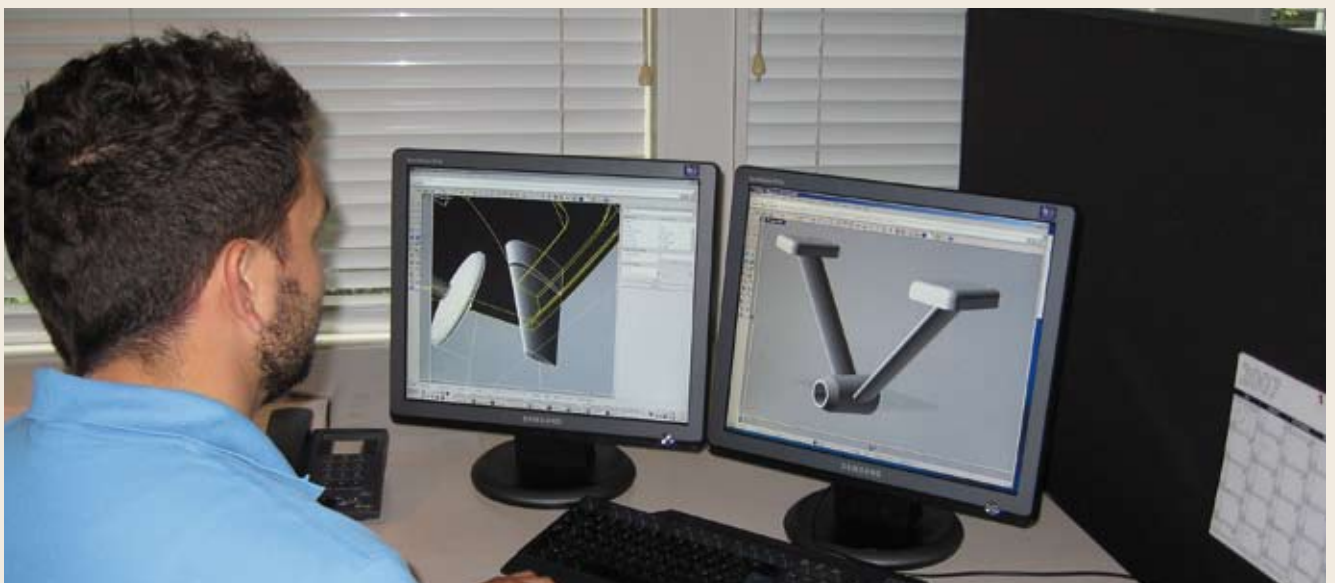
- NAPA (hull form design)
- Maxsurf (hull form design)
- FastShip (hull form design)
- Rhino (general 3D design)
- Catia V5 Solid Works (general 3D design)

We are thereby able to access the most 3D data files available from our clients, thus ensuring a fast and efficient handling and exchanging of data.

For all hull form design tools we can easily prepare input files for all our numerical tools again leading to shorter lead times. ■



Complete set of appendages in RPT.



FORCE Technology possesses the majority of modern 3D design tools used in the marine business.

Just Delivered

M/Y MOON GODDESS

M/Y Moon Goddess has been delivered from Danish Yacht in Denmark to its owner. FORCE Technology was assigned to perform the model tests from the shipyard and during the trials the vessel fully lived up to the expected performance.



NLV Pharos

NLV Pharos has been delivered from Remontowa Shipyard in Poland to its owners Northern Lighthouse Board (NLB) in UK. FORCE Technology was assigned to perform the model tests from the designers Burness Corlett Three Quays in UK and the owners.



ESVAGT CARPATHIA

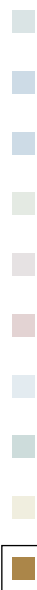
M/S Esvagt Carpathia has been delivered from ASL shipyard in Singapore to its owner. FORCE Technology was assigned to perform the model tests from the shipyard and the designer Ole Steen Knudsen A/S in Denmark. During the trials the vessel fully lived up to the expected performance.



FORCE Technology Becomes Member of the IALA

FORCE Technology is now a member of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA-AISM).

During IALA's ANM9 committee meeting in Oban, Scotland, Peter Sørensen from FORCE Technology presented a FORCE Technology memory-stick with a special "rope and fancy work" to Captain Eric Smith of Northern Light Board's new vessel NLV Pharos.



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