Maritime Engineering

– Accuracy, efficiency, flexibility and realism

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Providing sustainable decisions

View of one of our full-mission simulator bridges

As ship sizes increase, ports all over the world face new challenges. The new and larger ships require larger berthing facilities as well as improved training of pilots, captains and navigators in different and adverse weather conditions.

Changing a berthing facility or constructing a port is a decision with a wide-ranging impact on economy as well as on the surrounding environment. Today's technology combined with our competencies within mathematical modelling enables us to perform precise and realistic simulations of how a given change would affect vessels and facilities.

FORCE Technology has a long record of engineering studies and optimisation of port designs carried out for clients worldwide. Our mathematical ship and port models are recognised as being extremely realistic which is a prerequisite for accurate simulation. We offer knowledge about a port facility or terminal before it is built, thereby providing assurance and certainty about all implications of the project in advance.

About FORCE Technology
FORCE Technology works across fields, cultures and markets with the mission of developing solutions that focus on energy efficiency, safety and environment.

Our experienced engineers provide consultancy in e.g. the design of vessels and ports. We are experts within hydro- and aerodynamics and perform model testing on maritime and offshore constructions in our towing tank and wind tunnel facilities where we expose ship models to realistic wave, current and wind conditions. We know that an optimised design brings significant savings when it comes to the operation of ships and ports.

We also develop and sell simulators for training of ship crews. Our simulators are known for providing an extremely realistic virtual universe which is crucial when used for teaching, training and planning.

In addition we perform CFD model tests (Computational Fluid Dynamics) for hull optimisation. Finally, we offer courses on decision making processes and communication as well as the relationship between man and machine – also known as 'Human Factors'.

We offer support within:

- Placement of navigational aids
- Evaluation of breakwater layout and alignment including width and alignment of approach channels
- Under keel clearance optimisation and guidance
- Evaluation of arrival/departure conditions for existing or new port facilities
- Ship motions in both frequency and time domains giving accurate assessments of e.g. risk of grounding
- Ship motions of moored vessels along an open or a closed structure
- Controllability of vessels at limited water depth
- Operational guidelines including determination of tug assistance
- Risk analysis
- Evaluation of offshore operations and concepts

Services and products

Tug master simulator training on board a tug connected to an LNG vessel

Simulation – efficient, flexible and cost saving
Simulation offers a very cost effective approach during the evaluation of the port layout as well as when placing of navigational aids.

FORCE Technology has developed a wide selection of simulators ranging from desktop versions to full-mission 360° field of view bridges to be used for everything from initial investigations to extensive training programmes.

The SimFlex Navigator simulation software is used in both desktop and full-mission simulators. The simulators are based on the same mathematical model enabling users to shift between platforms without major changes.

Coupling of simulators
For engineering studies and simulations involving tugs we have the possibility of coupling up to 4 simulators. This advanced simulation tool and the involvement of tug masters in a realistic environment ensures valuable input to the manoeuvring strategies for new ports or terminals.

Offshore operations and strategies
By simulating offshore operations, our simulators can be used to evaluate different strategies and help optimise the operation with respect to operational limits, increased safety, risk mitigation as well as communication.

The simulators are used for tow out operations of deep draft platforms, analysis of different offshore loading concepts, jack-up operations including critical scenarios like punch-through, thruster leg/spudcan interaction, area and weather evaluation and many other tasks.

Port studies
At each port, the Port Authority is responsible for the maintenance and development of the port facilities and for maintaining navigable access to the port for commercial shipping.
To proactively plan the operations, the Port Authority needs to initiate solutions to comply with the demands for e.g. depth or operability in the approach and departure.

Constructing or changing a port facility has great impact on the surrounding environment. Simulation makes it possible to illustrate the consequences of a given change, and thus the acquired knowledge makes it possible to make sustainable decisions.

In order to evaluate and verify a port layout, a visual model of the selected area is used in the simulator.
Based on charts and harbour drawings provided by the customer, we are able to establish the numerical models of the bathymetry and topography. We can also implement wave and current fields calculated by numerical models.

The visual model is based on texture techniques. Photo textures can be applied to all fixed or moving objects, thus creating a highly realistic environment. The system can provide night, dusk, and daylight scenes as well as reduced visibility due to fog, snow or rain.

Ships are shown in the visual scene together with buoys and navigational lights and leads with appropriate colours, sectors and flashing characteristics.

Wave action is also illustrated according to the specific sea state and direction and the horizon moves according to the motions of the ship. The noises from the ship's engine and thruster as well as wind and sea noises are heard in our full-mission simulators.

Offshore simulation with a wind turbine installation vessel

Joined forces to improve operability
Together with DHI, FORCE Technology has developed a new method to evaluate and quantify the approach and departure operability issues.

As FORCE Technology, DHI is an independent research and development organisation working globally. DHI is one of the leading organisations within current and wave modelling, while FORCE Technology is leading with respect to ship manoeuvring and motions.

Based on a model of a ship in a given loading condition, we are able to calculate the theoretical motions of a ship in different sea states which, combined with statistical methods, enables the probability of grounding to be determined.

DHI use their 'MIKE by DHI' software package to calculate current, tide and waves for a given period and a given location.

Based on FORCE Technology and DHI computations, the DHI non-linear channel optimisation software (NCOS) then calculates the operability by checking passages of a route starting every half hour. The actual environmental condition is used to determine the risk of grounding. An agreed risk level provides the program with a span to mark a passage as operational or too risky. In the end, the program is able to provide estimates of the operational limitations for the channel.

Channel optimisation
A study based on the probability of grounding can be used to increase the operability, i.e. how an approach channel can be optimised in regard to dredged quantities and costs involved.

As the method provides operational percentages, it can pin point the high risk areas. This information enables the optimisation of the approach channel and minimises otherwise expensive dredging.

By simulating arrivals and departures through the optimised channel, the simulators can be used to confirm results and add observations made by the captain or pilot to these results. The objective is to provide port operators with a tool to assist ships with safe passage plans into the port based on the ship's specific particulars.

Desktop studies and tug simulators

A desktop simulator set-up

Desktop studies
The fast-time simulations might be followed by a short desktop study carried out at FORCE Technology or at the customer's premises, using portable equipment. The simulations are carried out real-time with a human navigator to manoeuvre the ship, e.g. assisted by tugs to the berth.

These low-cost real-time simulations are validated through full-mission simulations with participation of local pilots, port authorities and operators.

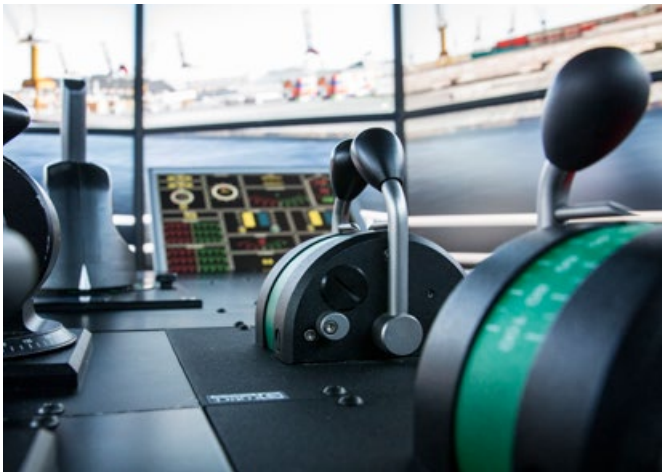
Accuracy – a key to perfection
FORCE Technology's mathematical ship model is among the most accurate on the market. It also serves as the backbone of our services within maritime engineering.

The model has been validated in numerous cases against model tests and full-scale measurements. With access to extensive experimental facilities including towing tanks, wind tunnels and professional mariners, the hydrodynamic models are continuously updated and refined.

Tug simulators
A realistic training environment is very important when learning to handle a ship. Realism ensures efficient and correct work routines, thus minimizing the risk of accidents. Consequently, FORCE Technology offers training facilities with real handles, joysticks, instruments, back-up systems etc. in the simulators, creating a true replica of the bridge equipment on board the simulated ships.

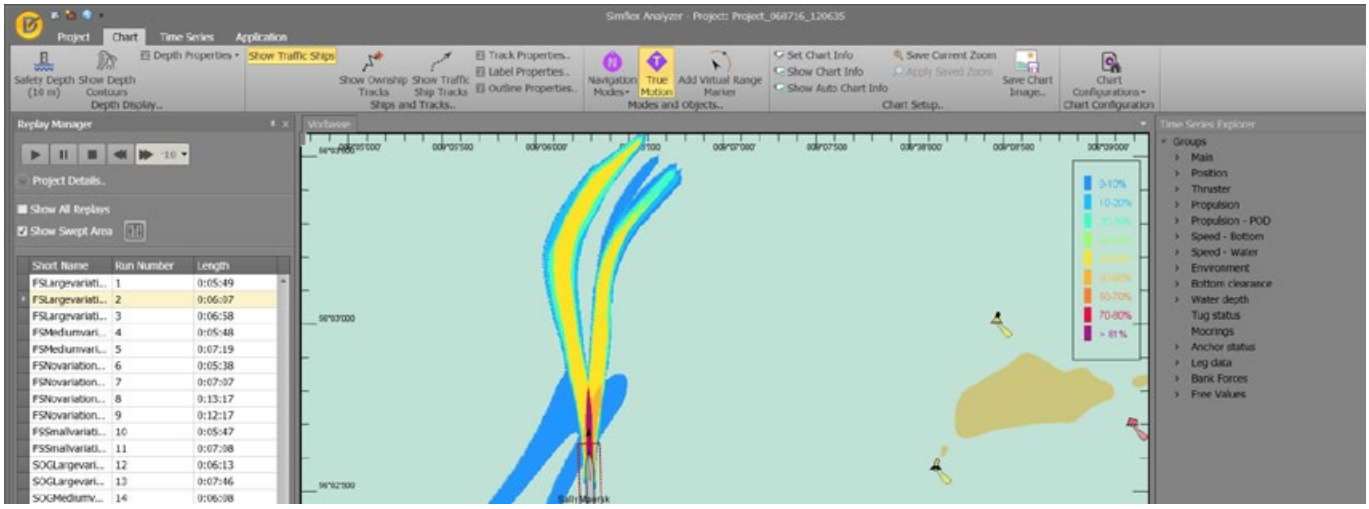
We specialise in providing training for crews operating special ship types fitted with special propulsion.

The need for tug assistance can be investigated in relation to tug size, number, type and strategies using our full-mission tug simulation system.



Authentic ship handles used in our simulator

Visual scene realism – 3D perception



Our replay/analyser program used for post processing of simulator black-box recordings

The SimFlex Navigator ship bridge and port simulator solutions are offered with state-of-the-art 3D perception projectors which contribute to achieving a high level of realism.

In cooperation with FORCE Technology, the customer decides the level of detail needed for the ship model and the port database.

FORCE Technology has been producing port models for more than 20 years. The close cooperation between engineers and instructors ensures the optimum solution while still maintaining a superior level of accuracy in the presentation of water depths, current, wave patterns, navigational marks, hydro- and aerodynamic effects and port layout.

Pilot training

One of the objectives of pilot training is usually to familiarise the pilots with a new port layout and the associated restrictive conditions. Using our part-task or full-mission simulators, the pilots can train arrivals and departures under a wide range of environmental conditions.

Debriefing is a crucial part of the training. After each session, the pilots and our instructors evaluate the performance using our debriefing tool in order to propose amendments to procedures or establish the operational envelope.

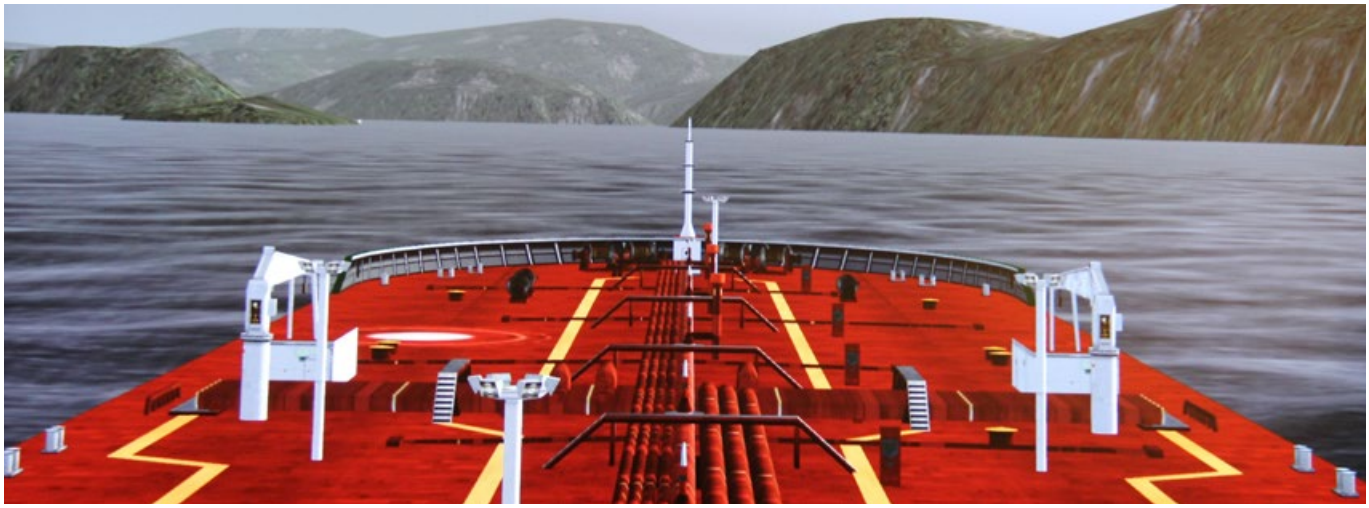
As a part of the study or pilot training, we can provide an operations manual addressing the manoeuvring strategies for various ship types under different loading and weather conditions. This is a great benefit to both the port and the pilots as it provides valuable information to plan and execute approaches, dockings and departures in a safe manner.

These guidelines will define the limiting conditions according to the most critical situations as well as the requirements for tug assistance. These will impact positively on both safety and efficiency.

In cooperation with the Swedish Marine Authorities we have been instrumental in the development of IALA's guideline No. 1058 for use of simulators for design of waterways and placement of aids to navigation.

Engineering studies are planned, executed, analysed and documented according to the guideline.

Simulated sailing of tankers on British Columbia's north coast



Simulation of a VLCC entering the Canadian west coast bound for Kitimat

The energy provider Enbridge contracted FORCE Technology to carry out more than 100 real-time simulations of the 200 km (125 miles) route from the open sea to Kitimat, Canada, and back with the assistance of BC Coast Pilots. The project was called Northern Gateway pipelines.

Fast-time simulations
The process of simulating sailings with large tankers is structured around both fast-time simulations and real-time simulations. Fast-time simulations are runs made by a computer programmed with navigational parameters. They are carried out quickly and provide an overview of how to sail ships safely through different areas, for example where the route becomes less wide. The fast-time simulations proved to Enbridge that the proposed marine routes could be navigated by vessels up to Very Large Crude Carrier (VLCC) class without the assistance of escort tugs for the selected weather conditions.

Real-time simulations
After the fast-time simulations, FORCE Technology performed real-time simulations. The real-time simulations verified the conclusions obtained in the fast-time simulations and also assessed the two-way traffic, crossing traffic and emergency scenarios which provided Enbridge with additional information required to develop marine safety plans.

The real-time simulations also focused on the number of tugs required for berthing and unberthing tankers at the marine terminal.

The advantage of real-time simulations is that both captains and local pilots navigate the same route under different weather conditions, thus gaining an overview of possible operational limitations and the optimal manoeuvring strategy for a given weather condition.

Moreover, real-time simulations uncover possible technical and human errors under difficult conditions, thereby increasing seafarers' ability to operate the ship safely in real life.

The importance of escort tugs
One of the more important outcomes of the project was FORCE Technology demonstrating the effectiveness of having tug escorts in attendance to assist when navigating from the marine terminal in Kitimat to the pilot boarding stations and open sea in case of a technical problem, for instance a blackout, on board the tanker. This led to Northern Gateway being the first to offer a marine terminal on BC's north coast.

FORCE Technology was subsequently asked to attend public hearings that took place in Prince Rupert, British Columbia, during the first quarter of 2013 and emphasised the important role that fast- and real-time simulations had in shaping Northern Gateway's marine safety plans.

Combining desktop and full-mission simulations

PROES performing full mission simulations

Spanish maritime design and engineering company PROES combine the use of their own desktop simulator with the full-mission simulators at FORCE Technology in order to bring their projects to the next level.

Desktop simulations are a necessity
PROES purchased their own desktop simulator from FORCE Technology three years ago as they found that they were offered a good balance between price and performance.

José Manuel Garcia, Head of Marine Terminals, port and development at PROES, elaborates, "We also appreciate the flexibility FORCE Technology offers. You can start with something simple and then build on to make it more complex and therefore more realistic. This way we got a flexible simulator system at an affordable price."

As PROES is involved in the engineering process from the conceptual stage to the finished product, they need a desktop simulator to help them through the design process to reach the best solution regarding different aspects such as required navigational areas and detailed sizing of marine structures. "Our customers demand a numerical verification when it comes to everything from optimising canal widths, structural response or moored vessel behavioural studies. Today this kind of tool is a necessity!," explains José.

Taking the project to the next level
When a project requires further detail and more specific devices, PROES uses the full-mission simulators available at FORCE Technology.

"When we bring the model to FORCE Technology's facilities, it is ready for implementation in the full-mission simulator. Therefore the workflow can be described as a seamless process," says José.

The knowledge of the employees is also a crucial part of the process. "We have obtained a lot of knowledge before we come here, but the tug masters and designers at FORCE Technology bring us further with their knowledge of e.g. manoeuvring strategies. On top of that, the realism of the virtual universe is an essential part," explains José.

According to José, the full-mission simulator also functions as a necessary validation and optimisation tool when designing a well-functioning harbour facility. The designers and engineers at PROES obtain the navigation areas using the desktop simulator. However, they need the full-mission simulator to confirm the design. They also involve pilots, captains, tug masters and others to learn what needs to be optimised or improved.

PROES brings the stakeholders on these visits in order for them to experience the realism of the virtual universe in the full-mission simulators. However, the situation is also an opportunity to incorporate the perception of the end-users into the project "By bringing the pilots, harbour masters, nautical and environmental authorities, owners and developers along, we can adjust, optimize and validate the project. This way we end up with a successful product that everyone feels comfortable with;" José concludes.

The world's largest ship tunnel in the making

Simulator view of M/S 'Midnatsol' passing through the Stad tunnel. Photo credit: The Norweigan Coastal Administration/Kystverket

NOK 1 billion has been earmarked for the establishment of the world's largest ship tunnel in the Norwegian Stad ocean during the second half of the National Transport Plan period 2014-2023. If the project is approved by the Norwegian Parliament, the work could begin after 2018.

Kystverket has been given the assignment of performing a feasibility study for the project, which will form the basis for further quality assurance and project assessment by the Norwegian government.

FORCE Technology assessed the safety and efficiency of the tunnel by designing and testing a digital model of the tunnel and existing ships.

The tunnel will facilitate a new high speed craft route from Bergen to Ålesund which is not possible today due to harsh weather conditions: "It will also make it safer and easier for commercial traffic to sail past the Stad peninsula. Normally it takes about two hours to sail through Stad, but during harsh weather, vessels must either navigate at low speed or wait for better weather conditions. It can take up to ten hours to wait for the weather to clear up. The long wait means that some freight ships carrying live fish could end up with low quality goods," says Terje Andreassen, Project Manager at Kystverket.

The tunnel will provide a shield making it possible to sail through sheltered waters safely regardless of the weather.

Controlling the traffic

As the tunnel will be surrounded by relatively narrow inlets on both sides, one of the biggest hurdles will be controlling the traffic capacity: "Our traffic regulation studies show that it is most efficient to send a convoy of ships (maximum of five) in one direction and then afterwards from the other direction. Some ships like high speed crafts will need to pass more often and will be given specific time slots," says Jens Erik Bay, Project Manager at the Department of Simulation, Training and Ports at FORCE Technology.

Collaborating throughout the process

In June 2016, Kystverket visited our facilities in Lyngby. Their captains and pilots tested the virtual model of the tunnel. We also developed models of two of the ships that would sail through the tunnel; a 150-meter long freight ship and the cruise ship MS "Midnatsol".

This provided us with a chance to confirm our suggestions and obtain indications of small adjustments so the model matches reality: "When the captains test the tunnel, we obtain indications of safe distances between the ships passing the tunnel at the same time, necessary navigation and manoeuvring tools, weather limitations and reduced visibility from fog and lack of daylight," Jens explains.

Kystverket has been very content with the simulations, "We had a very good outcome from the visit. We conducted many trial passages with different ships and tried sailing in a convoy through the tunnel. We discovered a few small adjustments; the angle of the eastern entrance way needed to be softened, making it easier for the vessels to enter the tunnel. FORCE Technology will also continue working on a way to bring down the time it takes a convoy of five ships to sail through the tunnel," says Terje.

Reference to national and international standards

In June 2011, IALA issued the second edition of (IALA Guideline 1058), Use of Simulation as a Tool for Waterway Design and Aids to Navigation Planning.

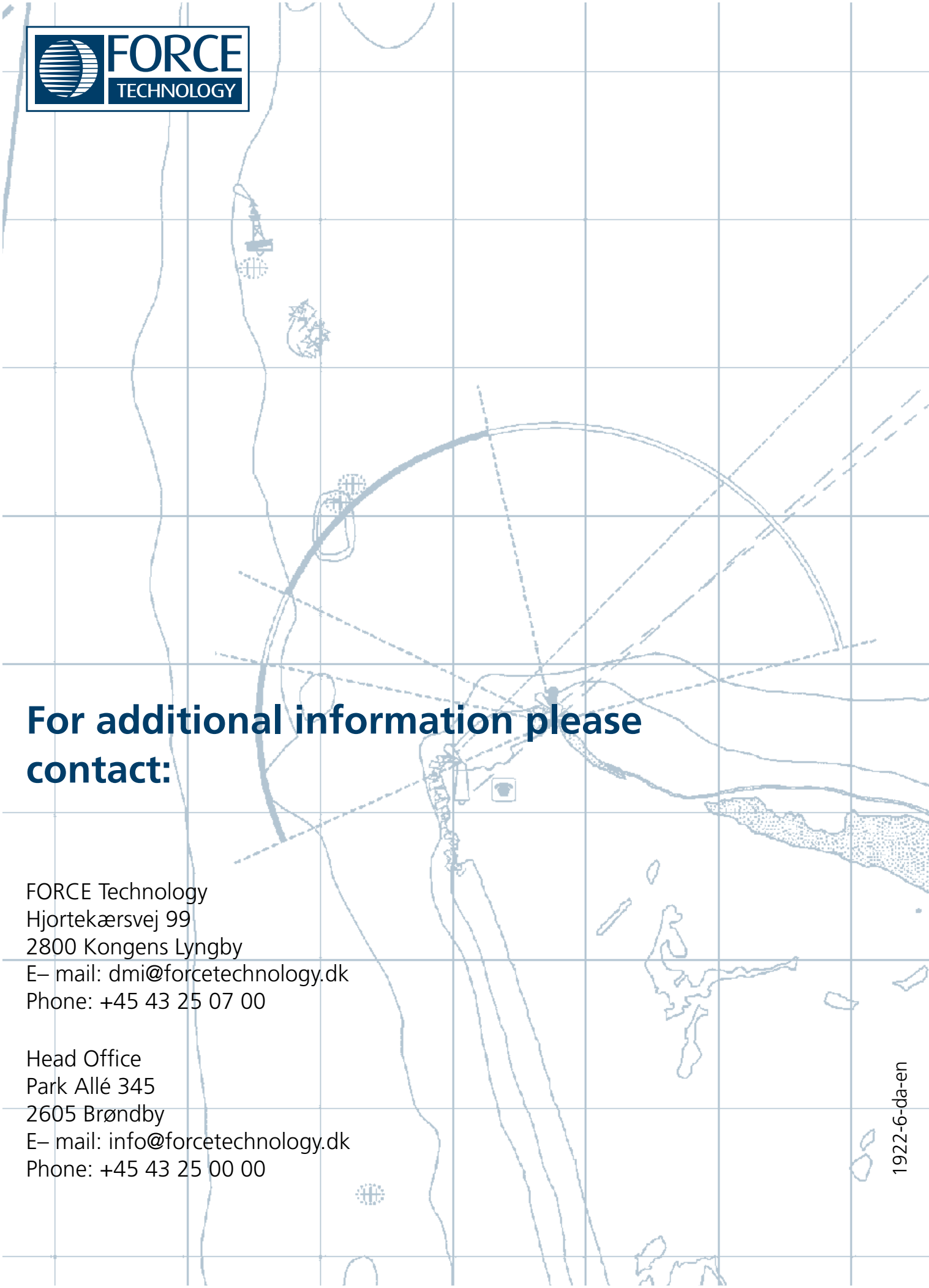
In general, the new guideline provides input to the available simulation tools (fast time, desktop, part task, full mission and traffic flow), how to select a specific simulation tool for a given task and how to plan, analyse and report a simulation study.

The guideline also suggests important issues to consider regarding the capability of the simulation software and the advantages and limitations of each type of simulation tool. Finally, the importance of accuracy and realism should be carefully considered.

In this connection, it is important to understand that such studies require very accurate mathematical models of the vessels and accurate input data (bathymetry, current, waves etc.) for the areas to be studied in order to be able to provide a sufficient basis for decision making.

In addition, the guideline stipulates that studies should be carried out by experienced engineers and mariners, including tug masters, with recent operational and simulator experience, that focus should be on the technical aspects as well as Human Factors and that the facilities should be of a certain quality and standard. FORCE Technology has fully implemented the IALA guideline and lives up to the best standards within the industry.

The simulator centre is recognised by the Danish Maritime Authority (DMA) as a maritime training institution and the development and implementation of training courses is conducted in full compliance with the Danish Maritime Authority's guidelines for Quality Management of Maritime Training and Education. Our centre is also recognised by STCW as amended and by DNV-GL as a maritime training provider.



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