RISK ANALYSIS AND WATERWAYS

Risk is primarily a judgement, not a fact. Risk analysis is needed for obtaining a figure concerning the unwanted but unsure possible events of the future. The aim of risk analysis is to model the state of the world or nature via simplified functions and links between observable parameters, actions and events.

Risk is determined by multiplying the potential consequence or loss amount by the associated occurrence’s probability or the frequency of said event. The aim of scientific activities related to risk is to build reliable risk models and to evaluate the statistical characteristics of the observable quantities. The risk models and related parameters can be studied using experience from the past, analysing the physics of the events by means of theoretical models or full-scale testing and studying the problem in tests using scale models. Simulation tools are rapidly improving such that both single events, such as ship collisions or incidents of running aground, and system behaviour (e.g., including all ships in a certain area) can be realistically simulated.

A lot has been done to decrease the risk of marine accidents in the Baltic Sea. In particular, new technology has provided new tools for monitoring the traffic in the area. Among these tools are the vessel traffic monitoring system (VTS), vessel traffic management and information system (VTMIS), mandatory ship reporting system (GOFREP) and automatic identification system (AIS). These systems can also produce useful data for research purposes, to guide in the building of reliable risk models and increase the quantity and reliability of statistical information on the sea traffic and related events in the area. The final aim of the long-term research is to determine classifications for risks along the sea routes of the Baltic and, on the basis of the picture thus provided, establish measures to decrease the risks.

The new professorship in marine traffic and winter navigation safety is to concentrate on these topics. The holder of this new position will act under the Merikotka marine research association, which conducts research related to marine safety, logistics of transport and the marine environment, especially in the Gulf of Finland and the Baltic Sea. The objective is to strengthen research and development in the maritime arena on the basis of a broad international co-operation network. The research staff are under the administrative jurisdiction of the Helsinki University of Technology, Kymenlaakso University of Applied Sciences, University of Helsinki and University of Turku.

Pentti Kujala
TKK Ship Laboratory
The research discussed here is part of the ongoing wave-maker renewal project at the Maritime Institute of Finland (Mikkola, 2006). The task of the project has been to assess the quality of the wave generated by triangular wedges of different angles and to estimate the size and power requirements of the traversing gear for the new wave-maker. The fully non-linear simulations have been performed by solving the unsteady Euler equations with the time accurate, unstructured finite-volume flow solver YAFFA (Yet Another Fine Flow Analyser), being developed by the author. In addition to the main task, much of the work in the project has gone into the validation of the new flow solver.

The solver is based on application of the SIMPLE/SMILEC type pressure correction method on unstructured 2D grids. Unsteady problems are treated with a dual time step approach and a three-level fully implicit scheme. For free surface flows, a surface tracking approach is used. The main features of the approach include deformations in the direction of the boundary normals, semi-implicit treatment of the kinematic boundary condition and a partial coupling of the free surface and the pressure correction equations. Updating of the grid is handled with a linear/torsional spring analogy and/or with Laplacian smoothing.

Before the new simulation method was applied to the design problem, it was validated in the project with similar problems. Attention has been paid to the simulated forces as well as to the wave fields created by bodies in harmonic motion. For the force validation, the heaving wedge test case of the ISOPE 2nd Numerical Wave Tank Workshop has been used. The results with different motion amplitudes and periods have been compared with the experimental results as well as with the simulation results of seven other numerical methods.

Additional measurements have been made with the wave-maker at the multipurpose basin of the Ship Laboratory in order to obtain experimental validation data also for the wave field. The measurements consisted of simultaneous recording of the motion of a wedge-type plunger wave-maker and the wave height at the centre of the basin. The measured cases were then simulated with the actual motion of the wedge as an input (see Figure 1).

The main part of the project has been the application of the method for a practical design problem. Three triangular wave-makers, with the same neutral water line but face angles of 25, 35 and 45 degrees, have been studied. The performance of the wave-makers has been compared in terms of the variation of the wave height and the quality of the wave field generated. The quality of the wave generated has been assessed primarily by studying the horizontal and vertical asymmetries of the waves. The quality assessment has taken account of both the space and time dimension by analysing the fluctuations of the asymmetries of the wave geometries during a motion cycle.

In addition to the differences in generated wave height, there are considerable differences in the quality of the wave produced – especially in terms of the variation of the vertical asymmetry. It can be roughly stated that increasing wedge angle results in increasing fluctuations in the wave geometry and thus decreasing quality in the wave. Differences are especially large for longer waves and larger motion amplitudes. The variation of the asymmetry for all wedges tested is also highly dependent on the motion frequency. There is a clear optimal area for each wedge, where the variation of the vertical asymmetry is at its minimum. The corresponding frequency increases slightly with the wedge angle.

On the basis of the quality assessment, the 35-degree wedge was selected for further study. The maximum force and power required of the driving mechanism at different frequencies was then estimated, using Fourier analysis for the force time histories combined with the maximum motion amplitude resulting from mechanical limitations and the limit for breaking waves (see Figure 2).

The final part of the project is going to be the validation of the simulation results with the installed system. Of particular interest is the correspondence between the simulated and measured transfer functions for the wave-maker.

![Figure 1. Calculated (red) and measured (blue) wave with motion amplitude $A = 150\, \text{mm}$ and period $T = 1.6\, \text{s}$.](image1)

![Figure 2. The maximum dynamic force and amplitude for the new wave maker with different masses](image2)
RANS PREDICTIONS FOR END-PLATE PROPELLER AND COMPACT AZIPOD AT MODEL AND FULL SCALE

VTT has numerically investigated the hydrodynamic performance of two multi-component propulsors, an end-plate propeller and a Compact Azipod unit at full and model scales at the design operation points, respectively. The analysis used the RANS (Reynolds-Averaged-Navier-Stokes Equation) solver FINFLO in the calculations. FINFLO is a multi-block cell-centered finite-volume computer code with sliding mesh, moving-grid and free-surface capabilities. Computations are made at model and full scale using Chien’s low Reynolds k-ε turbulence model. VTT generated the computational meshes with the IGG grid program and a program built in-house. The ENSIGHT program was used for post-processing the output files.

A summary of the results for the end-plate propeller analysis is presented here. For more details, the reader is referred to the original paper (Sánchez-Caja et al., 2006b). Special emphasis was placed on describing the flow over the end-plate. Relative differences between calculation and experimental results are presented for performance coefficients in open-water condition at model scale. Good correlation with the experiments was obtained in terms of overall forces.

The model scale grid used in the present end-plate propeller calculations consisted of 3,264,000 cells distributed in 11 blocks. The full scale grid was similar, but somewhat larger with 3,699,200 cells. Both grids have the same number of cells on the rotating surfaces. In total, 12,800 and 8,960 cells were located on the blade and endplate surfaces, respectively.

Table I shows the scale effect on thrust, torque and efficiency as percentages of their values at model scale. The increase in thrust is considerable (9.7 per cent). The torque coefficient is less affected by the scale effect. However, the change in torque caused by scaling seems to be higher than that apparent with conventional propellers.

Figures 1a and 1b show the pressure distributions for the suction side of the end-plate propeller. The low pressure areas at the leading edge on the suction side are typical for skewed blades and coincide with the location of the leading edge vortex as it proceeds downstream, develops and detaches from the blade at the outer radii.

The RANS calculations showed a large scale effect on thrust coefficient for this particular end-plate propeller (almost 10 per cent), much larger than that found for conventional propellers. Usually cavitation tests are made in such a way that a dynamic similarity prevails over the kinematic one: i.e. $K_\epsilon$ at full scale is sought in the model scale tests. For conventional propellers, where scale effects on thrust are not so acute, one can expect the kinematic similarity (J identity) to be more or less fulfilled in tests with $K_\epsilon$ identity. However, for end-plate propellers the kinematic similarity may be questioned if cavitation tests are conducted in the traditional way. Aiming at a $K_\epsilon$ or J identity in the tests would be a better choice in this respect.

A summary of the results for the Compact Azipod analysis is presented here. For more details, the reader is referred to the original paper (Sánchez-Caja et al., 2006a). Calculations with FINFLO can be made in three different forms; time-accurate, time-averaged, and quasi-steady. For the present study on a Compact Azipod unit, the quasi-steady approach was chosen to account for the lack of axial symmetry in the flow around the propeller blades that arises from the presence of the strut. This approach focuses on a single position of the propeller and does not take into account memory effects present in the time-accurate method. The selected propeller position was that of one blade at the 1200 position.

The computations were made using coarse grids of 0.6 million cells and fine grids of 4.9 million cells. H-topology was chosen around the propeller blades and O-topology around the pod and strut. The calculations were made using two multi-grid levels for the design operation point conditions. The propeller forces converged quickly, in about 3000 - 5000 iterations. However, the drag forces on the pod converged more slowly due to the presence of flow detachment. The slowness of convergence was more apparent in the full scale calculations. It was related to the calculation of the separation areas: the separation areas were moving to its final shape slowly on account of the very small cells within the boundary layer.

Qualitatively, as is shown in Figures 2a and 2b, the pressure distributions are similar in the full and model scale calculations. Some differences can be observed in the high pressure areas on the rear part of the pod. For the streamlines the tendency is that the separation areas are smaller at full scale than at model scale, which results in a decrease in resistance for the full scale pod.

Table II shows the change predicted by FINFLO in the performance coefficients from model to full scale as percentages of the model scale values. The unit thrust coefficient is expected to increase by 7.1 percent, the torque by 1.0 and the efficiency by 6.1.

There are many parameters affecting the scaling of a podded propulsion unit, or a multi-component propulsor generally, which make it difficult to predict the correct extrapolation factors to be apply in a particular case. Such factors depend not only on the shape and type of passive components in the unit but also on the scale ratio, type of pod configuration (pusher/puller), propeller location, propeller loading, and other elements. There is a clear tendency to rely more and more on CFD tools to assist in model test experiments for this difficult task.

The work for the end-plate propeller has been performed as part of the European Union LEADING EDGE project. The authors wish to thank the partners in the LEADING EDGE consortium for allowing the publication of the present data. Special thanks are given to NAVANTIA for providing the geometry subject to investigation. Also, the authors wish to thank ABB Marine and Turbo-Charging for allowing the publication of the Compact Azipod data. Special thanks are given to Tomi Veikonheimo for providing the data subject to investigation.
REFERENCES


Table I. Scale effect on performance coefficients of the endplate propeller relative to model scale values in percentages for J=0.78. First level grid.

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_T$</td>
<td>100.0</td>
<td>109.7</td>
</tr>
<tr>
<td>$K_Q$</td>
<td>100.0</td>
<td>103.6</td>
</tr>
<tr>
<td>$\eta$</td>
<td>100.0</td>
<td>105.9</td>
</tr>
</tbody>
</table>

Table II. Scale effect on performance coefficients of the Compact Azipod unit relative to model scale values, in percentages.

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_T$ - unit</td>
<td>100.0</td>
<td>107.1</td>
</tr>
<tr>
<td>$K_T$ - blades</td>
<td>100.0</td>
<td>104.9</td>
</tr>
<tr>
<td>$K_Q$</td>
<td>100.0</td>
<td>101.0</td>
</tr>
<tr>
<td>$\eta$ - unit</td>
<td>100.0</td>
<td>106.1</td>
</tr>
<tr>
<td>$\eta$ - blades</td>
<td>100.0</td>
<td>103.9</td>
</tr>
</tbody>
</table>

Figure 1a. Pressure distribution on the suction side of the blade. Model scale calculation

Figure 1b. Pressure distribution on the suction side of the blade. Full scale calculation.

Figure 2a. Rear view of the pressure distribution and streamlines for a Compact Azipod unit. Port side, model scale.

Figure 2b. Rear view of the pressure distribution and streamlines for a Compact Azipod unit. Port side, full scale.
EXPERIMENTAL STUDY ON PROGRESSIVE FLOODING

Pekka Ruponen, TKK Ship Laboratory

INTRODUCTION

A new time domain simulation method for progressive flooding has been developed at TKK Ship Laboratory (Ruponen, 2006a) and implemented in the NAPA software. Dedicated model tests for the validation of the numerical method were performed in January 2006 in the towing tank of TKK Ship Laboratory.

MODEL TESTS

A large model of a box-shaped barge was constructed of wood and Plexiglass (Figure 1). The nominal scale of the model is 1:10. The model contains a Plexiglass block that is subdivided by one transverse bulkhead and two decks. One compartment is further divided by two longitudinal bulkheads, so that there are eight compartments that are connected through various internal openings.

The size and location of the damage opening could be varied. In total, six damage cases were investigated and reported upon in detail (Ruponen, 2006b). In one test, the floating position of the model was kept fixed in order for there to be a case for the validation without any effects from the motions of the model.

Contrary to standard practice for damage stability model tests, not all compartments were equipped with large ventilation pipes, since the simulation method developed can deal also with air compression and this feature had to be validated.

Water heights were measured in every flooded compartment, and the motions of the model (heel, trim and draft) were measured by means of a three-LED high-precision non-contact motion measurement system (Krypton RODYM6D). In addition, air pressures were measured in the double bottom, where air pockets could be formed during flooding. Two video cameras were installed in the model for visual observations.

The model tests were performed for obtaining data for validation of a numerical method. Therefore, the average values of the discharge coefficients for each opening type (size and shape) in the model were needed. These values were evaluated experimentally by draining of water through the openings.

VALIDATION

The tested cases have been simulated with the new method in the NAPA software with a good correlation. An example of the results is presented in Figure 2, and a more extensive analysis of the validation in the reference work of Ruponen et al. (2006).

The results of the model tests are public and have been made available for an ITTC benchmark study on time-to-flood predictions.
DAMPING EFFECT OF BILGE KEELS WITH DIFFERENT ASPECT RATIOS

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VTT /Vehicle Engineering

Although ships’ motions at sea always have been difficult to estimate, it remains important to ensure that the ship can safely ride out the roughest storms and also that it can carry out specific missions successfully. Understanding of ships’ motions at sea begins with the study of the nature of the waves that constitute the environment of the vessel. The response of a ship advancing along a seaway is a complicated phenomenon involving the interactions between the vessel dynamics and hydrodynamic forces. The main goal of this research project was to improve the accuracy of numerical seakeeping analysis. Better estimation methods make the evaluation procedures for new vessels more useful. All ship responses are non-linear to some extent, but in many cases when non linearities are small a linear theory yields good predictions. Linear potential theory estimates of motion damping are generally adequate, and reasonable motion predictions are usually obtained. Rolling is an exception to this general rule: roll motions are large, and viscous damping is important. The damping term depends on the instantaneous roll amplitude, or roll velocity. The wave-making damping predicted for the potential flow around most hull forms is only a small fraction of the total roll damping that is experienced in reality. Hull forms with relatively sharp corners shed eddies as the ship rolls. Skin friction forces on the surface of the rolling hull may be significant also. By contrast, for a typical mono hull geometry without appendages, the roll is weakly damped. A bilge keel is an effective and efficient way to increase the overall damping. The bilge keel produces additional damping due to normal force on the keel plus pressure variation on the hull surface caused by the presence of the bilge keel.

Currently VTT is investigating roll damping. The non-linear roll damping of a ship at slow speed has been studied via ship model testing and through full-scale measurements. The rolling qualities of a 160-ton mono hull ship were investigated in calm water and in regular and irregular waves. The tests were carried out for two ship models of different size, with several bilge keel configurations. Linear and quadratic roll damping parameters for different appendage versions were obtained from roll decay experiments. The effect of bilge keels on roll damping was significant. The additional damping caused by bilge keels seemed to be directly proportional to the area of the appendages. A bilge keel of higher aspect ratio was more effective than one with a lower aspect ratio. The figure shows the experimental results of the bilge keel component for bilge keels of different aspect ratios. Each line in the figure shows the roll damping for constant rolling amplitude: 5, 10 and 15 degrees. The results demonstrate that a bilge keel with a large aspect ratio is better. In addition to the bilge keel’s shape and size, its location has a great deal of influence on the roll damping coefficient. Furthermore, bilge keels increase the resistance of the ship. Therefore, the location of the bilge keel should be set along a streamline to reduce the resistance of the ship. Although bilge keels with a large aspect ratio may be considered impractical, the location of such a short bilge keel can be optimised more easily. Design valuables in the problem are aspect ratio and bilge keel location. Further research is needed to create sophisticated methods to determine optimal bilge keel parameters. The utility of CFD is evident, and numerical estimation of bilge keel performance by means of RANS simulations, based on model- and full-scale experiments, remains challenging.

Figure 1. The bilge keel damping component of the bilge keel of different aspect ratio. Nonlinear damping calculated for three rolling amplitudes: 5, 10 and 15 degrees.

Figure 2. During roll decay tests the ship model was placed transversally in the pool. Vertical excitation was applied and rolling motion was measured with an optical measuring system where cameras mounted on the towing carriage were looking at three LEDs placed on the model. The 3D measurement system is based on three linear CCD cameras. By triangulation, the position of an infrared LED in space is calculated.
SAFEICE RESEARCH PROJECT HAS PASSED THE MID-TERM

Pentti Kujala,
TKK Ship Laboratory

SAFEICE is an EU-funded research project that began on 1 September 2004 and was set to continue for three years, running until the end of August 2007. The main aims of the SAFEICE project are to develop semi-empirical measurement-based methods to determine ice loads on a ship's hull, to find the relationship between operational conditions and ice load, to develop ship “ice interaction models for assessing the design ice loads on a ship’s hull, to develop methods to estimate the ultimate strength of shell plat- ing and frames and to develop methods to assess ice damage. The project is being carried out with the participation of universities; maritime authorities; and European, Canadian and Japanese marine research institutes. The partners represent the vertical chain from basic research to implementing the ice rules and enforcing safety at sea. The project is being co-ordinated by the Helsinki University of Technology / Ship Laboratory.

BACKGROUND

The practical motivation for the SAFEICE project comes from the fact that the present ice class rules and their application are based on empirical knowledge. Thus, common rules applicable for everybody – with due respect for local conditions and operative infrastructures – are difficult to form. It is easy to agree in principle that the requirements for shipping in ice-affected areas should lead to the same safety level, but to reach agreement at practical implementation level is less easy. Thus, the basic factors included in the ice rules and traffic restrictions should be analysed, for determination of equivalence relationships between different sets of ice rules. Further, a common policy in setting of requirements for ice class in accordance with the ice conditions should be developed. Here, assessment of the relationship between the risk level and severity of ice conditions is to be developed. This should result in a common way to describe and interpret ice conditions.

The scientific motivation of SAFEICE is to include new innovations in ice load description and modelling in the ice rules and winter traffic requirements. This is most efficient when the ice conditions are described using the same parameter set-up and format of presentation. Also, all parties involved in winter navigation should share a common basis for estimating the risks and safety level of ice navigation.

PROJECT STRUCTURE AND TASKS

The first step in the SAFEICE project is to bring together earlier ice load measurement results. Analysis of these results gives some idea of the design ice load levels of different ships in different sea areas. Measured data shall be organised for a common database designed such that different measurements are comparable with each other and that results from different ships can be combined. Analysis of different data sets yields a picture of the data gaps in each measurement and thus what additional measurements should cover in future in certain sea areas and/or ice conditions. The data and load prediction tools can be used for validation of theoretical ice load calculation models. From the analysis and database, it is possible to develop theoretical and statistical models for ice load calculation. Then, these results can be used when load responses are calculated. As a result, the risk of ice damage can be estimated. Acceptable risk levels are then defined by society and can be accounted for in ship design through, for example, ice class rules. Accordingly, the SAFEICE project is divided into four activities:

Activity 1: Compilation and analysis of the ice load data (WP 2)

Activity 2: Connection of initial conditions and operating environment to ice load (WP 3 and WP 4)

Activity 3: Development of theoretical load models and statistical methods (WP 5 and WP 6)

Activity 4: Risk modelling and hull strength requirements (WP 7, WP 8 and WP 9)

More information can be found on the project’s Web site, at: http://www.tkk.fi/Units/Ship/Research/SafeIce/Public/.

CONSORTIUM

The project is unique in the sense that it includes participants outside Europe as well, as it is being carried out with the participation of universities from Finland (HUT), Sweden (CTU) and Estonia (TTU); maritime authorities from Finland (FMA) and Sweden (SMA); a classification society from Germany (GL); and marine research institutes from Germany (HSV A), Russia (AARI), Canada (NRC) and Japan (NMRI). The partners represent the whole vertical chain from basic ice research to implementation of the ice rules and enforcement of safety at sea. Additionally, most icebreaker operators around the Baltic Rim are included in the project.

By their tasks in the project and also their expertise, the partners may be divided into four groups:

Group 1: Basic research into ice loads HUT, HSV A, NMRI, NRC, AARI

Group 2: Development and implementation of ice rules FMA, GL, SMA

Group 3: Structural response CUT, GL, HUT, AARI

Group 4: Description of operating environment FMA, HUT, NMRI, NRC, SMA, TTU

STATUS OF THE PROJECT

The main achievements of the project so far can be summarised as:
- The inventory of sources of ice loads and ice damage data has been compiled, the database design was conducted and the ice loading database was compiled. The database now contains 47 data sets, with over 10,000 events for the five ice-going ships.

- A series of model tests were conducted in Japan to measure the ice loads acting on the models. Two types of model ships were tested: an icebreaker and a cargo vessel. The detailed ice load data have been compared with ice load computations.

- Identification of the major lacks in existing field data on ice loads on ship hulls has been initiated. The results shall be taken into account in the design of the full-scale or model-scale tests planned for later in the project so that the missing data can be obtained.

- Current ice service and icebreaking practices have been summarised. The report contains a brief description of the main icebound sea areas of the Northern Hemisphere where shipping is active as well as an in-depth analysis of the various types of practices used in observing and describing ice conditions, together with an analysis of the Baltic and Canadian icebreaking systems.

- Specifications have been prepared for the identification of ice loading scenarios relevant for ship hull load and an inventory of calculation methods applicable for ice load estimates. Numerical simulations of ice load levels in specific ice conditions for a few ship types have been conducted, and these have been compared with the ice load database and the model-scale test results.

- A sea ice dynamics model’s development was initiated to calculate the plane stresses in the sea area in question. The main purpose of the model is to hind- and forecast ice drift, ridging and levelling, and the model also yields ice concentrations in real wind forcing conditions. This model can be used to compute the pressure in the ice field and also to give boundary conditions for a local FE model predicting ice forces on the hull of a ship in a compressive ice field.

- A literature study of the structural response calculation methods has been conducted for the strength of shell plating under ice load. Various methods for evaluating permanent deflection of the shell plating under ice load have been critically reviewed and compared with non-linear FE analysis.

- With application of non-linear finite elements, the ship/ice interaction has been simulated, including also the failure mechanism of ice in addition to the response of the shell structures. In a few cases of reported damage, calculations have been performed to determine the load configurations (i.e., contact area and the pressure that has caused the damage).

As a joint effort of HUT and Japan’s NMRI, a model testing programme is under development for comparing the ice loads encountered for various sizes of ships navigating a channel behind an icebreaker, which is in essence the design case used for Finnish–Swedish ice class rules. The idea is especially to study the effect of large tankers on the ice load level encountered and compare this to that for conventional ice-going vessels, which have so far been the reference ships in the ice class rule development, particularly in the Baltic Sea area.

The main challenge for the final year of the project is to study the various approaches that can be applied as a design method for ice rule development purposes.

Compressive ice is one the main risk factors for ships navigating in ice.

Source: TKK

Source: Finstaship

ONGOING ACTIVITIES OF HUT

At present, the main activities of HUT are devoted to analysing the risks related to the damage to the side shell of ice-going vessels and considering how to determine the probability of failure for various types of dents to the ice-strengthened shell structures. The calculated risks are to be compared with the figures specified from the damage statistics data. Calculation methods for evaluating long-term ice loads have been reviewed, and various approaches available shall be compared with the ice load database data, to determine a reliable method for design purposes.
TRANSPORTATION OF CHEMICALS BY TANKERS IN THE BALTIC SEA AREA

Around 2,000 sizeable ships are normally at sea at any given time on the Baltic, including large oil tankers, many large passenger ferries and ships carrying dangerous and potentially polluting cargoes. The Baltic Sea has some of the busiest shipping routes in the world.

In 2004, VTT published a study on oil transportation and terminal development in the Gulf of Finland. The report covers statistics on oil transport in the area and discusses future terminal development. During the project, the question of chemical transport came up several times. The report on transportation of chemicals by tankers in the Baltic Sea area was published in early 2006.

Marine chemical transportation is constantly growing, in terms of the number of chemicals and the total volume of goods transported. A great deal of this material is dangerous to the environment. Hazardous substances are transported in bulk either by chemical carriers or by gas carriers. Tankers transporting chemicals carry a wide range of products, which often pose a number of problems in the event of an accident, individually and in combination.

Sea transport is often seen as the largest risk in the chemical transportation chain. That chemical tanker accidents are rare in comparison to oil tanker accidents even on world scale is due in the main to the difference in the transport volume but also the very high standard regarding safety for the former. The greatest challenge is the control of the traffic.

In this study, statistics concerning chemicals transported in liquid bulk form on Baltic Sea area were gathered and the most important substances were chosen for further examination. Spreading of chemical spills was studied for: epichlorohydrin (MARPOL A), styrene monomer (B), vinyl acetate (C), soya bean oil (D) and ammonia (gas).

Table 1 Liquid chemicals handled in the Baltic Sea ports in 2004.

<table>
<thead>
<tr>
<th>Country</th>
<th>Ports in the study</th>
<th>Chemicals handled [tons]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>16</td>
<td>3,916,000</td>
</tr>
<tr>
<td>Sweden</td>
<td>14</td>
<td>2,543,000</td>
</tr>
<tr>
<td>Denmark</td>
<td>2</td>
<td>n/a</td>
</tr>
<tr>
<td>Germany</td>
<td>2</td>
<td>n/a</td>
</tr>
<tr>
<td>Poland</td>
<td>3</td>
<td>669,000</td>
</tr>
<tr>
<td>Lithuania</td>
<td>1</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Latvia</td>
<td>2</td>
<td>854,000</td>
</tr>
<tr>
<td>Estonia</td>
<td>3</td>
<td>74,000 +</td>
</tr>
<tr>
<td>Russia</td>
<td>3</td>
<td>40,000 +</td>
</tr>
<tr>
<td>TOTAL</td>
<td>46</td>
<td>9,126,000</td>
</tr>
</tbody>
</table>

Figure. The Baltic Sea and its liquid chemical ports (map prepared by HELCOM).
Seminar on Numerical Ship Hydrodynamics, 08.03.2006

The annual symposium of the Maritime Research Institute of Finland was held on 8 March 2006 in Turku and it was devoted to numerical ship hydrodynamic aspects. About 25 experts from industry and research institutes participated in the symposium organized by VTT and TKK. The opening presentation was given by Raimo Hämaläinen, Head of Hydrodynamics in Aker Yards, Turku. The eight presentations varied from practical use of CFD in shipyard to basic research in numerical hydrodynamics.

The presentations can be downloaded from our website: http://virtual.vtt.fi/maritimeinstitute/