Expanding Frontiers -
Challenges and Opportunities in Maritime Education and Training

Advances Through Fast Time Manoeuvring Simulation - New Technology for Teaching and Learning in Ship Handling

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Abstract: Safe and efficient ship handling in every situation and under all potential prevailing circumstances of the ship status and environmental condition is a substantial contribution to the safety of the maritime transportation system and requires a high level of training. New technologies such as Fast Time Simulation (FTS) have great potential for teaching and learning in the maritime training environment and for use on board ships. New concepts for application of these new technologies were developed at Maritime Simulation Centre Warnemünde MSCW in research projects for development of prediction tools for manoeuvring of ships. New concepts based on FTS were developed to simulate the ship's motion with complex dynamic models in fast time and to display the ship's track immediately for the intended or actual rudder or engine manoeuvre. These simulations allow for a new type of manoeuvring design and optimisation of not only the next manoeuvring segment ahead but also for the following or even for series of manoeuvring segments. Within this paper are selected case studies and existing solutions for using the new technology for teaching and learning processes in manoeuvring / ship handling. For practical application and testing, the new technology was interfaced to a

ship handling simulator at Maritime Simulation Centre Warnemünde to support briefing and debriefing processes. The potential of this technology will be identified and approaches for advanced manoeuvring education and training will be introduced and discussed.
Keywords: Fast time simulation, manoeuvring, ship handling, decision support, teaching technologies

1. Introduction – description of the concept

Normally, ship officers have to steer ships based only on their mental model of the ship's motion characteristics. This mental model has been developed during their education, training in a ship handling simulator in real time simulation and, most importantly, during their sea time practice. Up to now there was no electronic tool to demonstrate manoeuvring characteristics efficiently. Moreover, to design a manoeuvring plan effectively, even in briefing procedures for ship handling training, the potential manoeuvres will be explained and drafted on paper or described by sketches and short explanations. To overcome these shortcomings, a fast time simulation tool box was developed to simulate the ship's motion with complex dynamic models and to display the ship's track immediately for the intended or actual rudder or engine manoeuvre. This "Simulation Augmented Manoeuvring Design and Monitoring" (SAMMON) tool box will allow for a new type of design for manoeuvring plans as an enhancement exceeding the common pure way-point planning. The principles and advantages were described at MARSIM 2012 [4] specifically for the potential on board application for manoeuvring real ships.

This paper presents the potential of the new method specifically for the teaching and learning process at maritime training institutions. Manoeuvring of ships is a human centred process. The most important elements of this process are humans and the technical equipment to support their task (see Figure 1). However, most of the work is to be done manually because even today almost no automation support is available for complex manoeuvres. Even worse, the conventional manoeuvring information for the ship officer is still available on paper only: the ship manoeuvring documents are mainly based on the initial ship yard trials or on some other selective manoeuvring trails for specific ship / environmental conditions - with only very little chance to be commonly used in the overall ship handling process situations effectively.
Ship Handling Simulation for simulator training has a proven highly effective for qualification however, it is based on real time simulation, i.e. 1 second calculation time by the computers represents 1 second manoeuvring time in the real world. This means, despite all other advantages of full mission ship handling simulation, that collecting/gathering of manoeuvring experiences remains the utmost time consuming process.

For increasing the effectiveness of training and also the safety and efficiency for manoeuvring real ships, the method of Fast Time Simulation will be used in future. Even with standard computers simulations can be achieved in 1 second computing time for manoeuvres lasting up to 20 min using innovative simulation methods. This allows substantial support in both the training process and the real manoeuvring process on board ships. In Figure 2 a comparison is given for some essential elements of the real manoeuvring process on ships and in training within the ship handling simulators. Additionally, in the right column some of the Fast Time Simulation (FTS) tools are mentioned and their roles to support each element of the manoeuvring process are indicated. These tools were initiated in research activities at the Maritime Simulation Centre Warnemuende which is a part of the Department of Maritime Studies of Hochschule Wismar, University of Applied Sciences - Technology, Business & Design in Ger-

many. It has been further developed by the start-up company Innovative Ship Simulation and Maritime Systems (ISSIMS GmbH).
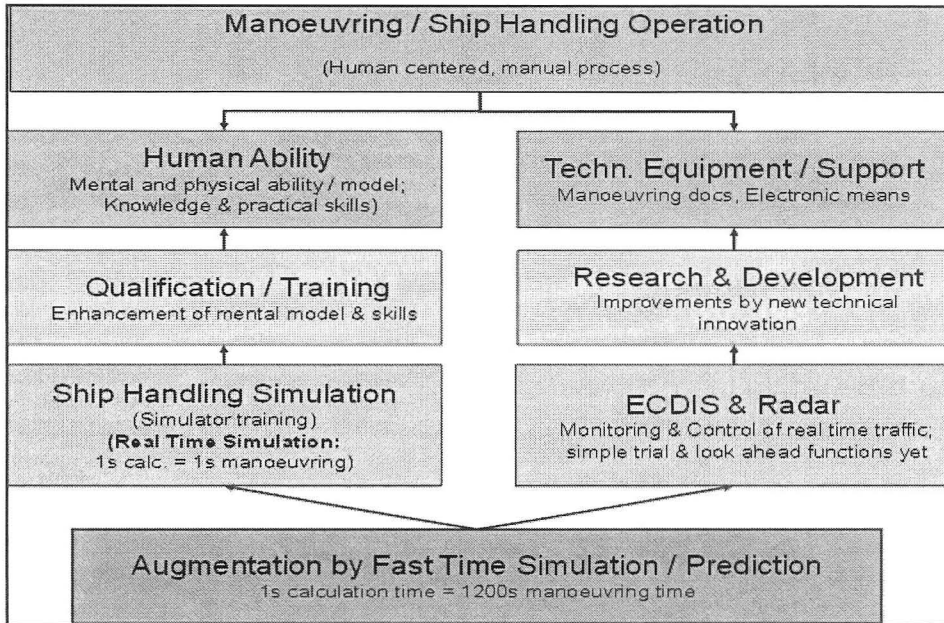

Figure 1 Elements of the manoeuvring process and potential for enhancement by new Simulation / Augmentation methods

A brief overview is given for the modules of the FTS tool and its potential application:

- SAMMON is the brand name of the innovative system for "Simulation Augmented Manoeuvring – Design, Monitoring & Control", consisting of four software modules for Manoeuvring Design & Planning, Monitoring, Multiple Dynamic Prediction & Control and Simulation & Trial. It is made for both:
  - application in maritime education and training to support lecturing for ship handling to demonstrate and explain more easily manoeuvring technology details and to prepare more specifically, manoeuvring training in SHS environment, i.e. for developing manoeuvring plans in briefing sessions, to support manoeuvring during the exercise run and to help in debriefing sessions with the analysis of replays and discussions of quick demonstration of alternative manoeuvres and
  - application on-board to assist manoeuvring of real ships e.g. to prepare manoeuvring plans for challenging harbour approaches with complex manoeuvres up to the final berthing / unberthing of ships, to assist the steering by multiple prediction during the manoeuvring process and even to give support for analysing the result and for on board training with the Simulation & Trial module.
- SIMOPT is a Simulation Optimiser software module based on FTS for optimising Standard Manoeuvres and modifying ship math model parameters both for simulator ships and FTS Simulation Training Systems and for on board application of the SAMMON System.

- SIMDAT is a software module for analysing simulation results both from simulations in SHS or SIMOPT and from real ship trials: the data for manoeuvring characteristics can be automatically retrieved and comfortable graphic tools are available for displaying, comparing and assessing the results.

Elements of Manoeuvring Process on Ships & in Education/Training and support by Fast Time Simulation Modules / Tools

Real World/ Ship Operation	Ship Handling Simulator Training	Fast Time Simulation Tools
Real ship /	Math model of the ship for simulation	**SIMOPT & SIMDAT** tool for developing & tuning of parameters of math models
Familiarisation runs	Familiarisation Exercises	**MANOEUVRING TRIAL & TRAINING** tool for Demonstration / Lecturing / Familiarisation
Mission / Planning	Scenario / Briefing	**MANOEUVRING DESIGN & PLANNING** tool to generate and edit a manoeuvring plan
Manoeuvring Operation	Execution of exercise	**MANOEUVRING MONITORING & MULTIPLE DYNAMIC PREDICTION** tool to monitor and control the vessels motion
Recording (VDR, ECDIS)	Recording by simulator	**SIMDAT** tool to display and assess recordings
Evaluation of success	Debriefing	**MANOEUVRING TRIAL& TRAINING** tool for verification of results by simulation & prediction

Figure 2 Elements of Manoeuvring Process on Ships & in Training and support by Fast Time Simulation Tools for Simulation / Augmentation

The SIMOPT and SIMDAT modules were described in earlier papers ([1] and [2]) for tuning of simulator ship model parameters and also the modules for Multiple Dynamic Prediction & Control [3] for the on board use as a steering assistance tool.

In this paper the focus will be on the potential of the SAMMON software for supporting the teaching and learning process.

2. Fast Time Simulation Tools for Standard Ship Manoeuvring Elements Ship dynamic model and SIMOPT / SIMDAT tools for fast time ship manoeuvring simulation and investigation

The following equation of motion was used as the math model for the ships dynamic:

$$X = m(\dot{u} - rv - x_G r^2)$$
$$Y = m(\dot{v} + ru + x_G \dot{r})$$
$$N = I_z \dot{r} + m x_G (\dot{v} + ru)$$
$$Q = I_{ME} \dot{n}_{ME}$$

On the right side are the effects of inertia, where u and v represent the speed components in longitudinal and transverse direction x and y; r is the rate of turn of the ship. The ship's mass is m and x_G is the distance of centre of gravity from the origin of the co-ordinate system. I_z is the moment of inertia around the z-axis.

The ship's hull forces X and Y as well as the yawing moment N around the z-axis are on the left side. Their dimensionless coefficients are normally represented by polynomials based on dimensionless parameters, for instance in the equation of transverse force Y and yaw moment N given as the sum of terms with linear components N_r, N_v, Y_r and Y_v and additional non-linear terms depending on speed components u, v, rate of turn r and revolution n. Other forces; for instance, rudder forces and wind forces are expressed as look up tables. There are other models, e.g. for the engine or thruster operation: for the sample in the fourth equation in (1) the variable Q represents the sum of the torque components of engine, propellers and others; on the right side there is the inertia moment of the rotation parts around the propeller axis.

Additional differential equations represent the calculation of heading and position. The solution of this set of differential equations is calculated at least every second; some internal calculations are even done with higher frequency.

The quality of the math model for the simulation and the parameters in the equations are of high importance for the effectiveness of the simulation. There is a great need for fast and effective modelling / tuning processes both:

- for the general operation of Ship Handling Simulators SHS where clients from several shipping companies need to be trained on their specific ship types and
- for the SAMMON dynamic predictor and manoeuvre planning modules.

The parameters of these equations of motions can be found by parameter estimation technology (some methods were described at MARSIM 2009 and 2006 [1][2]) using the SIMOPT and SIMDAT Programs. The advantage of the module is to be seen in the performance: it is remarkably faster than real time and the steering of vessels is organized automatically by prepared files from a library for Manoeuvre-Control Settings / Commands for standard procedures and individual manoeuvres.

These software packages were developed to be used for fast time simulation procedures by SIMOPT and assessment of the results by SIMDAT [6] . The advantages and capabilities of this software are: The Math Model reveals the same quality for simulation results as ship handling simulators (SHS), but it is remarkably faster than real time simulation (the ratio is more than 1/1000) and the steering of simulator vessels is done by specific manoeuvre-control settings / commands for standard procedures and individual manoeuvres dedicated for calculation standard ship manoeuvring elements (basic manoeuvres) but moreover for the estimation of optimal manoeuvring sequences of some characteristic manoeuvres as for instance, person over board manoeuvres.

Simulations can be done in SIMOPT either as a single run or as a simulation series for selection of up to a 3 parameter series to be simulated in parallel or sequential for: Simulation parameters, e.g. Manoeuvre series; Ship Parameters (L, B, T, or others); Hull / force parameters coefficient and Environmental data, e.g. wind force and direction.

The SIMDAT software tool (see Fig. 3) was originally designed at the MSCW to supply the instructor with semiautomatic assessment of the recorded exercise data in a ship handling simulator [3]. For the purpose of ships model parameter tuning, the optimisation of manoeuvres and for lecturing, this SIMDAT tool was extended. The Data for the manoeuvring characteristics can be automatically retrieved for all manoeuvres and enhanced Graphic tools are available for displaying various types of results. Some results of particular evaluations are shown in the next figures.
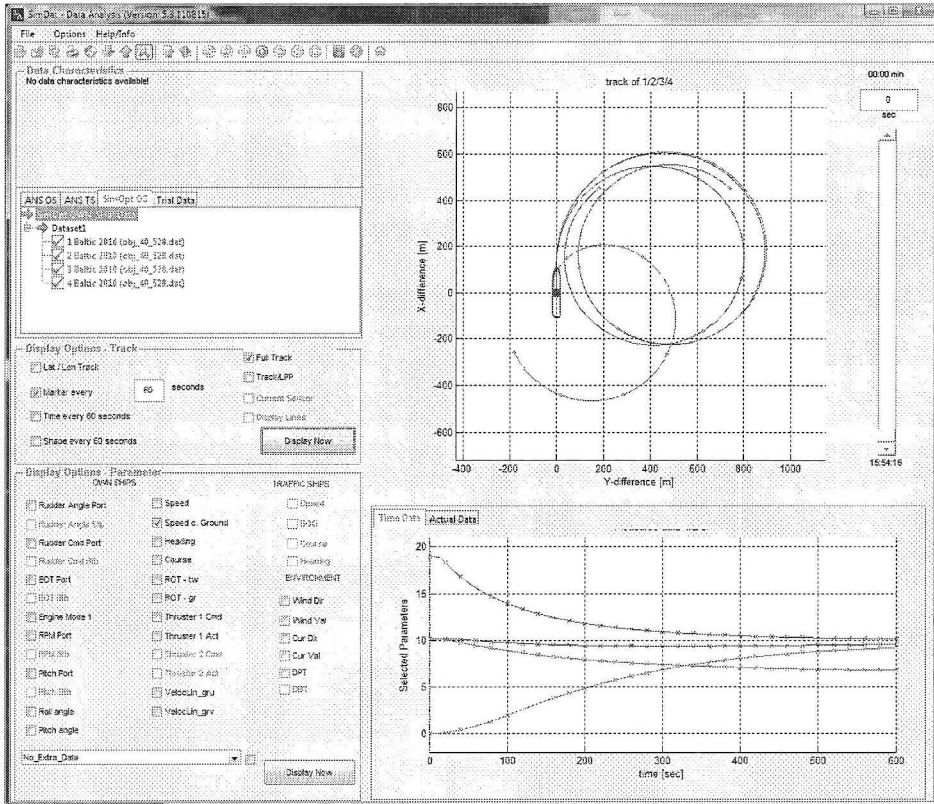

Figure 3 Comparison of turning circles for Hard Rudder (35° STB) and constant speed rates with kick turns (CV 2500, left: ships' tracks, right: speed history):

- Turning Circle with constant speed rate Full Sea Speed = 25.5 kn (blue)
- Turning Circle with constant speed rate Slow Ahead = 11.3 kn, (green)
- Kick-Turn from straight track with constant speed rate Slow Ahead = V_Start=11.3 kn) and change to Full Sea Speed (brown)
- Kick-Turn from STOP at zero speed V = 0 kn and change to EOT = 100 % (red)

Samples of Manoeuvre Demonstration and Optimisation with SIMOPT/SIMDAT

In order to explain ship dynamics, simulations are very suitable to demonstrate the effect of specific manoeuvres. In Fig. 3 the effect of so called "Combined Manoeuvres" will be shown where both rudder and engine will be changed at the same time to give some advantage in comparison with standard manoeuvres. The turning circles with constant speed rates for Full Ahead and Slow Ahead have nearly identical tracks however, in the case of using so called Kick Turns

from Slow Ahead to Full Ahead or even more for Stop to Full Ahead the advance and transfer of the tracks are much smaller. The final steady state turning diameter is the same in all four cases.

Also for crash stop manoeuvres with Full Astern the rudder can help to significantly reduce the speed and therefore the stopping distance: in Fig. 4 the standard crash stop manoeuvre is compared with a fishtailing manoeuvre where the ruder is used periodically from full starboard to port and vice versa additionally to the reversed engine to save nearly one third of the stopping distance. The smallest advance can be seen for the turning circle with hard rudder where also the speed goes to zero after nearly half of the time compared to the standard stop manoeuvre.
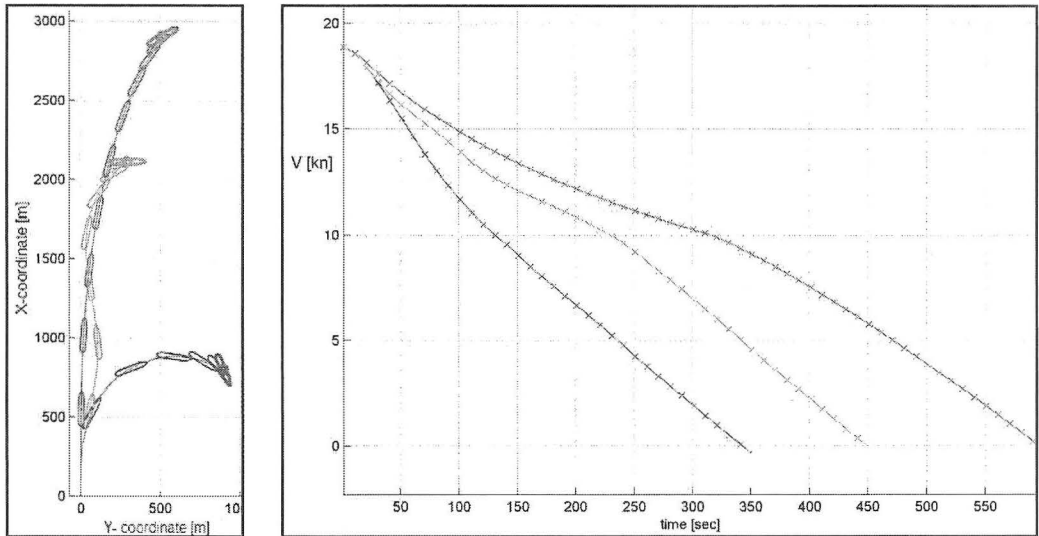

Figure 4 Comparison of Crash Stop Manoeuvre (red) with Fishtailing (grey) and Hard Rudder Turning Circle from Full Ahead to Full Astern (blue) (CV 7500, left: ships' tracks, right: speed history)

Another important issue is the behaviour of the vessel under wind impact which can be easily explained and investigated by means of the SAMMON system. The basic understanding of this effect can be given to the students by explaining the equilibrium conditions under wind impact on a straight track with constant ship speed. For this purpose a series of calculations were made varying the wind speed from 0-40 knots and also the wind directions from bow wind (0°) to stern wind conditions (180°). In Fig. 5 the table can be seen for the input control of the calculation series for simple Constant Speed Manoeuvres in SIMOPT. The results are shown in Fig. 6 in 2D and, more clearly, in 3D-representation respectively. It can clearly be seen that the rudder and drift angles to balance the wind moment and transverse forces are increasing with the wind speed, more precisely with the wind-to-ship speed ratio. The effect of these equilibrium conditions will be demonstrated in the next chapter for the turning manoeuvres under wind.
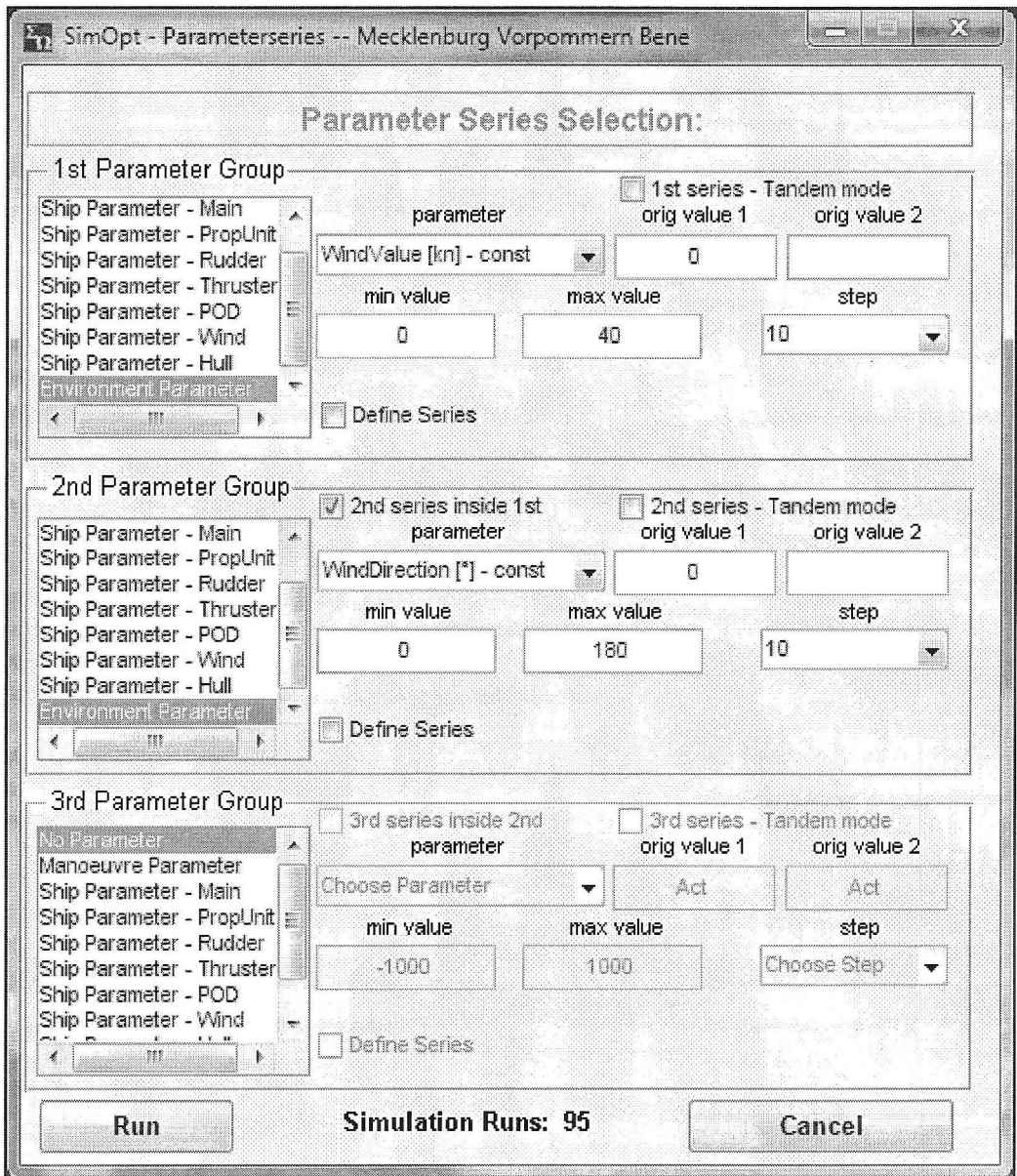
SimOpt - Parameterseries -- Mecklenburg Vorpommern Bene

Parameter Series Selection:

1st Parameter Group

Ship Parameter - Main
Ship Parameter - PropUnit
Ship Parameter - Rudder
Ship Parameter - Thruster
Ship Parameter - POD
Ship Parameter - Wind
Ship Parameter - Hull
Environment Parameter

☐ 1st series - Tandem mode

parameter	orig value 1	orig value 2
WindValue [kn] - const ▼	0	

min value	max value	step
0	40	10 ▼

☐ Define Series

2nd Parameter Group

☑ 2nd series inside 1st   ☐ 2nd series - Tandem mode

Ship Parameter - Main
Ship Parameter - PropUnit
Ship Parameter - Rudder
Ship Parameter - Thruster
Ship Parameter - POD
Ship Parameter - Wind
Ship Parameter - Hull
Environment Parameter

parameter	orig value 1	orig value 2
WindDirection [°] - const ▼	0	

min value	max value	step
0	180	10 ▼

☐ Define Series

3rd Parameter Group

☐ 3rd series inside 2nd   ☐ 3rd series - Tandem mode

No Parameter
Manoeuvre Parameter
Ship Parameter - Main
Ship Parameter - PropUnit
Ship Parameter - Rudder
Ship Parameter - Thruster
Ship Parameter - POD
Ship Parameter - Wind

parameter	orig value 1	orig value 2
Choose Parameter ▼	Act	Act

min value	max value	step
-1000	1000	Choose Step ▼

☐ Define Series

| Run | **Simulation Runs: 95** | Cancel |

Figure 5 Interface table for defining a parameter series in SIMOPT for calculation of wind effects on straight track with constant speed
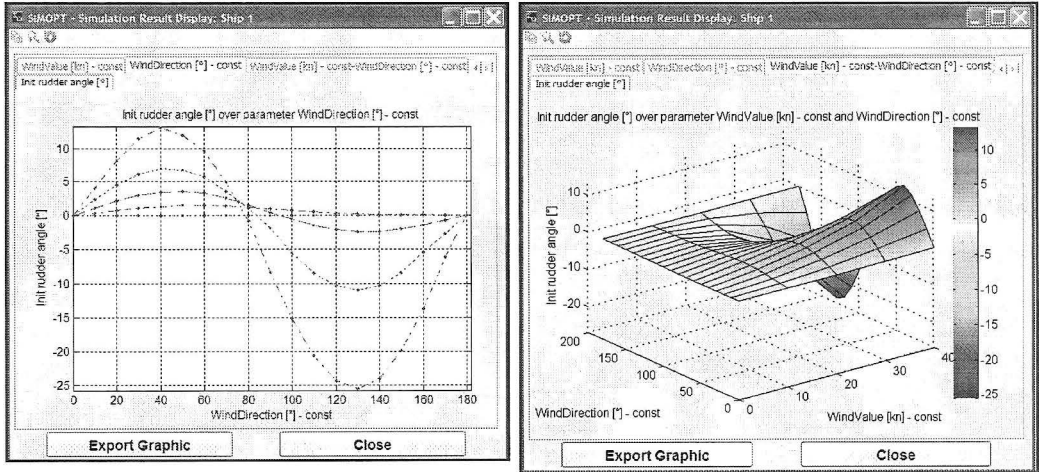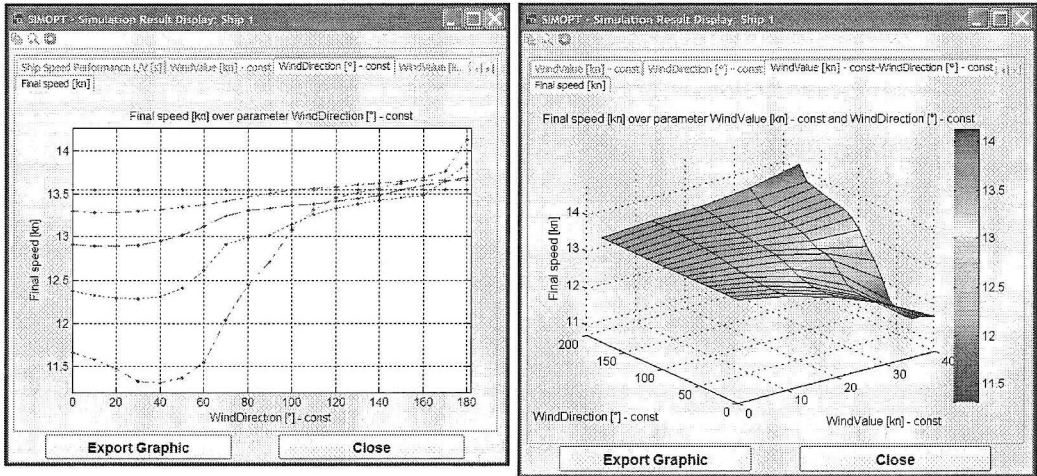
(a) Initial rudder angle versus Wind direction and Wind speed
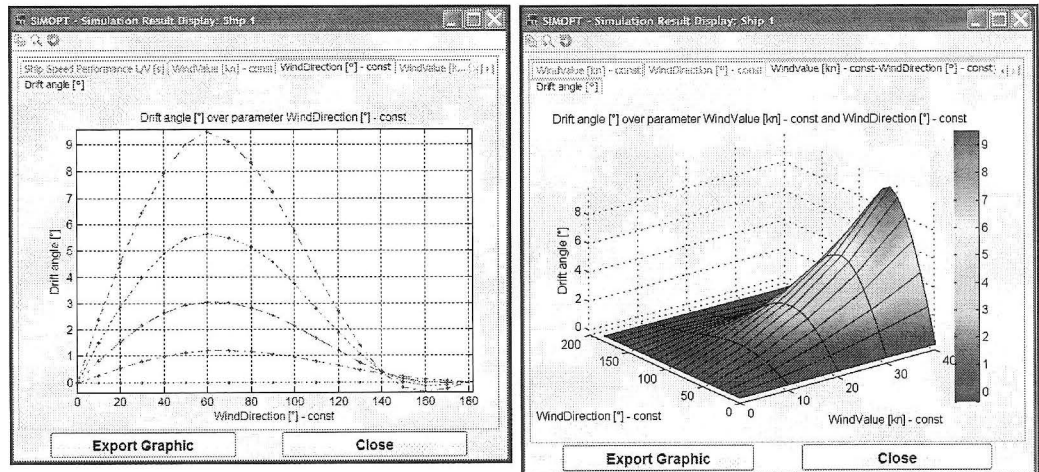
(b) Drift angle versus Wind direction and Wind speed

(c) Speed loss versus Wind direction and Wind speed

Figure 6 Balance of wind effects on straight track with constant speed in 2D & 3D presentation

3. Fast Time Manoeuvring Simulation for Manoeuvring Demonstration in ECDIS environment

The same fast time simulation tools can be used for the demonstration of manoeuvres up to the design of complete manoeuvring plans. Some basic functions are shown in the next figures.

Fig. 7 explains the operational interface in a sea chart environment which combines the electronic navigational chart ENC window (centre), the status of the current actual ship manoeuvring controls (left) and the interface window for the steering panel of the ship (right).
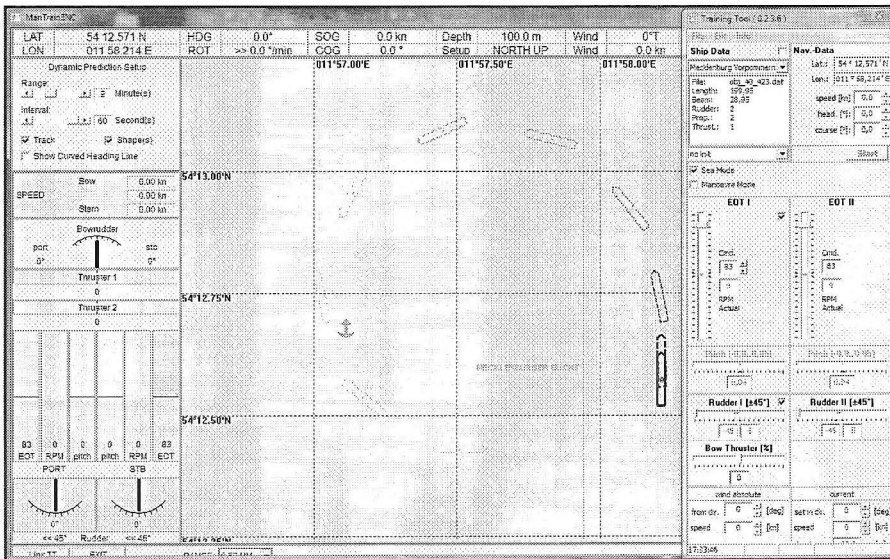
Figure 7 SAMMON Trial & Training Tool Interface with sample for Kick turn from zero speed to port as sample for potential ships manoeuvring capabilities

The ship was positioned in a certain place to demonstrate the ship's motion for a very simple manoeuvre kick turn from zero speed. The ship's motion can be controlled by the settings in the control panel window where any manoeuvre can be generated and immediately displayed in the ENC in full length within one second. The length of the track corresponds to the settings in the prediction window (left top corner). The range value represents the duration of the manoeuvre and the interval value controls the number of displayed ship contours on that manoeuvre track. The sample represents a kick turn from zero speed to full ahead with full rudder to Port.

For the demonstration of wind effect, the wind speed and direction can be set in the right bottom window. The effect can immediately be seen as in Fig. 8. The turning circle with full rudder to STB will be shifted in the direction with the wind from North (0°). This can be expected for low wind to ship speed because in the sample the engine order is set to 70%. If the EOT is set to only 30% the ship does not gain enough speed and therefore she goes on a straight track with beam wind where the full rudder is just enough for the equilibrium to balance the forces and moments due to wind as discussed in Fig. 6.
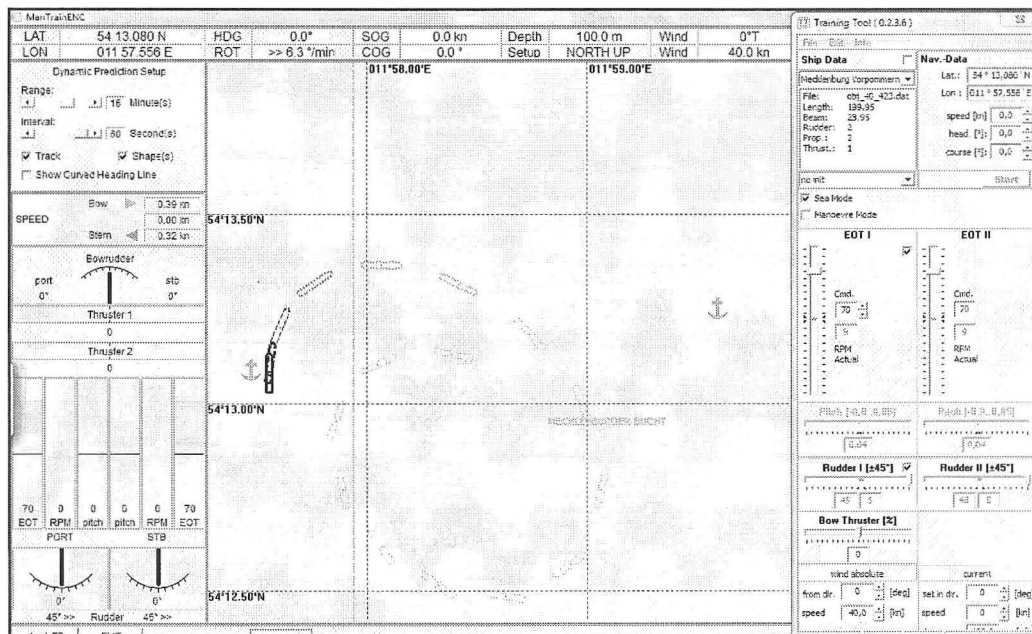

Figure 8 SAMMON Trial & Training Tool -Interface with sample for wind impact for low ratio of wind-to-ships speed
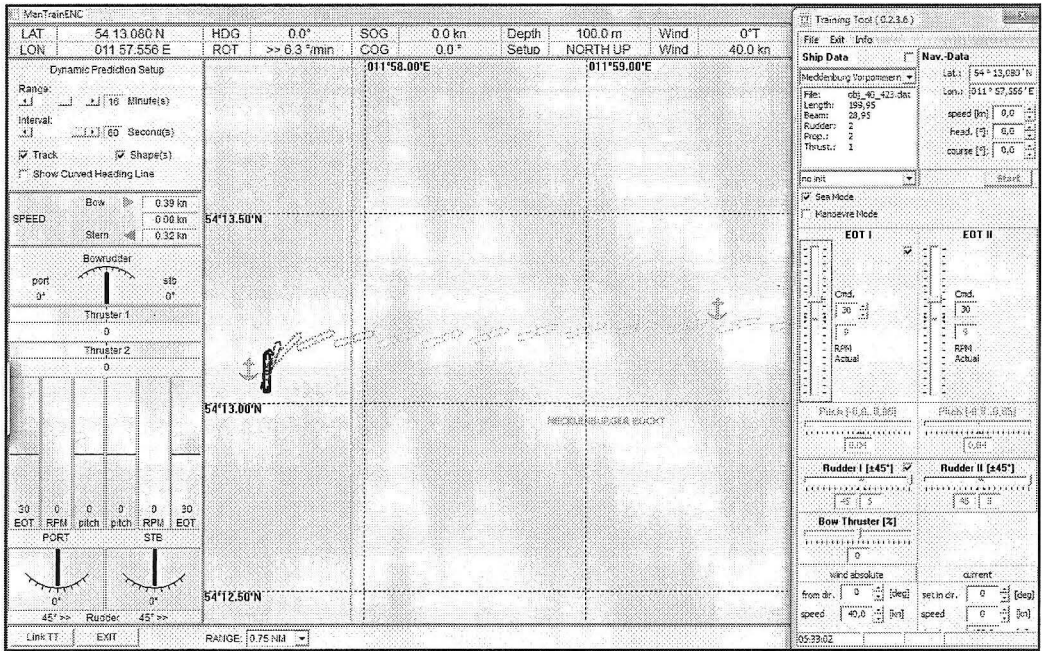
Figure 9 SAMMON Trial & Training Tool -Interface with sample for wind impact high ratio of wind-to-ships speed
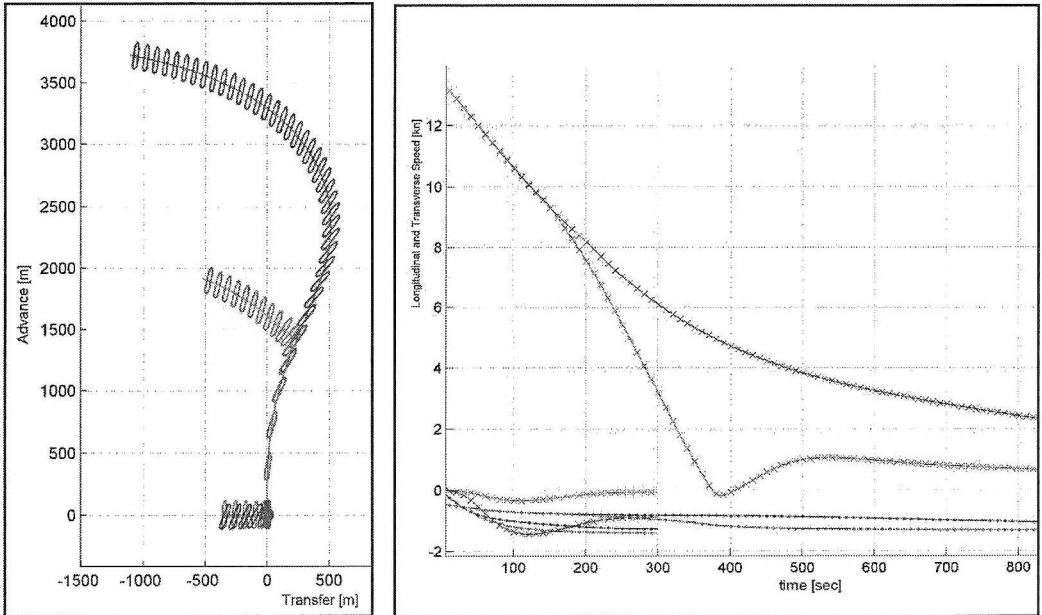

Figure 10 SAMMON Simopt tool: Transfer into a "lying abeam" situation under strong wind from several initial situations for ships speed (Left: ships tracks, Right: time history of longitudinal and transverse speed components)

In extreme heavy weather it is recommended to reduce the speed and to transfer into the "lying abeam" situation where the ship is only drifting with no engine power used. It is of great importance that this situation can be reached very quickly, i.e. that the transfer time from ahead motion into full drift motion requires a minimum of time to take advantage of the pure drifting motion as quickly as possible. These effects can be demonstrated in an ECDIS environment separately for every manoeuvring variant, but for an overview the different approaches are summarised in a SIMOPT / SIMDAT presentation as in Fig. 10. It can be seen that for a ship in the stopped condition this procedure happens very fast. In about two minutes the ship reaches the full steady state transverse drift speed (green for a ship with superstructure in the middle, brown for superstructure at the stern). If the ship has a higher initial speed then it is recommended to use a full astern stopping manoeuvre because in this case she needs only 7-8 minutes the full drift compared to the coasting stop where more than 20 min will be needed for the same result.

4. Fast Time Simulation for Designing Manoeuvring Plans

Principle of fast time simulation of manoeuvres in ECDIS and sample data

The fast time simulation method is used to find out efficient manoeuvres and even more for the design of manoeuvring plans within the briefing for Ship Handling Simulator exercises and practically for the route planning process on board [4]. The use of this tool will be explained by some sample scenarios:

The sample ship is the RO-PAX Ferry "Mecklenburg-Vorpommern" with Loa=200m, Boa=28.95m, Draft=6.2m, Displacement=22720t and Speed=22kn. She has two pitch propellers and two rudders located behind the propellers and additionally one bow thruster.

The test area is the Rostock Sea Port. The RO-PAX ferry is entering the fairway from north to be steered through the fairway and to be turned at the turning area followed by astern motion off the berth at west pier (as in in the sample Fig. 14).

Some basic functions and interface displays are shown in the following figures: Fig. 11 explains the method in a sea chart environment represented by an interface which combines the electronic navigational chart ENC window (centre), the interface window for the steering panel of the ship (right) for adjusting the controls for the selected manoeuvring point (MP) and the interface to display the status of the current actual ship manoeuvring controls (left) at the position of the next manoeuvring point which is indicated as ship shape in red colour in the ENC.

For purposes of demonstration of a complex manoeuvre procedure the ship is initially positioned in the fairway (black contour) and is going to enter the turning area as the objective for the first manoeuvring segment. For the planning procedure, the ship's motion can be controlled by the settings in the control panel window on the right side. Any manoeuvre can be generated and will be immediately displayed in the ENC with full length in less than one second. In this case the rudders are set 10° to STB to achieve a small turning rate ROT=4.5°/min to port. The length of the simulated track corresponds to the settings in the prediction window (left top corner). The range value represents the duration of the simulated manoeuvre and that means the track length of that manoeuvring segment. The interval value controls the number of displayed ship contours on that predicted manoeuvre track. The selected end position of the manoeuvring segment is indicated by the red ship's contour. Its position can be shifted and adjusted using the slider at the bottom line which is adjusted to 165 seconds after the beginning of the manoeuvre at the initial Manoeuvring Point (MP 0). If this position is accepted it will be acknowledged as the next manoeuvring point (MP 1).

This planning process guarantees the full involvement of the navigating officer. The best version of the manoeuvres can be found by trial and error but it is possible to bring in one's full knowledge and to take advantage of one's skills as it is possible to immediately see and to verify the results of one's own ideas and to make sure that the intentions will work. This is important for safety and efficiency, but also for gaining experience for future manoeuvres.

Figure 11 Display for Manoeuvring Design by Fast Time Simulation for immediate presentation of manoeuvring results: Sample for entering the turning area with slight turning to STB from initial conditions in a fairway at initial Manoeuvring Point MP 0

Sample of designing a full manoeuvring sequence as training concept

The planning procedure for a complete manoeuvring plan follows the principles as described for a single segment in Fig. 11. Following that, Fig. 12 presents the situation after accepting the manoeuvre previously planned and now the next segment is to be planned from MP 1 to MP 2 where the ship is going to enter the turning area and slow down. Both engines are set to STOP (EOT 0). In Fig. 13 the complex turning manoeuvre can be seen where the ship is using in-parallel engines, rudders and the bow thruster to turn as fast as possible. Afterwards the engines have to be reversed and the ship controls are adjusted to go astern to the berth. In Fig. 14 the result for the full manoeuvring plan is to be seen with the whole set of Manoeuvring Points (MP) for the complete approach and the berthing manoeuvre.

The different settings of the controls and the track of the planned manoeuvre sequences are stored in a manoeuvre planning file to be displayed in the ENC. For the execution of the manoeuvre this plan can be activated later to be superimposed in the ECDIS together with the actual position of the ship and, most important, with the prediction of manoeuvring capabilities for effective steering under the actual manoeuvring and environmental conditions.
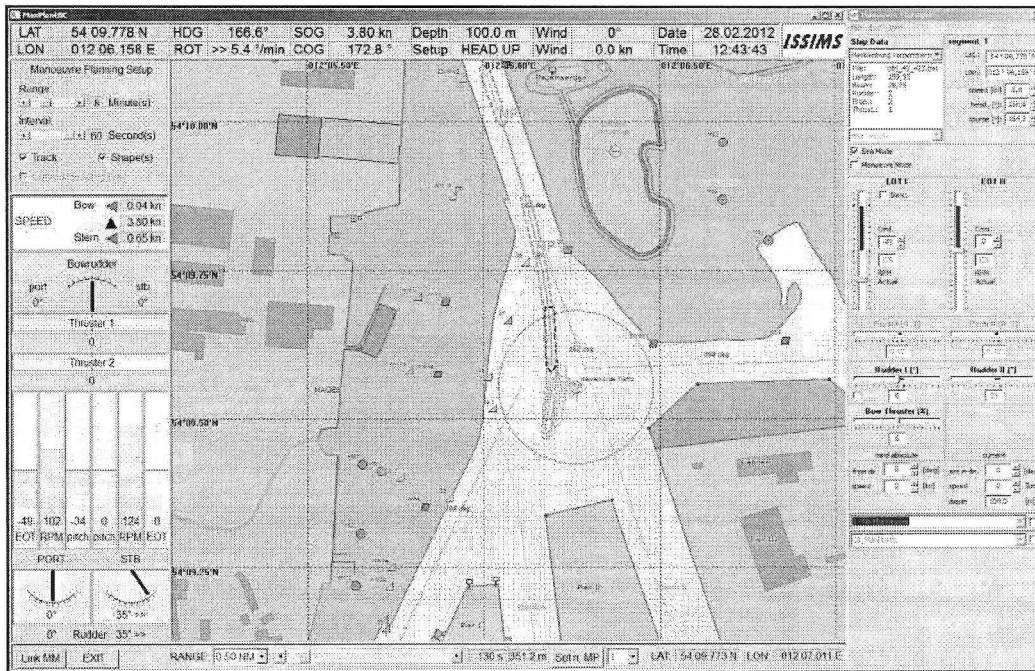
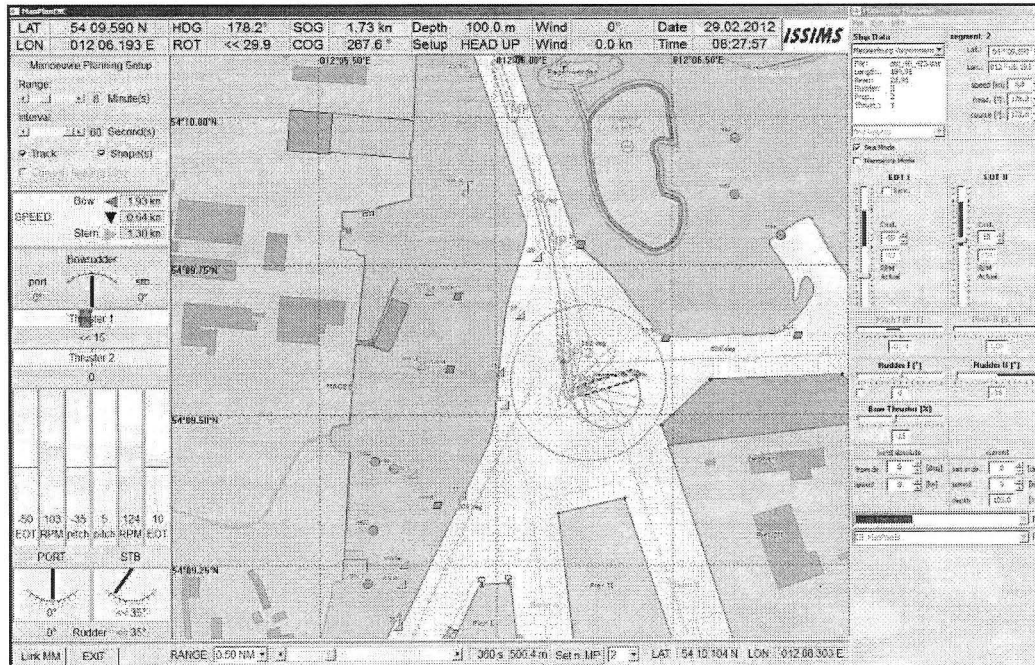*Figure 12 Planning of the next segment from MP 1 to MP 2 – speed reduction*

Figure 13 Planning of the next segment from MP 2 to MP 3 – complex turning and stopping with engines, rudders and thruster
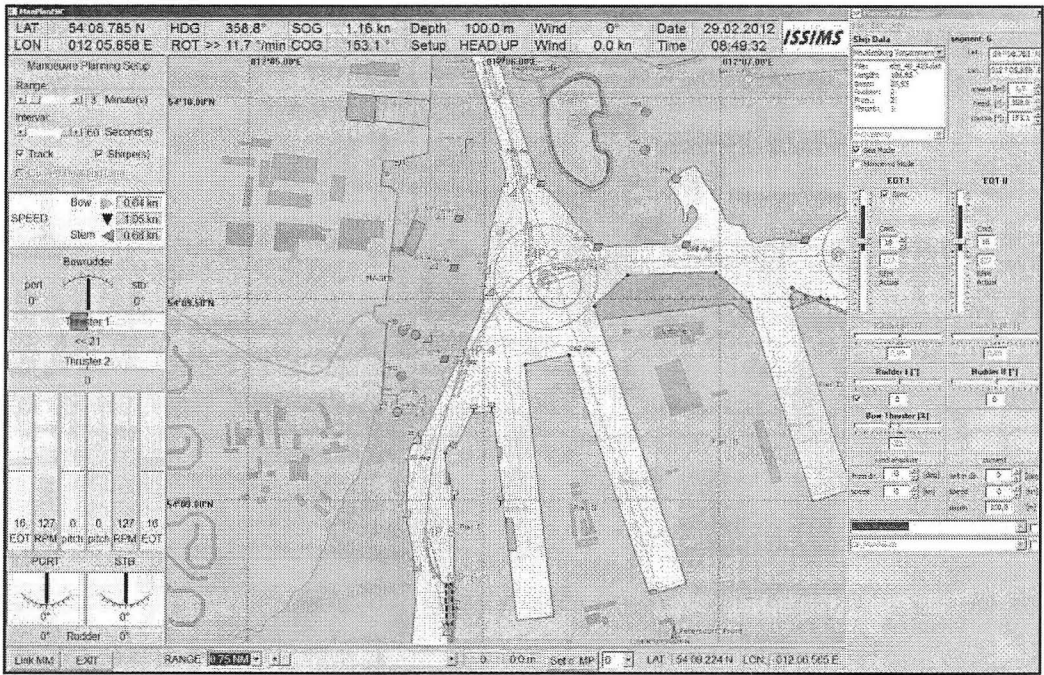
Figure 14 Complete manoeuvring plan for the route segment for passing the turning area and approaching the berth in astern motion

5. Manoeuvring Monitoring and Multiple Dynamic Prediction Module - Overlaid Prediction for On-line Manoeuvring Decision Support using Manoeuvring Plans

Presentation of dynamic predictions in ECDIS environment

For a compact presentation of information to the captain, pilot and responsible navigating officer respectively, a new layout of a conning display was designed and implemented into the equipment installed on an integrated navigation system. For the purpose of testing the technical feasibility and user acceptance the new conning display with the integrated MULTIPLE MANOEUVRING PREDICTION MODULE was implemented in the INS equipment of the large full mission simulator bridge of the ship handling simulator of MSCW. The sample ship is again the RO-PAX Ferry "Mecklenburg-Vorpommern" and the test area is the Rostock Sea Port. The RO-PAX ferry is leaving the berth to be steered through the fairway and leave the port.

The layout of a dedicated prediction display integrated into an ECDIS is shown in Fig. 15. It contains conning information together with the prediction and the planned manoeuvring track. The centre window shows the ENC in Head-up Mode together with motion parameters for longitudinal speed and transverse speed. Also, a circle segment with the rate of turn is shown. The ship's position is displayed in the centre of the ENC as the ship's contour where also the track prediction can be indicated as a curved track or as a chain of contours for the selected prediction time. The prediction parameters as range or interval of presentation can be set in the control window at the right side.
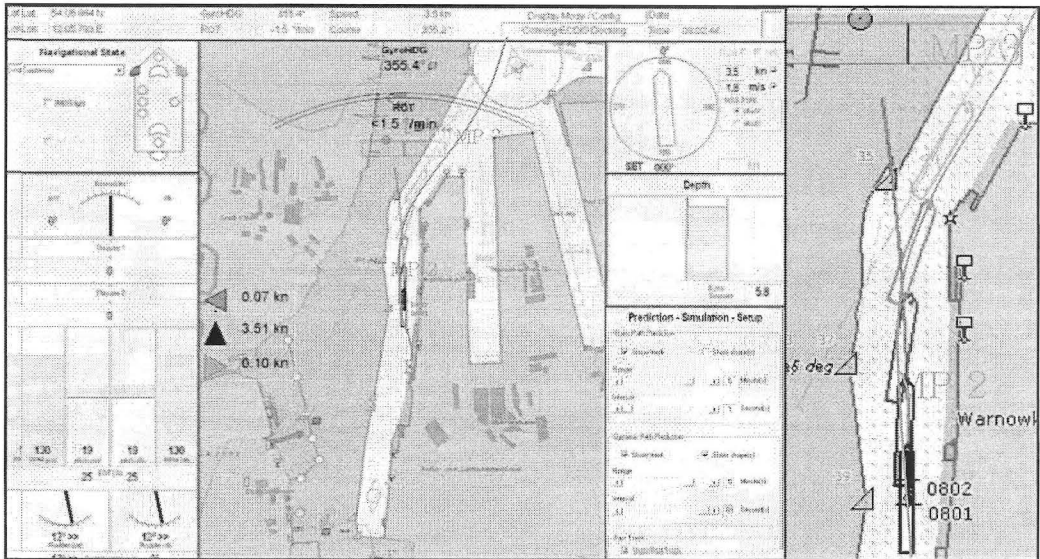
Fig. 15 Layout for Manoeuvring Prediction integrated into ECDIS and comparison of static and dynamic predictions together with planned manoeuvring track (blue line)

The Dynamic Path Prediction with the sophisticated simulation model is shown as a chain of ships contours based on the full math model (ship contours every 60 sec for 5 min with turning to STB). This dynamic prediction already reflects the effect of the setting of rudder and propeller control parameters shown in the left bottom window. In this sample, the two rudders of the ferry are set to 12° Starboard and the Engine Order Telegraph for the two controllable pitch propellers are set to 50% representing 130 rpm of the propeller. The actual pitch status is 19. This interface allows a presentation of dynamic predictions of steering and stopping characteristics as an immediate response according to the current steering handle or engine order telegraph position. It can be perfectly compared with the planned manoeuvring track as a reference line or curve, shown as blue line in the ENC window along the chain of manoeuvring points MP.

The predicted track for the simplified static path prediction based on current constant motion parameters (implemented as add-on in some ECDIS solutions) are shown as a magenta curve. According to the actual/present small rate of turn to Port the predicted track is presented as a circle segment at the left side.

The use of path prediction with simplified models was already mentioned in previous papers. However, the use of these new multiple predictions based on the full dynamic model including the propulsion / engine process together with the result of preceding manoeuvring design is a great innovation and advantage. It was found that, for the application of this dynamic prediction technology, new strategies were found to save some minutes in this area which is very important in tight time schedules [5].

SAMMON Manoeuvring Trial & Training Tool
This module combines a full simulation module for the ship manoeuvring process with all the modules above for planning and monitoring in order to test and try out manoeuvring plans and strategies, to be used both:
   •   as training tool in maritime education

> ○ in briefing / debriefing sessions for ship handling simulator training,
> ○ as well as in lectures on ships manoeuvring in classes and
> • as training tool on board ships.

In order to control the virtual ship during the simulation process a manoeuvring panel on the screen allows steering the ship in real time along the planned route supported by the Multiple Predictor.

6. Integration of SAMMON System into Education for Lecturing & Training Simulation

For training and education, the SAMMON System is available as a portable version based on Tablet PCs for Planning of Manoeuvres in Briefing, Instructor stations and use on Simulator bridges. The SAMMON system is interfaced to the Rheinmetall Defence Electronics ANS 5000 Ship Handling Simulator (SHS) at the Maritime Simulation Centre Warnemünde by WLAN connection. All ships which are available for the SHS are also ready for use in the SAMMON system for the following Concept of Application for Ship handling simulation:

Briefing:
- Demonstrating ship's manoeuvring characteristics by using SIMOPT for familiarisation
- Drafting Manoeuvring Concept as Manoeuvring Plan (using MANOEUVRING DESIGN & PLANNING tool) according to the training objectives
- Optimisation of the concept by several trials of the trainee (using MANOEUVRING TRIAL & TRAINING tool)

Execution of simulator Exercise:
- Training of conventional ship handling procedures by using new FTS technology with underlying manoeuvring plan and dynamic prediction (MANOEUVRING MONITORING & MULTIPLE DYNAMIC PREDICTION tool)

Debriefing:
- Assessment of the exercise results from the full mission SHS by comparison of exercise recordings with trainees own concept or optimised manoeuvring plan by using SIMDAT tool for displaying and assessing the results of the exercise, e.g. comparing the result with the initial concept developed by the student in the briefing session and additionally to discuss alternative manoeuvring solutions by using the MANOEUVRING DESIGN & PLANNING tool).

Figure 16 SAMMON System set up based on Tablet PCs within Ship Handling Simulator environment: as Bridge Version (top), Lecturer System (bottom left) and Instructor Version (bottom right)

7. Acknowledgements

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