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Enhanced Fast-Time-Simulation Features to support Ship-Handling Simulator Training

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Abstract: New technologies as Fast Time Simulation (FTS) have great potential for teaching and learning in the maritime training environment and for use on board of ships. New concepts for training application of these innovative technologies have been developed at Maritime Simulation Centre Warnemunde MSCW / ISSIMS Institute in research projects. The innovation is to simulate the ships motion with complex dynamic models in fast time and to display the ships track immediately for the intended or actual rudder or engine manoeuvre, steered by a smart interface. These simulations allow for 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. One obvious basic advantage in relation to conventional ship-handling training and navigators' preparation of harbour approaches is the easy creation, visualization and comparability of different manoeuvring strategies.

The FTS software system consists of various modules for (a) Manoeuvring Design & Planning, (b) Monitoring & Conning based on Multiple Dynamic Prediction, (c) Trial & Training and (d) Replay and Assessment. Specifically the Planning module is the missing link in Voyage planning because it allows to develop the concept of specifically the manoeuvres in the unsteady motion segment after entering the moles up to the final berthing manoeuvre –

and even to try out alternatives and limits of environmental effects. For practical application the new FTS-features were interfaced to the new Full-Mission and Desktop ship handling simulator Systems, configured by MarineSoft / benntec, based on Rheinmetall RME bridge simulator software ANS 6000.

During recent research activities it became obvious that the new FTS technology has great potential for teaching and learning in the maritime education, both for lecturing and for simulator training in briefing and debriefing sessions of exercises, to make ship handling exercises more efficient and valuable for all parties. Experiences have been made how this new technology can be used to improve the simulator training in the Advanced Ship Handling Training course at the World Maritime University, Malmoe / Sweden [12], at the Maritime Simulation Centre of AIDA Cruises at Rostock /Germany and at the CSMART Centre for Simulator Maritime Training of Carnival Corporation at Almere /NL. In addition to ship handling training, the combination of ANS and FTS can be used in port risk assessments and in harbour and waterway design studies.

Samples of application for briefing / debriefing and introduction lectures for simulator exercises specifically for typical cruises ships with Twin-Screw and -Rudder systems will be shown in the paper and at the conference. The potential of this technology for advanced maritime education and training will be discussed.

Keywords: Simulation, ship handling, training, voyage planning, optimising manoeuvring concepts

1. DESCRIPTION OF THE CONCEPT FOR USING THE FAST TIME SIMULATION (FTS) WITH A FULL MISSION SHIP HANDLING SIMULATOR (SHS)

1.1 Need for Fast Time Simulation (FTS) and manoeuvring support in SHS

Full mission Ship Handling Simulators (SHS) have to cover all training requirements on many areas: navigation, communication, resource management and last but not at least to manoeuvre a ship based on the mental model of the ship motion characteristics. Because in the SHS the simulation is in real time, all training processes are very time consuming and e.g. learning manoeuvring by Trial and Error turned out to be very costly. Therefore, the idea of Fast Time Manoeuvring Simulation was born - to present the outcome of certain rudder, thruster or engine commands in shorter time – and even more to allow for designing a full manoeuvring plan! For lecturing and familiarisation FTS plays the role of an “Electronic Smart Manoeuvring Booklet” which can answer any question on manoeuvring condition immediately and not only restricted to the standard manoeuvres in the conventional paper form booklet.

For voyage planning the IMO requires the complete distance from “Berth-to-Berth”. These plans are an important element in training to form a mental model in the trainee’s brain of the ships’ manoeuvring behaviour up to the full concept for a manoeuvring strategy (and later on-board they are necessary to agree on a concept within the bridge team and also for the discussion and briefing with the pilot). But even in training in a simulator, there is no electronic tool to quickly demonstrate manoeuvring characteristics or moreover to efficiently design a

manoeuvring plan effectively for port arrival or departure. The plan for the potential manoeuvres is still developed in a contemplative way by thinking ahead – only drafted on paper or described by self-made sketches and short explanations. Manoeuvring characteristic data are available still on paper only for calm water, impact of wind or current can be taken into account on rather vague estimations based on experiences or pure guessing. The plans are made by hand on paper charts or on a printout of electronic chart interface – by now there is no tool available to provide support for manoeuvring planning yet.

For increasing the quality and effectiveness of ship handling training and also the safety and efficiency for manoeuvring real ships the method of Fast Time Simulation will be used and has a great potential for future.

1.2 Overview on the software modules for the Fast Time Simulation (FTS) in the SAMMON system and interface with the ANS 6000 SHS

These Fast Time Simulation tools were initiated in research activities of the Institute for Innovative Ship Simulation and Maritime System (ISSIMS) 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 Germany. They have been further developed in close cooperation by the start-up company Innovative Ship Simulation and Maritime Systems (ISSIMS GmbH, http://www.issims-gmbh.com). Even with standard computers it can be achieved by the new methods to simulate in 1 second computing time a manoeuvre lasting to 24 min using innovative simulation methods. The FTS software is interfaced with the SHS ANS 6000 (ANS - Advanced Navigation Simulator) of Rheinmetall Electronics GmbH as shown in Fig. 1.

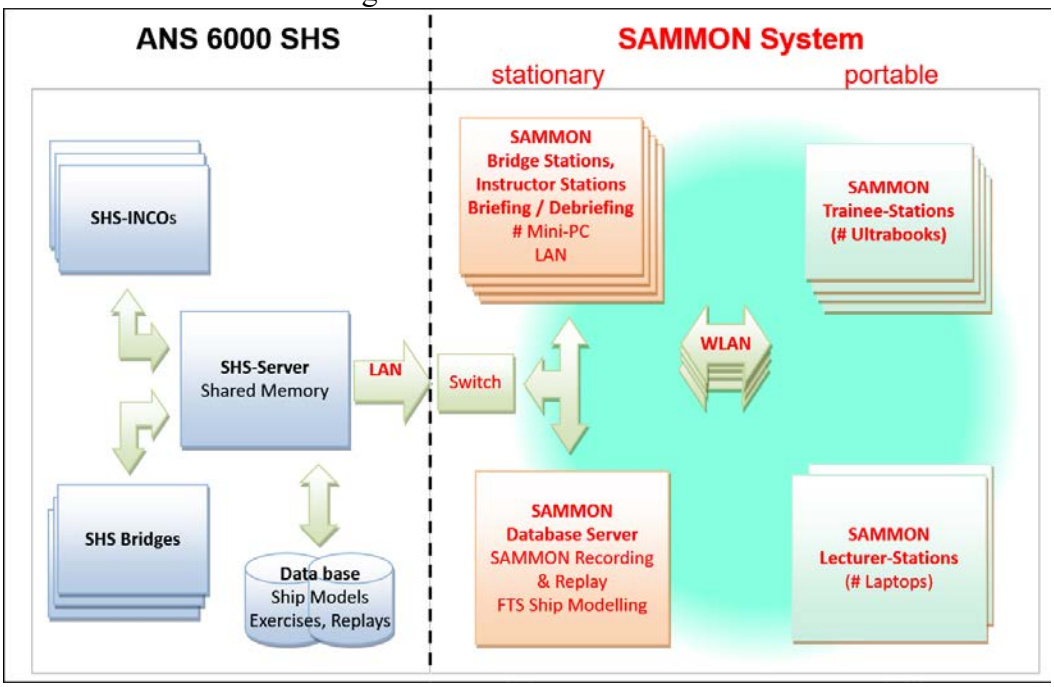


Fig. 1 The Fast Time Simulation System for Simulation-Augmented Manoeuvring Design, Monitoring & Conning - SAMMON is fully integrated toe the ANS 6000 by a smart interface using LAN and WLAN.

The SAMMON system has access to ANS 6000 Database and process data are communicated through Shared Memory and SHS Server via LAN. SAMMON uses LAN for stationary workplaces and WLAN for connecting portable stations to any exercise / bridge and replay.

The Ship Handling Simulator series manufactured and distributed by MarineSoft is a high-performance and high- quality system based on the Rheinmetall Electronics ANS 6000 with DISIXtreme visualization. The system is based on realistic behaviour due to integration of original hydrodynamic data of ships and environmental physics. The system is operated in academies and training centres as well as research institutes around the world. The bridge configuration is shown in Fig. 2 with samples for the additional elements of the FTS functionality.

Fig. 2 ANS 6000 brige simulator with Fast Time Simulation System for Simulation-Augmented Manoeuvring Design, Monitoring & Conning - SAMMON is fully integrated to the ANS 6000 by a smart interface using LAN and WLAN

- Left: Bridge simulator overview with SAMMON Planning station (right) and instructor station (left) in the foreground, manoeuvring console with displays and visual system in the background
- Right: Manoeuvring console with handles and screens with Monitoring Tool display on the left side

A brief overview is given for the modules of the FTS tools and its potential application: SAMMON is the brand name of the innovative FTS system for “Simulation Augmented Manoeuvring – Design, Monitoring & Conning”, consisting of four software modules for Manoeuvring Design & Planning, Monitoring & Conning with Multiple Dynamic Prediction and for Simulation Trial & Training and for Replay & Assessment:

- Manoeuvring Design & Planning Module: Design of Ships Manoeuvring Concepts as “Manoeuvring Plan” for Harbour Approach and Berthing Manoeuvres (steered by virtual handles on screen by the mariner)
- Manoeuvring Monitoring & Conning Module with Multiple Dynamic Manoeuvring Prediction: Monitoring of Ships Manoeuvres during Simulator Exercises or Manoeuvres on a Real Ship using bridges handles, Display of Manoeuvring Plan and Predicted Manoeuvres in parallel; Calculation of various prediction tracks for full ships dynamic Simulation and Simplified Path prediction as Look Ahead for the future ships motion.
- Manoeuvring Simulation Trial & Training Module: Ship Handling Simulation on Laptop Display to check and train the manoeuvring concept (providing the same functions as Monitoring tool; steered by virtual handles on screen)

- Recordings of scenarios from training sessions or from real ship voyage data recordings can be replayed together with the multiple prediction for assessment of the performance

SIMOPT is a Simulation Optimiser software module based on FTS for optimising Standard Manoeuvres and modifying ship math model parameters both for the ANS 6000 simulator ships and at the same time for the FTS Simulation Training Systems - and in future 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.

The SIMOPT and SIMDAT modules were described in [2] [7] for tuning of simulator ship model parameters and also the modules for Multiple Dynamic Prediction & Control, [5] for the on board use as steering assistance tool [6] [3] [4]. In this paper, the focus will be laid on the potential of the SAMMON software for supporting the lecturing and briefing / debriefing process with elements specifically for simulator training with the ANS 6000 for Advanced Ship Handling as it has been done in the MSCW and in the Maritime Simulation & Training Centre MSTC of the AIDA Cruises Company at Rostock / Germany.

2. USE OF FTS FOR BRIEFING

2.1 Task description – introduction, conventional Briefing and NEW CONCEPT

During the exercise briefing, the navigational officer is introduced into the ship manoeuvring characteristics, e.g. using the Manoeuvring Booklet, the harbour area, the starting situation and the environmental conditions within this area on a conventional sea chart, Fig. 3. The objective is to bring the ship through the fairway channel of Rostock Port from North, to turn the ship into the East channel and to berth the ship with Port Side at the Pier in the Southern basin.

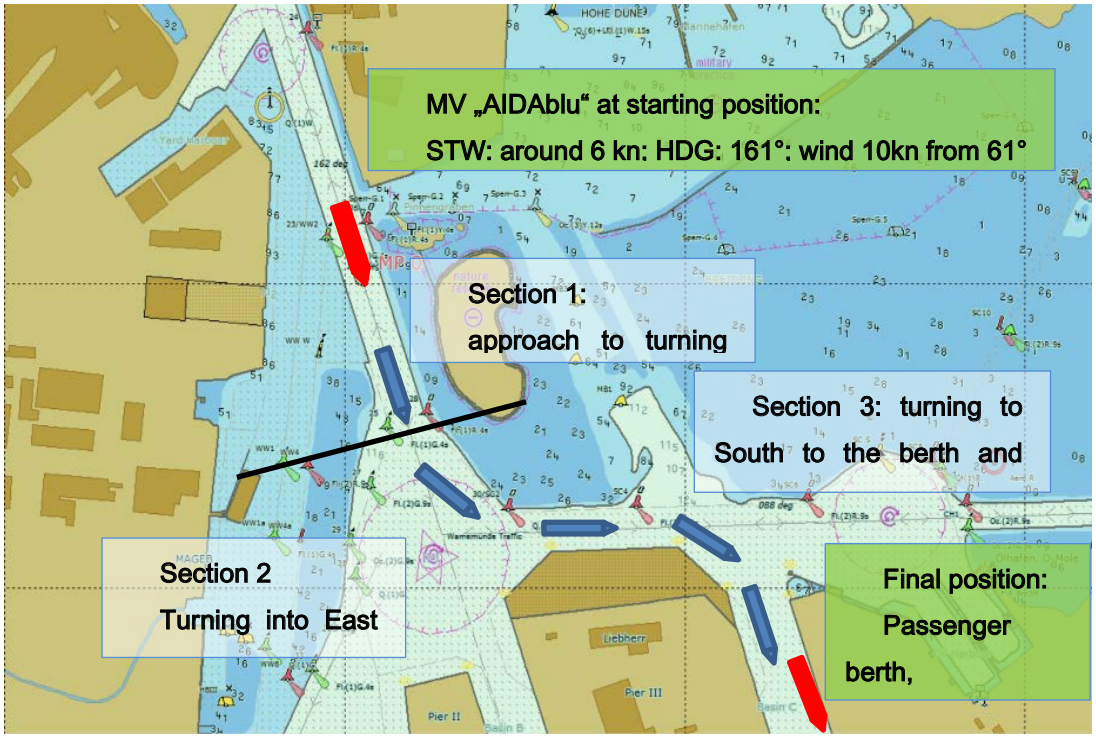


Fig. 3: Exercise area and environmental conditions in Port of Rostock for berthing scenario, divided into two sections for planning the manoeuvres and completed by guessing for desired positions as ship shapes

As shown in the figure, the respective harbour area is divided into manoeuvring sections, which are following a specific aim:

1. Section: ship speed should be reduced until she is ready to be turned, SOG should be around 3 kn to be prepared for section 2.
2. Section: the ship should be turned and adjusted to go in the fairway on East course
3. Section: the ship should be turned into South basin and stopped to be berthed.

In the conventional briefing, only these rough indications of the manoeuvring status can be used to develop a potential strategy for berthing the ship. In conventional berth plans only ship contours are used to be positioned in drawings with WORD or POWER POINT - The specific manoeuvres and settings of engine rudder and thrusters cannot be discussed in detail because specific manoeuvring characteristics can hardly be used for the specific situations. And real time simulation is too time consuming. The fast time simulation allows for new methods for individual exercise preparation with self-developed manoeuvring concepts:

- Using the simulator bridge handles to try out the manoeuvring behaviour for more conditions than in the manoeuvring booklet and also related to the specific geographic area - any potential manoeuvre commands e.g. on the distinguished positions in Fig. 3 and varying the external conditions as “what – if” discussions.
- Drafting Manoeuvring Concept in more detail as Manoeuvring Plan with the Design and Planning tool and optimisation of the concept by several planning trials with that tool,
- Pre-Training with Trial and Training Tool to try out the concept with real time simulation on a laptop

2.2 Ship familiarisation and briefing with Planning Tool and virtual handles as well as Monitoring tool with the bridge handles

By using the FTS for Ship Manoeuvring Familiarisation, the trainee can try out the manoeuvring behaviour for more conditions than in the manoeuvring booklet and also related to the specific geographic area and conditions given for the exercise. Furthermore, any potential manoeuvre commands can be tried out at any distinguished positions like exemplarily given in Fig. 3, even by varying the external conditions as "what – if" discussions.

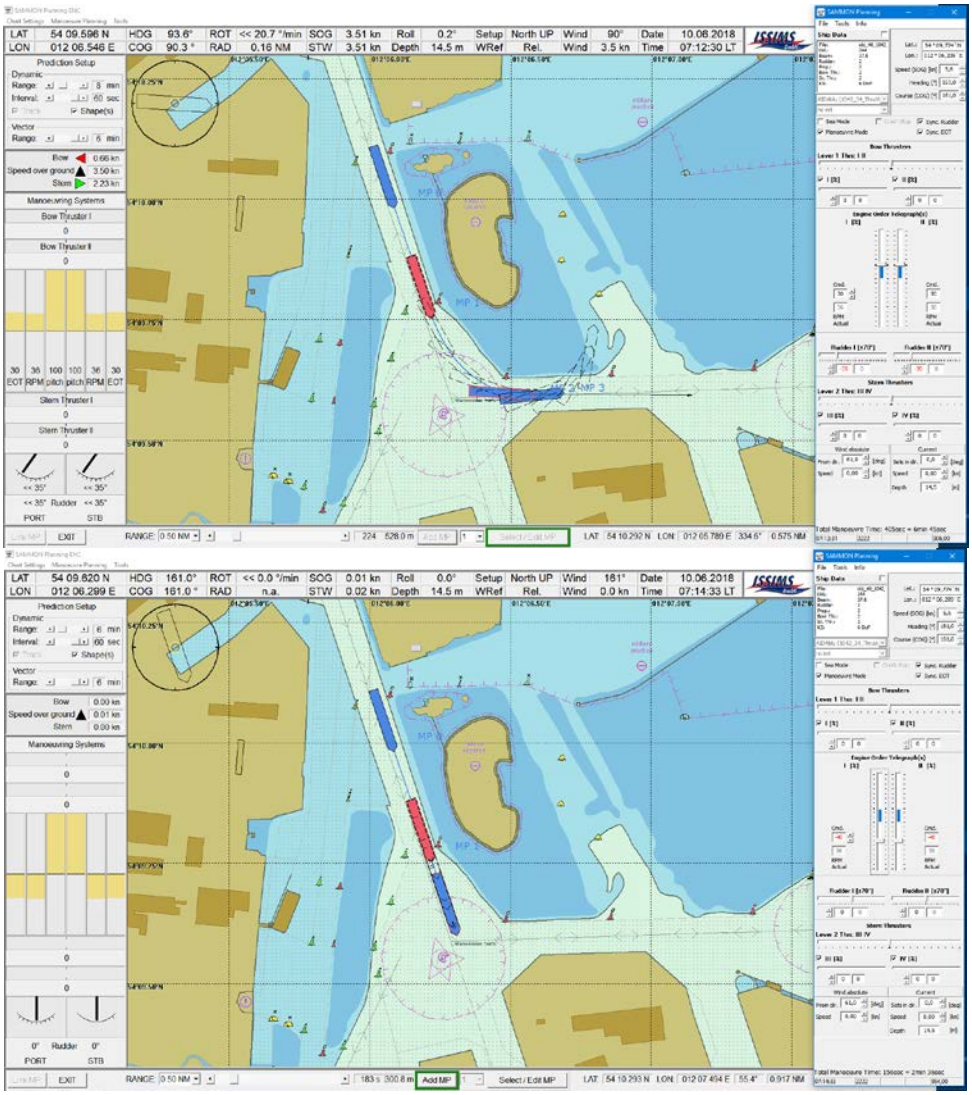


Fig. 4: Ship Familiarisation for turning and stopping characteristics with the Planning tool using the virtual interface on the right side. The Manoeuvring paths are shown in the centred ENC.

For the sample depicted in Fig. 4 the manoeuvre starts at the red shape for EOT 30% at constant speed SOG = 5.6 kn. In the upper part a turning circle with Hard Port -35° is predicted, while in the bottom picture a stopping manoeuvre with Half Astern EOT=-40% is presented.

Both, turning and stopping capabilities are investigated at the position when entering the turning area, this is done using the Planning Tool and virtual interface handle panel. The manoeuvres are started at the given speed in the scenario from Slow Ahead, in contrary to the standard manoeuvres Hard Rudder or Crash Stop in the Manoeuvring booklet which are commonly performed with service speed or Full Ahead speed, or alternatively with the real handles on the simulator bridge using the Monitoring tool.

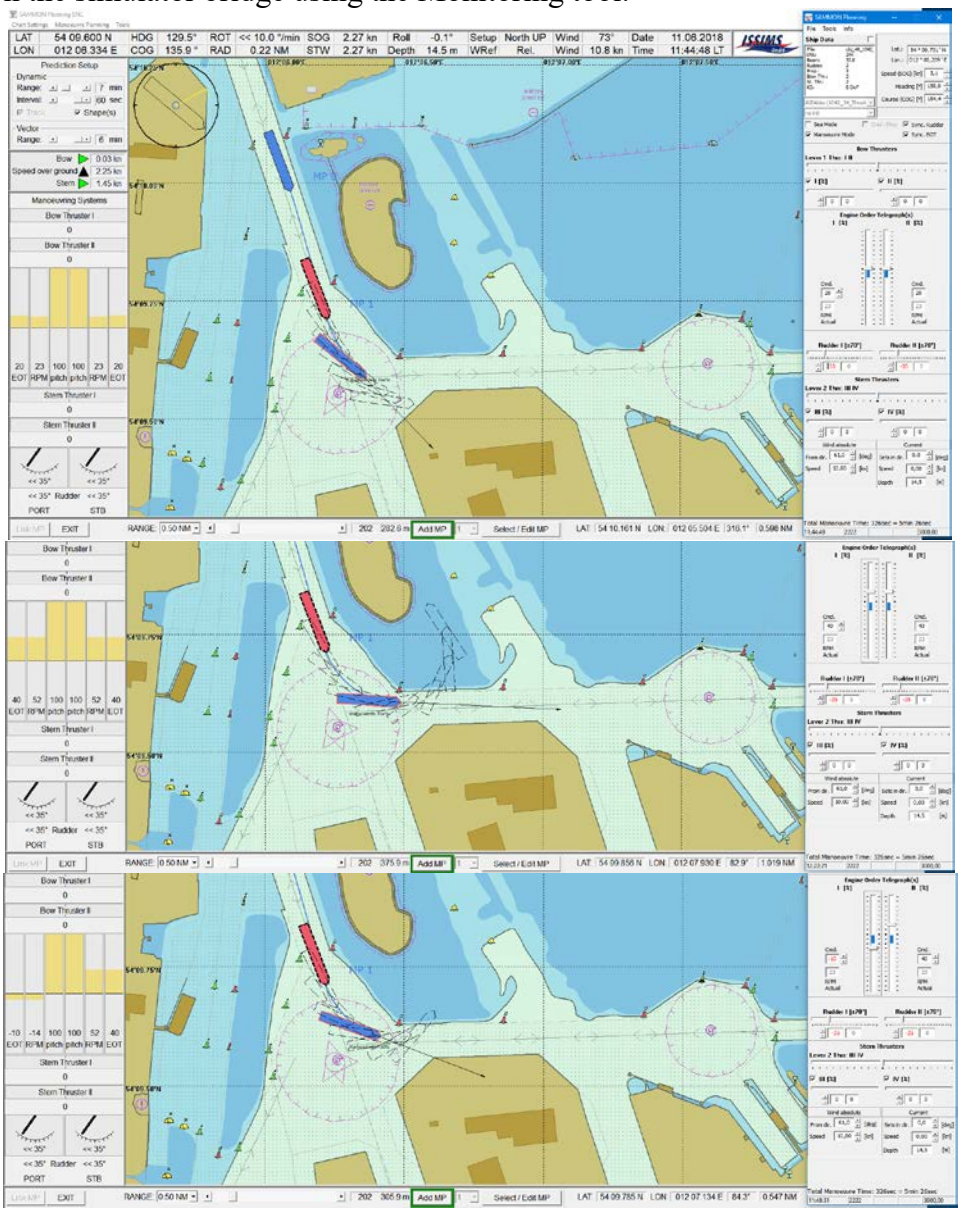


Fig. 5: Use of Planning Tool for Ship Specific Manoeuvring Tasks trying out different options for turning into the East Channel with rudder PT -35° and different engine commands. The manoeuvre starts at the red shape for EOT 20% at constant speed SOG = 3.1 kn (Top: constant engine EOT 20% - the ship is drifting away due to the wind, Middle: With increasing EOT to 40% - this “Kick turn” improves turning, Bottom: with Split Engines PT-10% and SB+40% the ship also increases turning

In Fig. 5 the planning tool is used to investigate Ship Specific Manoeuvring Tasks, e.g. for turning into a channel comparing different options with rudder only, kick turns, split engines and thrusters (to ease swept path).

In Fig. 6 the Monitoring Tool is used to also investigate different options for turning into the East Channel, but this time with the simulator Ship Bridge Handles. This improves the "Touch & Feel" for shiphandling and has some advantages specifically for complex control panels e.g. for azimuth thrusters

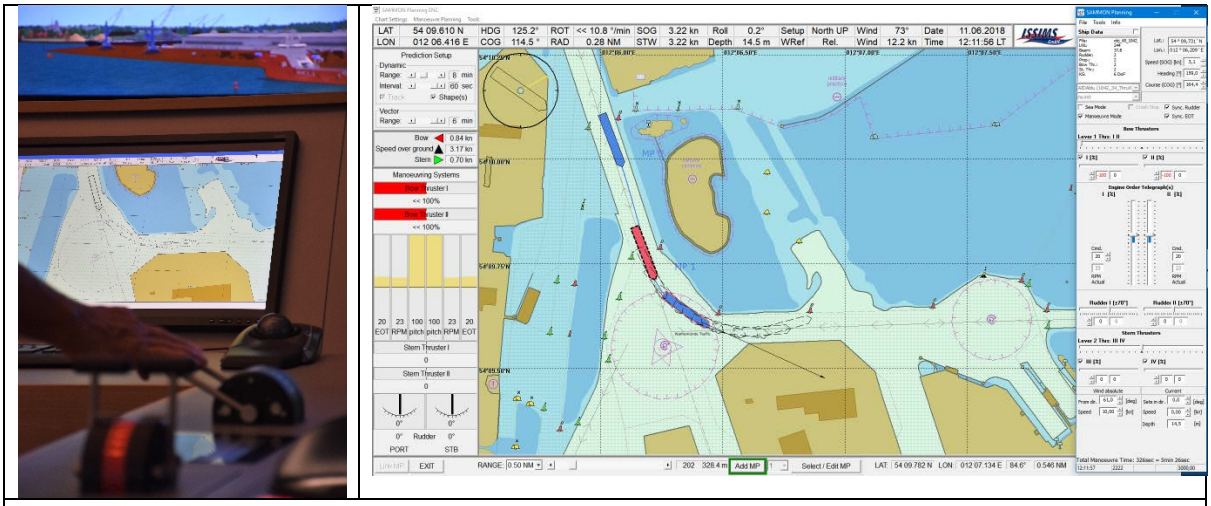


Fig. 6: Use of Monitoring Tool and Simulator Bridge Handles (left) compared to Planning tool (right) for Ship Specific Manoeuvring Tasks trying out options for turning into the East Channel with Bow Thruster. The manoeuvre starts at the red shape for constant EOT 20% at constant speed SOG = 3.1 kn using the Bow Thruster to PT -100% only - the ship is making the turn and has minimum swept path compared to manoeuvres with rudder

2.3 Advanced Briefing with preparation of Full Manoeuvring Concept by means of the "Manoeuvre Planning & Design Module"

With the new fast time Simulation there is the chance for designing a complete Manoeuvre Plan as a detailed strategy with the specific settings at distinguished positions called the Manoeuvring Points MP where the controls can be changed to adjust for the next segment to the next MP. Some basic functions and interface displays for the Fast Time Simulation within the Design and Planning Tool are shown in the next figures. Fig. 7 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
- the interface to display the status of the current actual ship manoeuvring controls (left) at the position of the next manoeuvring point MP which is indicated as ship shape in red colour in the ENC.

In the following, the course of actions is described in a series of figures to make a full

manoeuvring plan by means of the control actions at the manoeuvring points MP – this will be done for easy conditions with 10 kn wind from 61° and no current to explain the procedure of fast time planning: In Fig. 7 the initial position MP 0 is to be seen where the ship was set in the centre of the fairway. The first task for the trainee is to find the balance condition under wind in the fairway: after some easy attempts, a drift angle of about 2° and rudder angle -1° was adjusted as average value to stay in the fairway.

The ship has already been moved by the slider at the ENC bottom to set the next manoeuvring point MP 1: there the turning manoeuvre is started with EOT -30%. The prediction already shows that the ship would lose speed according to the handle positions.

Fig. 7: Fast time planning in sea chart on a big touch screen or on a laptop: Initial ship position (red shape) at MP0 is set with adjusted heading and rudder angles to balance the wind 10kn from 61°. The prediction (black dotted shapes) shows the motion of the ship due to the handle setting on the right window. The ship is moved as blue shape by the time slider at the bottom from MP0 to the next position to be set as following MP1

In Fig. 8 a manoeuvring point MP1 is set and the controls are adjusted to steer into the East channel using rudder and in parallel thruster to ease the swept path.

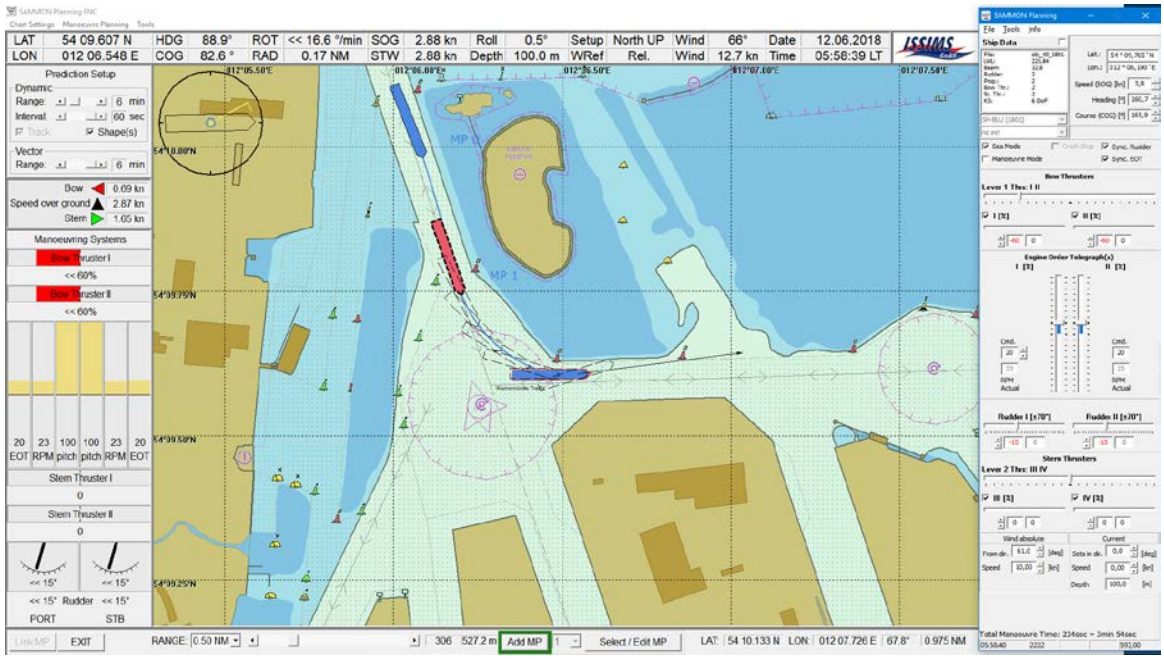


Fig. 8: Ship position at MP2 and prediction for the turning manoeuvre: The prediction shows that the ship is turning properly with small swept path due to the set handle positions of Bow Thruster with PT -60% and rudder PT -15°

The full potential of the fast time simulation can be seen for challenging weather conditions: In Fig. 9 in intermediate scenario is investigated for the case if a wind gust of 30 kn is suddenly blowing from 61°. With the same settings as in the previous example the ship would drift away but with an alternative strategy with split engines and stronger rudder the ship can by turned into the channel – and there are even reserves with thruster and others.

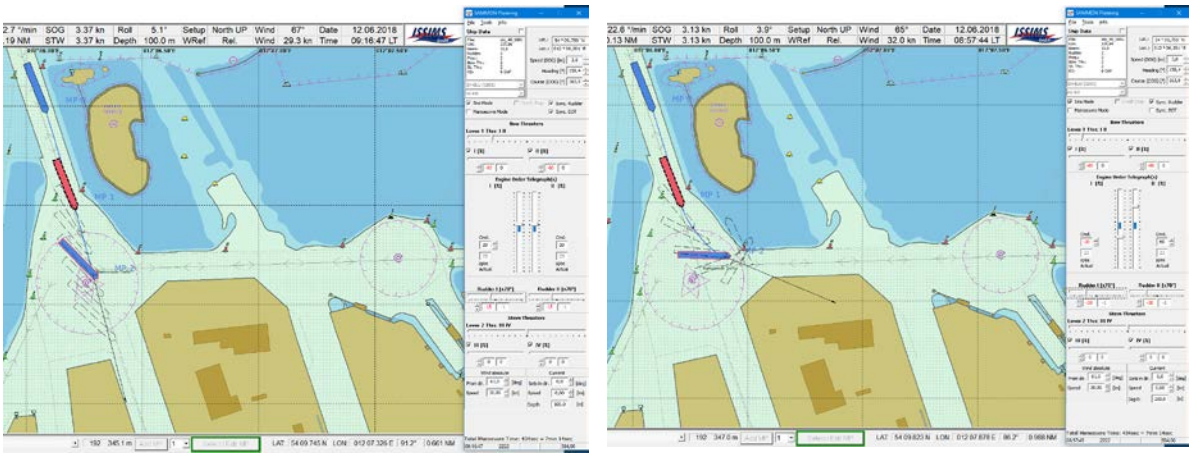


Fig. 9: What happens if at Ship position MP1 a wind gust with 30kn will start? - demonstration of consequences with no extra action and with alternative strategy:

- Left: With the original settings the ship drifts away Fig. 8),
- Right: more powerful solution with split engines (PT -20%, SB +60%) and more thruster -80% and stronger rudder support PT -30°

In Fig. 10 the regular planning for the manoeuvring plan continues with the next segment to stop the turning and proceed in the straight channel. In Fig. 11 the ship enters the South basin.

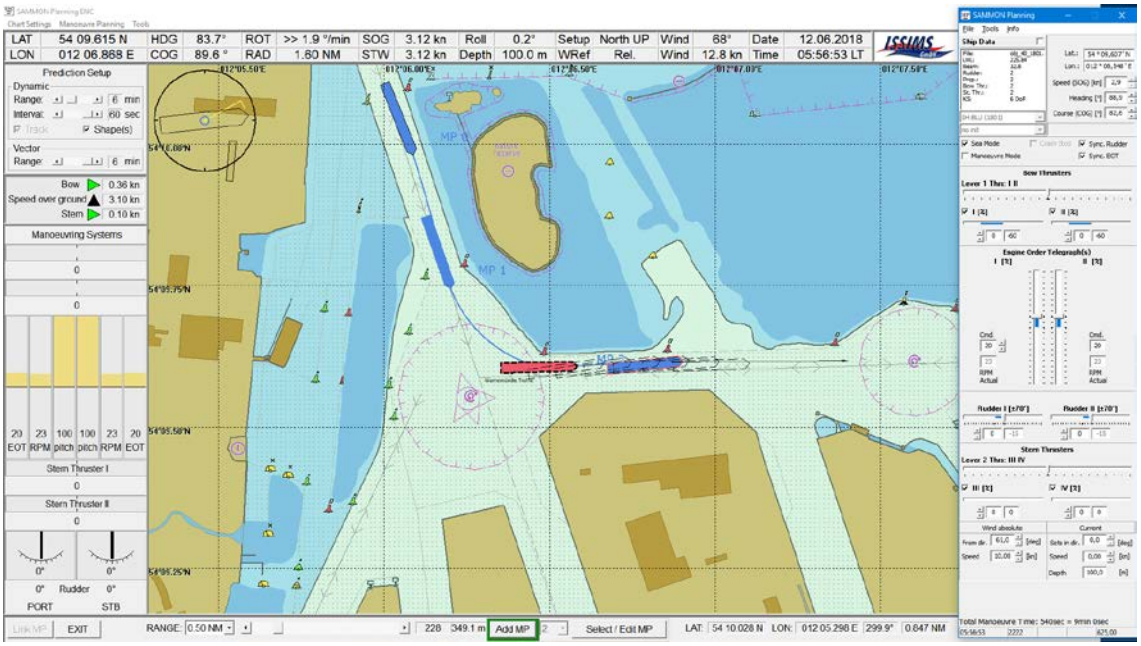


Fig. 10: Stop turning at MP 2 and steady at the straight channel segment – move for the next position to start the turning into the South basin at MP 3

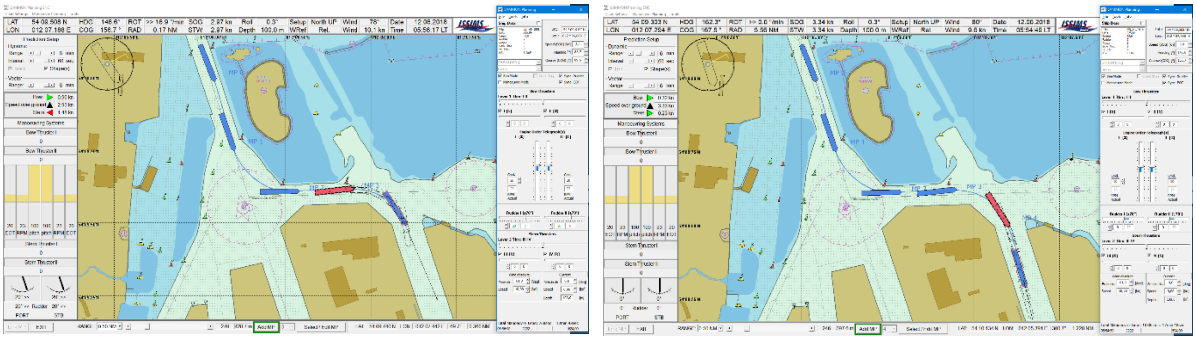


Fig. 11: Continuing the manoeuvring plan: Left: start the turning into the South basin at MP 3 Right: Stop turning and steady parallel to the berth, prepare for stopping at MP 4

In Fig. 12 the complete manoeuvring plan is shown with final stopping manoeuvre and using the thrusters to move the ship to the berth against the wind.

At MP 5 the engines are reversed to reduce speed and to stop the ships at a position parallel to the berth. With the following actions from the next MP 6 the ship is brought close to the berth to be shifted by thrusters to the pier. Afterwards the plan needs a further MP 7 and 8 in

order to reduce the transversal speed shortly before berthing.

For every manoeuvring point text boxes can be opened where information is displayed about the control setting and extra text can be entered for the briefing sessions. The whole manoeuvring plan can be saved and reloaded to be changed in the Edit Mode at every MP to investigate alternative concepts or what – if discussions.

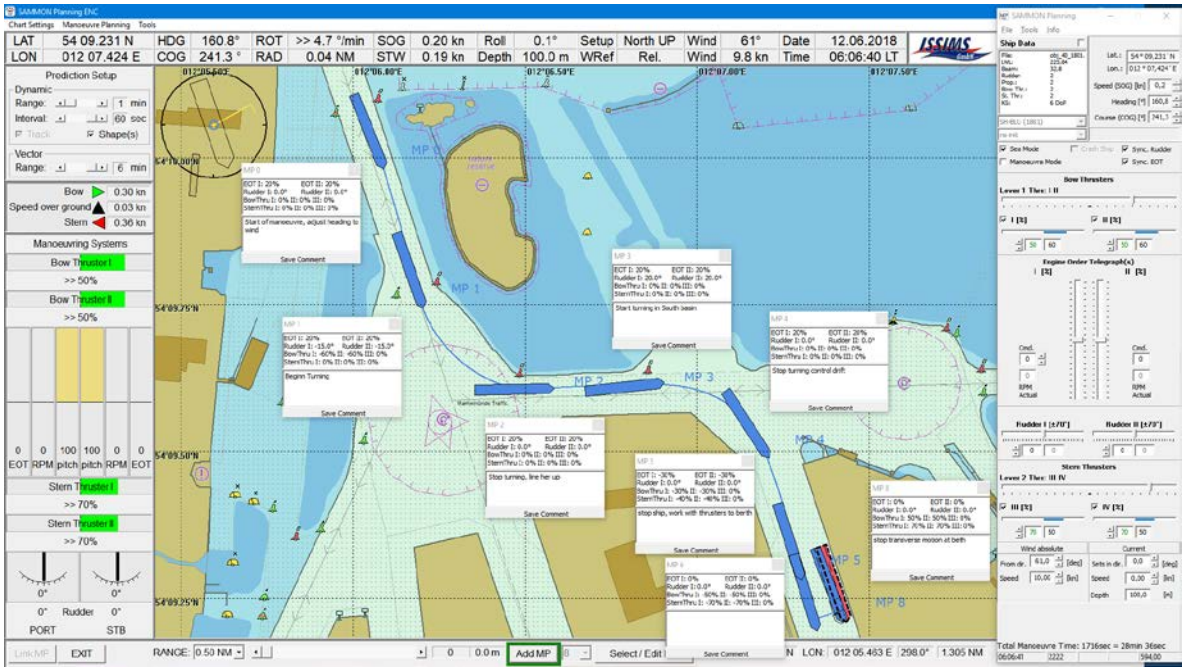


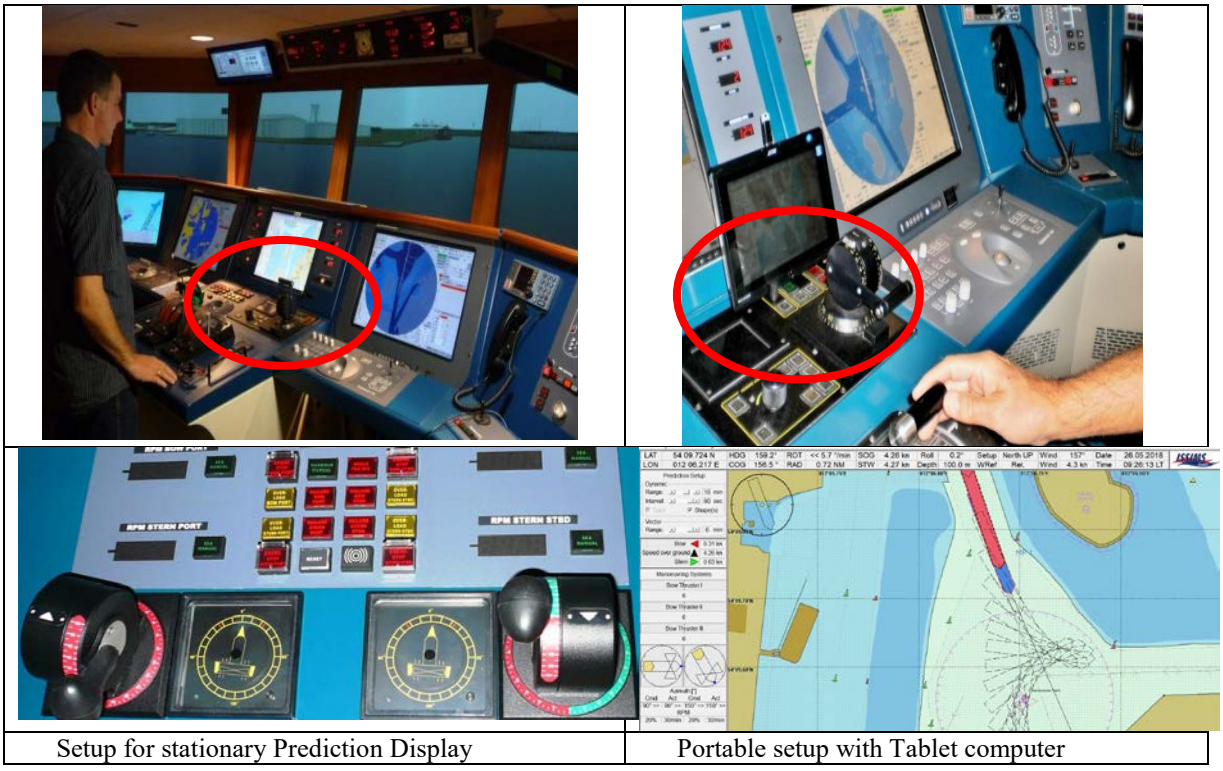
Fig. 12: Complete manoeuvring plan with final stopping manoeuvre and berthing by thrusters; additional manoeuvring point information text boxes show the control setting for the briefing session

1.3 Briefing by means of the „Manoeuvre Trial & Training Module“ on a laptop or on the simulator bridge

The Trail & Training Tool is a desktop simulation tool for real time manoeuvring simulation, Fig. 13. It contains conning information together with the prediction and it can display the planned manoeuvring track. The centre window shows the ENC together with motion parameter for longitudinal and transverse speed. The ships position is displayed as ship contour where also the track prediction can be indicated as curved track or 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 left side.

In Fig. 13 the planned scenario is shown, the ship is just entering the turning area and starts to turn at MP 2. The prepared manoeuvring plan is shown underneath in blue coloured shapes; the manoeuvre control settings from the planning can be displayed in a table on top of the ENC. An alternative briefing is possible using the simulator bride of ANS 6000 together with the SAMMON Monitoring tool. In this case all the handle signals are immediately transferred to the FTS Kernel to predict the manoeuvre and to display the result immediately in Fig. 14.

Fig. 13: SAMMON Trail & Training Tool: Real time simulation and Manoeuvring Prediction integrated into ECDIS with comparison of full dynamic predictions (dotted ship contours) and the simple static prediction (magenta curve) together with planned manoeuvring track (blue line) in (same in Monitoring Tool, except the handle panel))



Setup for stationary Prediction Display	Portable setup with Tablet computer

Fig. 14: Briefing by means of the „Monitoring & Conning Module“ using the simulator bridge handles of Bridge 1 in RME ANS 6000 Ship Handling Simulator of MSCW

In this figure on the left side there is shown a setup for stationary Prediction Display on ECDIS of Bridge 1 in RME ANS 6000 Ship Handling Simulator of MSCW – presenting immediate response to commanded position/ settings of handles during the manoeuvring process with Twin Screw Handle Panel (top) and POD Drive Handles (bottom). On the right side there is a portable setup with tablet computer which has been used for students' individual briefing /planning and afterwards for monitoring during execution on the bridge and debriefing (top) and sample of manoeuvring display when presenting a POD ship manoeuvre (bottom).

3. EXECUTION OF EXERCISE AND DEBRIEFING WITH FAST TIME SIMULATION

3.1 Use of Simulation augmented support with SAMMON monitoring Tool in Ship Handling simulator

There are several ways to support the execution and debriefing by the FTS. The support during Execution of Exercise is depending on the degree on what the trainee is allowed to use the new manoeuvring prediction technology during the exercise run.

- On a low level the multiple dynamic prediction may be used to gradually let the student know on his potential options for using the controls as a means for good visualisation of quality of manoeuvres – this is only to support the learning process specifically as long as the new technology is not available on the conventional ships
- On the highest level the trainees can make full use of the dynamic prediction and the prepared manoeuvring plan as underlying concept to achieve the best fit with the plan and the exercise result. The full use of the prediction is increasing safety & effectiveness even for advanced trainees
- For instructors (and peer students) multiple dynamic predictions are always a great help because the chances for success of a trainee's action can immediately be seen or the exercise could be stopped earlier if it is obvious that the trainee will fail.

During debriefing the fast time tools allow for an in-depth assessment of quality of manoeuvring results:

- Assessment of results by comparison with trainees own concept or optimised plan can be shown in the replay function of the Monitoring Tool which can be used with Multiple Prediction functionality; or more in detail within the SIMDAT tool where the time history of the trainees' action can be shown graphically e.g. for rudder, thruster and engine activities
- Discussion of alternative manoeuvres at specific selected situations can be supported by the Design & Planning tool by loading any specific situation during the exercise run and to operate the manoeuvring handles differently.

During the exercise, it is possible to take advantage from the Multiple Prediction for the manoeuvres. In Fig. 15: the setup is to be seen where the instructor or bring their laptop onto the simulator bridge (where the manoeuvring plan might have been developed), the prediction is controlled via the bridge handles. The same laptop with the Monitoring tool can also be placed at the instructor station.

Fig. 15: Using Multiple Prediction in Simulator Training at MSTC of AIDA Cruises Rostock. Left: Portable Setup for Prediction Display in Monitoring Tool on Trainees Laptop on Bridge - the prediction is controlled by the Bridge Handle via WLAN. Right: Prediction Display in Debriefing session (left screen): The dynamic prediction can be used even during Fast Replay to complement the simulator instructor display (right screen)

The benefit of using the FTS is to be seen for several purposes:

- The multiple dynamic predictions shown on the instructor's screen are always a great help for instructors and maybe also for peer students looking over their shoulders to learn from the actions of the other trainees in charge on the bridge. They have a better overview on the current situation and the chances for the potential success of a trainee's action can immediately be seen; the exercise could be stopped earlier if it is obvious that the trainee will fail.
- Multiple dynamic prediction may be used to gradually let the student know on his potential options for using the controls as a means for good visualisation of the quality of manoeuvres – this is to support the learning process specifically as long as the new technology is not available on the conventional ships.
- If the trainees are allowed to make full use of the dynamic prediction and also the prepared manoeuvring plan as underlying concept they achieve the best fit with the plan and the exercise result. The full use of the prediction is increasing safety & effectiveness even for advanced trainees and can support to find out the best performance.

3.2 Debriefing of Exercise and Comparison of results with Manoeuvring plan

Several methods of comparison exist for the debriefing after the training by using FTS software. Whilst in the Ship Handling Simulator (SHS) there is the possibility to additionally record the training session using the „Monitoring & Manoeuvring Module", there's a correspondent option to save the training and planning procedure in the „Trial & Training" as well as in the „Manoeuvre Design & Planning Modules". All of the files from the planning and from the execution can be shown together in form of the ship track as well as in diagrams from several parameters over the whole manoeuvring time in the SIMDAT program. The following figures show some possible methods to display the results.

Fig. 15 compares simulator results of the trainees with different level of preparation. The achievements of the better prepared trainee are obvious – the planned manoeuvre is very close to the executed track and the actions of the controls were nearly in accordance with the planned procedures. There is not just a reduction of manoeuvring time when applying the Fast Time

Simulation tool in briefing and training; the thruster diagrams show also that a well-prepared manoeuvre can minimize the use of propulsion units and therefore be more efficient. The great advantage of the Fast Time Simulation is the opportunity to discuss alternatives of manoeuvres and also effects and strategies for different environmental conditions, which might affect the ship unexpectedly at critical positions.

Additionally, the results of an exercise can be stored as simulator recordings and replayed afterwards in real time or fast mode on the bridge as "Live Replay" including the visual systems and bridges handle settings or alternatively in screens in the debriefing room. In parallel to the replay the Monitoring Tool can be used to display the manoeuvring process together with the multiple manoeuvring predictions and the manoeuvring plan as reference to the concept of the trainee - This is like looking through a spyglass to give a wider perspective on the actions of the trainees.

4. CONCLUSIONS / OUTLOOK

Fast Time Manoeuvring simulation has proven its benefits for both lecturing and training for improving ship handling knowledge and skills. It can be used as an individual training tool but unfolds its potential interfaced to a full mission simulator which is successful implemented with the Rheinmetall Electronics ANS 6000 Ship Handling Simulator, manufactured and distributed by MarineSoft / benntec. It increases the effectiveness of simulation training but also the success rate of the trainees is increasing: An analysis has shown that even less experienced navigators are able to successfully manage demanding ship handling exercises after preparation & briefing using the SAMMON planning tool on the same quality level and with a smaller failure rate as experienced professionals [8].

For the future, the use of the simulation modules for other purposes of ship operation will be investigated. This include the involvement into real ship operation on-board [10]. The majority of the participants in the ship handling courses expressed their opinion that the Design & Planning Module could be used for preparing berth plan on the ships. There is a high potential for optimisation to reduce manoeuvring time and fuel consumptions /emissions [11]. It is also possible to use the potential of FTS for various analyses (e.g. fairway layout, accidents) to find measures to make shipping safer.

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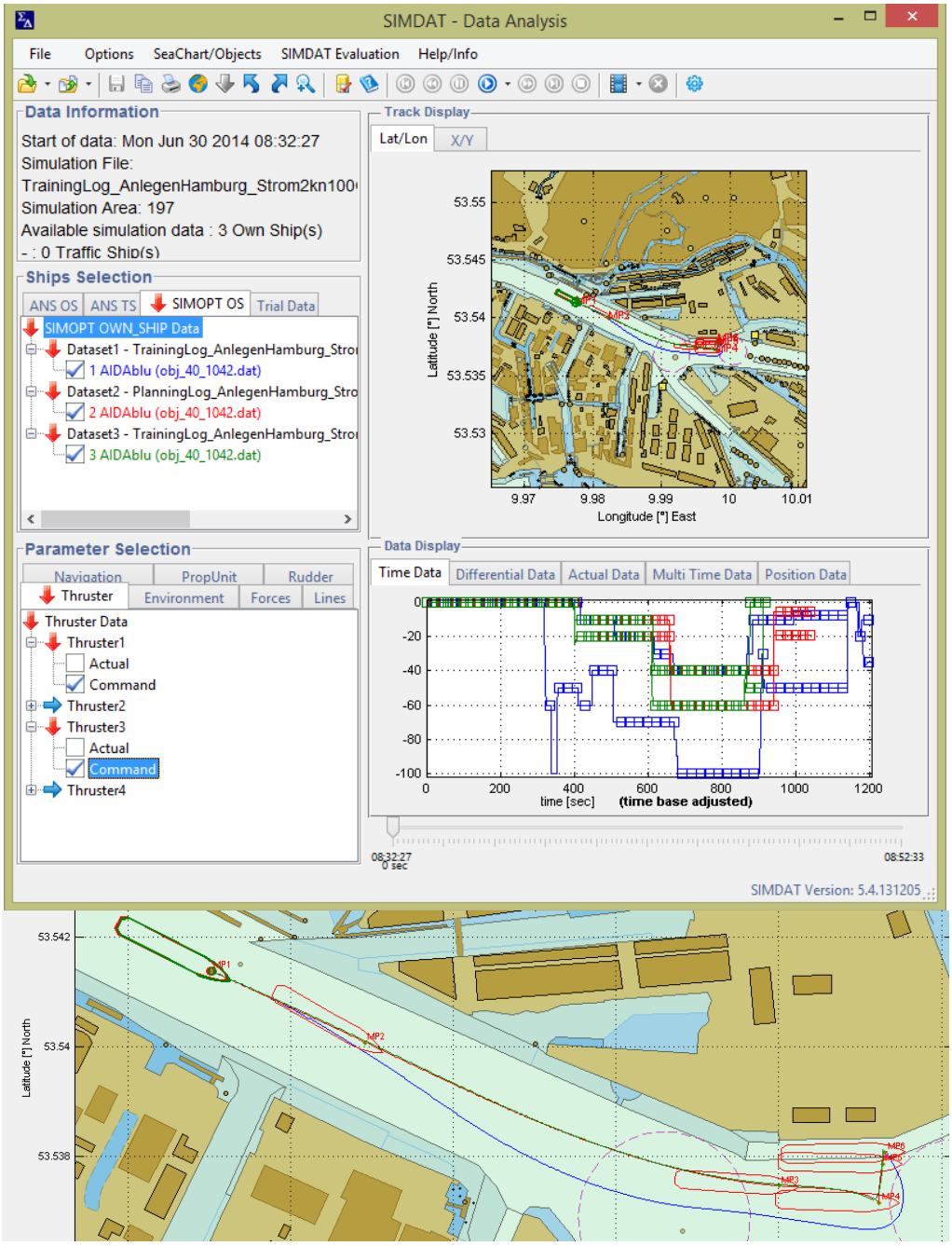

Fig. 16: Results from two manoeuvring exercises in Port of Hamburg with Cruise ship in SIMDAT interface (Top: "Track Display" with contours; Blow: „Data Display" for time history for thruster activities, Bottom: extract of sea chart from Track Display) and comparison to the prepared manoeuvring plan (below). Blue: run of the trainee without support by Fast Time Simulation; Green: run of the trainee with full support by pre-planning with Design and Planning Module; Red: prepared manoeuvring plan with manoeuvring points MP

REFERENCES

[1] BENEDICT, K. (2016), Control your pivot point position in ship handling - Multimedia approach by Fast Time Simulation, IMSF 2016 AGM Seminar, Ilawa

[2] BENEDICT, K.; BALDAUF, M.; FELSENSTEIN, C.; KIRCHHOFF, M. (2006), Computer-based support for the evaluation of ship handling simulator exercise results. *WMU Journal Maritime Affairs (2006) 5: 17*. https://doi.org/10.1007/BF03195079

[3] BENEDICT, K.; BALDAUF, M.; FISCHER, S.; GLUCH, M.; KIRCHHOFF, M.; SCHAUB, M.; KLAES, S. (2012), Fast time manoeuvring simulation as decision support for planning and monitoring of ship handling processes for ship operation on-board and training in simulators. *Proceedings Int. Conf. Marine Simulation and Ship Manoeuvrability (MARSIM),* Singapore

[4] BENEDICT, K.; BALDAUF, M.; FISCHER, S.; GLUCH, M.; KIRCHHOFF, M.; SCHAUB, M.; KRÜGER, C-P.; KLAES, S. (2016), *Simulation technology brings new visualisation of the future ships path – and advanced use of the well-known speed vector, 24th Int. Maritime Lecturers Association Conf. "Quality Standards in Maritime Education",* Galveston USA

[5] BENEDICT, K.; BALDAUF, M.; KIRCHHOFF, M.; KOEPNICK, W.; EYRICH R. (2006), Combining fast-time simulation and automatic assessment for tuning of simulator ship models. *Proceedings Int. Conf. Marine Simulation and Ship Manoeuvrability (MARSIM),* Terschelling

[6] KRÜGER, C-M.; SCHAUB, M.; BENEDICT, K.; KIRCHHOFF, M.; GLUCH, M.; FISCHER, S. (2015): Simulation-augmented manoeuvring support for ship handling on board and from shore. *Proceedings 14th Int. Conf. Computer and IT Applications in the Maritime Industries (COMPIT)*, Ulrichshusen, /Germany pp.74-88

[7] SCHAUB, M.; BENEDICT, K.; GLUCH, M.; MILBRADT, G.; TUSCHLING, G.; KIRCHHOFF, M. (2015): Modelling of ships for simulator-training and simulation-augmented manoeuvring support on board and from the shore. *Proceedings Int. Conf. Marine Simulation and Ship Manoeuvrability (MARSIM)*, Newcastle

[8] GÜNEKBAY, B: APPLICATION OF FAST TIME SIMULATION FOR TRAINING COURSES OF SHIP OFFICERS. *Master Thesis at Dept. of Maritime Studies Rostock Warnemuende, Hochschule Wismar, University of Applied Sciences - Technology, Business and Design.* Rostock / Germany May 2015

[9] Website Innovative Ship Simulation and Maritime Systems GmbH (ISSIMS GmbH; www.issims-gmbh.com).

[10] Baldauf M, Mehdi R., Schaub M, Benedict K, Milbradt G; Finger G, Fischer S (2018): Simulation-based Support to Minimize Emissions and Improve Energy Efficiency of Ship Operations. *In: Ölcer A et al (eds) Trends and Challenges in Maritime Energy Management. Springer International Publishing.* DOI 10.1007/978-3-319-74576-3

[11] Baldauf M, Benedict K, Kirchhoff, M, Schaub M, Gluch M, Fischer S (2018): Energy-efficient Ship Operation - The Concept of Green Manoeuvring. *In: Froholdt LL (ed.) Corporate Social Responsibility in the Maritime Industry.* Springer International Publishing. DOI 10.1007/978-3-319-69143-5_11 pp. 185-218

[12] Baldauf, M.; Benedict, K. (2018) Innovative Fast Time Simulation for Training. *SEAWAYS – The International Journal of the Nautical Institute*, March 2018, , pp. 6-11