MARSIM 2018

International Conference on Marine Simulation and Modelling

Proudly acknowledging 40 years
International Marine Simulator Forum

Halifax, Nova Scotia, Canada
12 – 16 August 2018

The International Marine Simulator Forum in cooperation with Lantec Marine Inc. and Virtual Marine Technology is pleased to announce the MARSIM 2018 conference in Halifax, Nova Scotia, Canada from 12 – 16 August 2018

This MARSIM 2018 Conference marks the 40 year anniversary of this event. In 1978 the first conference was organized by the IMSF founding fathers and held at Warsash, Southampton. Ever since the conference has been held with three year intervals in sequence with the AGM in the years in between.

The 2018 conference covers four days and includes the Annual General Meeting, paper presentations, simulation exhibits, technical tour and optional visit. The registration reception, conference and casual dinner, lunches and coffee/tea breaks are included in the conference. The programme and the paper abstracts are outlined in this document.

The IMSF is an organization for professionals involved in the advancement of maritime education, training and research through the use of simulation. Objectives are to provide an effective medium for the interchange of ideas, develop performance criteria for the use of simulators and to collaborate with all other organizations involved in marine simulation.
The MARSIM proceedings available to members form a source of information for anyone searching for knowledge on the topic of marine simulation and modelling.

At the present time the membership consists of some 100 member institutions from countries in all continents. The intention is to involve users and manufacturers of all applications of marine simulation. We see an ever increasing growth in the application of marine simulation giving a strong belief in the growing importance of IMSF. Assistance to any organizations and individuals who seek advice on use and manufacturing of marine simulators, will thus become an important task for IMSF.

We hope you enjoy the MARSIM 2018 conference in Canada.
Prof. Capt. Stephen Cross, PhD, FNI
Chairman IMSF

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PAPER 1

Applications of simulation and adoption of new function areas to the DNV GL Standard for Certification of Maritime Simulator Systems

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Abstract: The efforts of the International Marine Simulator Forum (IMSF) to reach a simulator classification for marine simulators was established in assistance of the development by Det Norske Veritas for a new set of rules. In the series of classification rules for maritime simulator centres, maritime academics and maritime training centres a new standard was developed and issued on the Standard for Certification of Maritime Simulator System [1].

The new Standard was published in January 2000 as a certification service from Det Norske Veritas, now DNV GL. It was introduced at MARSIM 2000 in Orlando under "Classification of Maritime Simulators, the Final Attempt Introducing DNV's New Standard by Stephen Cross, Martin Olofsson [30].

This paper discusses the follow up of and continuous work of adopting new function areas to the Standard.

Keywords*: Simulation, classification, standards, competences, function area's.*

PAPER 2

Comparative testing of an identification method based on the genetic and ABC algorithms

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Abstract A method for offline identification of ship manoeuvring mathematical models developed earlier by the authors was modified and tested on artificial training records. The method allows application of several different metrics but as the superiority of the Hausdorff metric had been demonstrated earlier, only this metric is used in this study. In addition to the classic genetic algorithm used for the internal global optimization, the recently proposed ABC (Artificial Bee Colony) algorithm was suggested as an option. The testing was performed on clean training records and those heavily polluted with the Gauss distributed white noise. In all cases, perfect results were obtained from clean records while no one method performed well when the noise was added. At the same time, contrary to optimistic conclusions that can be found in the literature, the ABC algorithm not only did not show definite advantages but even performed slightly worse than the classic genetic algorithm on the problem considered.

Keywords: *Ship manoeuvrability, Mathematical model, System Identification, Global optimization, Genetic algorithm, ABC algorithm*

PAPER 3

Effect of Load Condition on Zig-Zag Manoeuvres of a VLCC in Adverse Weather Conditions

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Abstract In this study, the effect of the load condition of a very large crude oil carrier (VLCC) on steady-state sailing performance and zig-zag maneuvers in adverse conditions is investigated by conducting an MMG-based maneuvering simulation [4]. The steady-state sailing condition in adverse weather conditions is quite different between the full-load condition (DF) and normal ballast load condition (NB): the absolute value of the check helm becomes small in NB, but the hull drift angle becomes large. In adverse weather conditions, the first and second overshoot angles (OSAs) in head wind and waves become smaller than those in still water (SW), and those in following wind and waves are almost the same or become larger than those in SW. In the case of 10/10 zig-zag maneuvers of a ship in beam wind and waves, the first OSA increases compared with the value in SW, because the effective rudder angle decreases, and the second OSA decreases, because the effective rudder angle increases. This tendency becomes opposite for -10/-10 zig-zag maneuvers. The effective rudder angle changes owing to the order of magnitude of the check helm in adverse weather conditions. These tendencies with respect to OSAs are the same in between DF and NB, although DF is more significant.

Keywords: *Load condition, zig-zag maneuvers, Steady-state sailing performance, VLCC, MMG-model, Adverse weather conditions, Course stability.*

PAPER 4

Rudder-equivalent pod propulsor helm angles for a gas carrier

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Abstract: The International Maritime Organisation (IMO) resolution MSC.137(76) - STANDARDS FOR SHIP MANOEUVRABILITY is mandatory for most of the ships. However, these procedures do not correspond directly to ships with other than conventional steering and propulsion systems, e.g. pod-driven ships. IMO is aware of this shortcoming and for ships with non-conventional steering and propulsion system may permit the use of comparative steering angles to the rudder angles specified by the Standards. To elaborate the mentioned equivalent angles, experiments with free-sailing manned model of a gas carrier have been carried out. For comparison, two sister ships have been taken into consideration, i.e. twin-pod propulsor with pulling propellers and twin-propeller twin-rudder version.
IMO required manoeuvres, i.e. turning circle and zig-zag test have been done during the experiments campaign. For both tested ship versions, manoeuvres according to standard IMO procedures have been carried out. Additionally, for twin-pod propulsor version, manoeuvres with various pod propulsor settings have been done to find the equivalent angles.
The present paper shows preliminary outcomes of investigation on described comparative steering angles issue. Results of the research prove, that it is possible to find such a value of pod propulsor helm angles, that IMO recommended manoeuvres for pod-driven ship version will give similar results to twin-propeller twin-rudder sister ship. However, it has to be noted, that the equivalent angle values vary for different manoeuvres.

Keywords: *IMO, Turning test, Zig-zag test, Advance, Tactical diameter, Rate of turn, Speed loss, Overshoot angles, .*

PAPER 5

A Study on the Manoeuvrability of KVLCC2 by Indoor Free Running Model Test in Calm Water

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Abstract This paper aims to study the manoeuvrability of KVLCC2 based on the indoor free running model test (FRMT). A position measuring system is developed by the electro-optical auto-tracking instruments, i.e. total station, for the indoor FRMT. The model ship speed is estimated by applying the low-pass filter to the data by Euler differentiation of the position measurement. The position and speed measuring system is verified by the outdoor and indoor test data produced by RTK-DGPS and the towing carriage in KRISO. A 1/100 scaled KVLCC2 is used for the manoeuvring test. Straight-line speed test, 35° turning test, and 20°/20° zig-zag test are carried out in the ocean engineering basin of Korea Research Institute of Ships & Ocean Engineering (KRISO). The KVLCC2 FRMT results of this study are compared with those of Maritime Research Institute Netherlands (MARIN) and National Research Institute of Fisheries Engineering (NRIFE).

Keywords: *KVLCC2, Ship Manoeuver, Indoor Free Running Test, Total Station, Speed Estimation*

PAPER 6

Research on Ship's Squat by the Effect of Swell in Marine Simulator

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Abstract The control of Under Keel Clearance (UKC)of ships is an essential method to make full use of waterways, which is also the basis of navigation safety. The crux of UKC control is to ascertain the ship's squat in specific situations. This study is conducted by using ship maneuvering simulator to calculate the squat of different ships in six degree of freedom (SDOF) motion with different speed under swell. The swell condition is further indicated by the angle between swell direction and the ship and significant swell height. The bulk carriers of two level of displacement are tested. The curve for the draught ratio of the vertical movement under the influence of swell is obtained accordingly. The mathematical relationship between the ship's squat and the draught under the condition of swell can be revealed based on the statistical results during simulation. The research could provide a theoretical reference for the seafarers during navigation and the port authority during plan and design.

Keywords: *ship's squat, swell, ship maneuvering simulator*

PAPER 7

Offline Vector Tugs Actuation Model
(An Efficiency Analysis of Towage Force During Pull Operations)

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Abstract: In BARRERA and TANNURI (2017) a static equilibrium model was proposed to correctly represent the positioning and towing force magnitude exerted by vector tugs during pull operations. Based on such model, by fixing main control parameters normally imposed by a pilot or by the environment such as the tug´s propeller thrust; the tow line angle; the current speed and its hull drift angle; the towed vessel's advance speed; one can obtain the remaining control parameters (i.e., the propeller's angle of actuation, the tug's heading angle and the resultant towage force) that represent the actuation of a vector tug during pull operations. Although useful for this representation, the model proposed rely on interactive solution solving methods based on optimization algorithms that require extensive computational power, consequently being time consuming and not applicable for Ship Maneuvering Simulators which possess a significative small integration time step. In this work, the algorithm proposed will be used to create efficiency curves relating a vector tug towline angle of actuation, several sets of external disturbances, and different demanded propeller actuation forces. Based on the data provided on this work, offline interpolation methods may be used to correctly obtain the actuation model of a vector tug during pull operations within a simulation time step. By using the offline model proposed, the maneuvers performed in Ship Maneuvering Simulators will gain a new level of reality when vector tugs are used.

Keyword: *vector tugs, static equilibrium, tug performance diagram, pull operations, maritime simulator.*

PAPER 8

Turning Characteristics of KVLCC2 in Regular Head and Beam Waves

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Abstract: Free-running tests for 1/100 scaled KVLCC2 model ship are performed in regular waves and its turning characteristics are investigated in this study. Model tests are carried out in Ocean basin of Korea Research Institute of Ships and Ocean Engineering (KRISO). Real-time motion measuring devices such as gyro, inclinometer, as well as self-propulsion and steering system are installed on the model ship. Model ship trajectories are measured by detecting the laser reflection beam from the target on the model. Wave height is fixed as 2.0 percent of model ship length, and the wave lengths are varied from 0.5 L to 1.5 L. 35 degree port and starboard turning tests are performed in regular head and port beam waves. Model propulsion point for the model ship speed corresponding to the full-scale service speed, 15.5 knots in calm water is fixed as 17.5 RPS in all tests. There are significant differences in the drifts of trajectories depending on the wave length. The effects of variation of speeds and yaw rates on the drifts of trajectories are analyzed. Although initial turning trajectories and speeds in beam waves are different from those in head waves, the drifts of trajectories show similar tendencies in head and beam waves during steady turns. In some cases, the wave heights are varied in range of 1.0 to 2.0 percent of ship length. The trajectories are compared to each other and the drifts of trajectories are analyzed with the concept of wave drift forces.

Keywords: *KVLCC2, Free-running model test, Regular wave, Turning trajectory, Turning speed, Speed loss*

PAPER 9

Locally Weighted Learning Identification Modeling for Ship Maneuvering Motion with Reduced Computational Complexity

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Abstract:Ship maneuvering mathematical model plays an important role in ship-handling simulator. This paper proposes a novel ship maneuvering identification modeling method based on locally weighted learning (LWL) scheme. To avoid the heavy computational burden in the LWL, the grid index subspace constructed algorithm is presented. The high dimension training data can be encoded, and training data are divided into the grids. The query point is encoded by using the same strategy, and grid coding which belongs to the query point is obtained. A subspace would be per-allocated to a query point by using the grid index which has a small computational complexity. Different form the general cluster algorithm, a subspace rather than a neighborhood is assigned to query point. LWL is carried out in a subspace, and the computational complexity is significantly reduced. Therefore, the real-time performance can be effectively guaranteed. Finally, the theoretical calculations and simulation examples are given to validate the effectiveness of the proposed scheme.

Keywords*: Grid Index, Subspace Constructed, Locally Weighted Learning, Ship Maneuvering Modeling*

PAPER 10

Withdrawn by author.

Replaced with:

Trends in Maritime Simulation Display - 2018

R. P. Higgins, MBA President – Electric Picture

PAPER 11

ELECTRONIC CONTROL OF MARINE CYCLOIDAL PROPELLERS: MODELLING AND SIMULATION STUDIES

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Abstract: The paper presents the modeling and simulation of electronic control of marine cycloidal propellers. It is shown that with electronic control, different designs of marine cycloidal propellers like Kirsten Boeing propeller and Voith Schneider propeller can be operated by a single electronic controller. The proposed idea is incorporated by introducing the state of independency in controlling the blades by replacing the existing robust mechanical control structure of marine cycloidal propeller with the electronic control mechanism. Model experiments are carried out in the air to demonstrate the phenomena. The hydrodynamic model suggests the non-linearity of the system. The transfer function model is prepared to represent the control system. It is demonstrated that synchronization of electronic actuators improves the performance of marine cycloidal propellers by the electronic control. Besides all, there are possible limitations of using electronic actuators as principal part of the system. Those are listed as the fluctuation in the rotational speed of the motor dedicated to rotating the propeller disc, fluctuation in the rotational speed of actuators responsible for the pitching of propeller blades, high-frequency data transmission through slip rings, efficient watertight seals, etc. Simulated results of hydrodynamic parameters like thrust, torque on propeller disc and blades help in evaluating the limitations of electronic control.

Keyword: *Control algorithm, Marine Cycloidal Propeller, Transfer function, Hydrodynamics, Pitch angle.*

PAPER 12

Ship Course Control based on BAS Self-Optimizing PID Algorithm

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Abstract: In order to improve the control accuracy of ships and solve the problem of poor navigation effect due to the difficulty in adjusting the ship motion control parameters, a Beetle Antennae Search (BAS) self-optimizing Proportion Integration Differentiation (PID) control algorithm is proposed in this paper. Firstly, the three-degree-of-freedom MMG model of KVLCC2 model ship is established, then an optimization function is constructed based on the ship course tracking error, and a course tracking controller is designed, which considers the actual ship rudder turning rate as the control parameter. Finally, the BAS self-optimization algorithm is used to adjust the PID control parameters to obtain the optimal course tracking results of the ship in real time. Simulation experiments show that BAS self-optimizing PID algorithm can optimize the system control parameters, and has higher efficiency and accuracy than manual adjustment of control parameters.

Keywords: *ship course control; BAS; PID; rudder turning rate*

PAPER 13

Design and Application of Multi-function Marine Simulators for the Future

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Abstract As the development of smart ships, marine simulators are expected to have multiple functions to fit the needs of future research, training, and practices for instance remote-control experience. This paper introduces design of a multi-function marine simulator that integrates state-of-the-art devices and technology. The composition of the proposed simulator consists of shore-based and ship-based facilities and devices, including, but not limited to on-board sensors, VR glasses, six-degree-of-freedom platform, and computation servers. The functions of the simulator introduced in combination of the application scenarios. Furthermore, the practical applications in remote control, enhanced navigation, and test and measurements of smart ships are presented. In the end, pros and cons of the proposed simulator and possible upgrades for further development are summarised.

Keywords: Marine Simulators; Smart Ships; Remote-control Ships; Test and Measurements

PAPER 14

Impacts of Rudders on the Performance of a Benchmark Inland Vessel in the Rhine

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Abstract: Even though new technics are rising, rudders dominate the steering devices of commercial ships. Years of research have been done to design a proper rudder while impacts of rudders on ship performance are still hard to quantify. Considering the rudder profile, the number of rudders, and layout of multiple rudders, new regression formulas have been proposed to calculate the lift and drag forces that are generated by rudders. Based on test data of benchmark inland vessels in the Rhine, the probability distribution of applied rudder angles during the voyage are analyzed. Applying these data to an integrated maneuvering model, impacts of rudders on maneuvering and propulsion performance of benchmark inland vessels are presented.

KeywordS: *Rudders, Resistance and Maneuverability, Maneuvering Performance, Propulsion Performance, Inland Vessels*

PAPER 15

The influence of wave drift forces coefficients in the assessment of navigable areas of ports and harbours exposed to high waves

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This paper assesses the influence of wave drift forces for the design of navigable areas in ports or harbours subject to high swell waves in terms of resources required for the manoeuvres (speeds, rudder angles, engine rpm, …), as well as in the area occupied by the vessels during the transit in approach channels.

Nowadays Operators and Terminals want to increase operational limits and for that reason wave limits are increasing to significant wave heights over 3 and 4 meters in exposed approach channels, which increases the difficulty of the manoeuvres and therefore the design requirements of the navigable areas both in vertical and horizontal dimensions.

The assessment is based on simultaneous consideration of the vertical and horizontal requirements. Therefore, determining the appropriate wave drift forces coefficients at a specific depth is required, as wave drift forces vary with the UKC.

The numerical model AQWA is used to assess and obtain the wave drift forces of the vessels at different water depths. Results derived from the numerical model AQWA have been compared with model tests results for validation purposes (KVLCC2 deep water results from CEHIPAR), and therefore assess the applicability of the numerical model AQWA to obtain the wave drift forces to be used as input in the manoeuvring models.

The drift forces obtained from the numerical model are later converted to the wave drift coefficients required as input in the manoeuvring models of vessel to be used, either fast-time models or real-time simulators.

KeywordS: *Numerical and physical Models. Wave Drift Forces. Validation. Real Time Simulators*

PAPER 16

Intelligent Control Strategies used in Fast Time Ship Manoeuvring Simulations

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***Abstract*:** Fast time simulations are an efficient method to assess and analyze ship manoeuvring behaviour in confined water. The track-controller plays an important role in controlling the ship trajectory in these fast time simulations. In order to improve track-controller accuracy and adaptability in different nautical environments, different intelligent control strategies are considered to be used in the simulation. The principle and characteristics of the track-controller as used at Flanders Hydraulics Research (FHR) and Ghent University are firstly described, then advanced and smart control methods depending on its characteristics are reviewed and compared. Finally, the grey relational decision-making approach is applied in selecting the proper control strategy for the track-controller. Based upon the results from comparison, the fuzzy logic control algorithm is the most suitable for track-controller designing due to its simple control structure and good adaptability.

Keywords: Fast time simulation; Track-controller; Intelligent control strategies; Autopilot; Ship manoeuvring

PAPER 17

Design and Experiment of the New Type Parallel Correction Guidance Autopilot System

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Abstract: This research work developed new type of parallel correction guidance method for marine vessel autopilot system on path-following maneuver. The motivation of this study is tried to enhance the original parallel correction guidance performance. The line-of-sight guidance law has been widely adopted by most of the marine vessel on the path-following practices. But there are also some limitations during usage. This study proposed an alternative trajectory correction guidance method which adopted the cross-track error and heading error as feedback information to increase the correction process to steering the vessel back to the desired path. By using the heading error information, alternative parallel correction guidance method improves the guidance ability. This can prevent the cross-track error in advance occurrence significant during the path- following maneuver. The feasibility of the proposed guidance autopilot system was verified with performing a series of path-following maneuvers by using numerical simulation experiments and shiphandling simulator-based experiments. The experiment results revealed that path-following mission have been successful achieved by using the new type alternative parallel correction method. Both deviation distance convergence of the ship and the heading error along the desired path have been shortening by using different types of alternative parallel correction autopilot system.

Keywords: *Line-of-Sight(LOS), Parallel Correction(PC), Autopilot system*

PAPER 18

Navigation Safety Analysis Based on Ship Squat Calculations

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Abstract: When a ship sails in relatively shallower water, the hydrodynamic interaction between the ship and the water bottom becomes more pronounced which may lead to a larger ship squat. Ship squat is an important issue that influences ship safety in restricted waters. This paper focuses on ship navigation safety analysis in such waters based on the results of ship squat calculations. Three ship types, the container ship KCS, the tanker KVLCC2 and a bulk carrier, are selected as the study objects. Ship squat of these ships sailing in restricted waters with different depths is calculated by using a Rankine source panel method and empirical method. The critical speed for each ship at which the Under Keel Clearance becomes zero (critical status) under different water depths is determined according to the calculated ship squat, and the critical status curves denoting that the ship just touches the water bottom are obtained. According to the critical status curves in various situations, navigation safety for a ship traveling in restricted waters can be analyzed qualitatively. The results presented in this paper may provide some references for ship handling in restricted waters and port or waterway design.

Keywords: *Ship squat; Under Keel Clearance; Rankine source panel method; Numerical calculation; Safety analysis*

PAPER 19

Effective Lookout by Decreasing the Workload Factor for Achieving Safe Navigation

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Abstract: In order to maintain safe navigation, navigational officers are required to deal with given navigational situations. These are tasks to be carried out, which constitute workload on officers. Accordingly, it is crucial not to get into situations where workload is deemed to exceed their own competency. Especially, lookout for avoiding collisions with encountering vessels are affected by the number and movements of encountering vessels, which increase workload. Deriving alternative measures for effective monitoring of encountering vessels in order to decrease workload, could improve effectiveness of lookout with a view to achieving safe navigation. Measures for lookout consist of multiple actions such as visual observation and instrumental monitoring. However, experienced officers judge the risk of collisions primarily based on visual observation. In this paper, the authors focus on lookout by visual observation to derive such effective measures. Consequently, using the crossing angle of courses and the ratio of velocity between one's own vessel and encountering vessel, a specified area for lookout with a higher risk of collision are proposed. This can be an effective guide for prioritizing specified vessels to be observed and decrease the burden from workload on officers, which enables effective lookout for judging risks of collisions.

Keywords: *Decreasing workload, Lookout procedures, Prioritizing, Specified area for lookout*

PAPER 20

Proposal for Progress of Full Automation of Ship Handling

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Abstract: Today the discussion on the full automation on ship navigation system is progressing by relating to e-navigation, reducing human mariners and so on. There are strong intentions by developing technology in ship builders, instrument maker and management sector in shipping companies. However, the significant question arises how necessary functions to maintain safe navigation are determined.

In this paper, the author discusses the following issues:
- discussion on the relation between device functions and environment from the view point of safe operation
- explanation why some devices can be operated using full automation
- special issues of ship operation comparing with other moving devices
- necessary discussion and conditions for realization of full automated navigation system

These discussions are indispensable in order to create perfect automated ship navigation systems from a safety aspect.

Keywords: *Ship operation, Full automation, Necessary conditions, Uncertainty, Safety aspect*

PAPER 21

A Study on the Effect of Heel Angle on Manoeuvring Characteristics of KCS

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Abstract: It can be anticipated that a ship's hydrodynamic characteristics is changed according to heel angle. Furthermore, it can also be anticipated that a ship's manoeuvrability is changed according to change in hydrodynamic characteristics. Generally, the effect of heel on a ship's manoeuvrability has been dealt with [3+1] degrees of freedom (DOF) (3-DOF manoeuvring + 1-DOF roll) equations of motion. However, if heel angle becomes large, the conventional equations of motion are not enough to simulate a ship's manoeuvring characteristics. In this paper, change of hydrodynamic characteristics by heel angle of a ship is studied through captive model tests. A 1/42 model KCS was used for the captive model tests. Through the analysis of the model tests results, modified equations of motion in the view point of manoeuvrability are presented to deal with the effect of heel. By a number of numerical simulations, changes of turning and zigzag characteristics according to heel angles are suggested.

Keywords: *Manoeuvring Characteristics, Heel Angle, Captive Model Test, Numerical Simulations, KCS*

PAPER 22

Advantages of Ship Simulation Screening Port of Long Beach, CA Case Study

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***Abstract*:** In 2012, the U.S. Army Corps of Engineers significantly changed the feasibility study process by implanting "SMART" Planning. SMART planning set limits on feasibility study funding, length of study time, and feasibility report size. Because of SMART planning requirements, the USACE pushed the required simulation studies into the Pre-Construction Engineering and Design portion of the project for many studies. However, proposed channel layout was determined during feasibility with little allowance for modification during PED. To include some channel design checkout during feasibility, the USACE Engineering Research and Development Center initiated simulation screening during the feasibility portion of the study. This paper will discuss the SMART process and its effect on ship simulation. The development of the screening process within the USACE will be examined and a case study presented for the Port of Long Beach, CA.

Keywords: *Ship Simulation Screening, SMART Planning*

PAPER 23

An Experimental Study on the Turning Characteristics of KCS with CG Variations

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Abstract: A ship in heeled condition has a different manoeuvrability when it sails. The aim of this study was to investigate the change of turning ability of the ship with different center of gravity (CG) positions. A free running model test (FRMT) with 1/65.83 scaled KCS was conducted in three easily heeled CG conditions: up, forward, and to port. The tests for each condition, such as GM condition (up), trimmed condition (forward), and heeled condition (to port), were analyzed with trajectories and navigation data, and the test results showed that the tactical diameters became shorter in three conditions. In the case of KCS, turning ability in trimmed condition was considerably changed due to the waterplane shape of the ship. These results indicate that the roll angle of the ship strongly affects the speed and rate of turn on the ship. The trajectory and navigation data from this study provides benchmark data sets for other simulation research to compare with for maritime accident analysis.

Keyword: *Free running model test, KCS, Center of gravity, Turning, Manoeuvrability*

PAPER 24

Squat Formula for Cape-Size Bulk Carriers Based on Towing Tank Results and Full-Scale Measurements

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Abstract: On behalf of the Common Nautical Authority, Flanders Hydraulics Research and Ghent University analysed the squat behaviour of cape-size bulk carriers based on both full-scale measurement and towing tank results.
The full-scale measurements focused on seven inbound cape-size bulk carriers (drafted approximately 16.5 m) to the port of Flushing/Vlissingen (NL). The voyages of this type of vessels corresponded with small under keel clearances (to a minimal value of 16%) and exposed wave conditions (with a wave height up to 2.6 m). By filtering steady and unsteady motions the motions related to squat and seakeeping were split.
Furthermore, Flanders Hydraulics Research performed a comprehensive test program in the towing tank for manoeuvres in confined water, with a scale model (at scale 1/75) very similar to the ships tested at full-scale. This test program provides squat data at different ship speeds and propeller rates and for four under keel clearances varying between 10% and 100% of the ship's draft.
Based on the squat measurements in the towing tank a squat formula was developed. This formula was applied on the conditions present during the full-scale measurements in order to compare the squat behaviour to the towing tank results and between the different vessels tested at full-scale.

Keywords*: Squat; Towing Tank, Full-Scale Measurements, Bulk Carrier*

PAPER 25

Machinery Simulator with prediction of fuel consumption and emissions in transient operation

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Abstract: *This article presents a detailed method to consider the behavior of the vessels machinery in transient operation. Transient engine operation means that the engine load, thus the engine's torque and eventually the engine's speed change over time during varying orders of maneuvering.*
The development and implementation of simulation models considering the described transient behavior will be discussed in this article. Meaning, detailed thermodynamic models are presented which will be integrated in the ship simulator to calculate the in-cylinder process of the vessels internal combustion engines instead of using tabled data for defining fuel consumption and emissions. As one of the main topics of this article, the most significant sub model to predict real transient efficiency and emissions is the engine model and especially its in-cylinder process model. Therefore thermodynamic approaches and elemental reaction kinetics are used. In addition, special test bed measurements in transient operation mode ("Caterpillar MaK 6M20") are part of this project to characterize the difference between stationary and transient operation. Furthermore, these data are utilized to calibrate and validate those models.

Keyword: *Machinery Simulator, Transient Operation, Modelling, Fuel Consumption, Emissions*

PAPER 26

Metocean Data Clustering For Real-Time Manouvering Simulations

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Abstract: With the increase of ocean resources exploration, Real-Time simulations have become a key process in officers training and ensuring the viability of maritime operations. In this context is important to use relevant metocean conditions during the simulation. This paper focuses on the study of unsupervised machine learning approaches to help to choose appropriate metocean conditions for Real-Time ship maneuvering simulations. The main objective of this research is to mitigate the issue of time constraints on Real-Time simulations by providing to the operator a few bins of metocean conditions that can characterize the simulated site along the year. During the research, the major issue tackled was how to properly cluster simultaneous data consisting of wind, surface currents and ocean waves, based on their effect on vessel maneuverability. The methodology applied was based on both statistics and consolidated clustering algorithms such as k-medoids and was compared to others methods applied for the Espírito Santo state basin, at southeastern Brazil.

Keywords: *Real-Time Simulation, Maritime Simulator, Clustering, Pareto frontier, Metocean Data Grouping*

PAPER 27

Investigation of Safety and Ease of Traffic on the River Danube by Real-Time Simulations

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Abstract: In the efforts to reduce bottlenecks in the German part of the free flowing river Danube, several variants of hydraulic modifications of the actual river have been developed and investigated. It had to be checked, whether the preferred option "A" would cause a change in the safety and ease (S&E) of traffic in comparison with the present situation.
The inland waterway simulator SANDRA of the DST helped to systematically investigate voyages with different ships and current velocities over a representative stretch of nearly 10 km between Straubing and Bogen. The extensive evaluation of the data recorded for each passage lead to specific numerical values describing different aspects of risk and difficulty dependent on the parameter variation.
At the end, a weighted summary of all these criteria led to a scientifically based evaluation with respect to a change of safety and a facilitation of traffic on this part of the Danube.

Keywords: Marine Simulation, Real-Time, Inland Waterways, Safety and Ease of Traffic

PAPER 28

Component Units, Interfaces and SW Modelling for Motion of a Small Leisure Boat Simulator

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Abstract The small leisure boat simulator is a good alternative for a novice to practice driving a boat safely on the ground. In this paper, we suggest the configuration of five units of the small leisure boat simulator, which are MIOU(Main and I/O processing Unit), MSU(Motion Solver Unit), DCU(Dashboard Control Unit), GDU(Graphic Display Unit) and MBU(Motion Base Unit), and the necessary interface information each other. In addition, mathematical model of six-degree of freedom(6 DOF) motion of a small planning boat is established. The hydrodynamic coefficients which are the parameters in the model are identified from the sea trial test result which are specially designed to estimate the coefficients well. Finally, modeling method of special dynamic characteristics such as porpoising, port contact and edging during turning are proposed.

Keyword: *Leisure boat simulator, Simulator configuration, 6 DOF motion, Dynamics*

PAPER 29

Development of USV Base Station Simulator and Usability Test of USV Base Station

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Abstract USV is defined as a powered surface vehicle that does not carry a human operator, which can be operated remotely or/and autonomously. USV base station is an system which is required at the site where the remote control and monitoring of the USV is conducted by human operators. In this study, USV base station simulator has been developed for the purpose of training USV operator and designing USV base station more user-friendly. USV base station simulator utilize most part of real USV base station as it is. However, it requires display emulation for the display of various information transmitted from USV platform such as radar signal, camera image and USV navigation data. Like ship-handling simulator, instructor station is also necessary for making game environment and scenario necessary for the simulation.

This paper introduces the concept of USV base station and describes the configuration of *USV base* station we have developed. The pilot USV base simulation test we have done is also presented to demonstrate the applicability of USV base station simulator.

Keywords: *USV(Unmanned Surface Vehicle), USV Base Station Simulator, USV Operator, Training, Usability*

PAPER 30

Mandating the Use of Simulation as a Policy Development and Procedural Implementation Tool for British Columbia Ports and Waterways

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Abstract: Since the 1970s maritime authorities at all levels have started to implement policies and procedures to create safer vessel traffic flow and to reduce the risk associated with complex ship manoeuvring situations. These mechanisms have included measures such as vessel traffic separation schemes/ management systems, expanded regions of compulsory pilotage, and tethered tug escort. In the past, the decision as to how to apply these measures, and which vessels to include, was based mainly on historical experience and the sometimes subjective judgements of mariners familiar with the area. On some occasions, they were simply implemented by regulators in response to catastrophic marine incidents. In both cases, decisions were often made with little aid from empirical information, or a thorough analysis of the risk mitigation options.

This paper will explain how the process for implementing manoeuvring procedures and restrictions has evolved in Coastal British Columbia, Canada. Simulation is now a mandatory and critical component of policy development for any new terminal construction, existing terminal expansions/ modifications, or at any time a vessel of significantly different size or manoeuvring characteristics intends to call upon an existing terminal. It will highlight how the inclusion of exacting vessel and environmental models, critical human factors, and the participation of key stakeholders, (Pilots, Tug Companies, Port Authorities, and Terminal Operators) has created a process that is not only effective, but also best represents the interests of the entire marine industry.

Keywords*: Policy development, port manoeuvring tests, simulation .*

PAPER 31

Training to Target Ice Management Performance Using Simulators

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Abstract This paper describes a method for estimating the amount of simulator training that inexperienced operators may need to reach a target performance level. The method is based on a two-phase experiment involving ice management operators. In the first phase, which has recently been completed, two groups of operators were tested. The first group was comprised of eighteen seafarers with at least ten years accumulated experience at sea; the second group was comprised of eighteen inexperienced cadets from a seafaring program. In this phase, "good operating practices" were identified and performance benchmarks were established. In the second phase of the experiment, which is in progress, two groups of inexperienced operators will be trained and tested. The first group will be trained in basic ice management operations using a ship simulator. The second group will undergo the same training, plus additional feedback and opportunity to practice. The "good operating practices" identified in phase one serve as the basis of the training curriculum. The combined results of the two phases of experiments will include the performance of three groups of cadets who will have received three defined allotments of training, as well as the performance of a group of experienced seafarers. Based on these results, it may be possible to determine a relationship between amount of training and performance. Using such a relationship, the amount of training an inexperienced operator may need to reach a specified target performance level can be estimated.

Keyword: *Ice Management, Simulator Training, Ice Management Performance*

PAPER 32

Assessing Lifeboat Coxswain Emergency Preparedness using Simulation

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Abstract: Lifeboat simulators have been specifically created for coxswains to practice emergency scenarios using representative equipment and virtual environments. As simulation is adopted as an alternative to existing training, operators will be required to demonstrate simulators are effective training tools. A human factors study was performed to evaluate how skills acquired in different training programs transferred to an emergency scenario.

Participants received quarterly training in one of three alternatives including a live boat, Computer Based Training, and simulators. At the end of one year, all participants performed an evaluation scenario emulating a plausible emergency event in weather conditions. This study compares the performance of each group and reveals experimental results that assess the effectiveness of methods for training coxswains to deal with a realistic emergency.

The study indicates the type and amount of training received has an influence on the trainees' ability to perform a successful lifeboat launch. The impact of hands-on practice and the type of scenarios used in training is examined. The study also measured skill retention between practice sessions. Results suggest more frequent training is needed to achieve a high success rate on first launch attempt. The study identifies a high degree of difficulty of performing slow speed maneuvering tasks in waves.

Keywords: *Lifeboat, Emergency Evacuation, Simulator, Skill Retention*

PAPER 33

Enhancing simulation training ecosystems through an Instructor focused approach

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Abstract Simulation training has enabled institutions to develop professional mariner's skills in a safe and controlled environment. Recent advances in virtual and augmented reality have placed significant emphasis on immersing participants in a simulated world that has become incredibly realistic. Yet, another key human component in maritime simulation is the instructor: the conductor of the scenario.

By applying rigorous attention to tools to develop, execute, and review scenarios we can empower our instructors to become far more effective in training the next generation of mariners.

This paper will examine how focusing not only on the student but also the instructor has potential to achieve significant improvement to both the quality and efficiency of training outcomes.

Keyword: *Instructor; Maritime Simulation; Human Computer Interface; Human Performance; Training.*

PAPER 34

Developing Pilotage Plans On Bridge Simulators: Methodology, Benefits And Challenges

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Abstract: The Transport Safety Board of Canada wrote in their Marine Investigation Report No. M09W1093 [1] that "The absence of a detailed, mutually agreed-upon passage plan deprives bridge team members of the means to effectively monitor a vessel's progress, compromising the principles of BRM." In a majority of cases when a pilot is boarding a ship for an arrival, the time for the master pilot information exchange is by far too short. It is unrealistic to think that detailed master/pilot information exchange and planning (according to IMO resolution A960 [2]) can be performed and agreed at the pilot boarding place. Except for the dynamic topics like weather and traffic etc., the master/pilot information exchange should be done in advance by both parties. To facilitate this, Carnival Corporation & Plc. Group has allocated significant resources for conducting bridge simulator assisted port risk assessment studies for ports from around the world. This risk assessment program is managed by and executed at CSMART, the Carnival Corporation's maritime training facility in The Netherlands. One of the primary objectives of this program is to develop pilotage plans on a bridge simulator together with bridge teams (consisting of captains and senior officers from Carnival's fleet) and local port pilots (when available to participate). In 2017, port risk assessment studies for 21 ports from around the world were successfully executed at CSMART. In 2018, a similar program is already underway. In this paper, the methodology used at CSMART for creating pilotage plans on bridge simulators will be discussed and its benefits and challenges will be highlighted.

Keyword: *Pilotage plan, waypoint route, manoeuvring plan, bridge simulators, critical navigational elements, shared mental model*

PAPER 35

Port Saint John West Side Terminals Modernization Project, 3D Hydrodynamic Modelling and Navigation Simulations

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Abstract: Port Saint John is undertaking the $205M West Side Terminals Modernization Project in order to significantly expand their container terminal. The project, which is presently in the final design phase, includes the extension of the existing wharf and deepening of the navigation channel to accommodate Neo-Panamax vessels, and various landside improvements to increase operational efficiency and throughput of the terminal.

Given significant spatial constraints and strong and complex flow conditions within the harbour, as well as the significant increase in vessel size as compared to those presently calling at PSJ, the ability of Neo-Panamax vessels to safely transit the channel and turn in the Inner Harbour was a key uncertainty. This paper describes the application of a three-dimensional hydrodynamic modelling (FVCOM) to quantify the complex flow conditions in Saint John Harbour, and the integration of the FVCOM model results into the navigation simulations for the project.

Keywords: *Hydrodynamic Modelling, Navigation Simulations, Port Saint John, Neo-Panamax*

PAPER 36

Fast-Time-Simulation as a Feature for Enhanced Training in connection with RheinmetallsANS 6000 Ship Handling Simulator

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Abstract: Rheinmetall Electronics ANS 6000 Ship Handling Simulator series is a well known, mature, high performance and high quality Ship Handling Simulator (SHS) system, operated inacademies and training centres around the world. Together with the advanced andinnovative functionality of Fast Time Simulation (FTS), developed and delivered by ISSIMS GmbH Germany,both technologies are now connected by a proprietary interface, which allows to use thestrength of FTS together with ANS 6000 in one and the same exercises. This provides a greatpotential for instructors as well as for trainees and may make ship handling exercises more efficientand valuable for all parties.
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. Corresponding results how the ship model will behave up to 24 minutes ahead are displayed either only for the instructor or for the instructor as well as the trainees. Instructors (and trainees) are able to see the results of changes in commands immediately and can make corrections, if necessary immediately in order to avoid dangerous situations (and wasting valuable simulator time). FTS takes into account varying external and internal conditions (e.g. wind, current, depth, draught & trim). The benefits of a combined ANS / FTS are: higher individual learning and improved effectiveness in training and most important after the exercise the trainees can be assessed against their own manoeuvring plan which might have been acknowledged by the instructor beforehand. So the final result is not based on “views” and “opinions” anymore…
Experiences using an ANS 6000 ship handling simulator together with FTS have been made in Advanced Ship Handling Training courses. Apart from Maritime SImualtion Centre Warnemuende (MSCW) / Germany it has been done at the World Maritime University, Malmoe / Sweden. In addition to ship handling training, the combination of ANS and FTS can be used in port risk assessments and waterway design studies.

Keywords*: simulation, shiphandling, voyage planning, optimising manoeuvring concepts*

PAPER 37

On The Ship Navigation In Geodetic Frame

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Abstract- Improving safety and propulsion efficiency for ship navigation is relevant even today. While computing the long range optimal navigation, the motion of the ship on the Earth's surface need to be considered. It is well known that navigation on a plane and navigation on a curved surface has several differences. These differences are significant and can change the outcome of optimal navigation results. Besides above, as the ships take long time and distance to avoid the collision or come to a stop, it may be necessary to account for curvature during navigation. In this paper simulation results for navigation in geodetic frame for the long duration concerning wind, Earth's curvature and prime mover characteristics have been carried out. Four degrees of freedom maneuvering model of DTMB 5415 with twin cycloidal propeller was implemented for simulation. The simulation has been carried out in the Bay of Bengal/ Indian Ocean region. Autopilot simulation with waypoint navigation is used. All simulation results are shown in ECEF frame with WGS 84 ellipsoid. This paper focuses on computation of the distance, azimuth along a great ellipse and position in terms of latitude and longitude. Accuracy of GPS measurements, gyrocompass for navigational accuracy are discussed.

Keywords*: Dynamic Modeling, motion performance, navigation, geodetic, Ship maneuvering, geodesic, sailing.*

PAPER 38

Study on Automatic Collision Avoidance Manoeuvre Using Full Mission Simulator (Automatic Collision Avoidance System and The System to Quantitatively Evaluate the Manoeuvring Results)

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Abstract
This paper aims at developing the automatic collision avoidance system to carry out strategic manoeuvring and the system to quantitatively evaluate the manoeuvring results. The automatic collision avoidance system introduced in this paper is a system constantly calculating optimal manoeuvring way from the risk and economic preference in the ship manoeuvring space where the course change and the deceleration are performed. Experiments using a simulator verified that it is a practical level including the congested sea area.
In addition, the proposed evaluation system successfully compared the manoeuvring result of the automatic collision avoidance system, the manoeuvring results of the veteran captain and officers.
As a result, the proposed automatic collision avoidance system is an effective system for realizing strategic collision avoidance manoeuvring and also verified that it is a system to prevent human error as a manoeuvring support system. It is also verified that the proposed system for evaluating the manoeuvring results can also be applied to the level evaluation of the automatic collision avoidance system on an unmanned vessel, which will be discussed in the future.

Keyword: *(Automatic collision avoidance, Strategic manoeuvring, Evaluating the manoeuvring results, Human error, Support system, Autonomous ship, Simulator)*

PAPER 39

The use of simulators in the Polar Code training program at Maritime Institute Willem Barentsz

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Abstract: The International Code for Ships Operating in Polar Waters (Polar Code) has been developed by the IMO in order to increase the safety of ships' operation and to mitigate the impact on the environment in the polar waters.

In order to meet the minimum training requirement while operating in polar waters, masters, chief mates and officers in charge of a navigational watch shall be qualified in accordance with chapter V of the STCW Convention and the STCW Code.
The IMO has determined two training programs for the bridge crew:

- basic training for ships operating in polar waters
- advanced training for ships operating in polar waters

The IMO has developed two Model Courses to assist training institutions with the development of the two training programs. The training programs have a theoretical and a practical part.

Keywords*: Polar code, IMO regulations, model courses, training*

PAPER 40

Simulare Necesse Est
Improving Safety And Economy In Shipping Operations

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Abstract

Safety and economy are often two opposing elements in operations such as shipping. Improving safety usually costs money and making more profit can jeopardize safety. The increased application of well structured maritime simulator training seems to be one method of overcoming this contradiction: the overall costs decrease and the safety is improved.

Statistics of maritime casualties continue to be the driver of improvement of human performance or rather reduction of human error. Still, too many accidents occur and some can even be traced back to the lack of proper training and the lack of certain required skills and competences of the seafarer.

Keywords
Casualties, quality training, safety aspects, economy,

PAPER 41

The Dutch perspective on the use of simulators and sea time reduction in Maritime Education and Training

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Abstract: The Netherlands has a high standard in international shipping and maritime education. To maintain this standard we look critical to the actual situation and reflect the Dutch situation in an international perspective. In a study performed for the Ministry of Infrastructure and Water management an overview of (inter)national legal framework is made with a focus on the Dutch interpretation of STCW guidelines regarding sea time reduction. This interpretation is compared with interpretations of some other countries. An inventory of the use of simulators in The Netherlands showed that its use is widespread in both education and professional training. In depth interviews with relevant stakeholders and additional research on trends and developments shows for instance an increased awareness of safety and the importance of the human factor. Recommendations to improve future maritime training include the use of simulators in blended learning environments, taking into account organisational and educational aspects in the design of training. Also the inclusion of higher cognitive skills like decision making and the addition of human factor measurements to objectify human behaviour are examples. Finally, the development of an individual continuous learning line with assessments as guiding moments for further development is mentioned. With this paper, we want to share these findings as a starting point for further (international) reflection on the use of simulators in MET.

Keywords*: simulators, education, regulation, sea going service, sea time reduction*

PAPER 42

Development of Generic Ship Models

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Abstract It is common for marine simulator facilities to have internal and external needs to provide ship models for training, assessment, and/or research. Ship mathematical models can be characterized into two different groups, ship specific or generic ship models. Generic ship models are a special category of ship model. Although the idea of generic models is simple, the implementation is not necessarily straightforward. This paper will review the evolution of the generic ship models concept at STAR Center, the adopted strategies to pragmatically meet the needs, and then discuss the challenges from business management and the technical sides. Finally the paper will summarize the lessons learned, and venture into the outlook of generic ship models inspired by the progress of technology.

Keyword: *Simulator, Generic, Modeling, Business & Technical Challenges, Prospect.*