Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Report Title:

Deliverable 2.10:

Map out the landscape of future research

1 PUBLISHABLE EXECUTIVE SUMMARY

WP2 Operational Practice is aimed at collating, reviewing and auditing available material that is relevant to the subject of Marine Simulation specifically for ships equipped with azimuthing control devices (ACD).

Task 2.10 reviews the work undertaken in Tasks 2.1 R*eview of ability to simulate azimuthing devices,* Task 2.2 R*eview of existing ship simulator capabilities,* Task 2.3 *Survey of industries ability to simulate azimuthing device interactions*, Task 2.4 *Review of ability to model bridge systems and human interface*, Task 2.5 *Encapsulate knowledge using 'task analysis' feedback,* Task 2.6 *Summary of simulation,* Task 2.7 *Assimilate cross disciplinary knowledge from other WPs* and Task 2.8 *Summary of simulation*

From the review this Task has identified areas in which future research and development would be beneficial in the area of Marine Simulation.

2 INTRODUCTION

This task will look at the conclusions and recommendations made in the previous tasks within Work Package 2 and from the results obtained and observations made will identify areas in which future research and development could be undertaken in the area of Marine Simulation for vessels equipped with azimuthing control devices. This covers both Full Mission Bridge Simulators (FMBS) and Manned Models Simulators (MMS).

3 REVIEW OF ABILITY TO SIMULATE AZIMUTHING DEVICES

Task 2.1 has reviewed the existing simulator capabilities for azimuthing control devices. The review has included the capabilities all simulators from PC-based simulators up to full-mission-bridge-simulators and in addition manned model centres.

This task has collected data, information on full-mission-bridge-simulators and manned models simulators. It has concluded that **there are few data related to technical qualities of the Full-Mission-Bridge-Simulators** which are in operation around the world. The details regarding technical qualities of those simulators are not known in majority of cases and the information which types of ships are simulated and on whether or not shallow water effect is included in the program is not available. This task has also analysed the interaction effects which are taken into account into simulators.

4 REVIEW OF EXISTING SHIP SIMULATOR CAPABILITIES

Task 2.2 has reviewed existing simulator capabilities with respect to the ability to simulate the most common influencing factors that affect ships when operating in close quarters including environmental effects such as effect of proximity of the shoreline, bank effect, effect of proximity of other ships and other effects experienced by ships equipped with azimuthing control devices when manoeuvring in their most typical and critical situations. This task has considered the hydrodynamic interactions experienced by the manoeuvring ship in shallow water or in the canal, either surface channel or dredged fairway in shallow water area, and their effect on manoeuvring characteristics of ships, either with conventional propulsion or pod, as well as the hydrodynamic reactions between two ships meeting or overtaking each other at close quarters. The task has also considered escorting operations performed with pod driven tug where the tug assists braking the escorted ship with rudder blocked or experiencing black-out by forcing sharp turn or keeping the escorted ship on straight course within the limits of the fairway.

Task 2.2 has concluded that most of the simulator centres have capability to simulate shallow water effect. However, the development of the shallow water effect with decreasing water depth is not always modelled correctly and therefore further investigations are needed. There is also a **general**

lack of information/data on tugs operating near the stern of pod driven ships. Further data should be collected in this respect.

5 SURVEY OF INDUSTRIES ABILITY TO SIMULATE AZIMUTHING DEVICE INTERACTIONS

Task 2.3 has reviewed the ability to simulate the interaction between azimuthing control devices of existing simulators. The capability and validity of the modelling used for the most common situations has been reviewed, namely the effects of hull-form on azimuthing control device performance, non-linear effect in azimuthing control device performance and operational models and effects on interactions. This task concluded that most existing simulator modules for podded propulsive drives do take into account propeller thrust, transverse propeller forces, and lift and drag forces on the pod body. They also adequately model the interaction effects between different pod units, and shallow water effects on podded vessels.

Interaction between two or more podded propulsors is important and it may affect the manoeuvring characteristics of a vessel in certain modes of control. When using large manned models for training this effect is automatically taken into account.

The installation of skegs and fins improves dynamic stability, however at the same time making the turning ability characteristics slightly worse. How this effect is taken into account in mathematical models is uncertain, but some **data from experiments with ship model tested without skegs or fins, and models tested with skegs or fins of different sizes installed are available and may be used**.

The task also concluded that there is a **lack of data on wake and form coefficients for ships with podded propulsors**. Further investigation might be needed in this respect.

6 REVIEW OF ABILITY TO MODEL BRIDGE SYSTEMS AND HUMAN INTERFACE

Task 2.4 has explored the use of existing bridge systems and reviewed their relevance when operating ships equipped with azimuthing control devices. The task focused on reviewing the capability and validity of the most common bridge systems. The methodology employed involved interviews with masters experienced in use of ASD propulsion and manoeuvring experts visiting some ASD vessels and examining actual ASD operations on the spot.

The recommendations are the following:

ISO 13407 Human Centred Design Process for Interactive Systems should be referenced. **Consultation with user experts** is an absolute requirement even though standardized elements have been identified and documents. The ACD system usage will become more widespread in the future, thus **education and training is a necessity.**

Aside from the more academic factor of the positioning of bridge equipment, **field of viewing** is sometimes overlooked and requires attention.

It is easy for the master while manoeuvring to find him/herself in a cognitive overload situation due to the fact that two levers must be used simultaneously and possibly in very different configurations. Again, **education and training** in this area not only by simulation but also **on-site** would be a great advantage, if not a necessity.

Optimal bridge layout for ACD propulsion varies widely between similar and different types of vessels and the type of ACD arrangement, i.e. Azi-push or Azi-pull. If we confine our discussion to, for example, tug use, an **optimal bridge arrangement** can be dictated by the type of work performed whether it be Open sea, Confined waters, Anchor areas, Narrow channel / rivers Port basins, Terminal approach, Open sea off shore, Short track ferry or Tug assistance.

The resultant thrust component is often difficult for the user to calculate/comprehend during operations. If a specific arrangement of thrusters is selected, this can present problems if the Conn is now changed to the bridge wing position. The joystick position on the bridge-wing (not yet connected) may not mimic the arrangement originally selected from the central conning position. **This may result in confusion or even in accidents**. When, and if, the Conn position is changed to the bridge wing the necessary information for manoeuvring must also be available. Tugs often change the Conn position from central looking forward to central looking aft. This is also an opportunity for confusion for the user. **Further investigations are needed**

Concerning the ergonomics of control systems, existing products differ in great extend from each other and are rather representing the individual view of the manufacturer than based on a general philosophy regarding implementation of relevant ergonomic rules. Each observed system has in one way or another a less optimal element in the design or layout of the ACD control components. For the future **more work has to be done to get more harmonized and optimal designed ACD control systems fully fit for the use by the ship handler in various manoeuvring circumstances.**

7 ENCAPSULATE KNOWLEDGE USING 'TASK ANALYSIS' FEEDBACK

Task 2.5 has provided guidelines for the selection of appropriate controls for different types of azimuthing devices and provided guidance on their use.

This task has identified that there are quite a large number (6) of different Azimuthing propulsion devices and these often differ in great extend from each other and are rather representing the individual view of the manufacturer than based on a general philosophy regarding such mechanical devices. There are also quite a large number (around 14) of different ACD control devices and these often differ in great extend from each other and are rather representing the individual view of the manufacturer than based on a general philosophy regarding implementation of relevant ergonomic rules. Each observed system has, in one way or another, a less optimal element in the design or layout of the ACD control components. At least a maximum 9 different types of manoeuvres have been identified which may be frequently carried out on board of at least 6 different ship types. Some of these manoeuvres can be very stressful for the bridge team (i.e. harbour tug boat operations while undertaking towing/pushing work). The various bridge layouts have been identified for the different ship types whereby number and position of ACD console stations have been discussed and stated. The number of consoles range from 1 to 4 and the position thereof from the centre of the wheelhouse, the bridge wings and the rear of the wheel house. Two new layouts have been identified for the double ended ferry and the inland waterway vessel.

Therefore, this task has concluded that for the future **more work has to be done to produce more harmonized and optimal designed ACD control systems fully fit for use by the ship handlers in various manoeuvring circumstances. Official standardization for operating systems should be consulted further** as well as further consultation of experienced users in order to come to a standardized bridge layout for ACD's. The use of ACD's and standardized bridge layout should be supported by **educating and training at the very least by simulator training and, if possible, supplemented by on-site training.**

8 SUMMARY OF SIMULATION

Task 2.6 has summed-up existing Marine Simulator capabilities with respect to their capabilities regarding azimuthing devices and their application and including their validation and limitations.

This task has concluded that in the range of small and moderate pods angles modern simulators capture pods interactions with great realism. **Azipod modelling and simulations for large pods angles will require the comprehensive CFD computations combined with the specialized**

model and full-scale trial testing. Hydrodynamic Interaction of the multiple pods also requires the additional research efforts (including CFD) and validation test data.

9 IMPLEMENT OBTAINED KNOWLEDGE IN DEVELOPMENT PLAN

Task 2.8 has elaborated a number of recommendations for the improvement of the technology and the marine simulation industry as a whole and specifically when dealing with ships equipped with azimuthing control devices.

Concerning FMB simulators, the general standard of visualisation of simulation scenario with relevant current, wind, wave and channel effects is rather high and so improvements could be recommended with regard **to visualisation of the ship itself and the inclusion of engine noise and ship motions (rolling and pitching).** Therefore as the best practice for standardised lay-out those simulators may be recommended that satisfy the above requirements. The **proposed best practice to simulate interaction effects would be to use experimental data from model as much as possible** and validate the results of simulations using results of model tests or results of full scale ships by employing system identification procedures.

For MMS simulators, several recommendations for best practices have been done.

- With regard to models that are suitable for simulation the following requirements should be met:
  - Models **should be large enough, suitable model scale should be not smaller than λ=25**. With smaller models (larger model scale) effect of Reynolds number may be important with regard to propeller and rudder forces;
  - Models should correctly represent the **form of underwater part** of the hull including all appendages;
  - Models should correctly reproduce a**ll quantities dependent on time according to Froude's law of similitude** (accelerated time scale), i.e. time to reverse engine, time to deflect the rudder, time of tug reaction etc., and also correctly reproduce characteristics of the main engine, either diesel, turbine or electric propulsion;
  - Models should be capable **of using tugs**, either in a way of simulating tug forces or tug models. Tractor tugs or reverse tractor tugs may be necessary to simulate escorting operations;
  - Model movements on the manoeuvring areas should be monitored on line making possible assessment of all manoeuvres performed.
- With regard to manoeuvring areas the following requirements should be met:
  - **Manoeuvring area (pond, lake) should be chosen as to be large enough** to perform different manoeuvres including manoeuvres requiring large areas, such as escorting operations, ship-to-ship operations and similar;

- Manoeuvring areas should be **sheltered from strong winds**. They should be free from other traffic – fishing boats, yachts, motor boats etc. that may disrupt manoeuvring with manned models;
- In manoeuvring areas there should be the **possibility to install different required arrangements** such as mock-up of port facilities, docks, locks, shallow water areas, submerged and surface canals, banks, piers and jetties of different configuration, river estuaries, etc.;
- In certain areas **current** should be created and also waves may be created where necessary.

10 FUTURE RESEARCH AND DEVELOPMENT

The tasks performed as part of Work Package 2 strongly suggest that there is still further work to be done, through research and development to improve the quality of marine simulation for vessels equipped with ACD.

10.1 Further data collections and use

Several lacks of data have been identified in order to improve the quality of numerical simulations, such as:

- Lack of data on tugs operating near the stern of pod driven ships
- Lack of data and proper use of data from experiments with ship model tested without skegs or fins, and models tested with skegs or fins of different sizes installed
- Lack of data on wake and form coefficients for ships with podded propulsors.

10.2 Human interface

This workpackage has underlined the essential need of proper education and training of crews and operators in normal and abnormal situation, including overload situation, not only by simulation but also on-site.

This issue of ergonomics of control systems is also particularly important, especially due to the fact that existing products differ in great extend from each other and are rather representing the individual view of the manufacturer than based on a general philosophy regarding implementation of relevant ergonomic rules. Therefore, further work has to be done to get more harmonized and optimal designed ACD control systems fully fit for the use by the ship handler in various manoeuvring circumstances.

10.3 Modelling

Simulations of manoeuvring with small pod angles have proven their efficiency. However, further work should be done to improve modeling and simulations for **large pods angles**, including the associated comprehensive CFD computations combined with the specialized model and full-scale trial testing.

Further work (CFD and validation test data) should be done for improving the simulation of **hydrodynamic interaction of the multiple pods.**

10.4 Improved lay-out

In order to increase the lay-out and replicability of simulations, full mission bridges simulators should improve the visualisation of the ship itself and the inclusion of engine noise and ship motions (rolling and pitching). For manned model simulators, models should be large enough, suitable model scale should be not smaller than λ=25, representing properly the form of underwater part, capable of using tugs, and evolving in large manoeuvring areas, sheltered from strong winds, capable to reproduce different types of configurations in terms of port facilities, docks, water depth, canals, currents.

11 Conclusion

WP2 has examined many aspects of the Marine Simulation domain for ships operating with ACD.
This analysis shown that there are still a number of further activities that can be undertaken in order to improve the quality of simulation (both full mission bridges and manned model simulations), addressing all stakeholders and especially ship owners/operators and pilots.