# SHIP SIMULATION – IMPORTANT ASPECTS FOR CONSIDERATION

**by**

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**ABSTRACT**

Full bridge ship simulation systems have developed significantly over recent years to the extent that they now present with very high levels of r[[1]](#footnote-1)ealism. However these high levels of realism cannot be taken as a proxy for accurate results. There are three factors that need detailed consideration to ensure that the results of the simulation series will be realistic. These are human, environmental and model factors. This paper discusses the importance of these factors and how, if given due attention, they can ensure high quality results. If they are not given the proper attention then the results from the simulation series will be believed due the high levels of realism but will be inaccurate because of lack of attention to other factors.

1. **INTRODUCTION**

Ship handing simulators have been available in many forms since the 1980’s and earlier. Since then simulators have developed significantly in realism and in the underlying model mathematical formulation to the extent now that they present to a pilot as being very realistic.

However, when an engineer is considering the use of simulation for detailed design of a port or, as is often the case, whether a larger ship can use existing port infrastructure then it is incumbent on the engineer that they address a number of matters before and during simulation. Otherwise realism becomes a proxy for truth but the results of the simulation may be inaccurate or even misleading. Realism is only one part of what is required to make a simulations series successful.

This paper explores the main factors that need to be considered when preparing and undertaking a simulation series. It does not discuss the methods that should be used to analyse the simulation data to support the outcome decisions from the simulations.

In this respect this paper only considers a small portion of the matters that will be covered by PIANC WG171 *Ship Handling Simulation Dedicated to Channel and Harbour Design* which is expected to be published in 2018-2019.

There are, however, a number of factors that still need to be considered when using these tools, whether as pilot training, scenario testing or for engineering design.

These factors can be generally divided into the following categories: -

1. Human factors
2. Environmental factors and
3. Modelling factors

This paper has been written from the perspective of a simulation that is being used as an engineering tool to carry out a detailed design of a new port or to look at a change of use of an existing port.

The use of simulators in the design of shipping channels and basins is described in PIANC WG121. WG 121 considers both concept and detailed design (simulation). PIANC WG171 will be updating the WG in relation to detailed design using ship simulation.

1. **HUMAN FACTORS**

All three factors are important but this is perhaps the hardest to assess. All pilots have their own personalities and pilotage preferences and not all pilots can easily move into a full bridge simulator and feel comfortable. The success of full bridge simulations relies on the pilot feeling comfortable within the simulation environment and for them to behave in exactly the same way as they do during actual pilotage.

The aim of a full bridge simulator is to put the pilot into an environment that closely matches the actual bridge of a ship with views out of the bridge that look very much like the port that they work in. This will ensure that the mental model of the Pilot is accurately recreated, which is necessary for the Pilots to be fully immersed in the simulation. Thereby ensuring the pilots information processing and recall is close to reality. Situational engagement is dependent on providing the same cues utilised by Pilots in reality to the simulated environment.

Consequently full bridge simulators are built to be as close as possible to real life and the bridge view is also modelled to be as close to real life as possible. All the visual aids that pilots use need to be realistically presented in the out of the bridge view. These visual aids are usually more than just the channel markers and lead lines for the port. They will include prominent features along the shoreline.

However the simulator presents a 2D view of the surroundings and the depth of view perception is not always easy to assess in the simulator. It is important to have at least a 180 degree view to allow the pilot to visually recognise their position in a 3D world.

Bridge protocol is also important. A helmsman should be provided in the simulations and pilot orders and responses should take the same form as if it is a real pilotage. A common mistake is to use the another pilot as the helmsman which has 2 problems:

1. It results in discussion between the pilots during the simulation and
2. Does provide independant views when the helmsman becomes the pilot

When tugs are being used not only is it important that the tug models are correctly prepared but also that tug masters are available for simulation (or for tug simulators which are part of the simulation). The tug masters comments provide practical input to the simulations.

So in summary the human factors that need to be considered are ensuring that each pilots are not influenced by a previous pilots experiences and ensuring that the out of the bridge view contains all the information that a pilot uses for a pilotage. This additional information may vary from pilot to pilot. And of course it is important that pilots who use the simulator feel comfortable in the simulations environment.

Research findings support the notion that simulation exercises are stressful activities regardless of experience, and that even well-trained pilots can overlook key information that is critical to the passage plan. At present, the evidence base regarding the utility and effectiveness of ship simulation is in its infancy, yet the available results are promising. High-fidelity simulators can seemingly fill the increasing void in maritime engineering by enabling experienced pilot to competently perform the role under a diverse array of conditions (e.g., poor weather, mechanical issues).

1. **ENVIRONMENTAL FACTORS**

Usually bathymetry may be seen as the most important input data for the model. Bathymetry is important and usually it is available without having to carry out any specific additional work. But of equal importance is the preparation of the environmental data.

A conclusion from a simulation series can be misleading if the metocean conditions presented for simulation are inaccurate.

The preparation of the environmental data for simulation can take some time to prepare, particularly if measurements need to be collected and/or hydrodynamic modelling is required to better understand the environment.

But often a simulation series might be requested with insufficient time being allowed to carry out the necessary studies which may them compromise the outcomes from simulation.

Some of the issues that need to be considered when preparing environmental conditions include: -

1. The wind speed that is generally used for simulation is the 10min average 10m height wind speed over water. A pilot will usually have access to this wind speed before and during pilotage but can also be influenced by the gust speed or the wind speed displayed on the bridge of the ship. The bridge wind speed is invariably sampled at a greater height than 10m and can be impacted by the ship itself. In addition wind in real life has gustiness and fluctuations in wind direction. Depending on the levels of these fluctuations they can impact on the simulation and create more uncetainty in the mind of the pilot than a steady state wind speed being applied to the ship. It does need to be noted however that a large ship is a big integrator of winds and very short fluctuations only have small impacts on the progress of the ship.
2. Currents are usually measured in depth cells (acoustic current meters) or as single depth measurements. The characterestics of the currents at the location of the port are very important. Are the currrents 3 dimensional? Are currents driven primarily by tides or winds? Or are both tides and winds important? Answering these questions takes skill and time. And, or course, it is the currents in the upper layers that are important. As with winds currents can also have a degree of instability and also display gustiness.
3. Waves can also play an important part in simulations. Vertical ship motions can place the ship in close proximity to the bottom and horizontal motions can increase the swept path of a manoeuvre thereby impacting on channel width. Usually wave spectra will change over the simulation path. Typically waves are well known at one location along the pilotage path and this will be used to calibrate a wave model to translate waves over the simulation area.

If the currents need to be modelled, because there is insufficient measured data, then an appropriate model must be selected. All the considerations that need to be covered for a quality hydrodynamic model including 2D vs 3D and grid scale size to define the features can impact the quality if the modelled results and need to be resolved. Often an existing hydrodynamic model that was prepared for some other purpose, without due consideration to the above, can produce misleading information. Often the information that has being prepared for an existing port will be challenged by pilots if it does not match their expectations.

The preparation of environmental data for simulation needs to be managed by someone who understands the technical requirement of ship simulation.

Pilots develop a good understanding of the impact of metocean conditions on pilotage without necessarily having a knowledge of the magnitudes of the currents, waves or winds. This knowledge is really important in ensuring that the environmental data prepared for the model is accurate. However if currents and winds in the model are estimated based on current port users experience then the metocean parameters will usually be overestimated. When the force on the ship exerted by currents or wind is a function of the velocity squared then the importance of good quality metcean data can be appreciated.

1. **MODELLING FACTORS**

There are a number of different ship simulation modelling systems that provide for full bridge simulation. If simulation is being used to assess a greenfields port or whether it is being used to assess the acceptance of larger ships into existing ports a decision has to be made on which ship/ships are going to be used in simulation to make the assessment.

The mathematical model of the ship can be prepared a number of ways from scaling from a similar ship to specific scaled model tests in a basin and wind tunnel. Full scale sea trials are almost always available which help in validing a mathematical model of the ship. Often, however, a new ship will be prepared by simply scaling up or down from an existing ship without due consideration to differences in engines, rudder or perhaps hull form. These situations usually occur when a quick decision needs to be made about a new (larger) ship that is going to visit a port and commercial pressures result in corners being cut. This may compromise the outcomes from the simulations.

In addition to the ship model there is the simulation model. Every model uses best available mathematical descriptions to model all the components of ship simulation including shallow water effects, bank effects etc. There are areas of ship interaction with the environment where the theory is still being actively developed. An example where active development is underway at the moment is ship/bank interaction. Another example is dynamic adjustment of Cd where a ship is moving in constrained waterways. An example of this is where a ship in swinging is a constrained waterway with low underkeel clearance. An specific example was the swinging of a large container ship in Fremantle Inner Harbour where in the extreme condition the ship blocked about 75% of the waterway area. The Inner Harbour is at the bottom of a significant estuary and tidal flows would exert forces on the ship. Normal simulation systems do not dynamically adjust the Cd to model the increased forces on the ship in this condition.

1. **CONCLUSIONS**

The increase in realism of modern ship simulation systems has provided mariners and managers increased confidence that the results that come from simulation systems closely represent real life pilotage of ships. For this confidence to be justified there are a number of matters that need close attention to allow the clients to make this assessment.

The paper categorises the matters that need close attention into human, environmental and model factors. If due attention is given to all these factors then the user will have justified confidence that the simulations closely follow real life pilotage. However if due regard is not given to all of these factors then the confidence in the simulation which flows from the high quality realism will be miss placed.

1. **REFERENCES**

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