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1. Preamble

1.1. This position paper is for the attention of pilotage regulators, port authorities, pilotage service providers, marine pilots and maritime colleges/simulator operators.

1.2. The use of marine simulators for pilotage training and port development is a complex topic, and this position paper should be read in conjunction with Appendix 1 – Technical Detail below.

1.3. In Australia, as it is worldwide, ship sizes have increased putting stress on multiple layers of Government to facilitate larger ship sizes using existing port infrastructure. Needing to minimise, or avoid, large capital outlays, marine simulation is increasingly being utilised to inform decisions around port development.

1.4. In Australia the supply of new pilotage entrant applicants with Master Unlimited Certificates of Competency (CoC) and command time has become increasingly restricted due to the contraction of the Australian Bluewater fleet. Statistics provided by the Australian Maritime Safety Authority show a continuous decline in the issue of STCW II/2 Master Unlimited Certificates of Competency. [1]

1.5. Pilotage organisations, Port Authorities, State and Federal Governments are identifying opportunities to build resilience into the pilotage task by examining alternative training pathways.

1.6. Concurrently, active competition and private investment have increasingly entered the Australian marine pilotage space. Financial metrics sit alongside safety metrics as requirements in developing a sustainable business.

1.7. Training costs and pathways to marine pilotage via “traditional” methods are being challenged. Widening the pool of workforce participants and reducing on water training hours are seen as ways of driving down training and associated costs. Marine simulation is being utilised as a tool to facilitate both.

1.8. Improper use of marine simulators has the potential to place marine pilots in situations where:

i. Pilotage tasks being undertaken are unacceptably high up the risk curve. They are possible; however, repeatability is compromised and may lead to undesired outcomes.

[1] AMSA Manager Seafarer certification and coastal pilotage. PTAB meeting 25th November 2023.

ii. Pilots may be licensed to perform pilotage tasks they have conducted via simulation, without the necessary on water experience to complete the task in a safe and efficient manner.

iii. Skills which would be learnt early within a structured on-water training program may be omitted or replaced (not supplemented) in a simulated environment using a single ship model, leading to a misleading understanding that the skillset has been learnt.

2. Position

2.1. The use of simulators is optimal for non-technical skills training. These skills are the cognitive and social skills that complement technical skills and are more easily replicated in a simulator environment.

2.2. The use of simulators for technical skill training, whilst still replicable, can be limited, due to the difficulty in accurate replication of the wide range of on-water forces and hydrodynamic effects within a computer model.

2.3. Skills obtained using simulators must be verified through other means, such as on water mentoring, in addition to check and assessment pilotages to ensure that simulator training is appropriate and effective. Simulation training should be led by a complete training needs analysis, which covers the required outcomes of the simulator training and the method of transferring skills to the trainee pilots. The training needs analysis should lead to the development of a simulator training plan.

2.4. Adoption of training systems based wholly on marine simulation are not recommended due to the limited ability of marine simulators to reproduce the variability of real-world response from ship models and the inherent limitations imposed in adapting port models with limited and/or costly datasets.

2.5. That all training must be conducted on an appropriate simulator which meets the inherent requirements for the specific training outcomes of the training.

2.6. The simulator models (ship and port) should be verified by a suitably licensed pilot(s) to verify model validity.

2.7. The majority of marine pilot training should be undertaken on a **DNV Class A**, or equivalent standard simulator.

2.8. Simulation which takes place on a marine simulator other than a **DNV Class A** or equivalent shall include a simulation training plan when being submitted for Continuous Professional Development (CPD) points. This training plan should demonstrate clear skill outcomes along with methods for determining an individual's assessment of those skills, in addition to an explanation of relevance of the outcomes to the role of marine pilot.

2.9. The operators Safety Management System should include methods of validating training outcomes and improving simulator training structure.

2.10. When incorporating simulation into safety management systems, the following should be considered:

i. voyage data using data analytical systems

ii. incident investigation data and outcomes,

iii. Safety committee and management feedback loops,

2.11. Incorporating all the above into the simulation training plan with clear outcomes to improve on water pilotage safety and incident response.

Appendix 1 – Technical Details

1. Introduction

1.1. The aim of this appendix is to provide technical information and guidance on the selection of simulators, best methods for training utilisation and safety management system guidance that a Pilotage Service Provider or Port Authority needs to consider when planning, structuring or using marine simulators for pilot training purposes.

2. Background

2.1. In recent years marine simulators have undergone significant advances in graphics, physical design and mathematical model development. Increased fidelity within a marine simulator does not necessarily equate to improved training outcomes which depend on many factors of which model accuracy and situational realism are but two.

2.2. Reliance on the technical issues of simulation and not on the social issues of the simulation has led to differing approaches being taken by the engineers and computer scientists who focus on the technology and that of the psychologists who concentrate on understanding the acquisition of knowledge, skills and attitudes in complex domains[2]. This has meant that whilst the simulations and simulators have evolved, the simulation training has not and thus there has been no consideration of what has been learned about individual or team training and cognition.

2.3. This appendix to the AMPI position paper sets out in detail the factors influencing the AMPI position on correct use of bridge simulation in marine pilot training by creating a baseline standard through adoption of industry best practice for the use of marine simulation in marine pilot training.

3. Simulator Equipment Standards

3.1. Reference to marine simulator training is common within many of the marine pilotage regulators around Australia. Reference to a simulator standard however is not common.

3.2. There are no specific or unified standards for simulators adopted by the IMO. Standards for marine operations bridge simulators have been proposed to the IMO which categorise simulators into Class I to IV. Specifically Full Mission, Multi-task, Limited task and Special

[2] Salas, E., C. Bowers, and L. Rhodenizer, It Is Not How Much You Have but How You Use It: Toward a Rational Use of Simulation to Support Aviation Training.

task. These categories broadly correspond with those of another maritime organisation which has a more formalised standard which can be audited against, DNV.

3.3. DNV have produced a standard document which is often quoted by marine simulator providers when advertising marine simulator construction standards. The purpose of the standard is to ensure that the simulations provided by a simulator include an appropriate level of physical and behavioural realism in accordance with recognised training and assessment objectives3 (DNV, 2014).

3.4. DNV audit and inspect simulators using this standard and issue a compliance certificate which is subject to renewal at intervals not exceeding 5 years. AMPI endorses the DNV standard and all other standards which meet, or substantially meet this standard. It is beyond the scope of AMPI to add further to this document.

4. DNV Simulator Standards

4.1. The DNV standard lays out in table 3-2[4] the relevant STCW simulator reference and required capabilities of a marine simulator to meet the training requirements contained within STCW. The DNV standard nominates four classes of marine simulator Class A, Class B, Class C and Class S.

4.2. The DNV simulator standard further defines specific requirements for marine simulators by classifying the operation of the simulator into the following categories:

i. Physical Realism[5]

ii. Behavioural Realism[6]

iii. Operating Environment[7]

4.3. Within each of these categories there is a specific list of operational, behavioural and physical requirements the marine simulator must meet to achieve classification as either Class A, B, C or S.

[3] DNV Marine Simulator Systems, 1.1.2.1 Objective.

[4] DNV Marine Simulator Systems, Table 3-2

[5] DNV GL Marine Simulator Systems, Table 3-3

[6] DNV GL Marine Simulator Systems, Table 3-4

[7] DNV GL Marine Simulator Systems, Table 3-5

5. Simulators as a Training Tool

5.1. The purpose of marine pilot simulation must be clearly defined prior to commencement and measurable outcomes for the training set. Simulations, and the use of marine simulators, may include the following purposes:

i. Emergency simulation pilotage task planning.
ii. Emergency simulation pilotage task training.
iii. Passage Plan pilotage task optimisation.
iv. Procedure development and training.
v. Pre employment and candidate selection.
vi. Pilotage troubleshooting including incident investigation.
vii. CPD maintenance which may include BRM training.
viii. Decision making training which may, or may not, cross over with contingency training.
ix. Port development.

5.2. The marine simulator refers to the hardware and apparatus that generates the simulation. Marine simulation refers to the representation of conditions approximating actual or operating conditions[8]. Simulation training aims to develop skills and knowledge that are transferable to any target situation[9]. To do so port and pilotage organisations must recognise the strengths and limitations of the marine simulator.

5.3. For training purposes, it is essential to provide the necessary level of realism and accuracy to support training objectives.

5.4. Simulator fidelity refers to the realism, or degree of similarity, between the training situation and operational situation being simulated. The two basic measures of fidelity are the physical and functional characteristics of the training situation. Physical fidelity is provided by ergonomic layout of the bridge, visual system and vessel manoeuvrability[10].

5.5. In a computer based marine simulation, the mathematical model contributes to the functional characteristics of the simulation[11] along with training program design, simulator session design and the role of the instructor[12]. Fidelity is determined subjectively, and the level of fidelity required to achieve training objectives should be based on a task needs

[8] Simulated Voyages, p37

[9] Dahlstrom et al, p308

[10] Systematic Literature Review in the Fidelity of maritime Simulator Training (Oliveira et al)

[11] Simulated voyages, p216

[12] Systematic Literature Review in the Fidelity of maritime Simulator Training (Oliveira et al)

analysis13. Flexman and Stark[14] have stated that "complete physical fidelity is rarely required for effective training and transfer"[15]. Fidelity then should be dictated by the cognitive and behavioural requirements of the task, not people's opinions. If this is done, then there should be transference of learning. There is a recognition that high fidelity is not close to reality.

5.6. Simulator accuracy is a deterministic measure of how close something is to being exact. The accuracy of a simulation model is typically determined by measuring variations of the predicted trajectory with the actual trajectory for a given set of controls and environmental operating conditions. The accuracy of the trajectory projection models can be compared with the level of fidelity specified in the training analysis to achieve the required training objectives[16]. The accuracy of the physical port model can be accurately judged based on physical location of aids to navigation and critical navigational cues however only be subjectively judged based on the localised effects of winds, currents and hydrodynamic forces where an incomplete port model is available due to the almost infinite requirement of data needed to create an accurate port model.

5.7. The requirements for marine simulator training are different where training outcomes include skills or procedural outcomes as opposed to ship handling for ship handling knowledge or port development outcomes in which case accuracy gains in importance.

5.8. Simulator training, particularly emergency training, prepares marine pilots with usable tools for situations where subtle and infinite variations may mismatch the exact circumstances of the training. For these incidents, ports and pilotage operators are reliant on generic competencies which add to the ability of the system to respond to the unexpected and escalating situations. The marine pilot is considered here as being a part of a larger system when under pilotage. The system undergoing the emergency training should include vessel operators if required. If no specific operator is available, as is the case most large ports, simulations should cover each vessel type prevailing in the port and as a minimum each key draft which covers the operational conditions of the port.

[13] Simulated voyages, p216

[14] Flexman, R. and E. Stark, Training simulators, in Handbook of Human Factors, G. Salvendy, Editor. 1987, Wiley: New York. p. 1012-1038.

[15] Flexman, R. and E. Stark, Training simulators, in Handbook of Human Factors, G. Salvendy, Editor. 1987, Wiley: New York. p. 1012-1038.

[16] Simulated voyages, p216

5.9. Critical to developing adequate emergency training are active tug models manned by tug masters using tug models which match the availability within the port. Mooring services and port authorities have a lesser active but increasingly important role in safe port operations.

5.10. The knowledge base for creating safety in complex systems, of which shipping is one of, is inherently imperfect[17] and emergency simulation should aim to develop the generic competencies which transfer to a developing situational deviation from a planned pilotage plan. Incident investigations and findings are fed back into the training to create a link for improving the training.

5.11. Effective simulation training structures involve individual simulated exercises with clearly defined and measurable outcomes, with multiple individual exercises combined to create a training program which allows both individuals and organisations to achieve safety improvements.

5.12. Pilots should complete emergency training based on a risk-based training needs analysis incorporating known and foreseeable risks during the pilotage operation. Unforeseen circumstances beyond this scope draw on the generic value of the otherwise specific emergency training bringing benefit in those circumstances. Responses with satisfactory outcomes which include learnt process improvements can be included as outcome-based exercises in marine pilot response training programs.

6. Simulator Models

6.1. In marine simulation there are two primary models which need to be developed, the port model and the ship model.

6.2. Port models, when used for training purposes, require the visual appearance to be accurate to create the perceptive link between reality and virtual reality. Hence visual port models based on photographs should be developed and built thereby creating a virtual environment with characteristic buildings, landmarks and structures[18]. Simulation in models which do not represent the port to a level of realism, or training using alternate ports for a port which is not modelled, is not adequate to be utilised for professional development on port specific items.

6.3. Ship models are created using vessel design data with the limitation that each model is created at a specific loading condition. The specific vessel type and load condition may

[17] Fidelity and Validity of simulator training, Dahlstrom et al

[18] https://forcetechnology.com/en/services/simulations-and-cfd/ship-and-port-models-for-simulators

have been developed for a specific use case such as port development work in one port and utilised for procedural training for another port due to lack of availability of a more suitable model and cost restrictions for further model development.

6.4. Both ship and port models should be verified and validated to ensure that the appropriate level of credibility can be ascribed to their results.

6.5. Verification refers to aspects of the model which determine whether the simulator fully satisfies the requirements of the developer's intent. Verification determines whether the simulator design and implementation is adequate for the required outcome.

6.6. Validation refers to whether the model or simulation be able to adequately support its intended use. Validation determines to whether the fidelity is appropriate for the intended use and can be divide into two aspects:

6.7. Conceptual validation when the anticipated fidelity of the model or simulator conceptual model is assessed.

6.8. Results validation when results from the implemented model or simulation are compared with an appropriate referent to demonstrate that the model can support the intended use.[19]

7. Limitations of Marine Simulator Models

7.1. A base requirement for training to be undertaken at drafts reflecting the ports operational needs introduces a potential limitation of marine simulator training. The requirement for draft accuracy will depend on the training needs analysis. Simulations on a vessel model which is too deep for the port, made possible by increasing tide height to produce sufficient under keel clearance reduces both accuracy and fidelity of the marine simulations. A risk-based training needs analysis should be undertaken which determines the adequacy or not of such levels of accuracy of the utilised models towards the desired training outcomes.

7.2. Similarly, the requirement to have a tug model which matches the assets available in the port. Ship and tug models are expensive to create, and beyond the limitation of most pilotage service providers to afford. As such, providers are usually reliant on the models that have been accumulated often from development work within other port jurisdictions. Simulators can automatically control tugs, however involvement of tug masters in simulator operations is seen as essential to the level of reality of the training. Utilising the correct tug model available within a port provides accuracy to the simulation, and involving

[19] Modelling and Simulation Verification and Validation Challenges. John Hopkins APL Technical Digest, Volume 25, Number 2 (2004)

tug masters provides increased fidelity when undertaking simulations. A thorough training needs analysis should be undertaken to determine what level of tug accuracy and training fidelity is required to meet the training outcomes required.

8. Marine Simulator Training and the Safety Management System

8.1. It is critical that learning as a system be enabled with regards to simulation training by promoting systems that allow this. This can only be achieved by shifting focus from the designing of simulation for realism and (hope that the learning occurs) to the design of human-centred training systems that support the acquisition of complex skills. [4][20] The safety management system should be updated to include desired outcomes from marine simulation and key performance indicators to measure effective outcomes from the training.

8.2. To determine if the simulation training has been effective then the decision must be based on whether the trainee has learned the required skills and then used them on the job[21].

8.3. Challenges in determining whether knowledge transference and skill learning has in fact occurred is mitigated by:

i. IMO A960 (M) (2004 Version) Section 5.2 in part which states that the practical experience gained by the trainee pilot "may be supplemented by simulation, both computer and manned model ..."[22];

ii. IMPA Resolution 7.1 (2000): Use of Shiphandling Simulators resolved that " ... the use of simulators to evaluate or predict a pilot's performance in the real world for licensing purposes to be an inappropriate use of an otherwise valuable technology"[23];

[20] Salas, E., C. Bowers, and L. Rhodenizer, It Is Not How Much You Have but How You Use It: Toward a Rational Use of Simulation to Support Aviation Training. The International Journal of Aviation Psychology, 1998. 8(3): p. 197-208.

[21] Kraiger, K. and K. Jung, Linking training objectives to evaluation criteria, in Training for a rapidly changing workplace: Applications of psychological research, M. Quinones and A. Ehrenstein, Editors. 1997, American Psychological Association: Washington DC. p. 151-175.

[22] IMO Resolution A960: Recommendations on training and certification and operational procedures for maritime pilots other than deep-sea pilots. 2004, International Maritime Organisation. p. 7.

[23] International Maritime Pilots' Association. IMPA Resolution 7.1: Use of Shiphandling

iii. IMPA Resolution 7.2 (2002): Simulators resolved that … "the sole use of simulators for training and certification to be inadequate in validating the appropriate levels of competence required for navigating in pilotage waters …"[24]

8.4. Ongoing analysis of voyage data should take place, monitoring areas of compliance or specific skills trained on marine simulators. Incident investigations should specifically look for response actions trained in the marine simulator environment or identify incidents where trained responses have not been carried out.

8.5. In doing this an ongoing appraisal of the simulation training can be achieved which in turn will determine whether adjustments need to be made to the type or amount of training given.

Simulators. in The XVth IMPA Congress. 2000. International Maritime Pilots' Association.

[24] International Maritime Pilots' Association. IMPA Resolution 7.2: Simulators. in 16th General Meeting of the International Marine Pilots' Association. 2002. International Maritime Pilots' Association.