MOVING THE BOUNDARIES OF MET WITH HIGH FIDELITY ERS TRAINING

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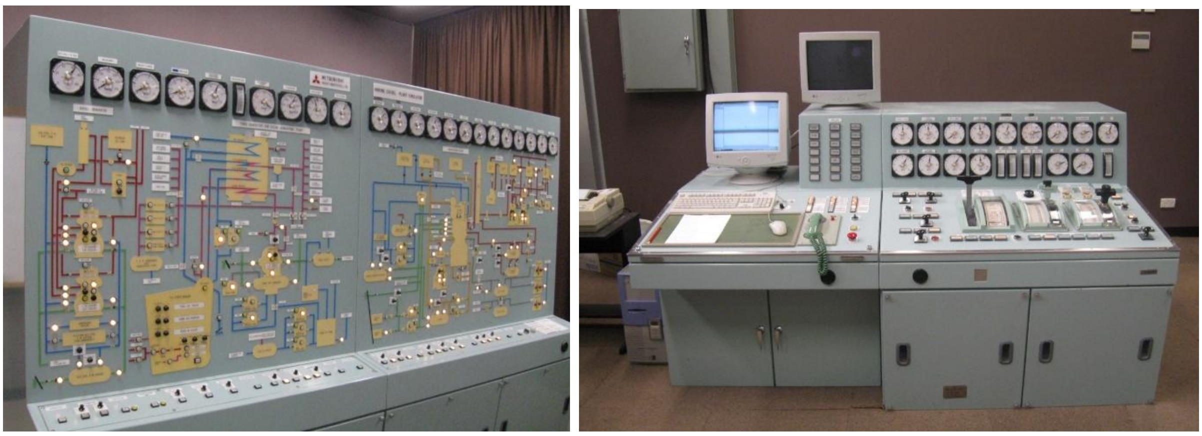
Abstract: Engine Room Simulators (ERSs) have become an attractive and valuable tool in maritime education and training (MET) mainly due to the associated cost, risk and convenience in providing training on-board ships. In addition, simulators enable training to replicate scenarios that are not otherwise possible for students to experience and interact. For these reasons, the international convention on the Standard of Training, Certification and Watchkeeping (STCW) has recognised the importance of the use of simulators in MET. With this recognition, the investment and innovation in simulation systems have evolved ERSs from a preparatory tool to a full mission engine room simulator over the last three decades. As a result, ERSs of varying capabilities and configurations are currently widely employed in MET institutes around the world. This paper explores the role of ERS and the opportunities it may present in the future to MET. It is identified that ERS has the potential to play a vital role in preparing the workforce for autonomous ships in the future.

Keywords: Autonomous ships, Engine Simulator Training, Maritime Education and Training, Marine engineer training.

Introduction

Engine Room Simulators (ERS) have been used in maritime education and training (MET) for over 30 years. Figure 1 shows an example of an early hardware based simulator system that was installed at the Australian Maritime College (AMC) in 1985, which had a number of limitations. Their training capability was mainly focused as a demonstration tool for marine engineering trainees, with limited ability to provide operational and diagnostic training, further exacerbated by the lack of realism in the presentation and interaction. With the rapid development of computer technologies, software based simulators have gradually replaced the hardware systems. Nevertheless, they yet consisted of many simplifications, abbreviations and schematic representations of the machinery and their associated systems. As a result, even if trainees excelled in their simulator training, they may not be able to respond with confidence and the required competence when faced with actual problems while operating the machinery on board a ship. In addition, the cost of software based simulators were a major concern with many MET institutions resorting to purchasing systems with significantly reduced capabilities, while others were compelled to stay with hardware based ERS systems.



(a) (b)

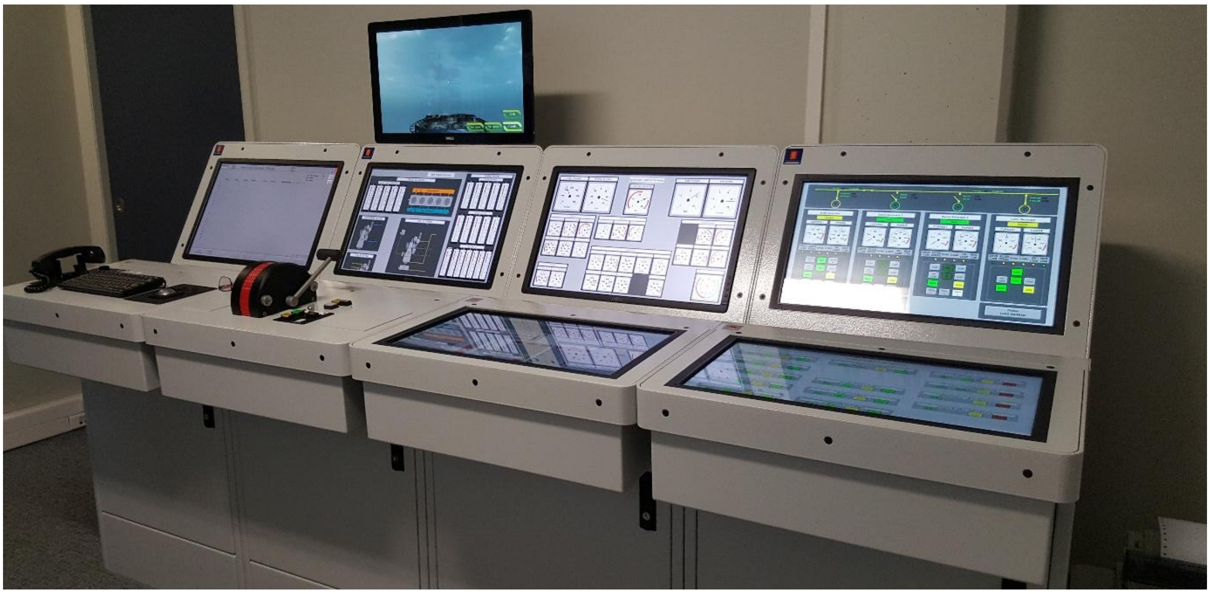
Figure 1. (a) Hardware based Engine Simulator installed at AMC in 1985, showing the entire engine room and the machinery space analogue mimic panel, (b) Engine Control Room console.

For the above reasons, many software based ERSs were used as a preparatory tool in MET focused on to familiarising students with the machinery and associated systems. With recent advancements in computer technology, high fidelity full mission engine room simulators are becoming more affordable to MET institutions. Modern ERS systems use the concept of virtual reality to mimic the actual engine room environment in an attempt to provide the user with realism. Figure 2 shows the big-view screens and engine room console of the current ERS installation at AMC.

There are a number of advantages of ERS in MET such as:

- active learning which provides better interaction and interest;
- authentic assessment to evaluate student competence;
- building confidence by providing an environment where students can make mistakes and learn from their mistakes;
- risk free environment where faults and hazardous can be simulated with no danger to personnel or infrastructure;
- realism, connecting learnings to real-life scenarios;
- understanding the consequences, with the ability to provide immediate feedback on the actions taken and decisions made;
- ability to develop teamwork and leadership;
- ability to supplement lectures through relevant applications; and
- repeatability and consistency.

(a)



(b)

Figure 2. (a) Current AMC Engine Room Big-view touch screen panels showing the virtual reality machinery space, (b) control room console

Therefore, the use of ERSs has now become a norm within the MET, with institutions investing in the required infrastructure, and embedding ERS training and assessments as a key aspect within their engineering training programmes.

Currently there are a number of initiatives being investigated by practitioners, researchers, and authorities to explore the possibility of replacing part of the sea time requirements in MET with ERS sessions. The first step in this approach has been taken by the United States Coast Guard (USCG) to acknowledge a 6 to 1 ratio, where one hour of simulation training is considered equivalent to six hours of on-board training (Barsan 2009). A study conducted by the Marine Safety International Rotterdam and TNO Human Factors Research Institute has revealed that a ratio of 7.25 to 1 could also be considered as pertinent (Marine Safety International 1994). Other studies (Committee On Ship-Bridge Simulation Training 1996) have revealed that this ratio could be increased further to a ratio of 12:1.

Amidst the increasing interest and acceptance, ERS based education and training has several shortcomings and challenges. The lack of situational awareness is a major shortcoming where students may face difficulties in perceiving the present situation and anticipating what will happen next. Modern ERS tools come with various features such as audio-visual effects to help solve this issue. Nevertheless, many physical aspects such as change in the engine vibration due to a change in the operating condition, smoke and smell coming from hot or burning equipment, and changes in temperature would be hard to simulate and thus the prediction that could be made by the operator by sensing these changes is not easily achievable with simulators. This further leads to the improper understanding of the risk of making mistakes, as simulator trainings can be viewed by students as being closer to video games than a real ship at sea, thus not fully appreciating the effect of making wrong decisions. Therefore, it is a challenge for trainers to create the environmental awareness and proper understanding of the risk involved in the actions taken by the students.

The abovementioned shortcomings are relevant to current ships where the engines are operated and maintained by seafarers on-board the ship. However, as ships move towards fully autonomous operation, the lack situational awareness will not be as significant as it is for manned ships. With the emergence of autonomous ships, the role of a marine engineer will gradually changes to a shore-based operator role, eliminating the repair and maintenance from their duties. As a result, the gap between the ERSs and real world applications become narrower, enabling MET institutions to use ERS as the main tool of training for the future marine engineer.

This paper explores the use of ERS in future MET programmes to meet the requirements of the changing industry and technology. It presents options to expand the boundaries, outreach and relevancy of MET through the planned increased use of simulators. Potential challenges and opportunities are also discussed, together with the results of a case study conducted at AMC.

Motivations for expanding the boundaries in MET through ERS

A century ago, the replacement of steam reciprocating engines by diesel engines created a revolution in the shipping industry. Subsequently, towards the end of the last century, the development in control and automation technologies created another significant change in the shipping industry, paving the way to unmanned machinery spaces (UMS). Currently, fully automated vessels are in operation, requiring no repairs or maintenance at sea, indicating the emergence of fully autonomous vessels that will not require engineers on-board the vessel (Levander 2017).

This exponential change in technology has had a significant impact on shipping in general and marine engineering in particular. However, MET has not always adapted, or indeed been proactive, to keep up with the pace at which technology has changed. Changes to the regulations and competency standards provide by the International Maritime Organization's (IMO) Standard of Training, Certification and Watchkeeping (STCW) and the relevant marine authorities, have for many reasons not been keeping pace with changes within the industry and in technology. Therefore, many administrations and MET institutions follow the minimum standard required by STCW and be guided within its provisions rather than following industry needs and developing innovative training solutions. Hence, MET has mainly evolved around the STCW model courses, thus not addressing future and impending changes, such as the introduction of automated shipping, which is already a reality in the industry. This will require drastic changes to how MET programmes are developed and implemented to address the competencies required by seafarers and related personnel in the near future.

The current MET is focussed upon STCW functions and the competence tables prepared to address the following functions for marine engineers (International Maritime Organization 2010):

1. Marine Engineering
2. Electrical, Electronics and Control Engineering
3. Repair and Maintenance
4. Controlling the ship and care for the persons on-board.

With the emergence of fully autonomous ships, the role of the marine engineer will gradually change from on-board operation, repair and maintenance personnel to the remote operators, involved in fault diagnosis and rectification. This warrants a complete overhaul of competence requirements and probably a complete removal of the last two functions. Thus, the first two functions and the competence within them will remain the core curriculum for MET. In addition, inclusion of new competencies reflecting the needs of future ships are inevitable. Furthermore, the tasks that seafarers perform in an automated ship could accurately be replicated within a modern simulator environment. This provides a major opportunity for the training systems. It also may provide possible reduction in sea time requirements with the judicious use of simulators. As a result of this rapidly changing climate, ERS have the potential to play a major role in training of future engineers.

Over the past four decades the IMO's STCW guided MET systems around the world. Although it has been successful in many aspects, one of the main shortcomings is its passive nature. This need addressing to make seafarer education more proactive to meet future needs. Autonomous ships is one major driving force to initiate change in the STCW guidelines for MET in order to keep pace with the developments within the shipping industry.

The importance of making a change to the current MET system is further corroborated in the Marine Professional Journal, which states, "…we should see remotely operated autonomous vessels by 2020. Although there are strong predictions that the autonomous ships will be sailing in 3 to 5 years' time, the question arises that, are we training future marine engineers to operate those ships when they are around?" (Nadkarani 2017).

Therefore, as all the evidence suggest, shipping industry is about to go through another revolution with autonomous ships and thus changes and expansion to the STCW guidelines and regulations pertaining to the use of ERS in MET is inevitable in order to meet the associated training requirements.

Advantage of current software based simulators

There are two very important features when training simulators are software based.

- The affordability and flexibility of use for MET Institution, as they provide training on any type of ship and engine by simply 'loading' the appropriate software to the simulator.

- Most 'high fidelity' simulators use the same software that is used on the actual ships. This enables the simulator-trained personnel to transition smoothly into their roles when they join their ship. This means the trainees who undergo simulator training in fact operate their future ships during their training in the MET Institution.

The design of modern simulators enable 'real-time' simulation models providing a knock-on effect on adjacent sub-systems. Faults and alarms will have cascading effects throughout the system if not acknowledge and attended to in a proper manner. In addition to an extremely high level of realism, these simulators offers user friendliness and flexibility, key features of providing high levels of instructor control and greater variety of course offerings – capabilities demanded by ship owners and MET Institutions worldwide (Kongsberg Maritime 2013).

The modern state of the art 'Full Mission' simulators offer a wide variety of training opportunities in the operation of machinery in the engine room using ICT. This is exactly what is required in future autonomous ships where shore based engineers remotely control and service the machinery and the associated systems of the ships that are out at sea.

A case study conducted at AMC to show the effectiveness of ERS in seafarer training

A survey conducted during the past four years at AMC revealed that school leavers who are commencing seafaring programmes find the ERS an exciting experience and an effective tool to grasp and consolidate upon the theories taught in class. This is clearly shown by the feedback obtained from students in the "Engine Resource Management" (ERM) unit. This unit enables the students to learn a comprehensive range of operational functions related to

marine engineering; for example how they can systematically start a Very Large Crude Carrier (VLCC) from cold ship status to finally being underway at full ahead. It is an elaborate process, which requires significant analytical thinking and problem solving skills.
For the purpose of this survey, students were provided with introductory sessions and videos explaining how to start up emergency and main generators to power up the ship. They then follow a critical path to start all the machinery in order to get the ship underway. An assessment was carried out at the end to evaluate the level of competence achieved by the students. The assessment rubric ensured that the students will not score 70% unless they managed to start the Main Engine and proceed to sea from the port.
A summary of the number of students who achieved more than 70% of this assessment is given in Figure 3. As the results indicate, 46% of the students did not have any prior sailing experience. This indicates that even without seeing the actual system, they were able to identify issues and take correct and timely decisions. Moreover, 89% of the students were below the age of 35 years, possibly indicating that simulators are more effective with the younger student population.

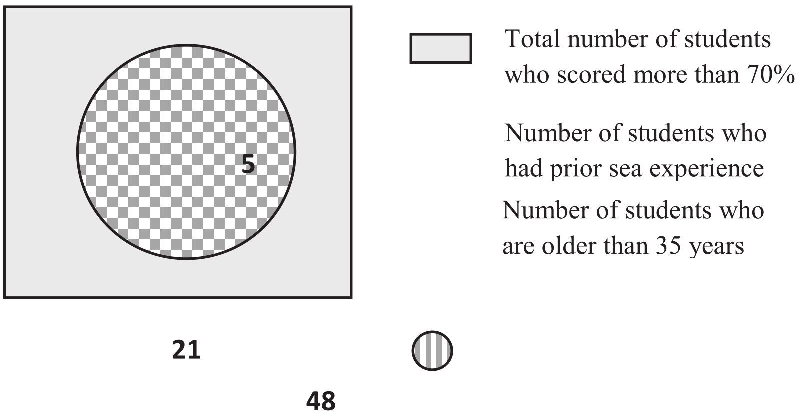


Figure 3. Venn diagram representation of the student distribution for the ERS assessment on machinery start up procedure.

Further observations revealed that, compared to the younger compatriots, the mature students struggled with the simulator training and ICT in general. The younger students come from a generation tuned to accepting ICT as the norm, whereas the mature students were moderately reluctant to give-up the old values of learning through traditional methods. A group of international students undertaking this unit stated that, “The simulator experience is like a real experience in an engine room. The subject has helped greater understanding on how the engine room operates and the learnings will surely impact our careers,” (Australian Maritime College 2017). Furthermore, students expressed that the technology was positively influencing what was being learned and were supportive of the changes to their way of learning. The move from content-centred curricula to competency-based curricula in this exercise is associated with the move away from teacher-centred to student-centred learning. Through technology-facilitated approaches, contemporary learning settings now encourage students to take responsibility for their own learning. In the past, many students become comfortable learning through transmissive modes. Students had become used to, and indeed expected, others to present them with the information for learning. The growing use of ICT as an instructional medium is changing, and will likely continue to change, many of the strategies employed by both teachers and students in the learning process (Oliver 2002).

Therefore, as evident from these results and the aforementioned trends, ERSs are not just an instructional medium, but also a key tool in the development of required competencies and attributes of marine engineers for future autonomous ships.

Summary and concluding remarks on moving boundaries in MET through ERSs

The increased reliance and dependence on ICT is unavoidable in the marine industry, and this must be reflected in the modern training systems. In this respect, simulation can provide educators with a capable and flexible tool to train future marine engineers to meet the technological competencies required on-board sophisticated future ships, as they can provide a realistic training environment and assist in authentic assessments (Wallace 2017).

From the current STCW content, for future autonomous unmanned ships only the following STCW functions will be applicable:

1. Marine Engineering
2. Electrical, Electronic and Control Systems

This is because the role of the marine engineer in the autonomous ship era will transform into a remote operator. Although ships of the future will still need repair and maintenance, this will be scheduled when the ship arrives in port, which is somewhat different to the current practice. The design of these future ships is such that "…almost every bit of equipment is encased in a standard container, including fuel tanks, batteries and gensets. The propulsion itself is fixed, but everything else is modular, and the vessel can even be operated on battery packs alone if required. The maintenance on the vessel would be almost non-existent, with majority of work being carried out on shore." (Kongsberg Maritime 2015).

As stated by Kongsberg, "Simulator training has over the last few years proved to be an effective training method when training engineers, especially where an error of judgment can endanger life, environment and property. A dynamic real-time computerized simulator can compress years of experience into a few weeks, and give knowledge of the dynamic and interactive processes typical for a real engine room. Proper simulator training will reduce accidents and improve efficiency, and give the engineers the necessary experience and confidence in their job-situation. It is important that the trainees experience life-like conditions on the simulator and that the tasks they are asked to carry out are recognized as important and relevant in their job-situation. The trainees should be challenged at all levels of experience in order to achieve further experience and confidence" (Kongsberg Maritime 2015).

Once the autonomous ship *Yara Birkeland* is in operation in less than two years (Nastali 2017) the reality of such vessels and the required competencies of the marine engineers to remotely operate such vessels will be clearer. In this context, current competencies, such as workshop competence, will not be required for future marine engineers working or operating autonomous ships. The industry may choose to have both ship operating marine engineers specialised in operation and ship repair and maintenance personnel competent in handling the STCW Code Function 'Repair and Maintenance'. Thus, the functions 'controlling the ship' and 'Care of the persons' will cease to exist. It is thus prudent for the industry stakeholders to prepare for the future, changing current regulations, competency standards and MET practices to meet future challenges.

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