Developing and Implementing a Skills and Competency Framework for MASS Operators: Opportunities and Challenges

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Abstract

Growth in diversity of innovation in the maritime and shipping industry, and the emergence of autonomous ship technologies is attracting discussion on Maritime Autonomous Surface Ship (MASS) operations in the academia, industry, and regulatory bodies. With predictions of both seafarers and non-seafarers to be involved in the critical operations of autonomous vessels, researchers are actively investigating the new skills and competencies that may be required by future MASS operators. Recent research conducted by the authors of this paper involved a qualitative study comprising in-depth interviews of stakeholders including seafarers, maritime regulators, maritime education and training providers, and other maritime experts. The research identified key technical and non-technical skills, and the need to include the identified skills and competencies in a framework. In this paper, the authors build on their past and present research and the first step towards building and implementing the framework by identifying the challenges of doing so in the context of maritime education and training. The challenges are drawn from a review of literature and a study of available skills and competency frameworks built for other industries' workforces. The challenges identified, if addressed, will be useful in building a regulated and regimented structure for the training of MASS operators and meet the expectations of the maritime stakeholders.

Keywords: autonomous shipping, maritime education and training, skills and competency framework, future ready, MASS

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1 Introduction

Recent research (Emad & Ghosh, 2023) by the authors of this paper determined that along with the current seafaring skills, future operators of autonomous and unmanned ships (Maritime Autonomous Surface Ship or MASS) should also be proficient in key technical (information and communication technology, electronic and computer engineering, artificial intelligence, etc.) and non-technical (communication, leadership, and problem-solving) skills. The aforementioned research findings were based on qualitative research study comprising of in-depth interviews of 37 participants who were a mix of seafarers, maritime regulators, maritime education and training providers, and persons involved in other facets of the maritime business. The research also identified the need for a skills and competency framework which will guide the delivery (by maritime educators) and administration (by maritime regulators and seafarer employers) of the required operational, cognitive, leadership, communication, and decision-making skills to the seafarers of the future. However, the development of the suggested framework is associated with challenges and implications.

The mere recognition or identification of predicted skills required in the future for MASS operations does not automatically translate into structured guidance for maritime stakeholders to upskill the workforce making them future ready. Lessons must be drawn from other industries which designed, developed, and implemented skills and competency frameworks for their workforce. Based on a review of available literature and academic research output, this paper presents the challenges and implications expected to be faced by the maritime industry and

categorizes them under aspects of training and education which should ideally be addressed by training providers, educators, regulatory bodies, IMO member states, and other maritime nations.

2 Challenges and Implications

2.1 The lack of definition for competencies

UNIDO (2002) defined competency as a set of skills, knowledge, and behavioural attributes required for an individual to perform workplace tasks successfully. It can be conferred that competencies should be observable and measurable actions that an employee is expected to demonstrate while performing their role (Kansal & Singhal, 2018). Hence, every competency should be named, defined by clearly outlining the associated key behaviours. For example, the non- technical skill of 'Communication' for MASS operators may be defined as below (Table 1):

Title	Communication
Definition	The ability to communicate operational breakdowns and technical specifications of shipboard machinery and equipment. It includes promotion of knowledge and information development and sharing within a major function, location, or project.
Key Behaviours	Establish mechanisms to analyze, evaluate, and report information; Coordinate the management and sharing of information and knowledge across departments

Table 1: Example of how competencies may be defined for MASS operators

Table 1 is an example and cannot be construed as an accepted definition. The task to identify, list, and define competencies and associated behaviours can be monumental. Some of the challenges (among others and not limited to) in defining the competencies may be:
  •   Inadequate knowledge of the future workplace and tasks expected to perform

- Inability to recognize and assess all associated behaviours especially with non-technical competencies
- Failing to recognize or establish a scientific process for defining the competencies
- Overlooking or failing to seek input from relevant maritime stakeholders

2.2   The need for the framework to be continuously revised

The need for a skills and competency framework for MASS operators has been identified due to the emergence of autonomous and advancing ship technologies in system operations which are almost ready to replace part or all of the human element (seafarers) on ships. However, as technologies evolve and automation becomes unconventional, the skills and competency framework will need to be updated to fulfil the requirements of the changing workplace. In the context of the maritime industry, it will be a challenge for the stakeholders to predict exactly how the importance of each specific individual competency will change, or which competencies will become redundant in the operation of MASS in the future. For example, Deloitte (2017) extrapolated employment trends between 2013 and 2030 on the basis of Federal Statistical Office data on employment growth between 1999 and 2013 and found that almost one million new jobs will be created in the growing occupations and there will be an overall loss of 350,000 jobs in the declining occupations. The challenge will be to revise the skills and competency framework for MASS operators at regular intervals with the advent of state-of-the-art and cutting-edge technologies.

2.3   The need for agreement from all maritime stakeholders

The International Maritime Organization (IMO) is the specialized agency of the United Nations comprising of member states (maritime nations) tasked with the responsibility of safe and secure shipping operations. The IMO is a regulatory body for the maritime industry and one of its key roles is to create a framework for the shipping industry which may be universally adopted and implemented by developed and developing nations (IMO, 2019). Hence, it can be expected that a skills and competency framework developed for MASS operators will need to be approved and accepted by the IMO to be implemented successfully and widely in the maritime industry. For example, amendments to IMO Conventions must be accepted by two-thirds of Member States to enter into force. However, acceptance by Member States can be time-consuming and plagued by bureaucracy. For example, Psaraftis & Kontovas (2020) pointed out that although the IMO is functional, its governance is falling back due to lack in the transparency in the process and selected countries (Japan, Germany, Norway, China, and the US) having the most potent influence in decision-making. To develop and implement the skills and competency framework for MASS operators, approval from a majority of the IMO Member States (currently there are 175 members) would need to be sought. This process would have to be repeated every time the framework is amended, revised, or incorporates minor/major changes to address the needs of the maritime industry.

2.4   The need for the framework to be aligned with the STCW Code

The recent research study by Emad & Ghosh (2023) recognized that during the transition period, future operators of autonomous and unmanned ships must ideally follow the traditional seafaring training before upskilling to be able to work on MASS and shore-based stations. Currently, the Standards of Training, Certification, and Watchkeeping (STCW) Code provide the global, minimum standards of competence required by seafarers to operate non-autonomous vessels. The Code lays out the knowledge, understanding, and proficiency required for units of competence (for example, 'Respond to a distress signal at sea'), the methods for demonstrating competence, and the criteria for evaluating competence (See Table 2).

Competence	Knowledge, understanding, and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Respond to a distress signal at sea	Search and Rescue Knowledge of the contents of the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual	Examination and assessment of evidence obtained from practical instruction or approved simulator training where appropriate	The distress or emergency signal is immediately recognized. Contingency plans and instructions in standing orders are implemented and complied with.

Table 2: Example of the STCW Code outlines the standards of competence

For seafarers to follow traditional training before upskilling to operate MASS, the skills and competency framework for the latter training must be aligned to the STCW Code to avoid issues like replication of training (and learning outcomes), training gaps, and wasting time and resources in delivering the non-required skills and knowledge. The challenge in achieving such an alignment will be to recognize and remove irrelevant competencies from the STCW Code, while making way for the newly identified and relevant competencies from the skills framework for MASS operators. One may argue that the STCW Code may remain unchanged with the new framework used as a supplement, but the question arises: Will it increase the time taken for the training to be delivered? An increase in training time will have implications for seafarer employers who are trying to source and employ trained employees in the quickest time possible to avoid gaps in the workforce. Keeping the STCW Code unchanged would also result in the implication that the maritime industry is failing to adapt to the changing landscape of the ships in business. On the other hand, making frequent changes to the STCW Code based on increasing automation on ships would require approval from the IMO Member States (which may be a time-consuming process) and overlook the training needs of the seafarers who may continue to be employed on non-autonomous ships.

Based on the assessment of the STCW Code on parameters of outcomes-based education, research (Ghosh et al., 2014) showed that the Code is too vague, and this may lead to individual interpretation in adopting learning and assessment processes towards competence development, which creates the risk of seafarers graduating with Certificate of Competencies (CoCs) but lacking the required competence for workplace operations (Emad & Roth, 2008; 2009). Similar concerns should be addressed when aligning the STCW Code with the skills and competency framework developed for the MASS operators.

2.5   The need for competencies to be understood by all

The skills and competency framework developed for MASS operators should not only address the skills gap but allow the matching of the right seafarer with the required skills. The framework will indicate the position and the level of competencies required for the seafarer to succeed in roles influenced by evolving technologies and increasing automation. It is an established fact that the competencies vary as per the assigned job/tasks and are different at different levels. Reflecting on Table 1, the different levels of proficiency for the non-technical skill of 'Communication' for MASS operators may look like what is described in Table 3 below.

Competence	Support	Operational	Management
Communication	Establishes mechanisms to analyze, evaluate, & report information; Coordinates the management and sharing of information & knowledge across departments	Makes decisions based on research, analysis, & review of information & knowledge. Disseminates information to senior maritime stakeholders	Develops communication plans to engage internal & external stakeholders. Communicates directly to reinforce the organization's brand and values

Table 3: Example of different levels of proficiency for competencies required by MASS operators

Table 3 lists the levels of proficiency for competencies which may be required by MASS operators at Support, Operational, and Management levels. This is an example only and the information about the levels are drawn from the STCW Code which outlines the standards of competence for seafarers at different ranks under the same categories. To develop a comprehensive skills and competency framework, levels of proficiency and the behaviours expected at different levels would have to be thoughtfully outlined for all identified and accepted competencies.

It should also be noted that the taxonomy of autonomous ships proposed by the IMO is as follows:

- Level 1 - Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.
- Level 2 - Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location, but seafarers are on board.
- Level 3 - Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
- Level 4 - Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself (Emad, Enshaei, & Ghosh, 2021).

Considering the different levels of autonomy proposed for MASS, the skills and competency framework should define the behaviours expected from operators at different levels of proficiency. This would imply that operators will constantly need to be trained as they get involved in managing ships at differing levels of autonomy.

2.6 The need for supporting resources to be developed and made available

Planning the development of a skills and competency framework should simultaneously also consider the capability of education and training providers of IMO member states to deliver the required competencies and instill the expected behaviours in the future MASS operators. For example, just like full mission bridge and engine simulators are utilized to train current seafarers for the operations of non-autonomous ship systems, digital twins and improving access to sophisticated digital resources may be required to train MASS operators (Shahbakhsh, Emad, & Cahoon, 2021; Waterstone et al., 2021). However, the STCW Code (only provides recommendations in Part B of the Code) does not specify the standards of simulators which should be used for training to accommodate the interests and financial capabilities of maritime nations in purchasing and maintaining such state-of-the-art facilities which cost millions of dollars. Similar policies may also have to be adopted by the IMO to ensure minimum standards of training can be delivered for MASS operators globally. The question thus arises: Will such training ensure safe operations and address the skills gap?

IMO member states would also need to consider adopting and implementing policies and resources, including educational and training systems, swiftly to help the workforce in adapting to and preparing for the rapidly growing future ships driven by autonomous systems.

2.7 The need for the framework to be supported by authentic pedagogical practices

Past research (Ghosh et al., 2020a; Ghosh et al., 2020b; Ghosh & Bowles, 2020) has provided empirical evidence to show that the use of authentic pedagogical practices, such as Communities of Practice (QC) (Emad & Roth, 2016), improve seafarers' achievement in developing the skills required at the workplace and overall achievement of the targeted (and valid and reliable) learning outcomes. Hence, an important step in the development of a skills and competency framework for future MASS operators is the recognition of how the skills will be assessed through authentic assessments which tests the ability of the student to apply the classroom learning in real-world contexts or contexts similar to the workplace settings. Doing so will ensure readiness of graduates to perform the tasks as expected in professional scenarios to standards which will deliver the outcomes for the employers, regulators, and other stakeholders, thus, addressing the skills gap in a holistic manner.

3 Conclusion

Recent research has identified a number of technical and non-technical competencies which are expected to be required by MASS operators for efficient operations and management of systems. This type of research is important for preparing the future workforce and addressing the anticipated skills gap as non-autonomous ships are increasingly replaced with MASS at differing levels of automation. The identified competencies for the future would need to be organized into a skills and competency framework which will provide guidance to maritime stakeholders (maritime education and training providers, maritime regulators, IMO, ship owners and seafarer employers, ship and autonomous system manufacturers). The framework will provide a pathway to the question of how the required skills will be delivered at different levels of proficiency. This paper presented the challenges, especially in the context of maritime education and training, in conceptualizing, developing, and implementing the skills and competency framework. As discussed, there is a need to provide clear definitions of competencies with associated behaviours which would need to be revised as technologies evolve and roles and responsibilities of operators change. The definitions need to be understood and accepted by maritime nations and aligned to the global standards of competence provided by the STCW Code. The competencies and behaviours, if listed and organized in the competency framework, would need to be delivered utilising the available advanced technology such as digital twin for training and assessment. This can assure operators can apply classroom training to the new real-world contexts as expected in the future professional settings. There is a need for research to address the identified challenges in order to provide recommendatory guidance to the IMO so that it may be disseminated to maritime nations for effective implementation.

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