STCW REQUIREMENTS IN A REGULATORY AND TECHNOLOGY LANDSCAPE CHANGE

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Abstract

STCW 78 as amended is the most comprehensive source of information regarding mariners' knowledge, understanding, and professions (KUPs), and is a reliable reference for curriculum design in maritime education and training institutions (METIs). However, the changing regulatory and technological shipping landscape requires continuous assessing the adequacy of current training requirements. Therefore, this study reviews safety, quality, and environmental management systems (SQEMS) from two large shipping companies. From the review, the expected seafarers' skills are deduced, then compared with the STCW 78 as amended requirements. The results of this comparison reveal some insufficiencies in the KUP requirements mainly due to the STCW *attitude*, *approach*, and *focus*. STCW attitude refers to the low reactivity of STCW, lack of details in expressing KUPs, and unbalanced details for different KUPs. The STCW approach to defining KUPs for different ranks is based on the ship's functions. Although this approach is comprehensive, its rigidity results in some skills in the interface of different ship functions being overlooked or not being sufficiently emphasized. STCW focus is primarily on safety, by highlighting the details of safety-related codes and conventions, procedures, and equipment, while in response to environmental features, it mentions only "protection of the marine environment", without explicit reference to environmental conventions, machinery, inspections, or procedures. Consequently, the study highlights KUPs weaknesses and recommends changes to improve training.

1 INTRODUCTION

Sustainable shipping requires a broad range of skills and competencies for seafarers to encompass safety, efficiency, and environmentally friendly ship operations. The International Maritime Organization (IMO) adopted in 1978 the Standard of Training, Certification, and Watchkeeping Convention (STCW) to ensure appropriate training standards. The Convention undertook two major updates in 1995 and 2010 and as regularly been amended [1]. The 1995 amendments transformed the Convention, adding, *inter alia*, the Code detailing requirements for each position. It responded to stakeholders' concerns that STCW 78 had not been as effective as expected, since it left interpretation to individual maritime nations, creating a vague and unclear picture of standards [2]. The STCW Code is an integral part of the Convention and lists its technical details. One mandatory Part (A) and one recommended Part (B) compose the Code [3].

Applying to seafarers in shipping, the STCW 78 as amended establishes standards of competence obtained by the acquisition of knowledge, understanding, and proficiency (KUP) requirements detailed in the Code. Consequently, maritime education and training institutes (METIs) must follow STCW 78 as amended standards to deliver approved certificate of competency (CoC). In short, the STCW 78 as amended and its Code are the reference system for METIs. As per Robson [4], the STCW 95 revision transformed mariner qualification from knowledge-based to proficiency-based examination; however, assessment methodologies have not been detailed within the Code. Ghosh et al. [1] argue that STCW remains vague even after its 2010 revision and later amendments, allowing METs to select their own method to assess proficiency.

By analyzing three levels of seafarers' competence, shown in Fig.1 (practical competencies utilized onboard, the outcomes of training, and requirements of STCW), mismatch and gaps may appear. The ideal situations would be the perfect alignment between training and operational needs.

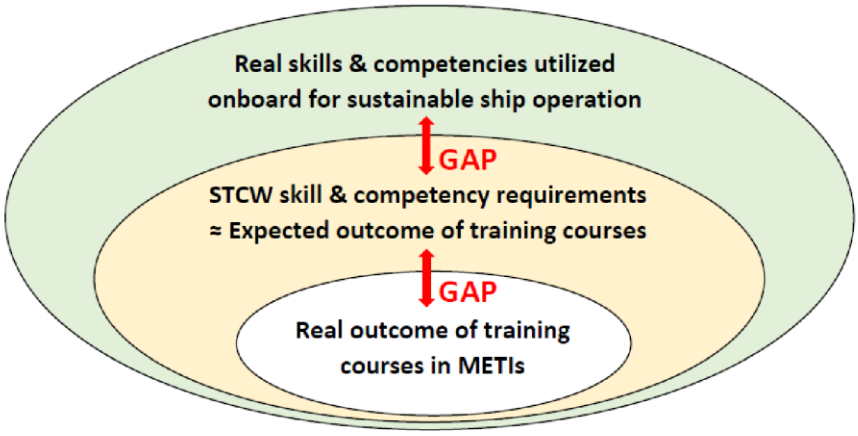

Figure 1: Structural gap between different level of competencies (Authors' own idea)

The paper proposes to focus on the gap between the applied skills and competencies expected onboard (as detailed in operational procedures of shipping companies) and STCW 78 as amended KUP requirements. The study investigates the current and future skill gap in the STCW convention. This research explores three concepts in the STCW namely *attitude, approach,* and *focus*. In this study, STCW *attitude* refers to the manner of STCW in expressing KUPs (level of detail and keywords), and in updating KUPs in response to new regulations and technologies (reactivity). STCW *approach* refers to the methodology that STCW employs in identifying KUPs and assigning them to different ranks onboard. In addition, STCW *focus* refers to the concentration of code on one particular aspect (e.g., safety) and less attention given to the other features (e.g., environmental concerns).

The study is deemed important because of the regularly inflation noticed in the shipping industry as well as the increasing shipping companies' requirements via the ISM and related management codes. Additionally, the period is characterized by important technology changes, enhance pressure to decarbonize shipping and

sustainability targets. Therefore, maritime education and training needs to meet shipboard challenges. Seafarers need skills and competencies equipping them to keep up with technological advancements and regulatory changes.

2 METHODOLOGY

This study compares STCW requirements with onboard competency expectations according to companies' procedures. As part of this study, the research team had access to documents from the HSEQ (Health, Safety, Environmental, Quality) department of two large shipping companies, including a tanker company and a fleet of chemical carriers. Details about instructions and job descriptions in the safety management manual (SMM), quality management manual (QMM), environmental management manual (EMM), owner manual, and forms and checklists file were accessible. These documents enabled authors to review safety and environmental procedures as well as the essential skills required for safe and sustainable ship operations. The findings of this review were evaluated and compared with STCW KUP requirements. In the following sections of this paper, it could be observed that the identified skill gaps could be attributed to the STCW *attitude*, *approach,* and *focus.*

3 ANALYSIS OF CURRENT SKILL GAPS

3.1 STCW attitude

Various METIs around the world follow the STCW convention in designing and updating their training curricula. The STCW convention plays an essential role in harmonising and standardizing maritime training and certification processes. As a result, it is expected that this convention to be proactive in interaction with other regulations and technological advancements, to be comprehensive including enough details, and to be easy to amend through a swift legislation process; however, in reality, this is not the case, and the reasons can be summarized as follows:

3.1.1 STCW reactivity

As a result of reviewing STCW's content and its amendment process, it may be apparent that the sensitivity of this convention in response to changes in other regulations and technological advancement is low. The process of amending a code or convention and enforcing the amendment may take a considerable amount of time. This long period of time might be sufficient to predict the set of skills and competencies required by this upcoming change in regulation, and prepare the ground for STCW updates accordingly. Experience has shown, however, that first a code or convention need to be adopted and enforced, and then (after another period) some proposal could be made to emphasize the need for new skills and competencies. This could be attributed to the low reactivity of STCW. For instance, cyberattacks which is the recent concern threatening shipping companies' ICT (information and communication technology) and cyber systems are on the agenda of many maritime forums, and IMO has received proposals regarding cyber security, but it has been addressed neither in STCW security related skill requirement nor in STCW part B. Similarly, the ballast water management (BWM) convention was enforced in 2017; however, the STCW text does not contain any reference to knowledge and skills related to BWM regulations and equipment. A similar statement can be made regarding the Hong Kong convention for ship recycling, with its minimum knowledge requirement regarding inventory of hazardous materials (IHM).

3.1.2 Lack of details in STCW code

In light of emphasizing the minimum requirements of KUPs in STCW, to address a basic level of knowledge and understanding, it could be perceived that referring to guidelines and best practices is insufficient. The lack of references to updated regulations, conventional guidelines, and well-known keywords may lead to divergent interpretations by training institutions. This shortage can be observed even in the case of special vessels and STCW part B. In the context of human resource management, for example, there is no value in using keywords related to ILO/MLC conventions.

3.1.3 Unbalanced details in STCW code

The unbalanced details provided in STCW at the operational and managerial levels could also be viewed as a drawback. For example, KUP requirements related to ARPA and ECDIS are three times more detailed than KUP requirements for leadership and managerial skills. For instance, human element management does not refer to the appraisal of seafarers onboard, the documentation of seafarers' work/rest hours, or the minimum safe manning requirements. There are no points associated with the types of resources in resource management, such as human resources, time, energy (bunker), spare parts, and consumables. Management of these resources requires managers (key staff onboard) possess a set of managerial skills, such as preparing Gantt charts for time management (e.g., at the dry dock), bunker calculations and bunkering operations, planned maintenance systems, spare parts inventory, and familiarity with IMPA manual (International Marine Purchasing Association) to prepare indent lists, among other things. Presenting such examples at least in STCW part B can direct training institutions to develop effective courses addressing the latest regulatory, customary, and standard guidelines.

3.2 STCW approach

In STCW code part A, different lists of KUPs have formed standard of competence for different ranks on board and these sets of KUP requirement are linked to the following seven ship functions:

1. Navigation
2. Cargo handling and stowage
3. Controlling the operation of the ship and care for persons on board
4. Marine engineering
5. Electrical, electronic, and control engineering
6. Maintenance and repair
7. Radio communications

The authors believe this is an appropriate and comprehensive approach, however, some essential knowledge and skills, mostly at the management level and at the interface of different ship functions, have been overlooked due to the inflexibility of this approach. By comparing the company instructions in SQEMS documents with different lists of KUPs in STCW part A, the following missing or underemphasized skills and competencies in STCW were identified:

- **Administrative skills**

Company instruction:

- It is the master's responsibility to maintain close contact with the chief engineer concerning the vessel's status with regard to all the statutory certificates issued by the flag and classification societies. (QMM)
- A monthly written report of all structural and machinery repairs should be prepared by the master and chief engineer for the attention of the technical superintendent. (QMM)
- Master and chief engineer are responsible for ensuring that all cargoes, stores, equipment and materials are correctly identified and traced to the appropriate documentation. (QMM)
- Following documents are only some examples that must be prepared and kept onboard: (QMM)
  - Master's, chief engineer's and chief officer's monthly reports
  - Superintendent's inspection reports
  - Fleet safety officer's inspection reports
  - PMS records
  - Classification society records
  - Port state control inspection reports
  - Vetting / oil majors' inspection reports
- Specification for dry-docking shall be prepared by the ship staff six months prior to the due date. (QMM)

The company instruction suggests that seafarers, both at management and operational levels, to possess a variety of administrative skills. The required administrative skills can include reporting, technical writing, and documentation, onboard various types of vessels [5-6]. This skill allows seafarers to deal with different documents and paper work utilized in the interaction with different stakeholders, such as ports, shore staff, agents, third parties, etc. A number of examples are provided in this regard, including the bill of lading, survey and inspection results documentation, statutory certificates and documents onboard, personnel competency documents, checklists and permits to work documents, daily noon reports, and planned maintenance systems. Moreover, for an efficient documentation and reporting mechanism, key personnel should possess a basic understanding of, for instance, marine insurance, guarantee claims, third party contracts, and different types of charter parties, which, in the authors' opinion, are not addressed in the STCW. According to IAMU [7], such topics require more detailed development (extension) in METI courses. The STCW code places less emphasis on administrative skills, including reporting and documentation.

- **Communication**

Company instruction:
- It is the master's responsibility to maintain effective communication with all concerned departments so that he or she may comply with the charter party requirements and amend or correct any instruction provided by the charterer. (QMM)
- Safety committee meeting, ship board management meeting, mess committee meeting, and onboard network communication between various users, considered as tools which have been employed for effective and efficient means of communication. (QMM)
- Communications encompasses all modes of communication, including ship-to-shore, ship-to-ship, and ship-to-ship (among the fleet of the Company). Additionally, this procedure outlines the activities and controls related to the GMDSS. (Owner Manual)

The wide range of ship-related communication can include ship to ship, ship to port, ship to company, ship to the third party, and shipboard communication. The evolution of communication systems broke the isolation of the ship and extended its network of interaction in terms of contacts and means (radio, emails, phone, telex, etc.). Ships communicate with other ships, ports, vessel traffic services (VTSs) and other safety information providers, important information related to safe operation, security levels at ports, warnings to navigators, and safe route. Ship to shore communication necessitates specific knowledge about the shipping companies' organizational structure and key personnel such as ship manager/technical superintendent, designated person ashore (DPA), fleet safety officer (FSO), company security officer (CSO), quality assurance representative (QAR), and other contacts spread in technical, training, human resource, commercial, chartering and operation departments. Knowledge about the line of report in general, and line of communication in emergencies, and knowing the company emergency response team (ERT) is essential. Communication with third parties like insurers, charterers, agents, contractors, machinery manufacturers, and inspectors is one of the vital responsibilities of key staff onboard. Shipboard communication including daily management meetings at sea and during ship repairs, safety meetings, and training sessions could play an essential role in the success of safety, environmental, and energy efficiency management onboard. Most of the above-mentioned aspects of communication are less or not emphasized in the STCW convention. The authors have a recommendation in this regard to modifying function number 7 from radio communications to a broader term of communication (see section 5). Indeed, the STCW emphasizes competencies related to the Global Maritime Distress and Safety System (GMDSS) requirements. However, holistic communication skills could be strengthened by proposing broader skillset including multiple channels [8-9].

- **Vessel inspections**

Company instruction:
- The Master should conduct an onboard navigational audit, using a standard questionnaire that includes company-specific navigational requirements. (QMM)

- The master, in consultation with the superintendent, is responsible for taking appropriate action to rectify deficiencies identified by the vetting, port/flag state control, and classification society and forwarding the results to the concerned superintendent to be considered by the technical director. (QMM)
- In all surveys conducted onboard, the master will arrange for a senior officer to accompany the attending surveyor. (QMM)
- In order to coordinate/cooperate with the surveyor or auditor, the master and chief engineer must attend the opening and closing meetings of any survey or audit onboard. (QMM)
- Following the completion of the survey, the Master will confirm in writing the results of the survey and any defects that require action either from the ship's resources or with assistance from the management. (QMM)

Vessel inspections by different objectives such as port/flag state inspections, vetting inspections, internal/external audits, voluntary inspections (e.g., ISO and Green award), and class surveys necessitate strong knowledge about the nature, scope, and objectives of each inspection and skills to conduct them consistently. The knowledge and skills related to inspections remained limited in the STCW. Stressing the role and type of inspections would support sustainable shipping. It would encourage training institutes to include this important subject in their courses to better prepare seafarers in facing such inspections. By minor modification in the title of function number 3, the required skills related to ship inspection could be categorized under this function (see recommendations in section 5).

- **Response to emergencies**

Company instruction:
- The fleet personnel manager should ensure that all key personnel onboard have received training in hazard identification and risk assessment. (QMM)
- Company in contingency manual has prepared contingency plan for different emergency scenarios including: Abandon ship (lifeboat test), fire, oil spillage, emergency steering, helicopter operation, GMDSS operation, entry to enclosed space, rescue of casualty from enclosed space, man over board, collision and grounding, acute personal injury, cargo vapor leakage, communication failure, explosion, extreme weather condition, flooding, port of refuge, propulsion failure, power failure (black out), search and rescue, and emergency towing. Relevant drill for this emergency scenarios must be conducted at the recommended time intervals and recorded accordingly. (SMM)

Companies' SMS and contingency manual tend to include many scenarios in their emergency preparedness. However, STCW remains generic. Important risks such as blackout, ship recovery from the dead condition, and enclosed space rescue require enhance attention as they are common to all ships. Furthermore, extension of emergency preparedness should include all ranks and departments to facilitate effective response. The synergy between deck and engine departments plays a crucial role in contingency management [9]. A recommended function, "response to emergencies" (see section 5), can cover multiple emergency cases including the elements contained in SOLAS (e.g., cybersecurity) and MARPOL (e.g., SOPEP and oil spill management), and should be complement STCW Code part A Chapter VI. It would highlight the multiplicity of emergency scenarios and facilitate the inclusion of new risks (e.g., risks associated with alternative fuels, wind assisted technologies, and Ballast Water Management systems).

- **Management of change**

Company instruction:
- To ensure that all changes to procedures or equipment on board the vessel are subject to risk assessment, the company has established a change management procedure. (QMM)
- To ensure that changes to equipment, personnel, operating conditions, or procedures do not compromise safety and environmental standards, change management procedures have been established. For

instance, the introduction of third-party contractors or the addition of a new vessel to the fleet can increase the risk of an accident. (QMM)
- Changes in SQEMS documentation (permanent or temporary) must be evaluated and managed to ensure that safety, security, health and environmental risks arising from these changes remain at an acceptable level. (QMM)

Introduction of new technical, administrative, and organizational tools imply the modification of the work environment. Risk assessment should be emphasized in STCW particularly in relation to change (e.g., the impact of new regulations and related activities) or downgraded situation (e.g., unavailability of some equipment). Specific attention should be dedicated to the impacts of crew change and the importance of handovers. For example, incoming master and chief engineer should be aware of the list of the items they should check before taking over the command, and further, they should be confident and familiar enough with the company policies and contacts, as well as reporting and documentation procedures. The strengthening of risk assessment and bolding of certain keywords in training courses, such as handover notes, master reviews, and document change requests, would better prepare crews for changes.

- **ICT and digital skills**

Company instruction:
- Fleet IT manager is in charge of ships network management, and training of seafarers. (QMM)
- Master & Chief engineer should maintain a comprehensive bank of software. (QMM)
- Master or his nominated officer should inspect ship's computer network in accordance with PMS job order. (QMM)

In many industries, managers have recognized and embraced the fast pace of ICT development, resulting in a drastic change in work skills towards digitalization. In light of the rapid development of modern information and communication technologies, the maritime industry is eager to increase the use of ICT applications in various functions onboard vessels [10-11-12]. It is important however to note that the current STCW does not mention ICT and digital skills [13]. IAMU [7] states that ship-shore information technology is one of the subjects not mentioned in the STCW, and METIs should include more detail on this topic. Notably, the disappearance of the radio officers on merchant vessels created a vacuum in terms of electronic equipment management. The GMDSS is insufficient to address aspects such as maintenance, repair and upgrading of electronic equipment and ICT systems. Strengthening seafarers' skills (in particular electro technical officers) or re-introducing radio or ICT or electronic officers' onboard ships could be considered in the STCW revision.

- **Cyber security**

Company instruction:
- Company's IT department in coordination with training department should ensure for provision of enough training for seafarers to raise their awareness regarding cyberattacks and cyber security. (QMM)
- Cyber security guideline to be updated and circulated to all fleet vessels. Controlling the availability of the updated guideline onboard and appraisal of ship staff in terms of cyber security awareness should be included in ISM audits. (SMM)

The maritime community is concerned about the risks associated with cyberattacks on shipping companies, ports and administrations. As a result, cyber security requires the understanding and awareness of seafarers and port operators [14]. Cyber security guidelines introduced by the IMO (MSC-FAL.1-Circ.3-Rev.2 and Resolution MSC.428(98)) should be considered in the STCW to allow METIs to prepare seafarers to such risks.

- **Retrofit and new ship delivery**

Company instruction:
- Fleet Personnel will identify training needs well in advance of the ship's delivery and other additional or supplementary familiarization will take place during the delivery process. The training department will plan and execute the identified training. (QMM)
- Upon introduction of the new vessel to the fleet, as per the management of change guideline, the technical superintendent, key personnel and remaining ship staff will attend the vessel in sequence as appropriate, prior to delivery of the ship, in order to become familiar with its equipment and instruments. (QMM)
- As a result of the installation of new equipment/systems, necessary training must be identified and communicated to the training department for the purpose of planning and executing the necessary training. (QMM)

Safety-related equipment and MARPOL machinery onboard are typically identified as critical equipment and given priority in the planned maintenance system due to the importance of safety and the environment. Key personnel on board ships are responsible for identifying the list of critical spare parts for different machinery and maintaining the minimum amount of them on board. Supervision of the quality of subcontractors' work and further, knowledge about the machinery items that could be surveyed by a chief engineer on behalf of the class should be part of the required KUPs in the maintenance section of STCW. It requires special knowledge and skills to commission new machinery as part of the delivery of a new ship or after a major retrofit in dry dock, along with an understanding of the documentation requirements and the clauses of the warranty and insurance contract. The STCW convention does not mention any of the above-mentioned KUPs.

3.3 STCW focus

Today, the world has realized that green shipping must be regarded as equally important as safe shipping. In this respect, the environmental instruments applicable to ships have been the most dynamic regulatory area of the sector. The following list of environmental conventions have significantly affected ship technology and work at sea:

- Ballast Water Management (BWM) Convention
- Anti-fouling Convention and the biofouling guidelines
- Hong Kong Convention on ship recycling. Entering into force in 2025, the Convention requires ships to maintain an Inventory of Hazardous Material (IHM).
- MARPOL Convention
    - Water pollution (by oil, chemical, dangerous goods, sewage, and garbage)
    - Air emissions
        - Air pollutant (SOx, NOx, ODS, VOC)
        - GHG emission (CO_2 in direct relation to ship energy efficiency, CH_4, N_2O)

To implement the regulations, seafarers must acquire extensive and non-traditional knowledge (ecology, chemistry, etc.). Environment-related KUPs are designed to assist seafarers in preventing marine pollution from ships. Among this web of regulations, the provisions to address air emissions from ships have a particular significance because of their impacts on ship operation and technology. The growing volume of MARPOL Annex VI requirements demand an enhanced attention from shipowners and seafarers. To comply with the regulatory changes, new technology and practices are needed and may require changing the shipowners and seafarers' mindset towards clean and efficient shipping practices. Currently, the question arises as to how much of STCW's requirements are related to environmental KUPs.

STCW is a safety-focused convention [7-13-15-16] that enumerates the details of codes, conventions, procedures, and equipment related to safety; however, when it comes to environmental features, it simply mentions "protection of the marine environment", without any explicit reference to environmental conventions, machinery, inspections, and procedures. Education and training of seafarers may not be as specific and in-depth as expected to enhance environment protection concerns.

The contrast is notable with the environmental management manuals of both shipping companies. These manuals are comprehensive and voluminous. The following box presents some points highlighting the level of details, which probably need to be considered in future STCW iterations.

Examples of companies' instructions: (EMM)

SOx scrubber

- It is each operator's responsibility to familiarise with the system and equipment and absorb the training information given by the specific maker of the equipment.
- When bunkering Caustic soda, a MSDS (Material Safety Data Sheet) will be handed over and adequate information of the PPE (Personnel Protection Equipment) needed will be provided.
- The procedure for discharge of EGCS sludge is applicable to ships fitted with closed loop or hybrid type scrubber systems. Discharge of sludge from the dedicated sludge tank will be made via the NaOH sludge discharge pump and the NaOH sludge discharge line to the main deck manifold.
- When operating the exhaust gas scrubber, the input and output parameters of the control and monitoring system should be continuously updated and recorded.
- An exhaust gas analyser is continuously monitoring the Sulphur dioxide emission from the exhaust gas scrubber by measuring the SO_2 (ppm) / CO_2 (%) ratio according to IMO MEPC 259 (68).
- The engine room operators are required to keep records on paper format in the engine control room. The EGCS record book shall be maintained daily and records must be saved. The document is to be stored onboard in the archives according to the company's engine room logbook retention policies.

Ballast water treatment plant

- The system should only be operated in accordance with the system design criteria and manufacturer's operational and maintenance instructions. When the system encounters malfunctions or failure, these are to be recorded in the ballast water record book.
- BWM convention requires that vessels must conduct ballast water exchange:
    - at least 200 nautical miles from the nearest land and in water at least 200 metres in depth; if this is not possible
    - at least 50 nautical miles from the nearest land and in water at least 200 metres in depth; or
    - in areas designated by the Port State.
- It must be noted that coastal states may deviate from the Convention with regards to the distance and water depth requirements for ballast water exchange. Examples of these areas are the Mediterranean Sea, North Sea, and the Baltic.
- The voyage should be planned to take into account when ballast water exchange in accordance with the above criteria can be carried out.
- When a vessel is required to conduct ballast water exchange and does not do so in accordance with these requirements, the reasons must be entered in the ballast water record book.

Energy efficiency

- Company uses annual data to benchmark the ships performance through Annual Efficiency Ratio (AER) and Energy Efficiency Operational Indicator (EEOI).
- Company processes and visualizes all data collected from ships entries through the environmental dashboards in regards of fuel consumptions and emissions including (EEOI and AER).

- The Master shall ensure all crew members complete the ship energy efficiency E-training. This is available through training portal and must be part of the Master's Review.

Ship recycling management

- Company has established a process for the recycling of ships in accordance with the Company's Recycling Policy.
- Company has kept all fleet vessels certified in compliance with the Hong Kong International Convention for the safe and environmentally sound recycling of ships, and regulation (EU) No 1257/2013 on ships recycling (SRR).
- Company has created procedures (Maintenance of IHM Record Part I) to fulfil the requirements of HKC Chapter 2 regulation 5.3, 5.2 of the IMO Guidelines, and EU SRR Title II Article 4 (6) in regard to identification of Hazardous Materials through the ship's life cycle.

Mixing both technical and operational requirements, these instructions require seafarers to self-adapt to such a changing environment without dedicated training. Indeed, companies rarely provide dedicated training to seafarers. Therefore, knowledge of Conventions and related equipment and operation requires adequate preparation. Training should be the responsibility of METIs while the onboard familiarization should stay in the hand of shipowners and seafarers as expected in the MLC, 2006 Regulation 1.3.

4 FUTURE SKILL GAPS

It was recently highlighted in a DNV report that decarbonization and digitalization are two predominant trends in maritime transformation, as well as the skills that seafarers will need to adapt to these changes [17]. Future technologies in shipping are expected to enhance safety and energy efficiency of vessels. In recent years, advances in automation technologies, communication technologies, digital and intelligent information technologies, decarbonization technologies, robotics, and drones have opened up new opportunities for sustainable shipping. This pathway may present challenges in terms of upskilling seafarers to work in transforming technology landscape. For example, seafarers who intend to work with emerging alternative fuels require appropriate training in order to minimize relevant risks. Further, the employment prospects of low-skilled seafarers would be adversely affected. In contrast, on the positive side, seafarers can gain new competencies by upskilling or reskilling, which can open new opportunities for employment in the maritime sector [16].

The current skill gap was examined in section 3. The future skill requirements for seafarers can be divided into mid- and long-term skills. In an investigation of the training programs provided by technology providers, Ölçer et al. [16] identified mid-term skill requirements to operate the following systems and technologies:

- hybrid propulsion system
- pod propulsion system
- NOx reduction equipment
- SOx scrubbers
- ballast treatment plants
- LNG system (bunkering/ storage/ usage)
- dual fuel engine technology
- advanced electrical systems
- advanced automation/control systems
- advanced alarm and monitoring systems in engine room and bridge
- ship operational software

In addition, based on the results of surveys and expert workshops, Ölçer et al. [16] have identified and weighted the following long-term skill requirements:

1. Competencies to handle alternative fuels
2. Proficiency to maintain/operate the advanced /electrified propulsion systems
3. Proficiency to maintain/operate the advanced electrical systems
4. Know-how to maintain/operate the wind-assisted technologies
5. Know-how to maintain/operate technical energy efficiency measures
6. Skills to operate/maintain Real-time Monitoring System
7. Proficiency to work with advanced navigational equipment
8. Ability to operate ship operational software

9. Skills to maintain/operate the pollution/emission prevention technologies

In addition to not being included in STCW, most of these mid- and long-term skills are rarely considered in METI curricula. Additionally, according to Ölçer et al. [16], the five most important soft skills in the future are: 1. quality control and safety awareness 2. resilience, stress tolerance and flexibility 3. management of personnel 4. operating digital technology, and 5. active learning.

Supporting decarbonization technologies is evident in most future skills and competencies in the literature. Zincir and Deniz [18] have emphasized on the lack of competency in handling alternative fuels and propose a training course for this reason. A report by ITF/ICS/LR [19] indicates a significant skills gap in handling zero or near-zero emission fuels. Yet, the future fuel option and regulatory environment remain uncertain. Due to these uncertainties, planning for the transition of the maritime workforce and attracting investments toward new skills programmes are challenging. However, regardless of which fuel or fuels end up being preferred, the transition to a decarbonized shipping industry will require additional training for at least hundreds of thousands of seafarers up to 2050 [19].

To compensate current lack of preparedness, technology providers have initiated courses to meet mid-term skill requirements based on technology maturity and penetration. However, seafarers are usually on voyage contract, hindering their ability to stay long on the same ship. Consequently, training provided for a specific equipment may become useless if the seafarer is transferred to another ship. Additionally, experience gained during a voyage may be lost if the seafarer is not coming back. In order to strengthen knowledge and adaptation to technology changing, the STCW convention should take prompt action to include appropriate KUPs relevant to decarbonization. Additionally, the conditions of employment of seafarers should be consider in order to stabilize the workforce and facilitate new technology learning.

5 DISCUSSION AND RECOMMENDATIONS

A key objective of the IMO model courses is to assist maritime training institutes and their teaching staff with the introduction and organization of new training courses and the enhancement of existing training material, without the intention of providing instructors with rigid teaching packages that they should blindly follow. In this study, different model courses for all officer ranks were reviewed (7.01[1], 7.02[2], 7.03[3], 7.04[4], and 7.08[5]). The application of model courses follows exactly STCW headings and topics, but with further details and a training timeline. The question is, instead of limiting the model course to STCW requirements requiring long time for update, why should the model courses not be used as a platform to test the inclusion of new training topics relevant to new skills and competencies?

A 'optional' section could be added to a model course to prompt new training topics. Volunteer METIs, exceeding the strict STCW requirements, could test and disseminate the results and provide lessons learned. The purpose of this approach is to establish a low-cost try-and-error platform that can either reject the addition of a KUP to the STCW, or, conversely, pave the way for a new KUP to be integrated into the STCW. Using this method may be an effective means of addressing STCW's low reactivity. Consequently, future skills could be anticipated and tested in the optional section of model courses before inclusion (or not) in STCW.

Additionally, this study recommends minor changes to the ship's functions and their scope as illustrated in Fig.2. Assessment of the STCW and KUPs related to the third function, controlling the operation of the ship

[1] Model Course for Master and Chief Mate
[2] Model Course for Chief Engineer Officer and Second Engineer Officer
[3] Model Course for Officer in Charge of a Navigational Watch
[4] Model Course for Officer in Charge of an Engineering Watch
[5] Model Course for Electro-Technical Officer

and providing care for persons onboard, confirms that the primary emphasis is on safety. There is little intention of highlighting the environmental impacts associated with ship operations. by changing the title of this ship function to "sustainable shipping", the intention is to stress on environmental issues and green shipping with the same weight as safe ship operation (see 3.3). Furthermore, the seventh function, in relation to radio communications cannot represent the broad concept of communication. To expand its meaning, the function could become "communication" to incorporate many more dimensions than radio communication (see 3.2). Moreover, it is recommended to create a new function (response to emergencies) to clarify different emergency and contingency scenarios and the required skills for both the engine and deck departments to tackle these situations, and strengthen the scope of Chapter VI[6] encompass emergencies not strictly addressed. With this approach, no emergency scenario is overlooked, and cooperation between deck and engine departments is emphasized in the event of an emergency. Moreover, this section could be updated consistently to include new identified risks associated with upcoming technologies (see 3.2).

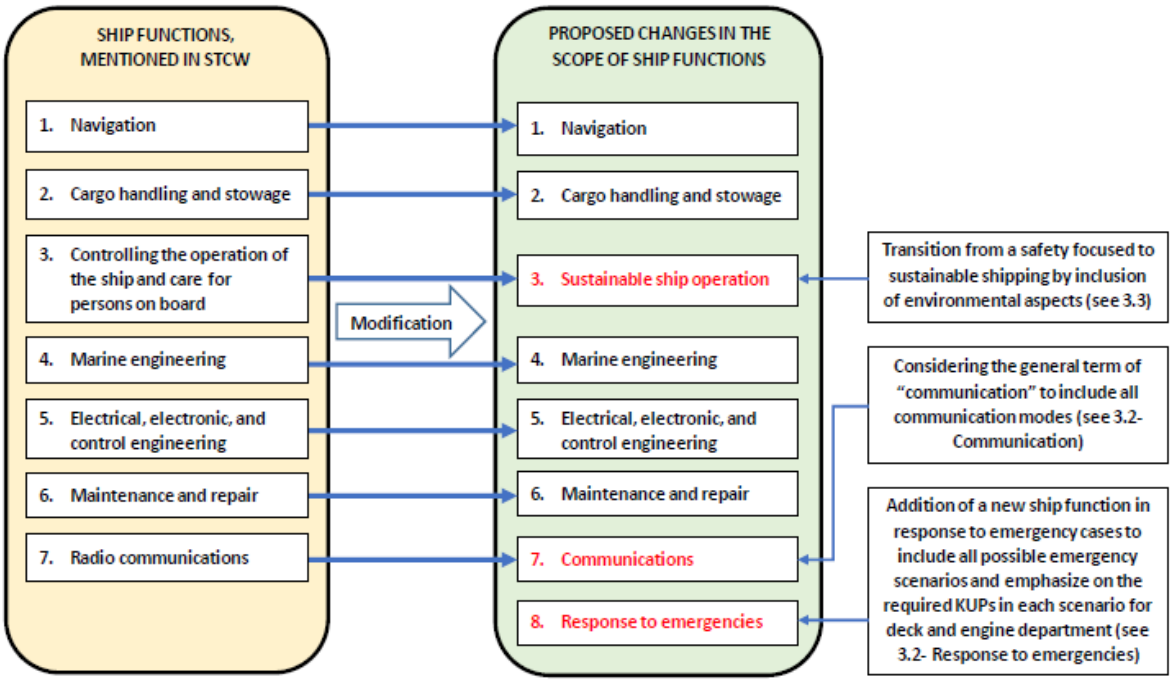

Figure 2: Proposed changes in ship's functions and their scopes (Authors' own idea)

Finally, the recommendation is to provide funding for reskilling and upskilling of seafarers. It is recommended that a portion of the future GHG fund be dedicated to training and upskilling the maritime workforce. A number of venues, such as METIs and maritime technology cooperation centers (MTCCs), could be used to invest in the modernization or renovation of training infrastructure, to train trainers, and to provide subsidized courses for seafarers. Furthermore, this funding can enable METIs and MTCCs to offer refresher courses and specialized training in collaboration with technology providers. There are also options for supporting shipowners financially to provide training onshore and through computer-based training (CBT) onboard.

6 CONCLUSION

An extensive effort is underway to revise the STCW convention within the next two years. This study aims to contribute to the discussion by proposing options to facilitate rapid inclusion of new knowledge in METIs. Reviewing companies' documentation has highlighted the gap between STCW requirement and companies practices particularly in link with the environmental and energy management. The findings of this study indicate

[6] Standards regarding emergency, occupational safety, security, medical care and survival functions.

that STCW should faster adapt to technology transformation because certain skills and competencies are becoming urgently needed. Finally, this study recommends an innovative application of model courses, as well as some minor changes to the ship functions to facilitate the inclusion of emerging technology and trends.

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