SAFETY AT SEA AND MARITIME ENVIRONMENT PROTECTION WITH SPECIAL REFERENCES TO TRAINING NEEDS FOR THE EMERGING NEW FUELS

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Keywords

Safety at Sea, Marine Environment Protection, New Fuels, Training, Human Factors

Abstract

The ISM Code and the STCW Convention are considered to be the two most important IMO instruments that contribute to "safe, secure and efficient shipping". From the safety and marine environmental protection point of view they should be considered the two sides of the same coin.

The ISM is not just about compliance to obtain certification, it is about both 'fitness for purpose' and 'compliance' with rules and regulations.

The ISM is a procedural system that outlines how to manage operations, rather than dictating what to manage. It does this through a system of policies, procedures, processes and plans. Its provisions cover areas such as quality assurance including risk assessment and control through verification and certification.

Several emerging topics such as new fuels and decarbonization require a comprehensive review of the STCW as well as the ISM.

This paper primarily focuses on human elements and the impact of new fuels, ship emissions and means to achieve the IMO and the EU net zero targets. Specific references are made to key safety issues for inclusion in an e-learning course on ISM Code implementation, as it is, with a view to help companies, particularly smaller ones to develop high quality safety procedures.

1 INTRODUCTION

This paper is the first among several articles aimed to help implement ISM Code more effectively as a part of the EU funded project, OPTIMISM. The paper presented here focuses on seafarer training and skills needed to support a decarbonized shipping industry concentrating on emerging new marine fuels. The foremost consideration is to get things right-first-time. Such an objective presents several challenges, such as: the slow pace of regulatory development and lack of clarity surrounding the viability and uptake of alternative fuel options and decarbonisation trajectories, which makes investment in seafarer training challenging; a need to increase investment in training centres and up-to-date equipment; a lack of competent trainers; and a shortage of experienced seafarers. For this reason, it is crucial to understand the nature of the emerging fuels and risks involved.

In a DNV report (2022) entitled Insights into Seafarer Training and Skills Needed to Support a Decarbonized Shipping Industry, it was reported that the expected potential decarbonisation scenarios point towards an immediate need to train seafarers. However, the timing and type of training provided will depend on the ambition of decarbonisation trajectories and the future fuel mix. It was further noted that the 'IMO 2018 scenario' modelled by DNV, the number of seafarers working on ships with alternative fuels and technologies would peak at 310,000 in 2050. In the 'Decarbonisation by 2050 scenario' modelled by DNV, 750,000 seafarers would require additional training to handle alternative fuels and technologies by 2050. The report contains a number of safety challenges related to alternative fuels in shipping. These include pressurized storage, low flashpoint and toxicity. Hydrogen, for example, is substantially more flammable than diesel. Ammonia, a method of chemically storing hydrogen for propulsion, is toxic to humans and the marine environment. With the exception of hydrogen, which was until recently only transported in packaged form, most of the alternative fuels are currently carried as bulk marine cargo. The shipping industry is therefore both knowledgeable and experienced with regard to their handling. However, seafarers will need additional training concerning the particular risks associated with using these fuels for propulsion in order to ensure not only their safety, but the safety of the environment and local communities.

In 2022, IMO published a Ricardo report, entitled: Report for the Study on Sustainability Criteria and Life Cycle GHG Emission Assessment Methods and Standards for Alternative Marine Fuels[1].

The review of these two reports and the information contained in the project proposal clearly outlines the knowledge, skills and competences required for seafarers' training on current and future fuels. Based on the

[1] Report for The Study on Sustainability Criteria and Life Cycle Ghg Emission Assessment Methods and Standards for Alternative Marine Fuels, Final Report, Report for: IMO Low Carbon GIA, Ricardo ref. ED14897 Issue: 1A 06/12/21

objectives outlined in the project proposal the following work packages and tasks have been prepared.

C4FF has an unrivalled experience and knowledge of ECVET and ECTS compliant maritime courses with novel assessment methods. The innovative aspects include a method for Accreditation and assessment of Prior Learning (APL) and assessing the assessed work to ensure consistency and fairness in grading[2]. All its courses have been funded by the EU and accredited by major accrediting, awarding bodies. Examples of these are given in a collaborative project with major coastguard agencies, professional bodies, maritime colleges and universities and industry bodies across the EU, see for instance C4FF internationally recognised ship cadet officer programmes[3]. However, for the proposed course to be effective it is first important to ensure the nature of fuels are understood and that aspects concerning energy efficiency and pollution reduction are included.

EFFICIENCY IMPROVEMENTS

Considering the life cycle of sea going vessels, often over 30 years, it is of paramount importance to focus on areas where existing ships can become energy efficient. In an IMechE COP26 report, Ziarati (2020)[4] stated that to reduce CO2 emissions, the shipping industry should implement some of the potential areas for energy efficiency that would lead to a substantial reduction both in energy use and in ship emissions as shown in Figure 1. This efficiency improvements could lead to some 60% overall reduction of fuel requirements and in ship emissions for a given ship (Wang & Lutsey, 2013)[5]. Other ways of achieving reduction both in energy use and in ship emissions are to use new alternative fuels such as Ammonia for reduction of CO_2 emissions and/or encourage the use of Flettner rotors and sails to assist in propelling the ships.

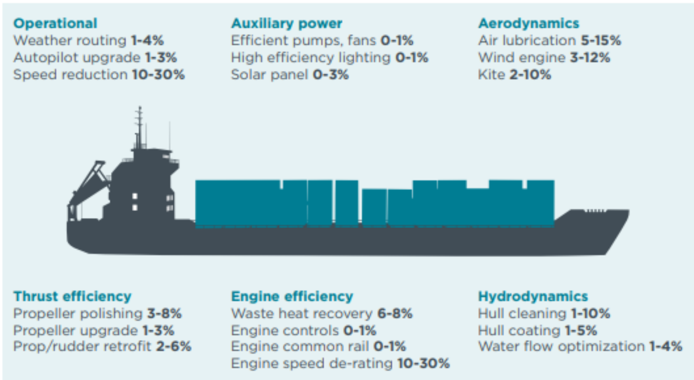

Fig. 1 Potential Fuel use and CO2 reduction from various efficiency approaches for shipping vessels Source: Wang and Lutsey, 2013

C4FF[6] in their studies have shown that provided the governments invest in local supply chains and provide funds for shipping companies to take advantage of energy savings as well as encouraging port electrifications through renewable energy; these could substantially reduce the level of CO_2 emissions by 25% by 2030. They claim such approach could counter the expected increase of possibly by 30%.

[2] Ziarati, R. (2018), Assessment development for apprenticeship and internship in-company WBL mentors Empowering EU In-Companies' Mentors, C4FF Report, Erasmus + KA2 Cooperation for Innovation & the Exchange of Good Practices 2018-1-EL0 - https://www.marifuture.org/Publications/Articles/IO4_Report_Mentor_Project.pdf
[3] https://www.marifuture.org/Publications/Articles/A_lifetime_opportunity_for_graduates_of_maritime.pdf and https://www.marifuture.org/Publications/Articles/A_lifetime_opportunity_for_graduates_of_maritime_II.pdf)
[4] The Transport Hierarchy: A Cross-Modal Strategy to Deliver a Sustainable Transport System https://www.marifuture.org/Publications/Papers/imeche-transport-hierarchy-report.pdf
[5] Wang, H., & Lutsey, N. (2013). Long term potential for increased shipping efficiency through the adoption of industry leading practices. Washington, DC, USA: ICCT.
[6] www.c4ff.co.uk – see GreenShip Project at https://www.marifuture.org/Projects/Projects.aspx

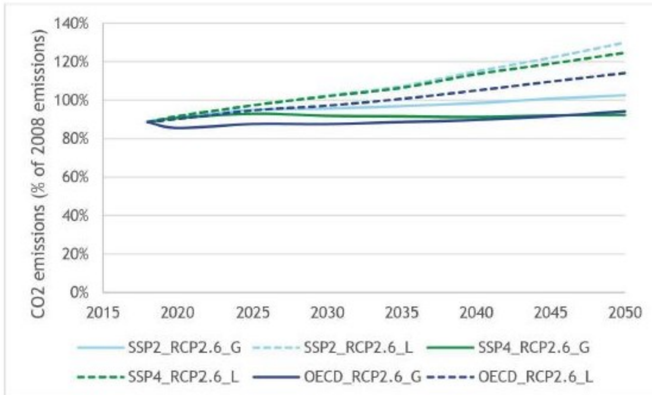

Fig. 2 Projections of maritime ship emissions as a percentage of 2008 emissions (Source: IMO 2020)[1].

To overcome the level of CO_2 emissions, shipping industry has started to implement some of the potential areas for energy efficiency by applying some of the following mitigation technologies.

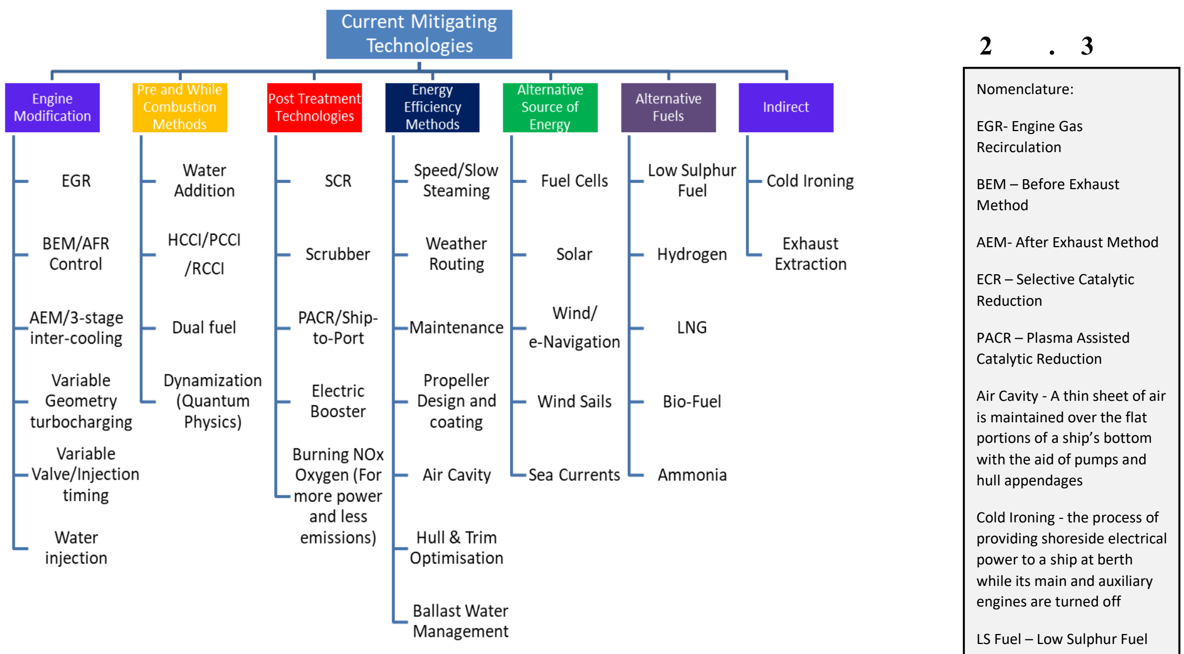

Fig. 3 Current Mitigation Technologies in Marine Industry

3 SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)

The IMO has also introduced regulations such as the Energy Efficiency Design Index (EEDI), Ship Energy Efficiency Management Plan (SSEMP) and Energy Efficiency Operational Index (EEOI) on January 1st, 2013. SEEMP assists the shipping companies in providing an approach for managing ship and fleet efficiency performance over time with the help of the EEOI, EEXI and CII as a monitoring tool. SEEMP is reported to provide cost savings of about 5 to 15% and help to bring down GHG emissions. (Ziarati, 2017)[7].

In terms of fuels, many ships have started using LNG, especially those operate terminal to terminal. But

[7] Ziarati, R. (2017). Towards Zero Ship Emissions – Project MariEMS, Proceedings of The International Association of Maritime Universities (IAMU), Varna 2017.

since this leads to an unacceptable level of methane leakage and slip with the possibility of leaked LNG combusting, for safety reason and methane use of such fuels should be kept to minimum.

4 AMMONIA, BIOFUEL, HYDROGEN AND FUEL-CELL POWERED SHIPS

Although poisonous, Ammonia (NH3) is a practical way of storing large volumes of hydrogen. Ammonia is liquid below -33 Degree Celsius or at room temperature at a pressure of 10 bars. Volumetric energy density of liquid ammonia is a third that of diesel and can be burnt directly in diesel engines with a suitable catalyst that provides long term pathway to fuel cells, (Zero Emissing HGV Infrastructure Requirements, 2020)[8].

IMO[8] has set a new decarbonisation milestone and new ammonia-powered vessels planned. Scheduled to be enforced by 2023, New Regulation 28 mandates: "a linear reduction in the in-service carbon intensity of ships between 2023 and 2030", such that the global fleet achieves an average reduction of at least 40% by 2030 when compared with 2008. Biofuels

C4FF's use of biofuels in line with what has been stated in the DNV[9] and Ricardo's reports[7,10]. The use of biofuels on ships may also require improved and more frequent crew training requirements.

The research so far carried out shows that another promising option available is the use of methanol (methyl/ethyl alcohols) as a fuel. It reports that the numbers of new shipbuilding orders for ships technically equipped to use methanol as fuel is 20 times those for ships with conventional technology in terms of gross tonnage (with 142 ships ordered in 2023).

Hydrogen has already been used as part of marine fuel mix using diesel fuel and ammonia. The key weakness of hydrogen is its very low energy density. It should be noted that hydrogen is extremely flammable with a large ignition rate, has a high-speed flame and invisible combustion,

The EMSA[11] Study proposes three specific fuel cell technologies are the most promising for marine use: Solid Oxide Fuel Cell (SOCF), the Proton Exchange Membrane Fuel Cell (PEMFC) and the High Temperature Proton Exchange Membrane Fuel Cell (HT-PEMFC). Several Classification Societies have already issued 'rule notes' applicable to fuel cell installation in ships, while the IMO MSC issued already in 2022, its MSC.1/Circ.1647, interim guidelines for the safety of ships using fuel cell power installations. Yet relevant minimum competence standards and training requirements are not yet specified.

5 FORMULATING TASKS FOR THE DEVELOPING THE TRAINING COURSE – FOCUSING ON ALTERNATIVE FUELS

The IMO's revised strategy on reducing greenhouse gas (GHG) emissions from ships has set a goal of net zero emissions from ships by or around, i.e. close to 2050, with partial goals of GHG emission reduction by at least 20% - striving for 30% - in 2030 and at least 70% - striving for 80% - in 2040, in comparison to 2008 levels, so far, this has not been achieved. In a IMechE COP28 paper, Ziarati (2020)19 asserts that IMO itself has predicted a rise of CO2e of between 3% and 30% by 2050. Therefore what is needed is a through preparation of companies and their crews to learn the means to ensure IMO strategy is achieved as is intended.

As the IMarEST Lecture outlines, at the EU level, shipping has been included as from 2024 in the EU Emission Trading Scheme (EU ETS), which is the emission trade and allowance system associated with the EU's 2030 target for a 55% emissions reduction, relative to 1990, and climate-neutrality by 2050.

Among the choice of technologies and fuel solutions for ships, Ziarati[12] offers a range of potential alternative fuels and technology solutions. Some of these fuels include low carbon, carbon neutral and zero carbon fuel similar to those identified in the recent IMarEST OPTIMISM Lecture. These are expected to contribute reducing emissions from shipping to the levels which are to help EU achieve its ambitious emission reduction targets. The maritime sector has already started experimenting with several alternative fuels as a substitute for conventional fossil fuels or in combination with them.

[8] Zero Emission HGV Infrastructure Requirements. Ricardo Energy & Environment reference (2020).
[9] Insights into Seafarers and Training and Skill Needed to Support a Decarbonised Shipping Industry, DNV Report no.: 2022-0814, rev. 0, 2022
[10] Ricardo Energy & Environment. (2020). Zero Emission HGV Infrastructure Requirements.
[11] Study on the Use of Fuel Cells in Shipping" commissioned by EMSA back in 2017.

The C4FF as well as DNV and Ricardo reports clearly suggest that this is demanding a technology transition, which also requires a change in ship operations. Hence the need to develop new and innovative training programmes for the existing and future seafarers to begin to learn how to handle new fuels competently and safely, and adapt associated technologies appropriately for expected operations.

As regards to the scale of the training needed to support a decarbonised shipping, the partners recent literature search found references to a report[13] commissioned by the Maritime Just Transition initiative14, implying that in a 'zero carbon by 2050' scenario, 450,000 seafarers would require some kind of additional training by 2030, and 800,000 seafarers would require some kind of additional training by the mid-2030s. This scenario assumes an immediate ramp-up of alternative fuels in the 2030s.

Currently, LNG, not as a cargo but fuel, is the main choice from the technological options available to shipowners for several types of ships such as car carriers and container ships; and is also becoming significant for tankers and bulk carriers.

Also, some efforts have been made to set the framework for establishing, in the STCW Convention and Code, the training requirements and minimum standards of competence for seafarers on ships subject to the IGF Code. Although, as also noted from research carried out so far and confirmed by Campion15, the LNG (the liquid form of natural gas) which is composed mostly of methane, is a hydrocarbon-based source of energy, it may still offer reduced GHG emissions when compared to diesel as a marine fuel in terms of CO2.

Although this proposal is primarily in support Chapter III of the STCW, it is also prepared in support of Chapters II, V and VII. C4FF and partners are of the view that tables A-V/3-1 and A-V/3-2 of the STCW Code for basic and advanced training for seafarers on ships, subject to the IGF Code, should include other alternative fuels as outlined in this proposal. Furthermore, the intention so far is also to revise the respective IMO Model Courses 7.13 and 7.14 as part of the response to the project proposal.

The proposal also identifies the knowledge, skills and competences in a long course (60Hours) needed both for senior ship, junior/cadet officers and also ratings. Further, this will be broken down to two sections; a course for ship engineering officers and a course for deck officers at three levels, senior and junior/cadet officers and ratings. The courses are designed for competences needed to handle and burn new and alternative fuels and use of systems and processes in this connection. A continuous professional development (CPD) short course (3-days with an optional assignment) will also be prepared for all types of ship crews and shipping company personnel making references to IMO and EU latest requirements and the trends in fuels and associated systems being developed as possible ship bunkers. The CPD course will be an e-learning short course, similar to C4FF's EU awarded 'Best in Europe[16]' and will form a supporting material for the long course. It will have a self-assessment section with the option of carrying out an assignment if an IMarEST CPD Certificate is required.

The lead proposer has been a developer of several ship officer and ratings courses for a major awarding body (BTEC/EDEXCEL/Pearson) and their chief assessor/verifier for many years. He has also served as the UK National Vocational Qualification (NVQ) Verifier, a UK Government Quality Teaching Assessor as well as an accreditor for a major engineering professional body (IEE now IET). The consortium members have all have been involved in ship cadet and officer course developments and were involved in EU funded MariEMS[17] and GreenShip[18] projects.

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[13] Insights into Seafarer Training and Skills Needed to Support a Decarbonized Shipping Industry, DNV report 2022-0814, November 2022.
[14] The Maritime Just Transition Task Force is 'Maritime Just Transition Task Force' is an initiative, set up during COP 26 in Glasgow, by the International Chamber of Shipping (ICS), the International Transport Workers' Federation (ITF), the United Nations Global Compact (UNGC), the International Labour Organisation (ILO) and the International Maritime Organisation (IMO).

[16] See project ACTs, ACTS Plus, IMPACT - https://www.marifuture.org/Projects/Projects.aspx
[17] Ziarati et al. (2017), Maritime Energy Management System (MariEMS) Online Delivery Platform, International Association of Maritime Universities Conference, Varna, Bulgaria, September 2017 -https://www.marifuture.org/Publications/Papers/IMLA_2018_MariEMS_Paper_2.pdf
[18] German de Melo et al. (2018), Towards Zero Ship Emissions II – Project GreenShip. IAMU 2018 - https://www.marifuture.org/Publications/Papers/Towards_Zero_Ship_Emissions_II-%20GreenShip-IAMU_2021.pdf

It is important to ensure some of the issues with education of seafarers as demonstrated Figure 4[19] are addressed.

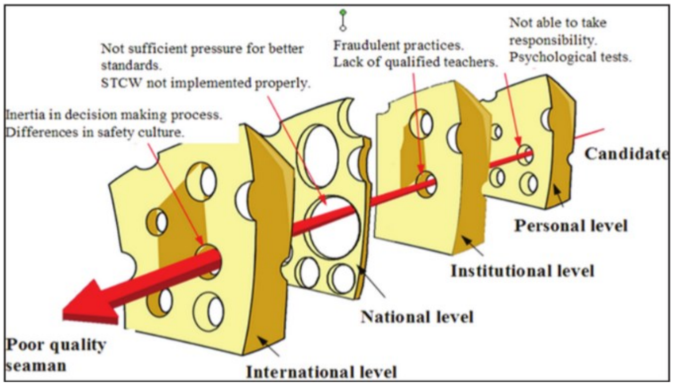

Fig. 4 Breached Barriers that Has Led to Poor Quality Seafarer

To do this innovate means of ensuring the training course is competence-based is required. Figure 5 shows one of the option of achieving this and ensuring the course is ECVET compliant.

Proposed Table of Competencies for OPTIMISAM Training programme – Option 1

Learning Outcomes	Indicative content: Learning Material	Assessment criteria
Ability to • describe all the ISM Code requirements (measures and regulations) specifically internal and external audits as well as certification process. • assess compliance with international legislations and requirements as well as the company's own policies, procedures and plans. • monitor and fitness for purpose of safety policies, procedures and plans. • assess compliance with audit and inspection, approval and accreditations	Chapter 1 - describes IMO and EU efforts and rule/regulations and targets and good examples of how ISM Code is implemented and how requirements monitored and actions carried out.	To be able to: a. demonstrate understanding of IMO ISM Code in regards to safety and marine environment protections specifically rules and regulations, shipboard operations, maintenance and emergency situations. b. assess the top management commitment c. describe how risks are assessed

Fig. 5 One of the options for ensuring the OPTIMISM Course is competence-based and ECVET compliant

6 CONCLUSIONS

The application of new fuels and mixes in transportation systems is in its infancy. The technology is progressing and new fuels are emerging as a matter of course. To this end, a novel and thoughtful lifelong methodology is needed which can be further developed on a continuous basis.

In developing the methodology for each aspect of OPTIMISM course viz., design, syllabus/curriculum, learning, teaching, assessment and delivery mode, method and strategy, an attempt will be made to benchmark against the best practice in each case and apply rapid prototyping methods. C4FF has applied this methodology for its training courses in several EU funded projects[20].

[19] Ziarati, R. (2016), What Is Wrong? A Review of National, European and International Efforts in Improving the Standard and Quality of Maritime Education and Training ,IMLA21 Conference, St. John's, Newfoundland and Labrador, Canada, 2013
[20] Ziarati et al. (2010), Harmonising Maritime Education and Training at Sea and Ashore, European Conference on Educational Research, Education and Transition, ECER Budapest, 2015 -

In summary, the methodologies used in designing the course (short and long), compiling the syllabus, developing the assessment systems and delivery arrangements are based on good practice and are developed through rapid prototyping techniques. This is to ensure, effectiveness (doing the right thing), relevance (industry related), efficiency (doing things right) and innovation (through sustainability) are achieved.

According to the European Commission "Vocational Education and Training (VET) is a key element of lifelong learning systems equipping people with knowledge, know-how, skills and/or competences required in particular occupations or more broadly on the labour market" (European Commission, 2020). It is obvious that VET is a win-win situation for the European economy and market-oriented enterprises but, also, for the European society as a whole, given that it improves the quality of the European labour force at a non-stop pace. The latter gives a significant boost to the evolution and competitiveness of enterprises across and beyond Europe. While high level research and development will no doubt be carried out on a continuous bases for new fuels and fuel mixes as well as propulsion systems, the intended course will have sections for different type of ship officers focussing on Engineering Officers and Ratings with some emphasis on roles of Deck Officers and Ratings with regard to handling of new fuels and the propulsion control systems. The course is designed as both a short course and long course, the latter for the ship engineering cadet officers as replacement and/or in addition to their existing STCW compliant programme of study and training.

The result from previous desk research findings following an iterative process and dialectic modality led to an understanding that a learning-centred backward design model for the intended course is justified and should consist of several steps. The step proposed are: the framing the contextual, situational factors with their implications on the course, the formulation of the learning outcomes primarily based on the Dee Fink's (2013) taxonomy for backward design, as derived from the performance criteria, the framework of the assessment, teaching and learning activities. Their full consideration is necessary for each specific target group (senior Engineering, junior/cadet Engineering officers, Deck officers and so forth) with regard to the course syllabus, assessment and certification, and their full alignment and integration for consistency. The Course design serves as the foundation for the course content/syllabus, assessment, the intended course accreditation/certification scheme. The course assessment process and the course content development require work in parallel while re-visiting the entire course once put together.

The proposed methodology takes account of the tasks outlined in the C4FF IMarEST OPTIMSM Lecture which also focused on the crews' new responsibilities regarding new fuels. The decision on methodology was based on understanding, describing, evaluating and transferring what can be considered as "Best Practice" in terms of type, governance, content, methodology, design, and other aspects relating to learning and marine training essential practices in European countries and worldwide. Therefore, it can be replicated contextually, with a view to its transferability to the course to be designed for the emerging new fuels and propulsion systems. The definition of the revised ship officer and rating job profiles with its relevant competence matrix of performance criteria, as demonstrated in Figure 5.

A new set of tasks are being formulated to develop an analytical framework which would define a best practice.

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https://www.marifuture.org/Publications/Papers/Harmonising_Maritime_Education_and_Training_at_Sea_and_Ashore.pdf
Ziarati et al. (2015), Good Practices in ECVET – C4FF Approach MariePRO Project, MariFuture, 2015 - https://www.marifuture.org/Reports/Development-Papers/ADP_02_2016_MARIFUTURE.pdf
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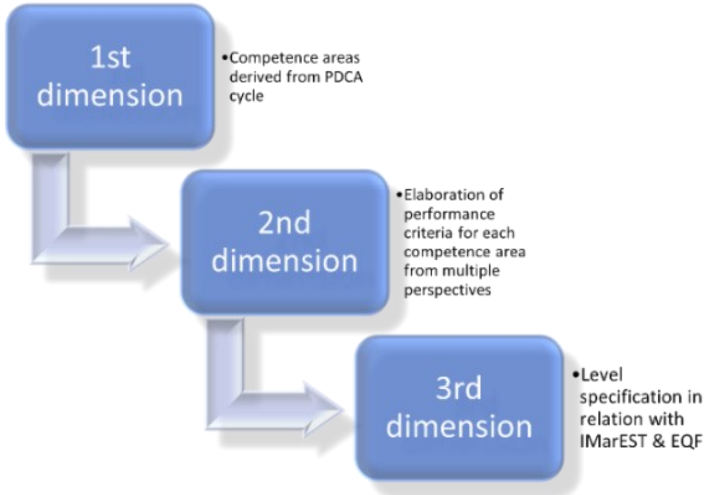

Fig. 3 The Competence Matrix development process

With the point of departure, the slippery texture of the conceptualisation of the term "best practice" due to its multiple interpretations within different contexts (Tuokuu, Idemudia, Gruber, & Kayira, 2019, p. 923), a clear understanding of what qualifies as a practice is important to pave the way for the identification of a best practice.

In this manner, the process initiated with the development of a template to be used as a desk research tool consisting of the essential course specifications which were necessary to be collected after being identified and mutually agreed with the project partners. The partners will be then invited to complete the developed template with information from courses which either already exist or found in the literature or the internet from 2010 onwards. The partners will identify and mutually agreed that, after the data collection period, they would focus their evaluation on the following course's elements (Figure 6):

Fig. 4 Data collection course elements for course development

The focus of this paper is on the nature of the new emerging marine fuels and hence the content of the course with some indication of the methodology being adapted for the course design and development. A second paper is being prepared on the training programme details which is expected to be similar to several award winning C4FF supported training platforms such as www.green-ship.eu/, www.mentor4wbl.eu or https://advanced.ecolregs.com. A new paper is also being commissioned to address other aspects of safety primarily from actions taken by shipping companies after accidents as well as after external audits and port inspections.

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