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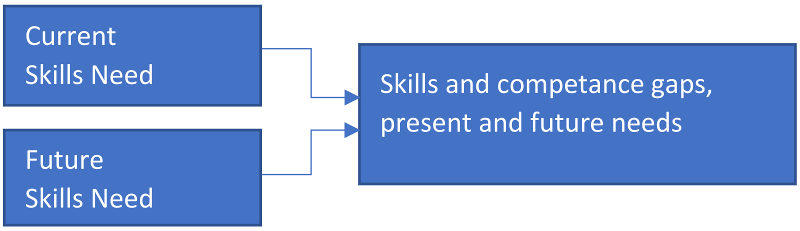
https://www.skillsea.eu/index.php

Document information

Short description	In this report we have reviewed **outlook** reports from key shipping businesses and captured insights (**interview**) from visionaries within the industry to establish a solid impression of the future needs of maritime shipping. Through this work, the resulting report places **maritime professionals** firmly in the 21st century.
Work Package	WP 1. Skills Need Identification
Work flow	In line with the methodology guides (see D 1.1.1), we have interviewed the experts and exchanged insights with visionaries within the industry. The intention is to capture the very uncertain mid-term and long-term future (see below, time horizon) with experts and visionaries to forecaste the future skills needs and possible development.



The time horizon was defined in Methodology document (D 1.1.1). We assume that the gaps in skills needs can parallelly and dynamically change with the development og global trends and technologies.

	Time horizons		
	Short 2020 - 2025	Mid-term 2025 - 2030	Long term 2030 - 2050
Current Skills Need			
Future Skills Need			

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Executive Summary

In this report we have reviewed outlook in the literature and reports from key shipping businesses and captured insights from visionaries within the industry to establish a solid impression of the future needs of maritime shipping. Through this work, the resulting report places maritime professionals[1] firmly in the 21st century. The results forecast future skills and competence needs originating from the four key trends that are shaping the future: sustainable development, collaboration of clusters, digitalisation, and education.

Ships will be smarter, data driven, connected and greener with a variety of power systems. The future maritime activity will integrate people and digital technology in a way that transform how we operate and interact. New operation paradigm needs to be created. The maritime experts also highlight the importance of transversal skills, sea-land mobility, and innovation.

In line with these trends and endorsed through our interviews, one of the rational solutions for improving current maritime professional education and training is high-tech based learning, such as virtual reality (VR), augmented reality (AR), and simulation-based learning with lifelong learning attribution.

As a summary, we address five must mastered skill areas as illustrated in figure 1.

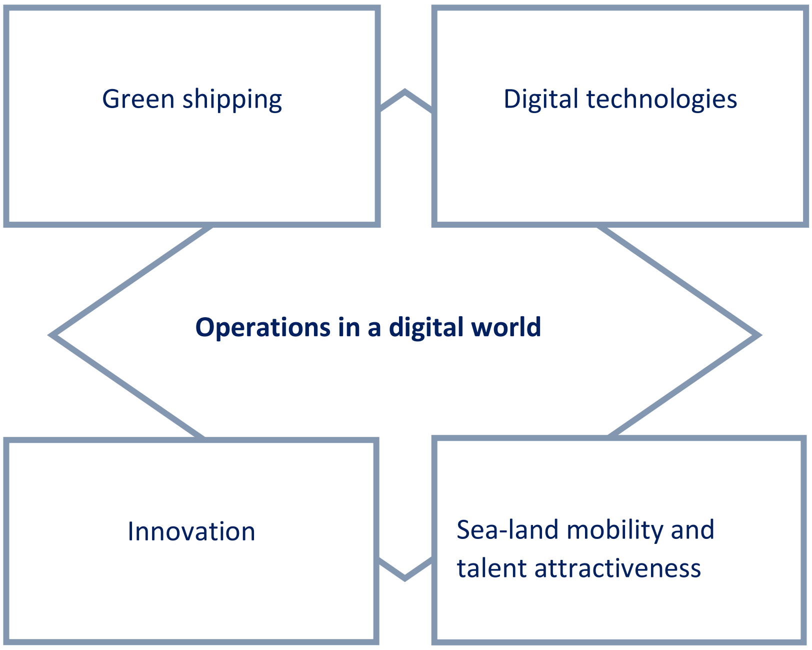

Figure 1: Five must mastered skill areas

In addition, the research points to the benefit for shore-based maritime personnel to develop a better understanding of the challenges and issues that seagoing professionals face. This will both facilitate innovation and enable better sea-land collaborations. It is further found that there is a need for more transversal skills between occupational profiles. When it comes to mobility in maritime education, this needs to become a reality. This study does not point in any direction as to where the solution lies for mobility; most likely it will be a combination of making existing solutions and new initiatives to drive mobility.

Covid 19 totally disrupt the classical learning methods and the privilege of close physical interaction. MET, colleges and universities responded very quickly, and training program turned into partly digitally

1 We mix use the terms - maritime professional and seafarer with the purpose of clarifying the scoped occupational profiles in this report, including both sea and land. Unless otherwise noted, maritime professionals refer to both seagoing and shore-based jobs.

and partly physical sessions. We have seen a tremendes development in tools allowing cooperation's as MS Teams and Zoome as well as introduction of many new learning management platforms.

On-line education has seen a massive development within the last year. In many ways, the 21 century begins in 2021, the true digital transformation. On-line education is growing, and it will not disappear.

Figures

Tables

Glossary

This glossary does not intend to provide official definitions but explanations terms based on recognised information sources.

Term	Definition
GDP	Gross Domestic Product
IoT	Internet of Things
IoIT	Internet of Industrial Things
AI	Artificial Intelligence
VR	Virtual Reality
AR	Augmented Reality
ITF	International Transport Forum
MEPC	Marine Environment Protection Committee
EEDI	Energy Efficiency Design Index
LNG	Liquid Natural Gas
LPG	Liquefied Petroleum Gas
IMO	Intenational Maritime Organisations
EU MRV	EU Monitoring Reporting and Verification
IMO DCS	IMO Data Collection System
HFO	Heavy Fuel Oil
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
ISCO	International Standard Classification of Occupations
GPS	Global Position System
NMA	National Maritime Administration

CoCs	Certificate of Competence
MET	Maritime Education Training
LLL	Lifelong Learning
Maritime domain	Includes maritime industry, shipping industry and ports and logistics
Maritime industry	Ship and equipment building
Digital twin	Collection of digital data representing a physical object
Blockchain	A list of records are linked using cryptography
Autonomous ship	Unmanned surface vehicle
Transversal skills	Sea-land skillsets
Cross-functional	Multi-skillsets in value chain
Transition education	Sea-land bridge education
Soft skills	Leadership, management and so on
UNCTAD	United Nations Conference on Trade and Development

Content

1 Introduction

Technology and digitalisation are transforming the shipping industry. 'Smart' ships are coming into service, creating demand for a new generation of competent, highly skilled maritime professionals. Europe is a traditional global source of maritime expertise and the four-year **SKILLSEA** project is launched with the aim of ensuring that the region's maritime professionals possess key digital, green and soft management skills for the rapidly changing maritime labour market. It seeks to not only produce a sustainable skills strategy for European maritime professionals, but also to increase the number of these professionals - enhancing the safety and efficiency of this vital sector.

The future-proofing project is developed by the industry's social partners, the European Community Shipowners' Associations (ECSA) and the European Transport Workers' Federation (ETF) and is comprised of a consortium from national maritime authorities, shipping companies, shipowners' associations, maritime trade unions and maritime education providers from 16 countries in Europe.

Key aims and objectives include:

Analysing the effect of technological developments on the industry's skills requirements

An even better match between the industry's skills needs and the education and training of maritime professionals

Overcoming barriers to the mobility of maritime professionals

Improving cooperation and synergy between education providers, maritime authorities and the industry

Ensuring that Europe retains a world-leading access to maritime skills and experience for improved competitiveness. Shipping is a global business and is affected by global development and politics. World trade is expanding, and transportation companies operate across the entire world. Global GDP has doubled since 1995 and trade has grown by a factor of four.

The impact of global trends and disruptive technologies can be studied and give important insight into possible future developments that will require a shift in priorities and open new opportunities. This document seeks to establish an understanding of how these broader changes affect the shipping industry and, thereby, determine the need for corresponding changes in education and training.

Europe has been a global leader in maritime business for centuries but is facing challenges – digitalisation, globalisation, and sustainability. Innovation is a crucial factor in enabling European maritime industries to handle these challenges. Research, competence development and collaboration are important to support and stimulate such innovation. New business and research areas are undergoing strong growth and development.

Research and development in autonomous ship functions, remote supervision and control are drivers for changes in the way that ships can be operated. Moreover, decarbonisation, environmentally friendly and safe shipping are also on the current research agenda.

Marine technology and ocean-related knowledge and expertise represent critical factors in these areas. What knowledge about the ocean operations will be sought in years to come is not known, but it is likely that a leap in technology and understanding will take place as opportunities for exploration and harvesting of the ocean space increase. With a high level of education and training, competence and research, Europe has a good prospect to not only retain but also to enhance an internationally leading position within such development.

Technology advances, demand for green solution and demographic changes may disrupt the labour markets. Some jobs changes or disappear and others demand re-training where new and updated skills are needed.

Future cannot be known with absolute certainty. One general principle upon is to use multiple reasoning methods to explore different views of the future. We have combined literature review, technology forecasting, trend studies, semi-structured interviews, and focus groups to gain better insight, see also figure 2.

In chapter 2 we will investigate what key global trends shapes the future. The investigation is based on a literature review.

The next chapters present technology forecast and how trends may change the future of the maritime landscape. The goal is to explore the trends and understand how they will change the industry and the need for new skills. Chapter 3 deals with the digital transformation. Aspects as connectivity autonomy, automation and remote operations and services will be explored. New skills are needed, but also the distribution of work tasks on-board and in other organisations may be changed.

Chapter 4 deals with sustainability and de-carbonizing. A variety of new technologies and fuels will be introduced in the next years. The technologies will have different risks and new skills are needed. The degree of urgency calls for retrofit solutions and step-by-step improvements.

Chapter 5 deals with development in the labour market. Chapter 6 deals with demographics and innovation. Globalisation has impacted people and countries throughout the world and is a major driving force of change in society. Global trade is growing, and international regulations simulate mobility of services, capital, and labour. Chapter 3, 4, and 6 are followed up by case studies to gain contextual knowledge and substantiate, challenge, and exemplify the findings.

Chapter 7 deals with the voices from maritime experts. Hypotheses and findings from the previous chapters will be tested and verified by interviews and focus groups of maritime experts. The chapter also includes interviews with visionaries in the maritime business to explore other possible developments.

Chapter 8 deals with future learning technology and methods. The last years with covid 19 has forced a huge development in learning technologies and understanding of how such technology can be utilised.

Future working environments and skill needs will be summarised and discussed in chapter 9.

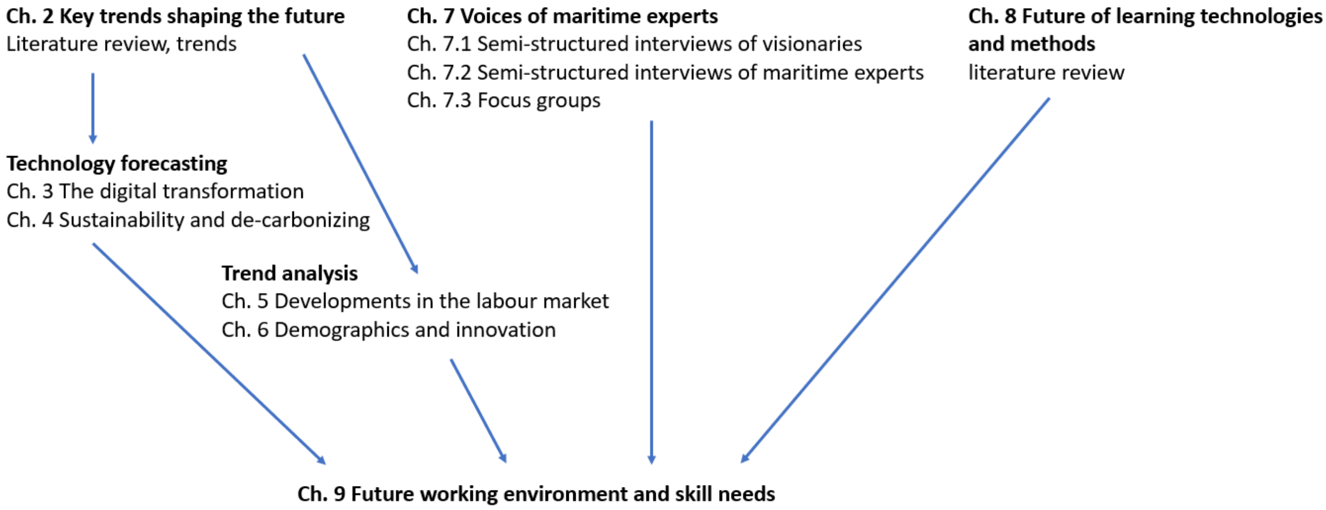

Figure 2: Structure of the report

2 Key trends shaping the future

2.1 Sources

When looking at future trends we will investigate reports concerning the future of the labour market and in particular the **maritime** labour market. Secondly the development of shipping markets in terms of growth and transport volumes are important, as the markets grow more ships, and more seafarers are needed. Lastly the change in shipping technologies will be investigated as the introduction of complex equipment require new training and more automation may reduce crewing on the one side but more use of automation equipment on ships may increase complexity and require new training programs. We will look at both sailing and shore side competence needs, although there are more reports concerning the future needs of sea-going personnel.

There are a number of organisations that release reports predicting the future and these organisations do this mostly to service the members of their organisation. The key institutions which we have sampled are:

Organisation Members/Role

- United Nations United Nations Member States (xxx?)
- International Maritime Organisation IMO Member states (187?)
- European Union EU Member states (27)
- European Transport Workers Federation ETF
- European Shipowners Association ECSA
- International Chamber of Shipping ICS
- DNV Class Society and Maritime Advisors
- Lloyds Register Class Society and Maritime Advisors
- Gartner Group Global commercial provider in IT/Digitalization

2.2 Reports on future developments

2.2.1 The Review of Maritime Transport 2020 by UNCTAD

According to UNCTAD, the world shipping tonnage has continued to grow at a pace of 4.1 % since 2019 into 2020[2], representing the highest growth rate since 2014. Ship size are increasing to achieve economy of scale to the benefit of shippers. Capacity management strategies such as service cuts enabled shippers to benefit from higher but volatile freight rates as the pandemic evolved in 2020. Seafarers mobility severely restricted and highlighted the key role the maritime crew plays for keeping shipping operational. Greenhouse gas emissions from shipping continued to rank high on the international agenda. Actions from IMO was initiated towards ship energy efficiency, alternative fuels and the development of national action plans to address greenhouse gas emissions from international shipping.

The current measures are however insufficient according to UN, and more severe changes are necessary: *"..these marginal improvements will not be sufficient to meaningfully decrease overall carbon-dioxide emissions as specified in the IMO target of reducing total annual greenhouse gas emissions by at least 50 per cent by 2050 compared with levels in 2008. Achieving these targets will require radical engine and fuel technology changes."*

Due to the pandemic the shipping industry has increased its focus on understanding vulnerabilities, risk management and being prepared for emergency response. It is likely that the use of digital tools and also training of seafarers will result from this focus, as well as more focus on early warning systems, scenario planning, forecasting and access to information.

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[2] Review of Maritime Transport 2020 -UNCTAD

Globalisation will adapt to a situation where supply chains may get disrupted and move towards increasing redundancy, multi sourcing and buffering and diversification of supplies.

Quick adaptation of innovative technologies has proven to deliver rewarding results and will continue to be important in the development of businesses.

Standards and interoperability are becoming more important for benchmarking providers and integrating value chains.

Cybersecurity has become a major concern and protecting against ransomware has proven very difficult as large organisation have been targeted. No single solution exists other than having a plan if one is attacked. Again, the technical measures against this threat has proven insufficient and what is left is more emphasis on backup, systems and competent people to deal with the situation when it happens.

According to an article in Ship-Technology.com[3]: «Crew need to be trained on when to give access, when not to, and how to report these emails if they suspect them to be an attempted hack» This article is typical of the attention cybersecurity is getting and is a using a well-known attack as an example with reported losses of $300 million. The risks and areas that are exposed are: Induced navigational errors, disruption of communication channels and lastly disclosure of sensitive information.

Key takeaways:

- Shipping volume is growing and thus the number and size of ships and this will require more qualified seafarers and shoreside employees.
- Radical engine and fuel technology improvements are necessary in order to meet UN/IMO emission targets of reducing total annual greenhouse gas emissions by at least 50 per cent by 2050 compared with levels in 2008. This will require new competence by seafarers and shoreside shipping employees.

2.2.2 MarTid 2020 Training Insights Report by World Maritime University

World Maritime University (WMU) is founded by the IMO and as such represents the view of both UN and IMO since IMO is a UN organisation. The report is based on pre-covid survey data but is released after Covid had impacted shipping. It is investigating Maritime Training Practices and key findings are:

From D 1.1.2 the MarTid database has been described:

Maritime Training Insights Database (MarTID) is a non-commercial initiative collaboratively founded by the World Maritime University, New Wave Media and Marine Learning Systems. The database was initiated in 2018, and since then has provided annual reports. The database provides a global picture of maritime training that is not currently available elsewhere. It provides data on current and emerging training trends and techniques, staffing models, training focus areas, training tools, training resource allocation, and assessment practices. It allows each organisation to benchmark their own practices, and enables governments and other regulatory agencies to be more informed and effective in their oversight and support of the industry. It helps to highlight training issues and training successes, and disseminates that information quickly and broadly through a free and widely circulated annual report. The overarching goal is to make the industry safer and more efficient, benefiting everyone. It is based on questionnaires sent to ship operators, seafarers and MET institutions.

The 2020 focus topic is “Quality in Training” and the report explores how the maritime community views the implementation of quality assurance systems in seafarer education and training. The survey was completed before the onset of the COVID-19 pandemic.

[3] https://www.ship-technology.com/features/cyber-attacks-how-hackers-are-targeting-seafarers/

Both operators and METs consider “reducing accidents” and “improving safety performance” to be two key drivers to maritime training. The “Allianz Safety and Shipping Review 2021” confirm that this focus indeed seem to work with annual losses being reduced by 50% in the last decade.

Spending on training is rising with nearly 60% of operators reporting an increase in training budget.

The cost of seafarer training is continuing to rise, with 35% saying it is self-funded, 33% are co-funded by the company and 32% is company funded.

Training drivers surveyed among vessel operators listed in order of importance:

- Reducing accidents
- Complying with external regulations
- Managing crew competency
- Increasing commercial efficiency and effectiveness
- Career development for seafarers
- Training for autonomous vessel operations

The method of delivering training is changing with the pandemic and more training is being conducted as online with an increase of 16% being reported. There will likely be an even stronger rise until next year when a full year with Covid-19 conditions have passed.

As to the quality of the training being delivered seafarers perceive the training that they receive less than optimal, even as 50% of operators and 80% of METs use external quality assurance bodies.

Key takeaway:

- Operators agree that more training is necessary to improve safety and operation, the cost is currently split between seafarers and operators.
- Quality of training should improve as seafarers are receiving less than optimal training quality.
- Training will become more digital and on-line as a result of travel restriction under Covid but probably will continue as cost will be lowered.

2.2.3 DNV Maritime Forecast – Energy Transition Outlook 2050

According to DNV[4]: The maritime industry will go through a period of rapid energy and technology transition that will have a more significant impact on costs, asset values, and earning capacity than many earlier transitions. Shipowners are already experiencing increasing pressure to reduce the greenhouse gas footprint of maritime transport. This report provides an updated outlook on the regulatory and commercial drivers for decarbonization of shipping:

- Three fundamental key drivers will push decarbonization in shipping in the coming decade: regulations and policies, access to investors and capital, and cargo owner and consumer expectations.
- **The Initial IMO GHG Strategy currently drives policy development within international shipping**, and the first wave of regulations will take effect from 1 January 2023 (i.e., EEXI, CII). We expect them to have a significant impact on design and operations of all ships.
- While all ships need to fulfil the minimum compliance requirements from the IMO, **commercial pressure may push shipowners to aim for a leading position in decarbonization,** as we expect that poorly performing shipping companies will be less attractive on the charter market, and may also struggle to gain access to capital.

There are some significant statements in this report which highlighs two key drivers that impact competence, regulation through IMO which push for decarbonisation at a high speed and customer expectations which will accelerate the technology change.

[4] DNV – Maritime Forecast to 2050

The report goes on to detail the competency areas that will be most relevant for the imminent decarbonisation:

The energy and technology transition in shipping has started, with nearly an eighth (12%) of current newbuilds ordered with alternative fuel systems. This is an increase from the 6% reported in the 2019 edition of DNV's Maritime Forecast to 2050. Except for the electrification underway in the ferry segment, the alternative fuels are currently still mainly fossil-based, and are dominated by LNG.

— There will be demonstration projects for onboard use of hydrogen and ammonia by 2025, paving the way for zero-carbon ships, and these technologies will according to our estimates be ready for commercial use in four to eight years. Methanol technologies are more mature and have already seen first commercial use. Fuel cells are far less mature than internal combustion engines, for all fuels.
— Safety is a prerequisite for the successful and timely introduction of the new fuels such as hydrogen and ammonia. Development of efficient safety regulations and guidelines is fundamental to evolve from largescale demonstration to commercial use.
— A range of new technologies are emerging, including fuel cells, CCS, and wind power.

Key takeaway:

- More competence in renewable energy systems, both technology and operation will be required in the medium term. For the market leaders it is already beginning to become a current need. Keywords: Hydrogen, ammonia, battery, fuel cells, wind power.
- The IMO GHG Strategy significantly impact design and operations of all ships and subsequently require new and updated competence in crew and shoreside employees.
- Commercial pressure pushes all shipowners towards decarbonization, requiring new competence.

2.2.4 Lloyds Register Global Maritime Trends toward 2030

This report explores three scenarios for the future and one of the scenarios do hit the mark quite well in that it explores a world called "Competing Nations with the following characteristics:

- Dogmatic approaches
- Regulatory fragmentation
- National preference, conflicts over values and religion give insiders an advantage
- A brake on globalisation
- Rise in protectionism, encouraging local production and consumption
- Gate communities
- Patronage and national standards exacerbate fragmentation
- Self-interest and zero-sum games

In developing the scenarios the underlying global trends are explored.

- Population growth from 6.9 to 8 billion people, ageing of population of the western Europe towards half the adult population in retirement, declining population in western Europe, increasing in all other regions.
- Urbanisation increasing in all regions, most major cities are also ports, Global trade, intra regional trade doubling, regional trade blocks may emerge
- Globalisation in shipping transport has brought the emergence of hub/nodal port cities. These cities compet with each other under a border-less battlefield of shipping markets. Over half the wealthiest cities are ports today, and such trend will continue in all three scenarios towards 2030.
- Resources. 40% higher energy demand, higher demand for steel and metals
- Environment; Pressure on water supply, coastal erosion, and ocean level rising

Commercial sector

- Oil consumption will rise by 38-63% until 2030
- Coal production and consumption will double from 2010 level. This prediction is not holding up as of 2020 IEA.org is reporting a decline in coal consumption until 2018 (pre Covid) of nearly 10% to 2009 levels.

- The report further predicts that seaborne transportation of raw materials between regions will nearly doble, but the rise of trade blocks within regions will promote intra-regional trade growth.
- GDP grows 3x from 2010 levels and USA, China and India will become the worlds biggest economies.
- Cities will grow and in particular port cities will become stronger: Globalisation in shipping transport has brought the emergence of hub/nodal port cities. These cities compete with each other under a border-less battlefield of shipping markets. Over half the wealthiest cities are ports today, and such trend will continue in all three scenarios in 2030.

Key takeaways:

- Cities will become more important and especially port cities will compete to become leading logistics hubs.
- Raw materials and energy trade will grow and increase demand for ships and thereby increase demand for crew and shore side employees.

2.2.5 Oxford Economics – The Economic Value of Shipping 2020 Update

This report presents updated estimates of the economic contribution of the EU shipping industry, prepared on behalf of the European Community Shipowners' Associations (ECSA).

This 2020 update focuses on two measures of the industry's economic contribution:

- the gross value-added contribution to GDP (referred to as the 'contribution to GDP' on the following pages).
- employment, on a head count basis.

Results are reported for the 'EU shipping industry' in 2018, which is defined as the industry within the 28 EU member states including the United Kingdom, plus Norway.

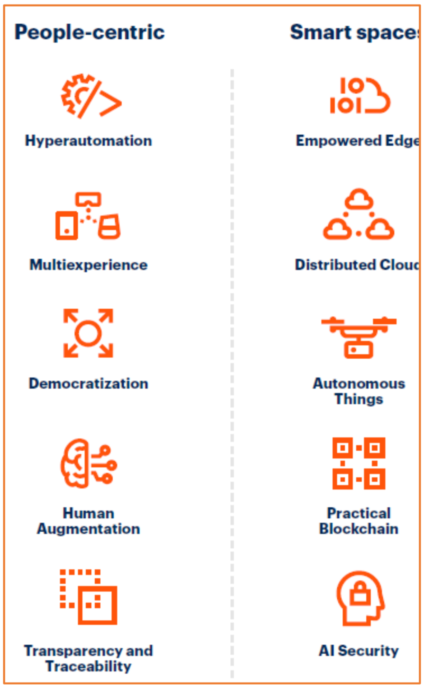
Some key statistics are: EU Fleet has grown 51.7% from 2010 to 2020 by gross tonnage. EU fleet is 39.5% of the world fleet and consist of 23.400 ships. The shipping industry employs 210.000 EU/EAA nationals seafarers, it directly employs 685.000 people and including indirectly employed the figure is 2 million.

The report estimates that direct employment in shipping has gone from 640' in 2015 to 685' in 2018, a 7% increase over 3 years.

Key takeaway:

- Shipping Industry is growing as an employer and as a result more seafarers will need additional competence in the future.

2.2.6 Gartner Top Strategic Technology Trends for 2021



The Gartner Group report does not specifically deal with maritime shipping but look at the overall trends in society. It identifies the top 10 strategic technology trends that will drive disruption and new business opportunities over the next 10 years[5]. The findings of the 2020 report is shown in figure 3. The focus has in several years been about the digital mesh with smart devices delivering insightful digital services everywhere. These technologies have a profound impact on the people and the spaces they inhabit.

We can see a shift in the 2020 report towards people centric focus. Organisations should consider the business and human context first.

The 2021 report is conducted after the effects of Covid-19 has set in and some interesting changes are appearing. It establishes the term *The internet of behaviour* from the collection and use of data to drive behaviours which has emerged.

The People centric trend from 2020 continues in 2021 and is complemented by two other trends, **Location independence**: COVID-19 has shifted where employees, customers, suppliers and organizational ecosystems physically exist. Location independence requires a technology shift to support this new version of business.

The third emerging trend, **Resilient delivery:** Whether a pandemic or a recession, volatility exists in the world. Organizations that are prepared to pivot and adapt will weather all types of disruptions.

The effect of Covid-19 are apparent especially in terms of the trend *location independence* and technology to support it as people have been in lockdown and prevented from physical meetings. Also, the *resilient delivery* trend is obviously a reaction to the pandemic which imposes restrictions on how business can be done and those who are able to deliver despite disadvantageous conditions will obviously gain an edge on the competition.

- We can see a shift in the 2020 report towards people centric focus. Organisations should consider the business and human context first.
- Location **independence** and **resilience** supported by relevant technologies are emerging trends.

2.2.7 DNV-GL Technology Outlook 2030

DNV-GL review trends and associated technologies and their expected impacts on society and industries in their report Technology Outlook 2030[6]. DNV-GL has used a two-step approach. The first step – top-down – look at technology areas and trends likely to be influential. The second step – bottom-up – drew on the insights of the wider group of experts to identify technologies that will have an impact before 2025 and those that we see emerging towards 2030. Findings were validated in a series of workshops.

The technologies are grouped in three categories, see Figure 3. These are also the key takeaways from this report.

- **Enabling.** Technology trends can be thought of as 'enabling' and fostering other technologies: acceleration of digitalization, virtualization and automation across the lifecycle.
- **Transforming.** Technology trends can be thought of as transformative in key industries: transport and logistics and low carbon energy systems.

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[5] Gartner Top 10 Strategic Technology Trends for 2020, https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2020/

[6] Technology Outlook 2030, https://www.dnvgl.com/to2030

- **Sustaining.** The third group of technology trends contains technologies that help to sustain our biosphere: the ocean space and other natural ecosystems.

The key enabling technology is the acceleration of digitalisation. Internet of Things allows low-cost implementation of sensors everywhere that will not only increase our understanding of systems but also our ability to remotely operate. Artificial intelligence and machine learning provide organisations with powerful capabilities to optimise their processes and offer entirely new services. Virtual and augmented reality offer not only visualisation of complex relationships but new methods for remote control and supervision.

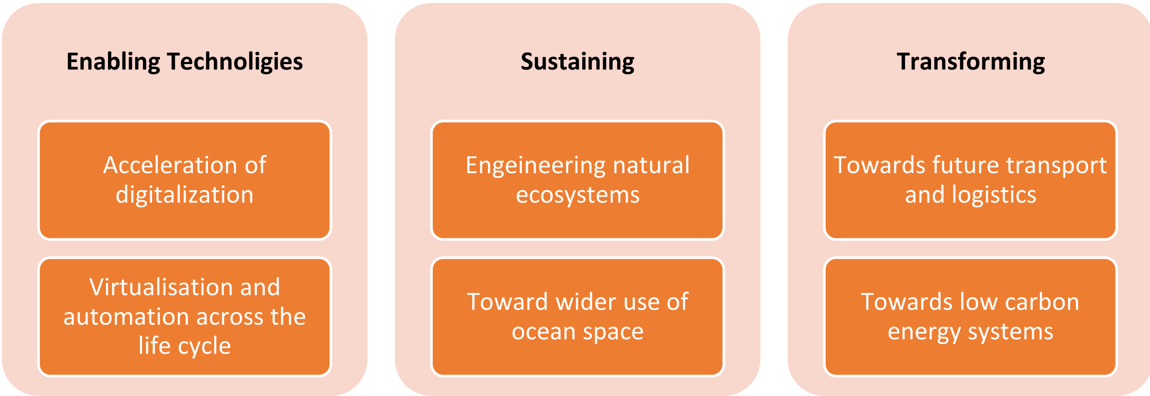

Figure 3: Technologies and trends shaping the future of maritime business

2.2.8 IMO

The IMO STCW convention was analysed in the SkillSea 1.1.2 Current Skills Needs report page 34 with part conclusions 9-14. In order to assess how IMO approaches future skills needs we look at the strategy of IMO[7].

Here we find that IMO has the highest of ambitions:

- *"The mission is to promote safe, secure, environmentally sound, efficient and sustainable shipping through cooperation.*
- *«This will be accomplished by adopting the highest practicable standards of maritime safety and security, efficiency of navigation and prevention and control of pollution from ships...*
- *"IMO will uphold its leadership role as the global regulator of shipping...*
- *..»while addressing the challenges of continuing developments in technology and world trade and the need to meet the 2030 Agenda for Sustainable Development.*

And has ambitions to achieve this through the strategic directions:

- *SD 1 Improve implementation*
- *SD 2 Integrate new and advancing technologies in the regulatory framework*
- *SD 3 Respond to climate change*
- *SD 4 Engage in ocean governance*
- *SD 5 Enhance global facilitation and security of international trade*
- *SD 6 Ensure regulatory effectiveness*
- *SD 7 Ensure organizational effectiveness*

These ambitions are very promising but as can be seen from other sources fall short of expectations such as the International Chamber of Shipping, see next chapter.

[7] https://www.imo.org/en/About/Strategy/Pages/Default.aspx

To understand the cause and effect that is giving rise to these apparent high ambitions but insufficient implementation in reality we look at a case of an IMO STCW proposal submitted by a member and opposed by another member.

The document is handled by the *SUB-COMMITTEE ON HUMAN ELEMENT, TRAINING AND WATCHKEEPING (formerly STCW) Development of training provisions for seafarers related to the BWM convention. Comments on document HTW 7/12. Submitted by Japan*

- *China and ICS have provided proposed amendments to sections A-II/1, A-II/2, A-II/3, A-II/5, A-III/1, A-III/2, A-III/5, A-III/6 and A-III/7 of the STCW Code in annex 1 to document HTW 7/12. The proposed amendments will require seafarers to have "generic training" related to the BWM Convention including maintenance and operation, for certification.*
- *Japan is of the opinion that, considering the diversity of Ballast Water Management Systems (BWMS), development of "generic training" that covers maintenance and operation of each BWMS is quite difficult. This document examines the feasibility of the proposed amendments and proposes an optimal approach for consideration under this agenda item.*

Here we have one country supported by ICS asking that the generic training to comply with the Ballast Water Management (BWM) convention is made mandatory and by this included in the basic educational program of officers and hence included in their certificate. Another nation is opposing this saying there are too many different BWM solutions to provide generic training. The former stance would have removed a training burden from ship operators and increased competence requirement for seafarers. The latter maintains status quo, where operators need to train their crew in BWM systems.

The document shows that balancing of different nations interest in IMO is delaying the addition of competence for seemingly sensible reasons. But since when was it a valid argument against training that there are many complex systems? The sensible answer would be that training cover all major technologies and then add a little familiarisation or onboard training on the ships actual system similar to how ECDIS training is handled.

The document highlights in this manner the weakness of IMO STCW in that it allows this kind of stalling of progress for what can only be seen as opportunistic or arbitrary reasons. This is not easy to see and the arguments presented for status quo is not easy to oppose, unless stricter guidelines are applied as to what can be used as arguments to keep training away from basic education. Too complex systems should not be an argument against adding competence to basic seafarer education.

- IMO strategy is to "…*promote safe, secure, environmentally sound, efficient and sustainable shipping ..... by adopting the **highest practicable standards** of maritime safety and security, efficiency of navigation and prevention and control of pollution from ships...»*
- *It is difficult to achieve agreement on what to include in the **highest practicable standards.***

2.2.9 ICS – International Chamber of Shipping

ICS is the principal international trade association for merchant ship owners and operators, representing all sectors and trades and over 80% of the world merchant fleet.

The ICS chairman expressed in a speech in January 2019 and reported by safetyatsea.net[8]:

The IMO convention was reviewed in 2010, with the adoption of the relatively minor 'Manila amendments', but the previous major overhaul of the STCW regime was last undertaken by IMO member states more than 25 years ago. Poulsson explained that ICS increasingly views the STCW 2010 amendments as an interim revision that added some new training and certification provisions without making the structural changes needed to accommodate developments in training or the competences that would be required to operate ships in the future.

[8] https://safetyatsea.net/news/2019/shipowners-call-for-stcw-revision/

Poulsson said it was common for employers to routinely provide additional training and assessments prior to the deployment of officers holding STCW certification. This, he said, called into question whether the convention was "still fit for purpose in the 21st century".

He called for a "fully revised" STCW regime that would allow the industry to adapt more effectively to fast-paced changes in technology, including increased automation.

ICS works on key issues relevant to their members interests: safety and environment, employment affairs, legal, shipping and trade policy.9

Key takeaway:

- IMO needs a revision to be able to adapt to fast changing technology.

2.2.10 Conclusions

- Shipping volume is growing and thus the number and size of ships and this will require more qualified seafarers and shoreside employees.
- Radical engine and fuel technology improvements are necessary in order to meet UN/IMO emission targets of reducing total annual greenhouse gas emissions by at least 50 per cent by 2050 compared with levels in 2008. This will require new competence by seafarers and shoreside shipping employees.
- Operators agree that more training is necessary to improve safety and operation, the cost is currently split between seafarers and operators.
- Quality of training should improve as seafarers are receiving less than optimal training quality.
- Training will become more digital and on-line as a result of travel restriction under Covid but probably will continue as cost will be lowered.
- More competence in renewable energy systems, both technology and operation will be required in the medium term. For the market leaders it is already beginning to become a current need. Keywords: Hydrogen, ammonia, battery, fuel cells, wind power.
- The IMO GHG Strategy significantly impact design and operations of all ships and subsequently require new and updated competence in crew and shoreside employees.
- Commercial pressure pushes all shipowners towards decarbonization, requiring new competence.
- Cities will become more important and especially port cities will compete to become leading logistics hubs.
- Raw materials and energy trade will grow and increase demand for ships and thereby increase demand for crew and shore side employees.
- Shipping Industry is growing as an employer and as a result more seafarers will need additional competence in the future.
- We can see a shift in the 2020 report towards people centric focus. Organisations should consider the business and human context first.
- Location independence and resilience supported by relevant technologies are emerging trends.
- Enabling. Technology trends can be thought of as 'enabling' and fostering other technologies: acceleration of digitalization, virtualization and automation across the lifecycle.
- Transforming. Technology trends can be thought of as transformative in key industries: transport and logistics and low carbon energy systems.
- Sustaining. The third group of technology trends contains technologies that help to sustain our biosphere: the ocean space and other natural ecosystems.
- IMO needs a revision to be able to adapt to fast changing technology.

[9] http://www.ics-shipping.org/key-issues/all-key-issues-(full-list)

3 The digital transformation (technology forecast)

This chapter presents a digital technology outlook and possible implications for the maritime industry and future skill needs. Digital transformation and disruptive innovation have become popular terms in recent years. Although most companies are more concerned about incremental improvements of their own business, there is no doubt that digital capabilities will be increasingly important in the entire maritime industry. Digitalisation will both challenge existing business models, create new opportunities and demand for new skills.

The research activity included following steps:

- Digital technology forecast and trends
- Possible developments in shipping
- Need for new digital skills

3.1 Digital technology outlook

3.1.1 Connectivity

Advancement in wireless communication, sensor technology and advanced analytics are fuelling the digital transformation. The challenge has been to establish high-speed internet access to and from ships everywhere. Existing satellite communications offer lower bandwidth compared to land based systems.

Connectivity is undergoing evolutionary change in most parts of the world and enhancement in satellite communication opens for rich cooperation between ships and land-based organisations. Data Bridge Market Research report that maritime satellite communication market is expected to growth by of factor of 3,5 in the next seven years[10], see also figure 4.

With increasing ship to shore connectivity comes huge amounts of data that shipping companies can extract insights and value from to make data-driven business decisions and optimise operations at all levels.

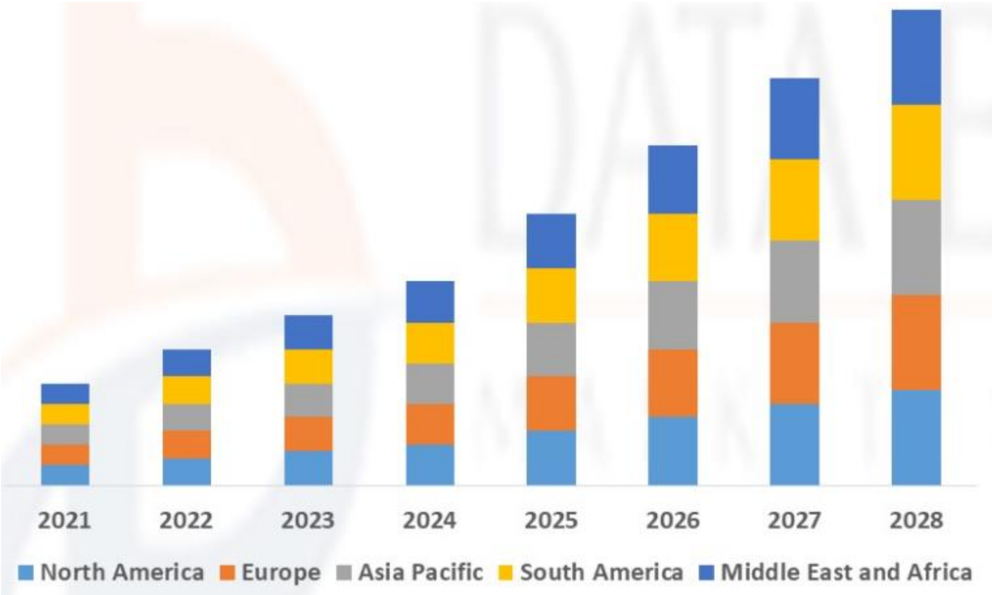

Figure 4: Expected growth of maritime satellite communication in the years

[10] Data Bridge Market Research, https://www.databridgemarketresearch.com/reports/global-maritime-satellite-communication-market

3.1.2 The internet of things (IoT)

The most obvious benefit of maritime IoT application lies in how it can optimise and streamline every aspect of operations at sea, at port and across fleet – from vessel tracking and predictive maintenance to crew safety and welfare.

Most of the transportation and logistics companies have already embraced IoT solutions. Right from utilizing IoT solutions for predictive analytics that help organizations make smarter decisions for route and delivery planning task to identifying the problem-creating areas, creating a smart location management system, real-time inventory tracking and warehousing, introducing self-driven vehicles and drone-based deliveries, IoT is revolutionizing the sector to its very core, see also figure 5.

In addition, the technology is also equipping the supply chain management across the globe in various ways. The integration of radio-frequency identification commonly referred to as RFID with IoT technology is being seen as one of the biggest impacts of IoT in Supply Chain Management. Through this integration, the supply chain management sector is looking forward to extensively improve its operations. Not only does it allow real-time updates but also helps the industry to combat counterfeit goods, enforce expiration on perishable goods, and detect the various factors that may impact the quality of the product while in the delivery process.

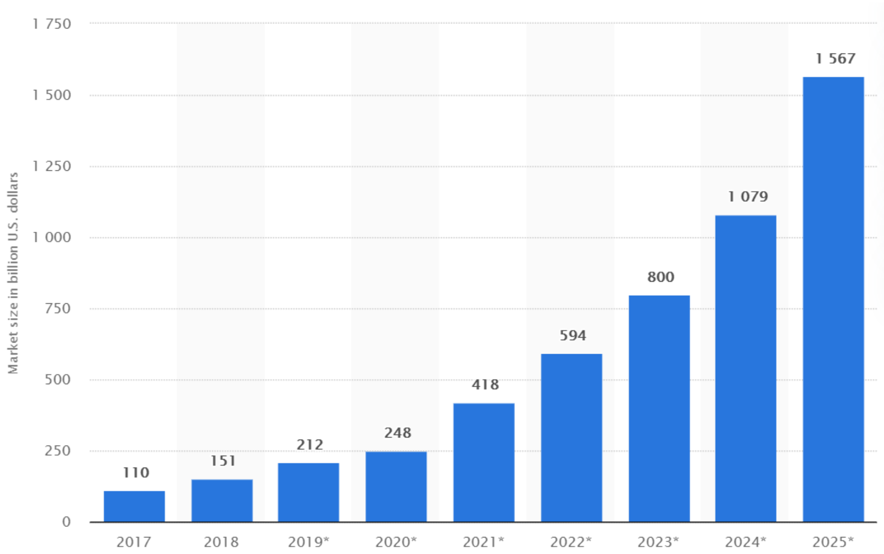

Figure 5: Expected growth of user spending on IoT solutions11

3.1.3 Autonomy

The term automation describes systems which are computerized and execute certain operation by a pre-programmed method without human control. The term autonomy is used for systems with control functions that can use different methods or options to solve selected classes of problems[12].

There is an increasing interest in autonomous and unmanned ships. The International Maritime Organization (IMO) has suggested the term MASS[13] (Maritime Autonomous Surface Ships) as a general

[11] Statista Business Data Platform, 2021, http://statista.com
[12] Ørnulf Jan Rødseth, Håvard Nordahl, Åsa Home; Characterization of autonomy in merchant ships; 2018 OCEANS - MTS/IEEE Kobe Techno-Oceans (OTO)
[13] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx

name for these new ship types. A MASS has been defined as a ship which, to a varying level, can operate independently of human interaction. IMO defines following levels of autonomy:

- Level one: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.
- Level two: Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.
- Level three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
- Level four: Fully autonomous ship: The operating system of the ship can make decisions and determine actions by itself.

Interest in autonomous shipping is growing fast and it is a popular topic in research communities[14, 15, 16]. Enabled by recent developments in sensor technology, connectivity, and decision support algorithms, the first commercial projects are ready for launch in the very near future[17].

There is still much confusion about autonomy and crewless shipping. We have seen major industrial advancement in sensor technology and control systems[18, 19, 20] and many new research projects are established. Leading experts from ship design, fleet owners, naval architects, classification societies, equipment manufactures and maritime research organisations cooperating and exchange ideas[21].

The IMO guidelines say that trials should be conducted in a manner that provides at least the same degree of safety, security and protection of the environment as provided by the relevant instruments. Risks associated with the trials should be appropriately identified and measures to reduce the risks, to as low as reasonably practicable and acceptable, should be put in place[22.].

3.1.4 Cyber security

Cyber security is the activity of defending computers, servers, electronic systems and networks from attacks. IMO has issued Guidelines on maritime cyber risk management[23] to support safe and secure shipping. IMO defines maritime cyber risk as "*a measure of the extent to which an asset could be threatened, which may result in shipping-related operational, safety or security failures as a consequence of information or systems being corrupted, lost or compromised*".

Cyber risk management is defined as; the process of identifying, analysing, assessing, and communicating a cyber-related risk and accepting, avoiding, transferring or mitigating it to an acceptable level, considering costs and benefits of actions taken to stakeholders[24].

The ISM Code, supported by the IMO Resolution MSC.428(98), requires ship owners and managers to assess cyber risk and implement relevant measures across all functions of their safety management

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[14] Montewka J.a,c,* , Wróbel K.a , Heikkila E.b , Valdez-Banda O.c , Goerlandt F.d,c, Haugen S.e; http://www.iapsam.org/psam14/proceedings/paper/paper_426_1.pdf, Challenges, solution proposals and research directions in safety and risk assessment of autonomous shipping,

[15] *T. Porathe, Å. Hoem, Ø. Rødseth, K. Fjørtoft, S.O. Johnsen,* Safety and Reliability – Safe Societies in a Changing World; At least as safe as manned shipping? Autonomous shipping, safety and "human error";

[16] Marko Höyhtyä, Jyrki Huusko, Markku Kiviranta, Connectivity for Autonomous Ships: Architecture, Use Cases, and Research Challenges; 8th International Conference on ICT Convergence, Jeju Island, Korea

[17]ttps://www.kongsberg.com/no/maritime/support/themes/autonomous-ship-project-key-facts-about-yara-birkeland/

[18] https://www.kongsberg.com/no/maritime/support/themes/autonomous-shipping/

[19] https://rasdelft.nl/

[20] https://www.wartsila.com/insights/whitepaper/the-future-of-smart-autonomy-is-here

[21] https://www.autonomousshipsymposium.com/en/

[22] https://www.imo.org/en/MediaCentre/PressBriefings/pages/MASSRSE2021.aspx

[23] https://www.imo.org/en/OurWork/Security/Pages/Cyber-security.aspx

[24] https://www.imo.org/en/OurWork/Security/Pages/Cyber-security.aspx

system, until the first Document of Compliance after 1 January 2021. This is a challenging task due to many suppliers of equipment's and systems used on a ship. See also end of chapter 2.2.1

3.1.5 Artificial intelligence and Machine Learning

Artificial intelligence (AI) is the ability of a computer-controlled system to perform tasks commonly associated with humans. In the last decades, machine learning (ML) has dominated the field of application. Machine learning is based on statistical methods, and is about extracting knowledge from data. Machine learning is defined as; *Machine learning enables a computer system to make predictions or take some decision using historical data without being explicitly programmed.*

Machine Learning methods is progressing due to the available data sources from online measuring, experiments, and simulations. This amount of data has made machine learning a powerful tool that has been successfully used to extract information and intricate patterns that can helping to solve many challenging problems throughout industry25. Within shipping machine learning is for example used to predict need for maintenance, freight rates, sailing schedules, logistics, supply chain management etc.

3.1.6 Digital twins

A digital twin is a digital model of and for a real system – for example, a ship. By bridging the physical and the virtual world, data is transmitted seamlessly (IoT) allowing the virtual entity to exist simultaneously with the physical entity[26].

Digital twins integrate the internet of things, connectivity with advanced analytics to create living digital simulation models that update and change as their physical counterparts, see also Figure 6. Analytics by simulation in combination with machine learning can be used to predict future situation in several areas. Examples are route optimization taking into account learning from earlier voyages, predictive maintenance and so on.

A digital twin continuously learns and updates itself from multiple sources to represent its near real-time status, working condition or position[27]. The digital twin is a hybrid consisting of a model and data-based decision support. A digital twin can also represent processes, people, places, systems and devices that can be used for various purposes.

The purpose of digital twin technology is to optimise the operations throughout the value chain by taking into consideration the real performance of the physical system. For example, estimation of optimum service intervals based on actual loading history.

[25] *Clark, Jack (8 December 2015b).* "Why 2015 Was a Breakthrough Year in Artificial Intelligence". *Bloomberg.com.* Archived *from the original on 23 November 2016. Retrieved 23 November 2016.*

[26] "Minds + Machines: Meet A Digital Twin". Youtube. GE Digital. Retrieved 26 July 2017.

[27] "Introduction to Digital Twin: Simple, but detailed"Youtube. Retrieved 27 June 2017

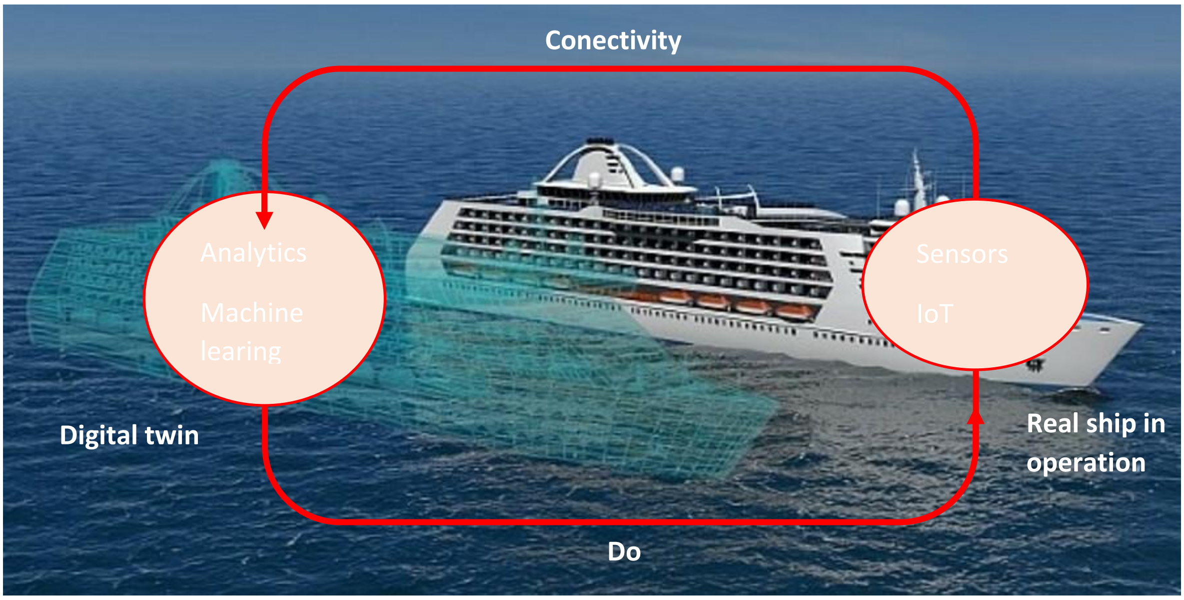

Figure 6: Digital Twin

3.2 Developments in shipping

In this chapter we will summarise how digital technology advancements may affect different aspects of shipping.

Autonomy and operation of ships: Autonomous ships are new concepts that will challenge the conventional methods for designing, testing, and operation of ships.

We will probably not see unmanned fully autonomous ships on a significant scale in the coming decades, but we will see an increasing number of autonomous functions on a ship. For example, optimum routeing considering weather conditions and collision avoidance algorithms. Such systems will require complex human-machine interactions and in-depth system understanding is needed. Such autonomous functions may enable fewer crew onboard and allow remote control and operations.

Autonomy and crewing: Autonomy has a lot of attention the last decade and it is a discussion whether seafarers may lose their jobs. Most predictions are that autonomous or semi-autonomous operation would be limited to short voyages, for example from one specific port to another. Research in autonomy focus mostly on navigation and answers how to keep engines and machineries up running in long voyages are missing.

There are additional regulations that rely on the crew on board and become a barrier for autonomous shipping mass adoption. Specifically:

- The ISM Code requiring shipowners to; ensure that each ship is manned with qualified, certificated and medically fit seafarers. [28]
- SOLAS Chapter V Regulation 5, stating that all ships must be; *sufficiently and efficiently manned.*[29]
- The United Nations Law of the Sea Convention, Article 94, requiring that each ship must be in the charge of a master; *who possess appropriate qualifications, particularly in seamanship, navigation, communications and marine engineering*.[30]

[28] https://www.imo.org/en/OurWork/HumanElement/Pages/ISMCode.aspx
[29] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/343175/solas_v_on_safety_of_navigation.pdf
[30] https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

The size of a crew may evolve in response to technological changes on board; however, there may also be considerable additional jobs ashore which require seafaring experience.

New connectivity technologies, IoT and data analytics and blockchain can simplify and secure the supply chain, reduce the amount of paperwork, and enable a holistic, real-time, data-analytic rich management and operational view of the entire supply chain.

Remote operation: Crewless shipping seem still far away. But shipping companies opens to an idea of ships controlled from land – remote control. Remote operations enabled by improved connectivity and autonomous functions, operations can be inspected and controlled from shore-based centres. Such functions can then be optimised across the whole fleet by experts in the control centres. Another potential benefit is to reduce the crew onboard, allowing the remote centre to fulfil some functions[31].

Cargo tracking: By installing connected sensors to every single item, either on the inside or outside of packaging, the stakeholders in the supply chain can, at any given time, see the item's location and velocity. This will enable transport companies, clients, and insurers to accurately monitor assets in motion[32]

Cargo condition monitoring: IoT enables data-rich, event-triggered alerts and tracking of numerous metrics (temperature, humidity, velocity, light, vibration, etc.) to ensure cargo is transported and delivered as agreed. This will help to ensure that cargo delivery terms are met.

Logistics and value chain: IoT technology[33] is extending its benefits across the entire value chain in the logistics world right from operations, warehousing, freight transportation, to last-mile delivery. Online retail leader Amazon has initiated integration of own ships to control the value-chain end to end. This means that seafarers increasingly need to understand and operate in a fully integrated logistics environment. They are no longer only in charge of conducting a safe sea voyage, they are part of a logistics operations and are expected to make their decisions accordingly[34].

Smart port operations*: Rotterdam will host connected ships by 2025, as announced by the Rotterdam Port Authority. Sensors will collect, process and analyse real-time data to check availability of berths and other data points such as weather, tide, clearance etc. This collection and curation of robust data sets will allow more efficient communications and decision-making to realise operating cost reductions.*

Traffic and fleet management: The next significant paradigm shift will come with fleets becoming autonomous. Kongsberg has announced plans to launch autonomous cargo ships, or as the Economist called it "Ghost Ships", by 2030 while aiding or replacing personnel was the critical criteria. Autonomy and remote operations present a potential for reduced costs and safer operations and can help make sea transport competitive in new segments. Digital twin technology can be used to optimise lifecycle service and maintenance, considering real loading condition of critical systems.

E-brokerage platforms: For example, imagine that a mobile application is incorporated to match shipper rates, truck drivers, schedules, and routes. This advance is expected to automate various processes concerning the delivery status, load-finding, driver payment, delivery status, apart from sharing critical real-time information on asset tracking or consignments right from pick-up to delivery.

Smarter commerce with blockchain: Blockchain technology is demonstrating its potential to generate new innovative channels for the development and deployment of logistics applications or solutions. This

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31 https://safety4sea.com/cm-the-advantages-of-remote-operations-centers-in-shipping/?__cf_chl_jschl_tk__=pmd_M5DGTa_MPSy812EM4.LUEzEe6PjHeNwFez2e60px7Uo-1632806049-0-gqNtZGzNAiWjcnBszQk9

32 School of Software and Microelectronics, Intelligent Cargo Tracking System Based on the Internet of Things, 2012 15th International Conference on Network-Based Information Systems, Lixin Zhou, Peking University, Beijing, China

33 Y.P. Tsang, K.L. Wu , An IoT-based cargo monitoring system for enhancing operational effectiveness under a cold chain environment, International Journal of Engineering Business Management, 2017

34 Maersk close to acquisitions to bulk up land-based logistics https://www.ft.com/content/d71a46ec-2263-11ea-b8a1-584213ee7b2b

means that the technology can emerge entirely as a new operating system for the supply chain networks, combining the software apps with B2B connectivity.

Optimal routeing: Ship routeing can be optimised based on weather forecasts (waves, wind and current) in combination of datasets from similar crossings.

Ship operations performance: Digital twins can be used to optimise operations by extensive use of data. Service intervals of equipment, fuel saving, and optimal routeing. Another area of opportunity for IoT-based solutions in the marine sector is Energy and Fuel Consumption. The smart meters are enabling better and more accurate recording and tracking of the fuels, allowing the sector to not only save on cost but also go environment friendly.

Reducing administrative costs: Presently, with the help of IoT-based solutions, the marine sector is eyeing on reducing the administrative costs of regulatory compliance and enhancing security and safety. Adding more on that note, the technology is also assisting in making cargo handling and preventive maintenance easier and quicker.

IoT enables real-time tracking and monitoring of cargo at all levels to determine location, delivery, and a host of related matter. While IoT saves time and increases efficiency, security is one of the main challenges of successful IoT implementation.

Maintenance: By deploying machine learning algorithms, a better schedule for maintenance work can be developed and thereby improving the liner services in the long term, especially during the times when a ship may need to be out of operations temporarily for maintenance work.

Freight Rates: Machine learning can help in handling the deficits and offer more reliable container capacity utilization; hence more consistent freight rates would prevail.

Sailing schedules: By using machine learning, better and reliable sailing schedules can be achieved as more accurate calculations would be there to predict the delays or estimate the time of arrival of the cargo.

Logistics: Machine learning will have potential impact on the global logistics chain. Machine learning can predict accurately on arrival of container shipments. Using information from a variety of sources across the supply chain—including live demand and pricing data. A more accurate demand forecast can also help to scale up capacity of the existing fleet.

Supply Chain Management: The supply chain management may utilize machine learning algorithms to locate new patterns in supply chain data almost on a daily basis and use those patterns to improve the supply networks' success. Improved demand forecasting and production planning, better supplier delivery performance, minimized supplier risk, improved supplier chain and transportation management, physical inspection and maintenance tasks, lower inventory and operation costs, quicker response time, extended life of supply chain assets are the key evolutions happened within supply chain management by the introduction of machine learning algorithms.

3.3 Need for new digital skills

The digital transformation and distributed technologies change our societies as well as the maritime business. The ships will be smarter, data driven and connected to the rest of the world. The future maritime activity will integrate people and digital technology in a way that transform how we operate and interact. A new operation paradigm needs to be created to meet these challenges.

Reliable connectivity, at high bandwidth, between a land-based organisation and the ship anywhere open for sharing of work tasks between land and sea. Control functions, routing, communication and so on can be done from a shore centre. The consequence of such development is that the work experience from the ship also needed to be transferred to the shore organisation. The key to achieve such knowledge and skill transfer is mobility between ship and then land organisation. Such development will demand other skills and methods to organise work in dispersed teams.

Autonomy and advanced support systems onboard will continue to be developed. Most experts suggest that ships without crew will not be a reality on a large scale within the next few decades. However, integrated systems already onboard ships and technological developments will cause increasingly challenging interactions between complex autonomous systems and the crew.

The gap between common practice and future opportunities is observed to be growing. For example, connectivity, IoT, common broker platforms and e-commerce will simplify and secure the supply chain and reduce the amount of paperwork in the value chain. Technological advances offer possibilities to make the business process seamless and potentially eliminate transaction costs.

Skills supporting business development taking advantage of technology will be important.

Digital twins enable real-time data analytics by using AI and machine learning tools to support a rich management and operational view of the entire supply chain. This technology will offer the possibility of a high degree of optimisation of operations from ship control centres in the ship owner’s office ashore. One possible outcome will be to transfer power and work tasks from the ship to the control centre and be supported by highly advanced tools for the optimisation of the entire fleet.

The developments described in this chapter will be based upon the further development of ship control centres optimising operations of the fleet. Work tasks will increasingly be transferred from the ship to shore-based control centres. Advanced skills in analytics and use of data in optimisation of the fleet will be needed.

All in all, the maritime professionals (both seagoing and shore-based) need in-depth understanding of the complex systems onboard to be able to serve the needed redundancy of all systems.

1
- **Basic digital skills** needed to operate in a increasingly digital environment. (For example Ship 4.0 / Industry 4.0, sensors, IoIT, networks, connectivity and cyber security)

2
- **Deep understanding of the complex systems** onboard to be able to serve the needed redundancy of all systems)

3
- **Transversal skills** needed to encourage work positions on-board, ship owner office or shore based control centre or other organisation in the value chain

4
- **Work in dispersed teams.** Teams with both seagoing and shore based team members

5
- **Understanding of business development taking advantage of digital technology** (for example: cargo tracking, cargo and machinery condition monitoring, logistics in digital connected value chains, smart port operation, fleet management, e-brokerage, smart commerce with blockchain)

Figure 7: Need for new digital skills

3.4 Case study

A case study is done to gain concrete and contextual knowledge of the digital transformation. The idea is to explore key characteristics and implications. Our findings will be substantiated, challenged, and exemplified.

Yara Birkeland, - the world's first zero emission, autonomous container feeder

The vessel YARA Birkeland will be the world's first fully electric and autonomous container ship, with zero emissions. KONGSBERG is responsible for development and delivery of all key enabling technologies.

THE SHIP
A 120 TEU (Twenty-foot Equivalent Units) open top container ship. It will be a fully battery powered solution, prepared for autonomous and unmanned operation. The vessel will reduce NOx and CO2 emissions by reducing diesel-powered truck transport by around 40,000 journeys per year. This eco-initiative will help to meet the UN sustainability goals, and improve road safety and congestion.

For the first phase of the project a detachable bridge with equipment for manoeuvring and navigation will be implemented. When the ship is ready for autonomous operation this module will be lifted off.

ESTIMATED FACTS & FIGURES

MAIN PARTICULARS • Length o.a.: 79,5 m • Length p.p.: 72,4 m • Width mld.: 14,8 m • Depth shelter deck: 10,8 m • Draught (full): 6 m • Draught (ballast): 3 m • Service speed: 6 knots • Max speed: 13 knots	PROPULSION • Propulsion system: Electric • Propellers: 2 Azimuth pods • Thrusters: 2 Tunnel thruster • Battery pack: 7 MWh CAPACITY • Cargo capacity: 120 TEU • Deadweight: 3 200 mt	PROXIMITY SENSORS • Radar, Lidar • AIS • Camera, IR camera • CONNECTIVITY & COMMUNICATION • Maritime Broadband Radio • Satellite Communications • GSM

LOADING / DISCHARGING / MOORING

Loading and discharging will be done automatically using electric cranes and equipment. The ship will not have ballast tanks, but will use the battery pack as permanent ballast.

The ship will also be equipped with an automatic mooring system - berthing and unberthing will be done without human intervention, and will not require special implementations dock-side.

The autonomous ship will sail within 12 nautical miles from the coast, between 3 ports in southern Norway.

OPERATION / CONTROL CENTRES

To ensure safety, three centres with different operational profile are planned to handle all aspects of operation. These centres will handle emergency and exception handling, condition monitoring, operational monitoring, decision support, surveillance of the autonomous ship and its surroundings and all other aspects of safety. An interface towards Yara logistical operation will be implemented at the operational centre at Herøya.

Findings

The Yara Birkeland project partly proves that autonomy and unmanned shipping is possible from a technology point of view. There are still challenges to be solved, but the ship will be in operation soon.

The bridge and machine officers will be on-board in a test period. They will be trained to operate the ship both on-board and from the shore control centre. Specialised training program for the crew is in preparation. Service and repair will be done at the harbour. The sailing distance is very short and only to specified location in predefined harbours.

Crewless shipping in general still seems far away. The challenges are not solved, and machineries are not designed with enough robustness and redundancy to operate for longer periods. But shipping companies open to the idea of ship with close support from land – remote support.

By this, our findings are substantiated and exemplified.

4 Sustainability and de-carbonizing (technology forecast)

This chapter presents technology forecast for de-carbonizing the shipping fleet and future skill needs. Many alternative fuel technologies are available for reducing the CO_2 emissions of shipping. For alternative fuels and power sources, the technical applicability and commercial viability will vary greatly for different ship types and trades, where deep-sea vessels have fewer options compared with the short-sea segment.

The IMO 2050 targets for CO2 can be met by LNG in combination with bio-LNG as a drop in fuel. LNG is currently not a complete answer to the marine fuels problem but a steppingstone to meet emission target.

The research activity included following steps:

- Rules, regulations, and agreements
- Outlook and development trends
- Need for new sustainability skills

4.1 Rules, regulations and agreements

The IMO has reached an agreement on a strategy for the reduction of CO_2 emissions from shipping. Its Marine Environment Protection Committee[35] (MEPC) announced that member state delegates have agreed on a target to cut the shipping sector's overall CO_2 output by 50% by 2050, to begin emissions reductions as soon as possible, and to pursue efforts to phase out carbon emissions entirely. The agreement includes a reference to bringing shipping in line with the Paris Climate Agreement's temperature goal, which seeks to limit global warming to below two degrees Celsius.

The 50% CO_2 reduction goal is roughly in line with a proposal endorsed by the International Chamber of Shipping[36]. In addition to the percentage target, the initial strategy also includes strengthening the efficiency requirements for new ships and reducing shipping's carbon intensity - that is, the amount of CO_2 emitted for each unit of transport work completed (Energy Efficiency Design Index[37], EEDI).

The DNV-GL analysis, Energy Transition Outlook 2020[38], assumed annual growth of 2% until 2030 and then growth of 0.2% until 2050, giving a total growth of 37%.

To achieve such a reduction will mean major improvements in logistics, hydrodynamics, machinery, and fuel. Within fuel we will see several sources as LNG/LPG, electric systems, biofuels, synthetic fuel, hydrogen and nuclear power. Not all options have potential to reach deep-sea stage due to limited energy density. Such improvements will have to be implemented in a significant scale by 2030 if there is to be the necessary impact by 2050.

A major part of the fleet has introduced speed reductions to lower fuel consumption. Further reductions can be achieved by optimisation of the operations. The average waiting time[39] to get into a port is reported to be up to several days and many ships are sailing without utilising their full cargo capacity.

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[35] http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-%28MEPC%29/Pages/default.aspx

[36] International Chamber of Shipping.

[37] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Technical-and-Operational-Measures.aspx

[38] Energy Transition Outlook 2020, DNV-GL, https://eto.dnvgl.com/2020/

[39] Park N.K. and Suh, S.C. Tendency toward Mega Containerships and the Constraints of Container Terminals. J. Marine Science and Engineering. 7, 131.

4.2 Outlook and developmet trends

DNV-GL and Lloyd's Register have produced comprehensive studies of maritime energy transition developments.

- Maritime Forecast to 2050, Energy Transition Outlook 2020[40], DNV
- Global Marine Fuel Trends[41], Lloyds Register

For example, Lloyd's Register Marine forecasts three different scenarios for global marine fuel trends by 2030 – status quo, global commons, and competing nations. Lloyd's Register answers a question: What does the marine fuel mix look like for containerships, bulk carriers, and tankers by 2030? Decreasingly conventional, it suggests, stating that heavy fuel oil (HFO) will still be very much around in 2030, but in different proportions for each scenario: 47% in the status quo, to a higher 66% in competing nations and a 58% in global commons. A high share of HFO means a high uptake of emissions abatement technology. The takeaway from the Lloyd's report is that the greater installed power reduction occurs in global commons, due to the combination of design speed reductions and greater efficiency technology take-up.

The DNV CO_2 Barometer[42] shows the total emission level is still increasing. If the IMO targets are to be met, it is vital that uptake of low- and zero-emission technologies should begin on large ocean-going ships soon.

Many alternative fuel technologies are available for reducing the CO_2 emissions of shipping. For alternative fuels and power sources, the technical applicability and commercial viability will vary greatly for different ship types and trades, where deep-sea vessels have fewer options compared with the short-sea segment. It is important to find technically feasible and cost-effective solutions for the deep-sea segment, accounting for more than 80% of world fleet CO_2 emissions. Currently, the only technically applicable alternatives for this are liquefied natural gas (LNG) and sustainable advanced biofuels.

Biofuels are drop-in fuels requiring only limited or no modification to engines and fuel systems to replace or blend with traditional fuels used by internal combustion engines.

DNV's maritime forecast to 2050 also emphasises the concern about sustainable use of fuel and the management skills regarding sustainable use of new environmental technologies and fuels and their relations with digitalisation.

DNV made 30 future scenarios of the energy transition in the report Maritime Forecast to 2050[43]. Scenario 11 and 19 is shown in figure 8. Scenario 11 (to the left) represent IMO ambitions with the assumption of growth of the fleet and low electricity prices. Scenario 19 (to the right) represent ambitions to decarbonization by 2040 and assumption of low growth of the fleet and low price on biomasses. The bar representing biomasses will partly be replaced by e-ammonia if the price of electricity is low or blue ammonia if the price of blue and fossil fuel is low. The future replacement of LNG depends on costs of alternative fuels. We will therefore probably have a mix of many solutions.

[40] DNV GL https://eto.dnvgl.com/2020/maritime
[41] Lloyds https://www.lr.org/en/insights/global-marine-trends-2030/global-marine-fuel-trends-2030/
[42] Barometer fro frønn omstilling av skipsfarten, DNV-GL rapport 2019-0080,
[43] MARITIME FORECAST TO 2050 Energy Transition Outlook 2020

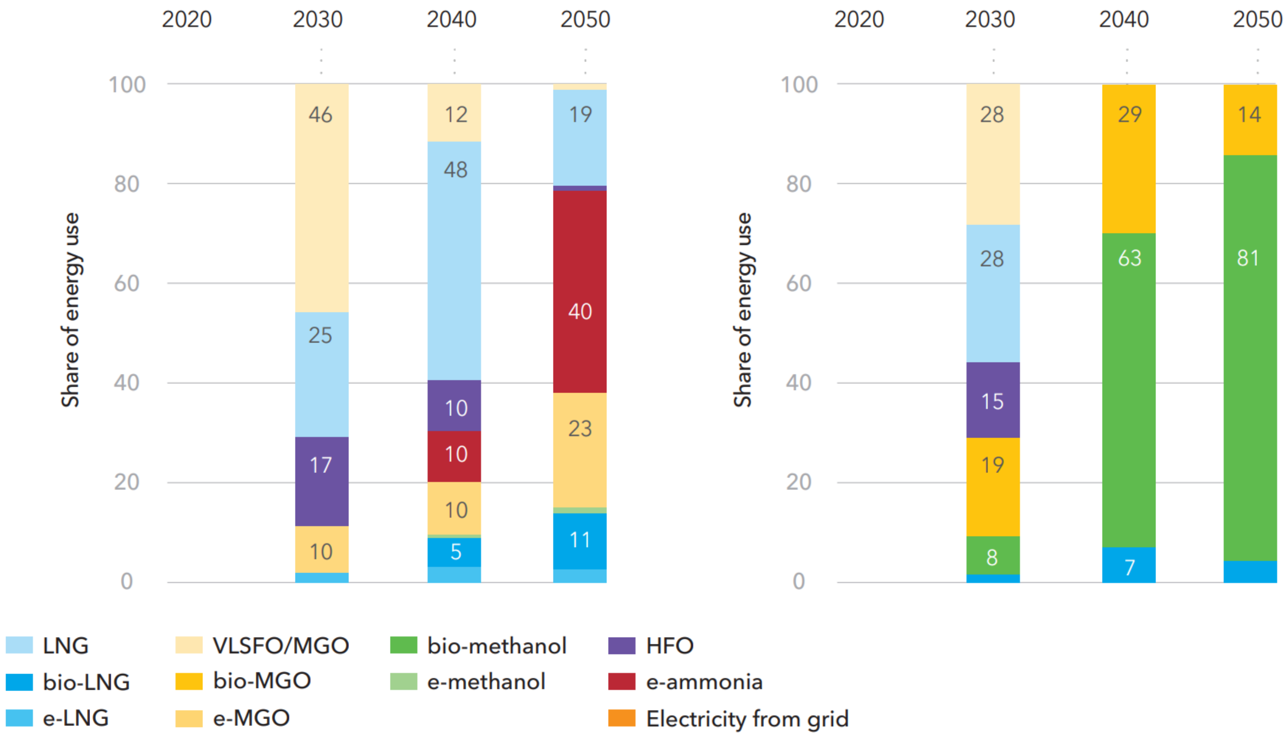

Figure 8: Transition pathways and share of total energy use by shipping per decade to 2050. The pathway to the left represents scenario 11 and is within the IMO ambitions. A precondition for this scenario is low electricity price. The figure to the right show ambitions to decarbonization by 2040. A precondition for this fuel distribution is low price on biomasses.

Clarkson[44] data shows that alternative fuels are now in use on 3.5% of the current fleet and approaching 30 per cent of the orderbook by tonnage (see table below). LNG is the most popular alternative fuel, followed by LPG, but there are increasing numbers of alternately fuelled ships under construction such as 13 ethane-powered vessels. When these vessels are delivered, this will subsequently amount to a substantial part of shipping's overall capacity.

Clarksons now records 124 ports with LNG bunkering facilities, up from 114 at the start of the year and forecasts this will increase to 170 by 2022. Clarksons also projects that the LNG bunkering fleet will double in size in the next two years.

Vessel owners and operators continue that LNG reduces SOx and particulates to negligible levels, NOx by up to 85 per cent, and GHG emissions by up to 23 per cent. It can also achieve the IMO's 2030 target of reducing CO_2 emissions by 40 per cent compared to 2008 by the use of bio-LNG products as a drop-in fuel. Later, the transition to bio-LNG, and eventually synthetic LNG, will enable the industry to meet the IMO 2050 targets.

LNG is currently not a complete answer to the marine fuels problem but a steppingstone to meet emission target.

Table 1: Use and order book of ships with alternative fuel

Alternative fuel	Fleet	% Fleet	Order Book, #	Order Book, %
LNG	609	0,6	365	10,7
LPG	1	0	37	1,1
Biofuel	23	0	7	0,2
Methanol	12	0	11	0,3

[44] https://splash247.com/more-than-a-quarter-of-all-tonnage-under-construction-will-use-alternative-fuels/

Ethan	7	0	13	0,4
Hydrogen	0	0	3	0,1
Ammonia	0	0	0	0,0
Battery	141	0,1	109	3,2
Total (Number)	776	0,8 %	520	15,2 %

There are several additional solutions focusing on battery or hybrid technology that seem better suited to the short sea fleets as these have to travel less distance between potential recharging/refuelling stations. Norway will have 70 ferries crossing fjords by pure battery power in the end of 2021 and 200 ferries within 2025.

Hydrogen is most commonly made by reforming natural gas. If the CO_2 produced from such reform could be captured, hydrogen could provide shipping a zero-emission solution. The same outcome can be achieved if hydrogen is generated using renewable or nuclear produced energy. Currently there is no hydrogen bunkering infrastructure for ships on a global level because of the very low demand. The technology for producing hydrogen from electrolysis is known and available and therefore could be applied in ports if there is sufficient non-carbon electrical power to sustain the production process.

It is clear that no one fuel currently presents a complete solution. Those listed above that currently have widespread commercial application, but do not eliminate, carbon emissions from their use. Hydrogen and ammonia which appear to be cleaner alternatives for the future are not yet ready for widespread commercial implementation and that day seems some way into the future.

4.3 Need for new sustainability skills

The CO_2 reduction targets as referenced in previous chapters cannot be achieved by one single technology. A range of areas must be improved, such as:

Fuel and energy sources: LNG/LPG, batteries, biofuel, synthetic fuel, hydrogen, ammonia etc.

Logistics: reduction of speed, ship size, utilisation of ships, reduction of waiting times, optimum routeing

Hydrodynamics: optimum design of hull[45], hull fouling and cleaning[46]

Machinery: use of surplus heat, optimisation of machinery, batteries, etc.

Systems for effective harbour operations.

Our findings are in-line with the EU Action in the 2050 long-term strategy[47]. In addition, systems to reduce emissions and particulate emissions in localised harbours and ports close to cities will be important. Unique solutions must be optimised for unique transportation needs. The consequence is increased complexity to operate and optimise. The technology shifts with respect to energy systems and operational challenges are more significant than before. The gap between common practice and expected competences is growing.

Alternative fuels as LNG, LPG, biofuel, mathanol, ethan, hydrogen, and ammonia will have different risk factors and needs specialised training. LNG is currently not a complete answer to the marine fuels problem but a steppingstone to meet emission target. Retro-fit and updates will then be common in the ears to come.

[45] Kim et al. Optimum design of ship design system using neural network method in initial design of hull plate. KSEM International journal 18, 1923-1932. 2004.
[46] Hull fouling clauses and prolonged stays. Skuld 2019.
[47] https://ec.europa.eu/clima/policies/strategies/2050_en

In addition, there is the need for improved seafarer training which has been made apparent in the areas of low-sulphur fuel switchovers, the correct use of scrubbers, additional wear and tear on machinery, and the safe operation of ballast water management equipment.

Seafarers must be able to gain knowledge on the safe use and storage of carbon and LNG as well as battery packages. All these are beyond current IMO conventions and require new thinking in maritime education and training.

Thus, the following capabilities of seafarers are needed:

1. • **Understanding of risk related to differnt fuels and energy sources**
2. • **Operation** of complex hybrid, low and zero emission machineries
3. • **Documentation of emissions,** EU and international legislation (CO_2, NOx, SOx)
4. • **Environmental economics, performance management systems**
5. • **Logistics** and optimisation method to achiceve hig vessel utilisation
6. • **Advanced routeing,** considering factors such as wind, current, and waves

Figure 9: Need for new sustainability skills

4.4 Case study

A case study is done to gain concrete and contextual knowledgedge of skills needed in de-carbonizing a fleet. The idea is to explore key charectiristcs and implications. Our findings will be substantiated, challenged and exemplified.

The CMA CGM Group with a new generation LNG powered container ships

Energy Transition, IMO 2020, LNG Commoditization

The Marseille-based company currently operates 12 LNG-powered ships, a fleet that will grow to 32 containerships of various sizes by 2022. CMA CGM has set a goal of carbon neutrality by 2050.

CEO Rodolphe Saade announced in February it would begin deploying LNG-powered ships on trans-Pacific trade lanes from Asia to the US West Coast from October onward as more US companies seek to reduce the carbon footprint of their supply chain. Most of the LNG-powered ships currently deployed by CMA CGM operate on Asia-to-Europe routes.

Major players are using LNG as a step-stone to renewable energy.

CMA CGM has launched an ambitions training program “LNG master” running from August 2020 to February 2022. The training program is set up in conjunction with ENSM the French Maritime Academy) for the crew of LNG-powered vessels and is working with the French government to design special courses. It takes 570 days to train a complete crew, with the course for the main officers taking around a year. Training is both theoretical and practical, with three simulators being used—one for the bridge, one for engine room and one for managing the gas tank. In all, 160 French sailors have already been certified under the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code), and another 200 are set to follow suit. CMA CGM is playing a leading role in LNG training and competency development in France as part of its fleet's quest for excellence.

The transition to green shipping challenge existing skills and demand new specialised training.

By this, our findings are substantiated and exemplified.

5 Developments in the labour market (trend analyses)

The labour market for seafarers is demand driven. Seafarers are in “short supply”, that is the main finding of the most authoritative report on the subject, the Seafarer Workforce Report from BIMCO and the International Chamber of Shipping (ICS) in its latest edition from July 2021[48]. Essentially, the report warns “that the industry must significantly increase training and recruitment levels if it is to avoid a serious shortage in the total supply of officers by 2026.”

As already indicated in the previous report from five years earlier, despite the eventual possibility of more automation on board vessels, there is a growing demand for STCW certified officers. ICS and BIMCO conclude that there will be a need for an additional almost 90.000 officers by 2026. Already in 2021 there is considered to be a shortfall of more than 25.000 STCW-certified officers. The shortfall is insofar remarkable as the number of officers has increased more than 10% in five years. However, the number of vessels has increased even more and continues to increase.

The main supply countries for seafarers are all non-EU. For officers it is the Philippines, Russia, China, India and Indonesia and for ratings the same countries with Indonesia, China and India trailing Philippines and Russia.[49]

However, companies gave consideration to those countries that would have the most important potential for future supply of seafarers. Beyond those five main supply countries, the following ten were mentioned most often as having an important potential for future recruitment:

1. Ukraine
2. Myanmar
3. Philippines
4. India
5. China
6. Romania
7. Greece
8. Indonesia
9. Croatia
10. UK

Three of these countries are EU members. Most important in the consideration of the possible future recruitment sources where the level of English of the respective seafarers and visa/travel restrictions. Especially the latter may have been strongly influences by the COVID pandemic.

Particularly short supply of officers has been acknowledged in some areas: technical officers on management level and specialists for tankers and offshore. Countering this trend have been initiatives by the industry to reduce the turnover rate of officers. They have been decreased by 25% from 8 to 6% p.a., statistically increasing the average age of officers.

On the baseline, the report estimates 1.89 million seafarers currently (2021) being active. The report estimates that an average of 1.4 officers are required per berth.

[48] ICS BIMCO. "Seafarer Workforce Report." London/Copenhagen, 2021, 108 pages.
[49] For the complete list of seafarer supply by country see appendix.

Table 2: Global supply of seafarers[50].

	2010	2015	2021	2026 (forecast)
Officers	624.000	774.000	857.540	947.060
Ratings	747.000	873.500	1.035.180	1.069.500
Total	1.371.000	1.647.500	1.892.720	2.016.560

The demand for seafarers is distributed across all ship types, depending on the number of such vessels and their respective manning level, see figure 10:

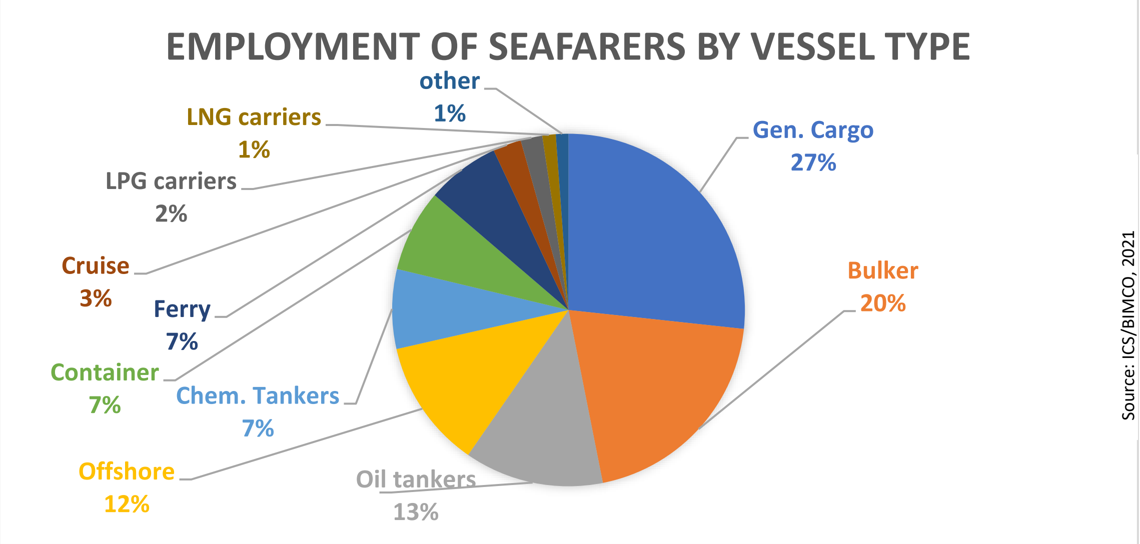

Figure 10: Demand for seafarers across ship types

It is also important to note that the over-supply of ratings that was most notable in 2005 and 2015 has diminished in absolute terms despite the significant increase of jobs. On the other hand, the gap between supply and demand for officers has increased.

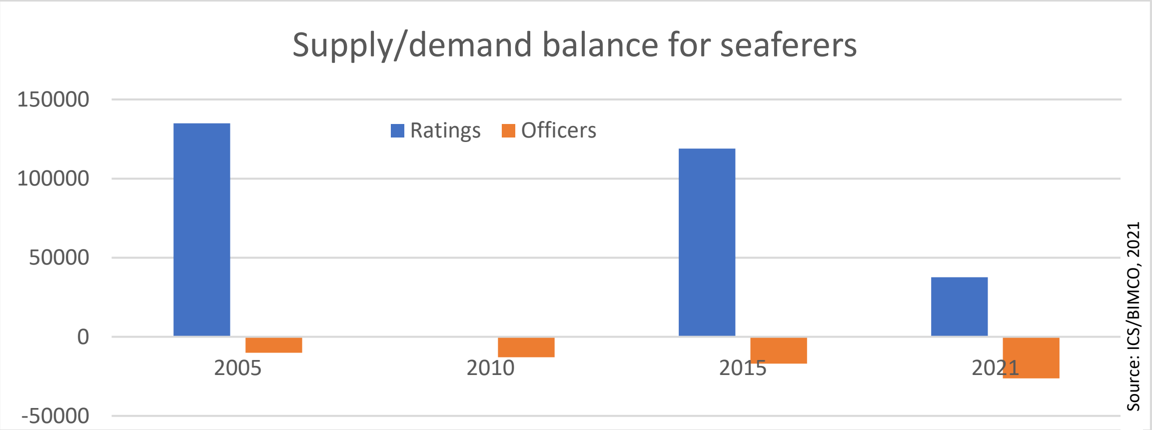

Figure 11: Increasing demand for officers

In order to close the gap on the officer side it would need an additional 18.000 STCW certified officers every year in the next five years[51]. Most important seems to cover the shortage of technical officers. All engineering positions (management and operational as well as ETO) are already today at least "difficult" to

[50] ICS BIMCO. 2021. "Seafarer Workforce Report." London/Copenhagen, 108 pages.

[51] The ICS/BIMCO study has been based in questionnaires, interviews and statistical assumptions.

recruit. The lack of experience on a specific ship type or on the job competency are most often cited as drawbacks.

There appears to be a moderate improvement of the gender balance. Though the figure of women seafarers has increased by almost 50%, the general number of female STCW officers is still strikingly low with 1,28% of the total.

Looking into the future, the world merchant fleet will increase by number of vessels and tonnage. The most dramatic increase is predicted for cruise vessels, container ships and specialized tankers (LNG, LPG). The demand for future officers will focus very much on such vessel types. Focus needs to be put on respective training and development of appropriate career paths.

Reflection on the EU labour market

While almost 40% of the global fleet is controlled from Europe, this share is relatively decreasing. Though the EU fleet has increased in the last decade (2010-2020) by 51,7%, this increase has lagged behind the increase of the global fleet (57,6%). The productivity of each worker in the EU shipping industry is far above average with € 78.000 per head[52].

Employment in the EU shipping industry has increased in absolute terms from 2015 to 2018 from 640.000 to 685.000 (+7%)[53].

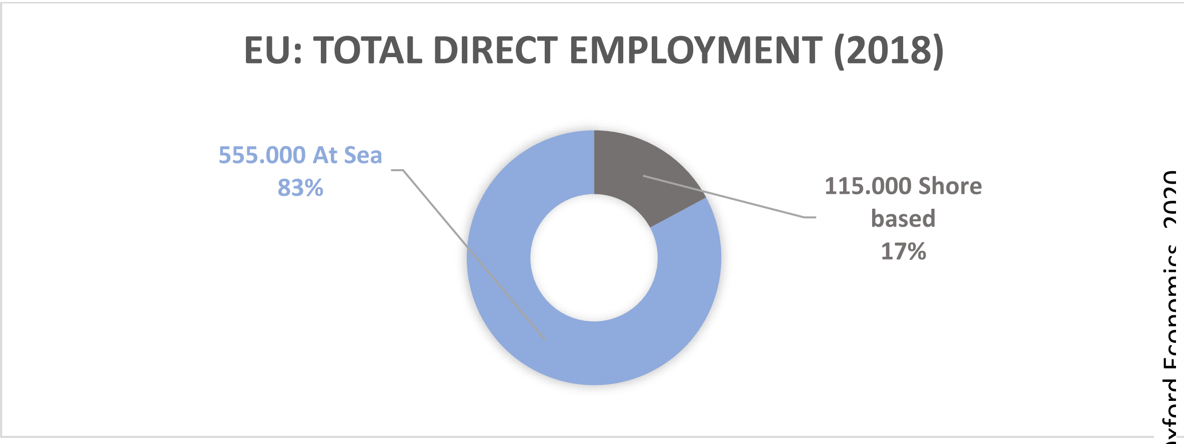

Figure 12: Total direct employment in EU shipping in 2018

While total employment of seafarers on the EU fleet accounts for 685.000 positions, the vast majority work on board vessels.

[52] Oxford Economics. 2020. The Economic Valua of the EU Shipping Industry, 2020. Brussels: ECSA, 9.
[53] EMSA. *Seafarers' Statistics in the EU.* Lisbon: EMSA, 2020, 63 pages.

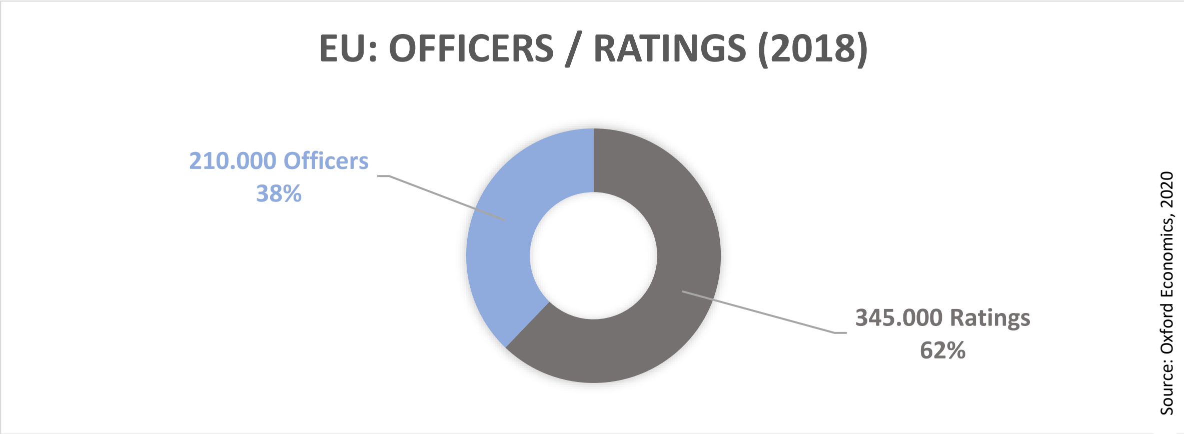

Figure 13: Employment of officers and ratings

Of the employed seafarers slightly more than one third works as officers on deck or in the engine room. Only five EU Members had more masters and officers holding CoCs issued by themselves than those that they had endorsed: UK (30.716), Poland (20.467), Greece (20.450), Norway (16.366) and Croatia (14.291). The non-EU countries which had most masters and officers holding CoCs recognised by EU Member States were the Philippines (39.145), Ukraine (23.449), Russia (16.766), India (8.594) and Turkey (4.997)[54].

However, these figures for the European labour market as well as the global market need to read with caution. As the recent MapMar study on behalf of ETF and ECSA highlighted, “these kinds of headline figures are drawn from a range of disparate sources and, in at least some instances, are based on a set of assumptions, estimates and extrapolations[55].” The authors indicate that the considerable lack of statistical accuracy has been known at least since 2011, when an EU Task Force on the maritime labour market stumbled across the lack of data after commissioning a study[56]. The Task Force concluded somewhat frustrated that “it is clear that detailed data on maritime employment is scarce, sometimes outdated and often not reliable. Moreover, the great differences from a country to another in data collection and presentation of results prevent all serious analysis on employment structure and evolution”[57].

[54] EMSA 2020, http://www.emsa.europa.eu/publications/reports/item/3977-seafarer-statistics-in-the-eu-statistical-review-2018-data-stcw-is.html.

[55] Mapping Maritime Professionals: Towards a full-scale European data collection system . 2021

[56] Sulpice, Guy. Study on EU seafarers’ employment: Final Report. 2011.

[57] TFMEC, Task Force on maritime employment and competitiveness. Report of the Task Force on Maritime Employment and Competitiveness and Policy Recommendations to the European Commission. 2011.

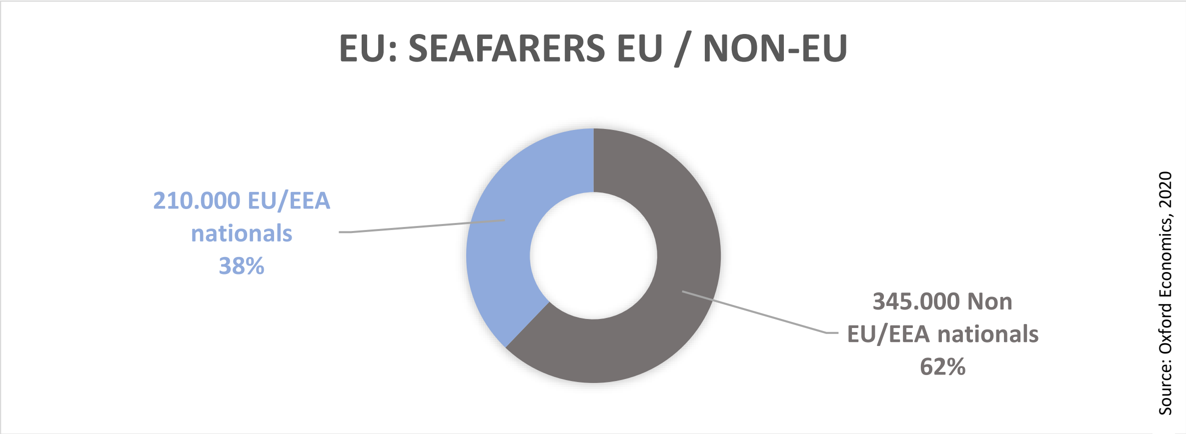

Figure 14: Distribution seafarers among EU/EEA and non EU/EEA

This graph indicates that still more than one third of seafarers on EU vessels are also EU nations or originate from EEA countries. EMSA provides further detail, showing that by the end of 2018, 209,192 masters and officers held valid certificates of competency (CoC) issued by EU Member States while another 106,334 masters and officers held original CoCs issued by non-EU countries (with endorsement).

6 Demographics and innovation

This chapter describes how globalisation impact maritime communities and industrial clusters. Though seafaring is an age-old employment generating sector, as international trade has grown, it has evolved into globalisation and this favoured collaboration in the form of clusters. The clusters enabled increased recruitment of professionals and semi-skilled resources from different countries around the world. Maritime clusters with a variety of job opportunities and career paths to new occupations are a key to talent attractiveness

The research activity included following steps:

- Demographics and shipping
- Innovation in maritime clusters
- Need for new skills

6.1 Demographics and shipping

Globalisation has impacted people and communities throughout the world and is a major driving force of change in society. Global trade is growing, and international regulations stimulate mobility of services, capital and labour. Energised by changes in technology and mobility, globalisation has greatly changed economies and has made our world more interconnected.

The speed of globalisation is relentless. Cities already generate 80% of global GDP[58] and the importance of cities and surrounding regions will strengthen. Cities provide efficiency benefits, which result in gains in productivity and competitiveness. Cities are the centres of knowledge, innovation and specialisation of production and services. In today's world, cities are to an increasing extent competing to attract the best companies and the most talented people.

Shifts in global demographics coupled with long-term economic growth in developing markets, will have implications for the maritime sector. The middle class is growing in the emerging economies of Asia, Africa, and Latin America where disposable incomes will drive growth in demand for imports of commodities and finished goods.

For decades, the world economy has become increasingly integrated. And there is a rise in protectionism encouraging local production and cunsumption[59,60,61].

The world in 2020 could continue on a path of becoming increasingly integrated, but political events started in 2016 suggest that it might be heading in the opposite direction – not least, with the UK's decision to withdraw from the EU and the US performing a shift in its approach to international cooperation and trade. The trade war between US and China is ramping up and the long-term consequences are not easy to predict. Geopolitical tensions and trade policies will continue to influence the industry, but it is very hard to predict the pace and direction of development[62].

One consequence for the maritime sector of a rise in consumer spending in developing markets will be long-term growth opportunities for container ships.

More and larger container ships will require investment in ports, infrastructure, technology, and services to ensure that the flow of business remains efficient.

[58] The World Bank; Urban Development; https://www.worldbank.org/en/topic/urbandevelopment/overview
[59] Frankel E., Shipping and its role in economic development, Marine Policy, Elsevier, vol. 13(1), pages 22-42, January.
[60] Gallegos C., Trends in maritime transport and port development in the context of world trade.
[61] ECSA. Shipping and global trade. Towards an EU external shipping policy.
[62] https://www.forbes.com/sites/billconerly/2020/03/10/rolling-recessions-are-the-likely-economic-impact-of-new-coronavirus-and-covid-19/#33c282fd1320

Though seafaring is an age-old employment generating sector, as international trade has grown, it has evolved into globalisation and this favoured collaboration in the form of clusters. The clusters enabled increased recruitment of professionals and semi-skilled resources from different countries around the world [63]. This has resulted in a shift from national to multinational crews. This change contributes strongly to shipping becoming more dynamic[64]. Although the IMO STCW has resulted in standardised competency requirements, the Shipping Industry is clearly requiring different and additional qualifications on board. These new skills and competences put pressure on the IMO STCW Convention to change. However, extending skills and competencies is a key to competitiveness, so the shipping industry don't wait for international standards to change but adopt own standards. Maritime clusters' promote collaboration with both private and public actors to generate this know-how that update future skillsets[65].

6.2 Innovation in maritime clusters

We have to recognize that shipping has very tight profit margins[66]. Collaboration of clusters and innovation can be a way for shipping companies to work together to promote sustainability while fulfilling the demands of markets[67]. As Wärtsilä[68] adds; *a common recognition is that clusters are a big part of the future in responding to economic and environmental challenges.* The following section of the report seeks to focus on globalisation with respect to maritime activity. Research by Menon and DNV-GL which aimed to identify the future leading maritime capitals of the world[69] ranked maritime cities on a combination of objective data from leading sources and subjective measures. The top 30 cities were identified by a benchmark of 24 objective indicators, then reduced to 15 cities based on the objective indicators and an additional 23 subjective indicators evaluated by an industry experts' panel. The subjective criteria is used to include issues that are difficult to measure such as cluster dynamics, technological expertise, innovation capabilities and so on.

Objective measures, gathered from widely used and renowned sources like Bloomberg, Marine Money, Dealogic, Lloyd's List, IHS, and Legal 500, is used to rank the cities by size and magnitude on all four dimensions of maritime activities and their sub-groups. The subjective indicators are combined with judgements from an expert panel of 260 ship owners, executives, professors and journalists located in more than 50 cities on all continents were to assess the leading maritime cities.

63 Maritime 2050. UK Gov. Department Transport.
64 Lee, P. and Cullinane K. Dynamic shipping and port development in the globalized economy. Palgrave Macmillan, 2016
65 EU. Cluster ACT Cluster ACT
66 Making a fragmented and inefficient container industry more profitable through PortCDM | Hellenic Shipping News Worldwide
67 EU Enterprise and Industry. Tactics. Better cluster policies and tools for implementation. Cluster internationalisation. 2012.
68 Wartsila. Maritime clusters: the future of the marine industry? Maritime clusters: the future of the marine industry? (wartsila.com)
69 https://www.menon.no/wp-content/uploads/2017-28-LMC-report.pdf

When combining the objective indicators and expert judgments equally, Singapore[70], Hamburg and Athens take the top three positions in the total ranking of the leading shipping centres, see Figure 15. This is due to their consistency both in the quantitative data and in the experts' assessments. Four of the top six centres are still located in Europe.

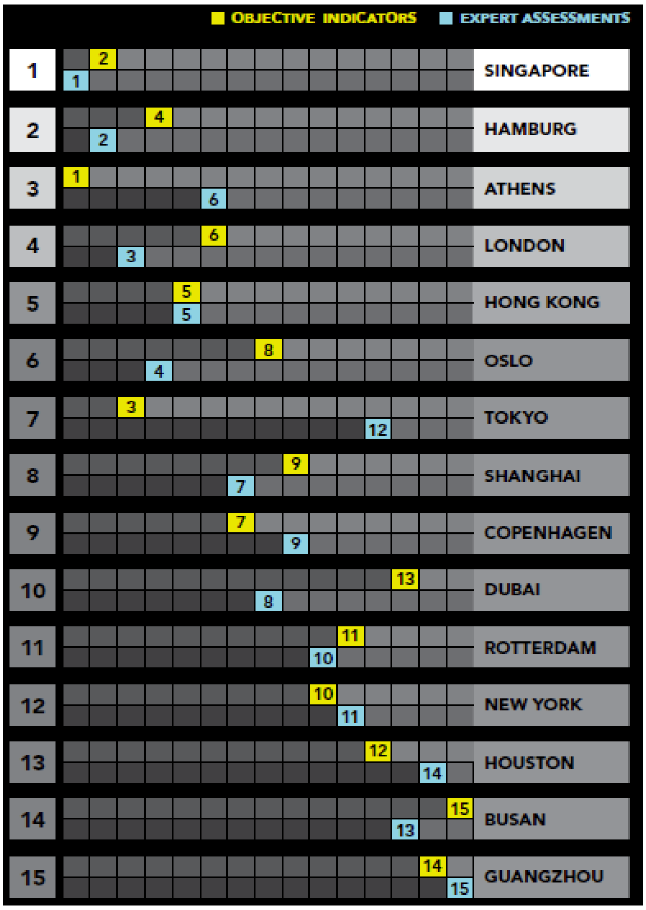

Figure 15: Ranking of maritime cities, Menon see footnote 89.

Singapore's strength lies in its geographic location, with close distance to important markets. The city is a key marketplace for shipping, with an important centre for commercial management. The industry experts rank Singapore highest, while the city scores slightly weaker on the objective criteria.

When measured at city level, the worlds' third largest fleet is controlled by owners in the Hamburg region, making it an important shipping hub in Europe. Despite this, the value of the German fleet has fallen considerably over the last years. Owners in Hamburg have focused on container shipping, a segment that has seen low rates during the last years.

Athens' strengths lie in an impressively large and strong ship owning community. Athens is home to the world's largest fleet and has a strong ownership position, with more than 700 Greek shipowners located both in Athens and around the world. Many Greek shipowners are in cities outside of Greece, something that can explain why Athens only ranks sixth on the subjective indicators, while it is number one on objective indicators. Furthermore, Athens is perceived as primarily serving the local Greek shipping market and not international shipping and hence the experts have voted for other shipping centres that are taking a dominant regional or global role in international shipping. Greek shipowners have played a key role in the industry for decades, and while their orderbook has been halved in the last year alone, they are still expected to be a strong player in the future.

London is ranked as the fourth strongest shipping city in the world, but scores higher on subjective than objective criteria.

Oslo is ranked as number six and is stronger with respect to the subjective criteria. The strength of Oslo is technology. One of the most important technology companies in the Norwegian cluster is DNV GL, with its head office in Oslo. DNV GL is one of the world's leading maritime R&D companies, investing 5% of its revenues on new technology development, as well as the world's largest ship classification society. Note that most of the equipment manufacturers are located along the west coast of Norway but are included in the strength of Oslo in the analysis. Oslo (Norway) is at the forefront of environmentally sustainable technologies and solutions for the oceans.

Rotterdam is ranked number as number 11. The strength of Rotterdam is ports and logistics services.

[70] Singapore is not involved in our analysis. We only illustrate that Singapore is one of the maritime top centres in the world.

Copenhagen is ranked as number 9 and its strength is with respect to attractiveness and competitiveness.

During the last five years the world fleet has expanded by more than 20%. Europe has historically been dominant when it comes to ownership, and still almost half the world fleet is under European control. On the other hand, operations have increasingly moved away from Europe and today many Asian cities are more important for operations than traditional European centres. We also see that European ownership dominance is falling, as Asian shipowners have taken most of the growth in the last few years. Chinese owners, for example, have increased their share of the fleet and now own more than 11% of the world fleet.

6.3 Need for new skills

Strong maritime cities and clusters are expected to grow. Cities with good maritime education and training, combined with surrounding industrial clusters of advanced companies, will have a precondition to develop new competencies for the maritime industry's future workforce. Within maritime cities and corresponding industrial clusters there are complementary competence profiles around the world. However, a unique opportunity for maritime cities and clusters is to achieve a close cooperation and thereby encourage collaboration and specialisation. Unique competencies and thereby education programmes and training will be nurtured in these collaborated clusters.

Companies offering specialised knowledge-based services are probably the least mobile companies in the maritime industry. The reason being that knowledge-based companies often have links to universities, and universities show almost no mobility compared with companies. A key competitive advantage for cities will be those cities that are able to attract:

- Science and higher education
- Owners and headquarters
- R&D – product and technology development
- Financial, legal and other advanced business services

The quality and variety of maritime education institutions, as well as industrial clusters with the necessary density of companies, are key to attractiveness. Clusters of companies, competing and cooperating, support innovation[71], entrepreneurship[72] and access to talents.

Examples of the collaboration of clusters are as follows. Maritime companies will benefit from the ease of finding a skilled maritime workforce through the collaboration. When considering the number of maritime education institutions found in each maritime city, London is a city and home to some prestigious maritime academies such as Cass Business School and the London Shipping Law Centre. Maritime-focused educational institutions in Rotterdam, Hamburg and Athens have a global reputation for excellence. Norway also has a strong education position in maritime technology through NTNU in Trondheim and Ålesund. The closely-knit Norwegian maritime industry gives Oslo an advantage; from Oslo one can easily connect to other local maritime clusters in the country. Hamburg has been the centre for R&D in the German maritime industry. Since 1965, the city has been home to the Centre for Maritime Technologies, and its predecessor Forschungszentrum des Deutschen Schiffbaus. The centre's goal is to promote cooperation between various players in the industry and the academic world, universities and government agencies.

Rotterdam has several universities and research institutions specialised in maritime. MARIN, the Maritime Research Institute Netherlands, is one of the leading institutes in the world for hydrodynamic research and maritime technology. Netherlands' Maritime University offers a MSc in Shipping and Transport (both full and part time) and has been set up in close cooperation with the maritime business community in and outside of the Netherlands. Norway and Germany both have a long tradition of producing maritime

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71 Engel, Jerome S, "Global Clusters of Innovation: lessons from Silicon Valley", California Management Review, winter 2015, Vol. 57 Issue 2, pp. 36-65

72 Porter M., Delgado M. and Stern S., "Clusters and entrepreneurship", Journal of Economic Geography 10, 2010, pp. 495-518

equipment within a high cost environment. This has pushed Norwegian and German maritime equipment suppliers to develop and deliver innovative and advanced equipment with a high level of added value.

Hence, close links between educational centres, shipowners and manufacturers are critical for the strength of such a R&D development strategy.

In the long term, the competitiveness of maritime companies in cities is shaped by the cluster dynamics, that is, by relationships between the different players.

Openness and information-sharing are particularly important, both for reducing transaction costs and even more important for knowledge-flow and innovation.

Shipping's employment problem is that it is seen as low-tech compared with industries such as the aviation, automotive and technology. To attract the next generation of maritime professionals, shipyards must become more technologically advanced and innovative, and seafaring must learn new skills and integrate new technology.

Figure 16: Outlook based on cluster collaboration and innovations

6.4 Case study

A case study is done to gain concrete and contextual knowledge demographics and innovation in clusters. The idea is to explore key characteristics and implications. Our findings will be substantiated, challenged, and exemplified.

Economic Cluster Maritime - Hamburg

Major players from the worlds of business, academia and politics in five federal German states work together in the Hamburg maritime cluster (MCM). A network of more than 350 members. The purpose of the cluster is stated as:

The MCN gives the industry a voice, creates platforms so stakeholders can interact with one another, and promotes interfacing with other industries — innovative, technology-oriented and forward-facing. From shipbuilding, engineering and ocean technology to shipping and offshore activities, the maritime economy has many facets and enormous future potential. In Northern Germany the maritime industry has been key to the economy for decades and will continue to play a decisive role in determining future economic development.

The driving force for this initiative is go gain high-performance in the maritime industry. MCN state that future challenges depend on innovative solution for matters that connect the sea to the shore. MCN helps to find partners for innovative projects and products. MCN creates dialogues platforms, and facilitates contact to other relevant networks. Common projects as 3D printing, greenCoPilt, Blockchain, GreenShipping.

MCN do also have a specialist group of valuable key topics as Innovation management, Maritime law, Maritime Safety, Maritime economy, Offshore wind energy, and Ship efficiency.

MCN follows the theories about innovation in clusters. Innovation is stimulated were experts exchange information on forward-looking topics and solutions. MCN creates exactly these dialogue platforms, and facilitates contact to other relevant industries and networks. By this, our findings are substantiated and exemplified.

7 Voices of maritime experts

We explored key trends shaping the future maritime business in chapter 2. We did a closer look at core technology forecasts in chapter 3 and 4, labour market trends in chapter 5, and demographics in chapter 6.

To get in-dept understanding of how such trends are reshaping the maritime business with respect to needed skills and competences are more challenging. To verify and complement our findings in previous chapters we have done following investigations:

1. Semi-structured interviews of 5 visionaries in the maritime industry
2. Semi-structured interviews of 12 maritime experts from across the maritime industry
3. 3 Focus Groups

Our starting point is to draw viewpoints from a diverse group of companies representing the breadth of shipping industries, including ship owners, ship managers, insurers, brokers, finance, technology, trade organizations and education.

From these categories we wanted individuals that had demonstrated a vision for the future for the company that they represent and that are either successful or dominating in their category. We asked five shipping industry 'visionaries' about their ideas on the way in which the sector is changing and of the necessary future skills. The five visionaries have key roles in major maritime organisations representing the segments ship owners, class society, insurance, brokers, and technology.

We also interviewed 12 maritime experts across the industry. All occupational profiles as stated in the SkillSea application are covered, including shipping, classification society, finance, technology, and manufacturing (equipment production, including IT), workers' union, as well as education. We also covered ports and logistics; however, we only highlight data for those who have an interest and do not analyse this data in this report.

Finally, we conducted three focus group sessions in three countries with multiple stakeholders from various European countries. The first was conducted in France using MS Teams and split in two sessions, one session covering onboard positions of seafarers and one session covering land-based positions. The 8 participants came from 6 shipowners, 1 ship manager and 1 shipyard in Germany, France, Sweden, Norway, Italy, and Belgium. In the second session one person participated from ship design instead of the ship yard and one ship owner was absent.

The second focus group was conducted in Germany using MS Teams in one session. Participants included senior managers from container lines, charter owners and reefer container services from Germany, the Netherlands and Denmark.

Questions were prepared to follow up the interesting topics we identified in our previous interviews with maritime experts. In this manner, our aim was to specify and investigate further our findings for the future.

For these reasons we landed on short lists of candidates as follows:

Table 3: Overview of visionaries, interviewed experts and participants in focus groups

Segment	**Company/organisation**	**5 Visionares**	**12 Interviews**	**Focus groups**		
				1	2	3
Finance:	NORDEA		1			
	DNB		1			
Insurance:	Guard					
	Skuld	1	1			
	Lloyds					
Brokers	Clarksson	1	1			
	Plato					
	Pareto					
	Rystad		1			
Technology	Kongsberg	1	1			
	Transas					
	Furuno					
	Ulstein Group		1			
	Fincantieri			1		
Ship Owner	Maersk		1			
	BW Group		1			
	CMB	1	1			
	Frontline					
	MSC			1		
	Bernhard Shulte					1
	Color Line			1	1	
	Ponant			1	1	
	Hapag Lloyd					1
	MD Offen Containerships					1
	Seatrade					1
	Stena			1	1	
	Carnival			1	1	
Class society	DNV-GL	1	1			
	Lloyds					
	ABS					
Trade unions	Ships engineer union of Norway		1			
Education	NTNU					
	SIMAC					
	UoR					
	UdC					
	LJMU					
	FORMARE					
	STC Group					
	EF					
	UofEgean					
	ENSM (France)					
	HSBA					

7.1 Voices of Visionaries

Knut Ørbeck-Nilssen

CEO DNV GL Maritime

The fleet of the future will be continually communicating with its managers and perhaps even with a 'traffic control' system that is continually monitoring vessel positions, manoeuvres and speeds. Fleet managers will be able to analyse this data, enabling them to advise the captain and crew on navigation, weather patterns, fuel consumption, and port arrival.

I see an industry bringing people together and keeping the world's economy healthy and growing. But the industry itself, the vessels, the infrastructure, and the systems that connect them could change substantially.

The biggest challenge for seafarers is understanding the data. For example, connectivity between ship and shore will have vastly improved and will be much more common.

DNV GL is an international classification society headquartered in Høvik, Norway.

Industry	Various
Founded	1864
Area served	Worldwide
Revenue	NOK 19,639 million

The fleet of the future will be continually communicating with its managers and perhaps even with a "traffic control" system that is continually monitoring vessel positions, manoeuvres and speeds. Fleet managers will be able to analyse this data, enabling them to advise the captain and crew on navigation, weather patterns, fuel consumption, and port arrival.

This will help to reduce the risks of human error leading to accidents, increase cost efficiency, and help to improve environmental performance. Some of this data will also be shared. Ports will use the data to help them plan and optimise loading and unloading.

Classification societies will analyse the data to check on the status of machinery and hull, letting the owners and operators know when a survey is required based on the condition of the systems, helping them to reduce downtime and avoid unnecessary maintenance. At DNV GL, we are excited to be a part of this coming transformation. We will continue to work with stakeholders across the maritime world to realise the potential of our industry and make sure that the outlook for shipping tomorrow is brighter than today.

Alexander Saverys, CEO

Compagnie Maritime Belge (CMB)

We are convinced of the potential of hydrogen as the key to sustainable shipping and making the energy transition a reality. The expertise that we acquire with the HydroTug will enable us to further develop the use of hydrogen as a ship's fuel.

CMB is working on the construction of the HydroTug. This tugboat will be the first in the world to be powered by combustion engines that burn hydrogen in combination with diesel. The port of Antwerp, which requested the construction, has a world first with this project. The HydroTug should be ready within two years.

We are convinced of the potential of hydrogen as the key to sustainable shipping and making the energy transition a reality. The expertise that we acquire with the HydroTug will enable us to further develop the use of hydrogen as a ship's fuel.

CMB is one of the oldest Antwerp ship-owners, headquartered in Antwerp, Belgium.

Industry	Shipping
Founded	1898
Area served	Worldwide
Revenue	USD 496 million (2014)

The hydrogen dual-fuel tug is a new opportunity in a world which demands all businesses, services and industry to reduce their emissions. CMB has looked at the available technologies and found that green hydrogen and hydrogen-based fuels are the only fuels which can provide a zero-emission future for sectors that demand high levels of energy (e.g. long distance transport with trucks and ships).

If the shipping industry moves to new fuel types, it will be crucially important that the people onboard of the ships and onshore can learn new skills with regards to the handling and bunkering of alternative fuels. CMB therefore believes that the implementation of specific education with regards to low and zero carbon fuels is a top priority for the European shipping industry.

Egil Haugsdal

Precident Kongsberge Maritime

Seafarers should know how to interact with the computer systems to respond to challenges in the operation of autonomous ships, such as when routes are changed, or ships are in hazardous waters.

The maritime community is on the cusp of a major technological revolution, and a growing number of industries and companies are going through major changes and a digital shift. Digitalisation provides unique opportunities, which can be seen as an opportunity for new products and services. It is important that KONGSBERG's digital platforms are able to securely integrate shore- and vessel-based data within a broader context. We need seafarers who have the knowledge to translate those experiences so we can develop better products and services for them. For example, autonomous technology is developed on land.

Kongsberg Maritime is a Norwegian technology enterprise.

Industry Marine systems provider for on- and offshore, merchant marine, subsea, navy, coastal marine, aquaculture, training services and more.

Founded 1814

Area served Worldwide

Revenue NOK 22 600 MNOK

However, the users of the autonomous technology will for a large part be seafarers. ***Seafarers should know how to interact with the computer systems to respond to challenges in the operation of autonomous ships, such as when routes are changed, or ships are in hazardous waters.*** Land-based ship operators will need to know how to re-gain manual control of a ship and they will also need knowledge of international and national laws and regulations, to safeguard the company's profits. Humans will always be in the centre when we are developing autonomous ships. The important thing is to understand the new roles and skills that will be required of humans in the future, such as communication abilities in different languages, information security knowledge – how to secure and safeguard ships; negotiation ability – knowing specific cultures and laws in specific areas; and data analytics ability – retrieving knowledge from different data resources, such as GPS, lidar, radar, and other systems and devices.

Andi Case

CEO, Clarksons OLC

Shipbroking is intrinsically a relationship-driven business and we are acutely aware that any technology we look to develop or adopt must not lose sight of the human element of our business. This is not about replacing, but enhancing the tools that our brokers, operators and support staff have in their armoury.

Shipping is an industry steeped in tradition and Clarksons has been established within it for 167 years. As a business, it is important that we lead by example, embrace innovation and ensure that the impact of digital transformation is to improve the efficiency and capabilities of all our employees. **Shipbroking is intrinsically a relationship-driven business and we are acutely aware that any technology we look to develop or adopt must not lose sight of the human element of our business.** This is not about replacing, but enhancing the tools that our brokers, operators and support staff have in their armoury. Clarksons pioneers digital change by developing and investing in digital solutions to support our industry, and this continuous investment in technology is transforming the transaction lifecycle across our four segments. As technology redefines the shipping markets, we are implementing new processes and technologies to be at the forefront of all new regulations that may come into effect.

Clarkson plc is a provider of shipping services and is headquartered in London.

Industry Broking, financial, support and research.

Founded 1852

Area served Worldwide

Revenue £337.6 million (2018 consolidated figure)

Trude S. Husebø,

Chief Human Resources Officer, Skuld.

Skuld collaborates with shipowners and their skilled seafarers in order to prevent injuries to people, the environment and property.

Skuld is dedicated to protecting ocean industries. This is our purpose, our reason for being.

We contribute to sustainable solutions through assessing and surveying shipping risks, conducting comprehensive casualty response service and performing extensive loss prevention programmes which aim at safeguarding casualties and preventing injury to people, environment and property. ***Skuld collaborates with shipowners and skilled seafarers who have their proud expertise in sailing***. In that way, our loss prevention team can get a better understanding of what to look for when entering the field for inspection. If we know the situation better; we know better how to prevent loss.

Skuld is a world leading marine insurance provider with a strong financial position and an 'A' rating with Standard & Poor's.

Area served Worldwide

Founded 1897

Headquarter Oslo

7.2 Key finding from visionaries

- Sustainability and digitalisation are also focused by the group of "visionaries".
- Improved connectivity open for new opportunities in shipping. Control centres will have continually access to data onboard. Fleet managers will be able to analyse and advice the crew on navigation weather patterns, fuel consumptions, port arrival, need for service, and so on.
- However, the users of the autonomous technology will for a large part be seafarers. *Seafarers should know how to interact with the computer systems to respond to challenges in the operation of autonomous ships, such as when routes are changed, or ships are in hazardous waters.*
- Despite introducing more digital technologies the human element of the business is needed. It is vital importance to maintain skilled seafarers that have their proud expertise also in a world getting more digital.

7.3 Structured inteviews of maritime experts[73]

All above skills could be realised in current trends of digitalisation within the shipping industry as interviewees stated (Interview with technology provider and shipping companies, 11.06. 17.06, 18.06.2019). *They believe that we can provide more flexible training through digital platforms and lifelong methods, i.e., e-learning platforms. In that case, people can be trained at home or on vessels. That request not only gaining skills for use technology, but as shipping companies expected, we must expend effort to lead the technology to survive in the future.*

We need systems allowing the best captains to train seafarers anywhere and anytime, supported by high-tech facilities to address any subjects and interdisciplinary skills as needed in industry (Interview with technology provider and energy consulting firm, 28.06.2019, 04.07.2019).

Thus, our interviewees acknowledged that although IMO certificate requirements are a priority and IMO certification requirements seek to ensure a level playing field globally, the future skills of European maritime workforces depend on how well we are able to help them to find their own ways to co-build maritime studies in an interdisciplinary field (Interview with shipping company, agency, union and banks and insurances,13.06, 17.06, 20.06, 25.06, 04.07.2019). This is urgent and necessary. It is probably unrealistic to request other disciplines to take on courses that cover seafarer-specific maritime knowledge. But as a minimum, it should be ensured that nautical studies are kept up to date with a rapidly changing, technology-driven maritime world. To prepare for the future, new courses and teaching methods must be introduced, such as using simulators (including the supported tools, such as VR, AR, and IoT) to train high-risk operations and team performance, both ashore and at sea through e-learning platform (Interview with shipping companies, 13.06, 18.06, 20.06, 04.07.2019).

If we take above advises from the industry, seafarers will be needed other areas as in banks and insurance industries. For example, according to the interviews the banks need talents from the shipping industry who have knowledge to help building up technologies and how data come from those technologies can impact a company's safety and insurance cost (Interview with bank, 25.06.2019). Based on this imagination, the banks and insurance industries hope university could take the responsibility to uplift lecturers' capability to teach seafarers to obtain some financial forecasting skills (Interview with banks and insurance companies, 21.05, 04.07.2019).

In addition, to support new programmes in seafarers' training, the collaboration between the business community and research-based universities should explore new methods and new technology, according to educators in the interview (Interview with educators, 09.05, 11.05.2019). Most skills required in the future, as our interviewees forecasted, are beyond the scope of current training courses and cover areas such as: advanced data analysis, operational economics, future onboard power, and energy production, developing and using statistics and risk analysis (Interview with shipping company, agency, union and banks and insurances,13.06, 17.06, 20.06, 25.06, 04.07.2019). This requires educators to establish

[73] Interview guide, interview analysis and details are summarised in Appendix 1

suitable lifelong learning programmes that enable seafarers to work across industries and services in the maritime shipping sector. For example, although seafarers can be indirectly used, in businesses such as shipbrokers and banks, that does not mean that they will be hired in these industries. The employers only require intensive use of seafarers for some specific tasks.

In this manner, our interviewees said that foreseeing future skills is not the same as manpower planning (Interview with educator, technology provider, and shipping companies, 11.05, 11.06, 13.06, 18.06, 04.07.2019). It would not make for a good prediction of how many *seafarers,* or even maritime professionals, will be needed in the future. However, foreseeing the future requires examination of the ways in which labour markets are developing and consequently, how jobs, skills and learning are changing. *In that case, education system should be flexible, scalable, and most importantly, it is that maritime training institutions encourage specialisation for seafarers to dive into* (Interview with technology provider, bank and insurance industries, and shipping companies, 13.06, 17.06, 20.06, 25.06, 04.07.2019)**.** For example, below are the referred expectations for the future interviewees.

Integrating sustainable skills and digital skills in maritime training to enhance the competence and skills of maritime professionals.

Integrating maritime law, business finance, remote operation, and other new technology-based skills in maritime training to expand STCW training.

Uplifting instructors' knowledge of the future to be able to update training programmes.

Creating strong interdisciplinary environments to link researchers and maritime professionals to shape the technology-driven maritime world towards innovation. Maximise maritime professionals' experience and competence for developing a sustainable technology innovation system.

Establishing effective transfer schemes between academies and companies to address mobility and culture issues.

7.4 Focus groups

7.4.1 Focus Group 1: Cruise and Passengers, seagoing crew (Mai/June 2021)

The first group covering sailing crew consisted of the following participants:

- Furio Boschieri – Innovation Department - FINCANTIERI
- Tino Hensel – Vice president Marine HR – CARNIVAL
- Adam Wallhult – HR Specialist – STENA
- Isabelle Daumas – Global Training Director – PONANT
- Einar Monstad – HR Executive Vice President – COLORLINE
- Stewart Inglis – Director maritime policy and government affairs – MSC
- Moderator; Prof. Dr. Gersende Le Dimna, ENSM

Before the pandemic, 29.7 million passengers took a cruise (2019), growing from 17 milloin passengers in 2009. The Covid-19 Pandemic caused a significant setback for an industry that were growing strong[74]. During the pandemic many employees have left the industry – permanently or temporarily as ships have been laid up. The industry however remains positive and hope to re-employ many of these. Ships laid up and seafarers made redundant.

One company line had temporarily laid off 1300 people out of 2000 employees. Many of the laid off crew moved on to new positions in other industries, making It unlikely that the company can bring them back once the activity picks up again. Therefore recruiting new seafarers and providing them with training will become necessary. This will require additional resources from the company. More operators confirmed this experience and it remains to see how many more will be facing similar challenges. As the duration of

[74] https://www.statista.com/statistics/385445/number-of-passengers-of-the-cruise-industry-worldwide/

the pandemic and the duration of inactivity of many cruise ships have caused a high number of laied up ships it will likely force seafarers to look for alternative employment. Whether any significant number leaves the industry in favour of other trades or industries remains to see but it will likely remind them of their employability or lack thereof. In cases of a lack of employability outside of the cruise and passenger industry it will certainly increase the demand for additional and transitional education

One operator added that finding large numbers of new recruits could be challenging in some locations, as there is a lack of people with the right competencies. Remote working and digital training were pointed at as a possible mitigation to this. One should think that shipping was less location sensitive, but this example shows that the home port and the location of the crewing office is indeed important and that the proximity to the departure/arrival port is a factor when recruiting.

Several participants emphasised the need for investigative skills, connected with the need to conduct thorough analysis of incidents and record accident findings. Such skills are commonly associated with safety & risk management which has become increasingly important, and a significant number of organisations have expressed a vison of zero serious accidents, which take on a lot of different meanings. Nevertheless it signifies that accidents will be investigated with the purpose of preventing it from repeating in the future, thus improving both working conditions and safety for the passengers.

A broad set of skills were agreed upon by the group as becoming increasingly important: leadership, language skills and communication skills and for engineers in particular; green skills, digitalization and cybersecurity. These views are in line with what we have identified through the literature review.

It is a clear statement from the focus group that the competence required by STCW is not sufficient and the industry need to establish additional training programs. Ponant emphasised that its priority is mandatory training first, then training beyond safety training, and much more than what is mandatory. This neither goes against nor supports the issue regarding interns but emphasises rather the need to train candidates in addition to STCW competency. The need for specialised shipping segments such as cruise and passenger to train its crew in addition to STCW requirements is neither new nor surprising and is something which is expected of all specialised shipping segments. What is significant in this discussion is however the competence needs and subsequent training that is not segment specific but is a more general need to be qualified.

Some of the participants have established their own training departments to handle the increased need for crew training, including crews that do not have operational STCW certifications, such as hotel staff, bar and restaurant crew. New occupational roles seem to be emerging, to handle cyber security issues and environmental performance. As one representative added:

> *Lean thinking is also coming, agility, the way of doing IT projects has totally changed and is now run differently. Need different people with different competency for this.*

The participants agree that the cruise and passengers industry will have to change the culture to retain the younger seafarers. The current culture assumes seafarers are willing to stay long periods at sea while the younger recruits expects to stay in touch with land based social life. This means the industry struggles to attract younger talent and faced with this realise it has to change. There is no obvious solution, and the industry needs the young workforce. A possible solution would be better connectivity to enable better digital communication, or to re-think how rotation and periods at sea are planned. Also the idea of internships may help to recruit but more is likely required to retain these recruits in the longer term.

There are some different national rules that influence training. One country (Italy) has a requirement to provide 24 hours of training every third year. There is no guidance as to what kind of training so can be both STCW and non STCW. For both sea and land-based crew this is a positive measure as it ensures a minimum of additional training is conducted and can absolutely contributes to upskilling for transitional opportunities and make the sector more attractive.

Another issue that was raised was crew loosing touch with their workplace while off duty. Changes are sometimes implemented so fast that when there is a crew change the onboarding crew needs to be introduced and trained before the departing crew can transfer responsibility. A mitigation could be to have a connection with the crew through digital tools, such as e-learning courses or similar.

Transversal skills training is becoming important and is observed connected with new technology, as for example when learning to use AI fuel pilot[75] and adopting an engineering mindset for navigators. In this context the navigators and engineers must expect to see their competence needs become increasingly overlapping and similar.

In the workplace the industry needs to ensure a gender-balanced workforce and must make sure it stays up to date on social and cultural issues, with equality and respectful attitudes. The goal of gender balance is both about attracting genders in balanced numbers and providing safe and healthy working conditions for genders while communicating such an image for successful balanced recruitment. Ships may not always be suitably equipped and there seem to be a lack of role models for a gender balance among seafarers in maritime cultures.

The focus group emphasized that a good collaboration with unions is necessary for the future. As the industry is dependent upon qualified and motivated workforce a good relationship with employees and labour unions seems advantageous for both parties. One relevant question, how is the need for competence influencing the role of unions? is it becoming more important? Unions that collaborate with employers to facilitate members lifelong learning and promote career development (such as SkillSea) should be very much in line with operators needs.

7.4.2 Focus Group 2: Cruise and Passengers, shore side employees

- Stefania Ricco – Head of transfer of technology – CETENA
- Tino Hensel – Vice president Marine HR – CARNIVAL
- Adam Wallhult – HR Specialist – STENA
- Isabelle Daumas – Global Training Director – PONANT
- Einar Monstad – HR Executive Vice President – COLORLINE
- Moderator; Prof. Dr. Gersende Le Dimna, ENSM

According to participants, customer orientation was becoming important, and the sales and marketing departments had increased in size due to an increase in customisation of passenger experiences. Customer data platform specialist was emerging as a new occupational profile, tapping into big data.

More training of the crew to cater for customers' needs was mentioned by one representative of a cruise owner/operator who said:

«The cruise industry is much more about providing good customer experience»

The number of people employed in positions handling customers have increased sharply. Beyond regular safety-related training is increasing, soft skills (i.e., leadership, teamwork, culture of inclusion to handle diverse crews, and communication) which is normally used ashore are becoming more important for the cruise industry to deliver on board. One company reconised that pandemic makes it clear more soft skills are needed.

As a leader you have to have the soft skills to manage people working remotely. It requires more communication skills.

[75] https://marine-digital.com/fueloptimizationsystem
The Marine digital voyage planning system allows the operator to build From & To ports routes, determining the optimal route in terms of ETA. The route operator can see the predicted values, taking into account the weather conditions. The system contains an AI module that predicts the best route that provides the lowest latency and maximum fuel economy. Online tracking of the vessel and external parameters allows making decisions in real time. Storm, geo, and weather prediction for navigation planning based on noon-reports and satellite data.

A common viewpoint in the group was that skills for future markets would become essential. This can seem like a somewhat predictable statement but it implies that future markets require an actual skillset, and that this needs to be learnt. It implies that future markets are going to demand insights into its customer composition and understanding and adaptations to their needs. This is supported by McKinsey[76]: *Companies of all stripes have invested heavily in tools and technologies to help them understand their customers more deeply and to gain the advantages of superior customer experience.* The takeaway from this is that understanding customers and generating a unique and superior customer experience will become an important future skillset.

Hospitality was highlighted as a new area where more competence will need to be introduced to crew. Cruise lines must 'mould' their staff to create a work culture supporting this new opportunity. The successful cruise and passenger industry will be the ones who are prepared to train crew through a career road map, not just competitive wages with good vacation arrangements and pensions. *The crew needs to see a future career in the industry, not only an employer.*

Young recruits are behaving differently as participants had experienced that they frequently needed to learn to work in physical team but knew well how to work in digital team. The case in question was of generation Z. (age up to 25 yrs) The group offered no solution to this other than if not addressed these individuals would not be productive in physical teams until they were trained in how to behave, and this has not been something that organisations had to concern itself about previously. It is possible that teamwork in person will become a skill that needs to be trained after graduation of young people that have been educated mainly through online connectivity. One ship owner had initiated an activity that could be a solution to improve this issue by training young seafarers on a sailing ship for two weeks to learn teamwork and to get familiar with classic seamanship. The outcome of this exercise was not discussed.

One representative suggested internships as a useful means for motivating young people to enter the industry, i.e to increase the attractiveness of the industry. In that case, the group underlined the industry has to pay specific attention to ensure the crew you hire are suitable candidates, not only in terms of STCW competency but according to the additional requirements of the cruise and passengers industry. Another solution could be to provide better connectivity so that longer stays at sea is more acceptable for young seafarers. An added benefit would be for online learning to become more available onboard, enabling lifelong learning. This will also make seafaring occupations a more attractive choice for the younger generation. (mentioned earlier)

Global partnering was emphasised as important for the future creativity in the cruise and passengers industry. This points strongly to competency in language, cross cultural understanding as well as digital competency for collaboration and market communication. It connects with the issues raised earlier of developing markets with improved customer experience and passenger loyalty.

7.4.3 Focus Group 3: Container shipping

The participants were:

- Silke Muschitz, SVP Fleet Personnel, Hapag Lloyd AG
- Aashish Puri, SVP Talent & Development, AP Moller Maersk/Hamburg Sud
- Christoph Gesser, MD Offen Containerships
- Vincent Peeters, Technical Director, Seatrade
- Moderator Prof. Dr. Max Johns, HSBA

As the container shipping is transforming digitally, the pressure for operators to adapt is increasing. The rapid pace of change calls for seafarer education to catch up and even anticipate future modifications to the mariner's role on board and possibly on shore.

[76] https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/prediction-the-future-of-cx

On the question of how Container Shipping will be affected in terms of emerging, declining and disappearing jobs in particular through automation, the group had a conservative view. Technology and automation have been an integral part of container shipping for a long time. The “game changer” now is fast evolving software. It was pointed out that some senior officers may be getting lost when they are not prepared for the latest software-based designs. Shore based operations and owners may have an idea for the concept of vessels, but they have to take the people with them. Automation is there to support operation, but will not take jobs away in the foreseeable future.

“We have reduced crew in container shipping to a minimum”

If applied properly, technology is making ships safer and more economical – but eyes and people on the bridge cannot be replaced.

Technology can also help to reduce workload, especially of repetitive tasks. However, sensitive areas like maintenance (and in particular troubleshooting) still need to be supervised and executed by crew. Technology is there to support the crew, not to replace it. Acceptance of technology can be slow, though. Performance monitoring systems were originally refused but have gained slow acceptance. All these data now support seafarers. More knowledge and data bring ship management to a new level. It must not be forgotten, that automation on ships is not a disruptive event, it is already there for decade. Ships and their operation have dramatically changed in the last 20 years; the speed of change may still increase. Seafarers have adapted fast and well to the swift changes. But they have to continue to interact with technology.

On the issue of how seafarers’ jobs will be affected and how reskilling, upgrading, and similar adaptations can be implemented, the focus group had a firm stance. Despite significant differences between types of trade (inter-continental liner shipping, shortsea, reefer etc.), technology will significantly change jobs and may even reduce crew. But technology is not the driver, it is how management does apply technical possibilities. Thus, it comes down to choices. There was the unanimous opinion, that there will be a significant shift in tasks. Ships may operate with smaller crews dedicated to “old” functions. For key functions crew may rather increase. Such key functions will involve new applications at the beginning of the learning curve (i.e. operation of scrubbers).

Some rather occasional and foreseeable supportive functions may rather be done by riding gangs instead of permanent crews. One of the most drastic changes will be driven by significantly improved communications between short and ship. Numerous jobs will be based on substantive integration between seafarers and shore-based staff.

As vessels are getting bigger and built-in parts much more complicated, shipping companies will probably employ more riding gangs with special skills. According to MLC, 2006 definitions they will in most cases be considered seafarers. However, there education and training may be focused on particular aggregates or engines.

The focus group was adamant that already the mid-term (the next 10 years) will bring about big changes in demand of what is needed as skills on board. Though the basic watchkeeping may not change very much, even this will be enhanced by technology and supported by shore-based functions as is already the case in so-called Fleet-Support-Centers. Alone the large variety of new fuels (LNG and many others) will demand significant upgrades of skills among all seafarers, not only engineers. There will be a drastically increased demand for functions on board that can deal with data, their collection, immediate interpretation and transfer. Data and IT skills will be much more needed than ever before. Especially this function will be partly on shore and on board and will have to mediate between both. Generally, the group was of the opinion that few if any really new jobs will emerge. Shipping will mostly have to deal with constant upgrades of existing jobs.

Several group members were of the opinion that there will be a continuous paradigm shift from the current generalist as seafarer to much more specialized knowledge. A diversity of fuels and software operating systems will drive this development. Though it appears quite obvious that specialized skills will be needed, the exact set of such skills is much less clearly defined yet. This will depend on future regulation, future design of vessels and several more variables. A similar but different view was expressed to the effect that there may not come a reduction in the scope of jobs but rather a diversification of tasks – from hardware to software, from bridge service to administrative tasks.

There was no doubt among this group that seafarers with their mindset and general capabilities were perfectly able to learn these new skills once needed.

Finally, the group shed some light on transferable skills for other types of jobs that seafarers may have. It was made clear, that administrative jobs have significantly increased (not only under Corona). These require particular skills which are often not yet part of the typical skill-set of seafarers. There was an interesting distinction that Non-Operating Owners (NOOs) would focus much more on maintenance than charterers.

There was no doubt among the focus group that it is always good to have new talent on board so people see that there are different and better ways to do things. It was also admitted that longer serving staff may be hesitant to learn new skills.

„We see younger people much more motivated to accept training"

One tried and tested method to bring new skills to all age groups and experience levels is the offer of computer-based training. This works particular well, if it directly linked with the possibility to move up the hierarchy. It was also mentioned that in shipping there is a two-layered employment reality with directly employed seafarers and those employed by crew managers. The approaches of both types of employers may differ.

The industry needs to provide seafarers as much as the same training that comparable to the other industries, specifically, STEM competence – Science, technology, engineering and math. Digitalization requires that seafarers have to have a certain understanding of STEM.

New and different skill sets, different work methods, software-based work and much closer cooperation between ship and shore will also require very different transversal skills, where leadership becomes a key. This is about developing a culture within the organization so that training and team work across a much larger group will be vital. As one of our participants says:

Moving to digital platforms to enable remote training is a key. Soft skills or specific skills can be trained with a good training plan for each employee.

This leadership training will be a game-changer. It will help with being aware of strengths and weaknesses, having role-awareness, and self-awareness that is taught through reflection, personal profiling analysis, discussion and having a new mindset. This will increase and widen the career paths of seafarers.

7.4.4 Key findings from focus groups

- Recruitment
  - Challenging to recruit new seafarers
  - A complete career path is needed to attract young talents
  - Recruitment is sensitive to home port and the location of crewing office as well as proximity to the departure/arrival port
- Competence required by STCW is not sufficient
  - Need for additional investigating skills (analysis of incidents etc)
  - Leadership, language skills and communication skills
  - Digital skills and cyber security are more needed than ever before.
  - Green shipping and variety of new fuels
  - Need for specialist educations
- Soft skills to manage teams and people working remotely.
- Sea-land mobility and transferable skills to other types of jobs

7.5 Need for new skills

The industry urges everyone to think of new roles and new abilities of seafarers. Many representatives confirmed that technology changes the whole way of working. In the future, seafarers will be motivated by lifelong learning through various e-learning platforms to widen their skills when flexible and scalable education programmes are in place.

Seafarers are expected to dive into specialisations that, as pointed by the experts from the industry, maritime training need to take the current IMO STCW basic training courses a step further. Seafarers are encouraged to gain knowledge of various skills, such as digital skills, information security, negotiation ability, law, finance, and data analysis. Without a good coloration of clusters in the shipping industry, it is impossible to make a success future. Below, we summarise six key takeaways.

The focus groups also underlined leadership, language, and communication skills as a key competence. The groups made a clear statement that the competence required by STCW is not sufficient and the industry need to establish additional training programs.

1. • ***Seafarers are expected to be able to analyse data, enabling them to advise the captain and crew on navigation, weather patterns, fuel consumption, and port arrival***.
2. • **Seafarers should know how to interact with the computer systems to respond to challenges in the operation of autonomous ships, such as knowing specific cultures and laws in specific areas**
3. • **Seafarers are expected to be able to help banks and insurance companies to prevent loss, to estimate energy use, to improve pollution and reduce fuel emissions.**
4. • **It is important to use digital approach to enable lifelong learning programmes** that **enable seafarers to work across industries and services in the maritime shipping sector**
5. • **Seafarers need a flexible, scalable training system, and it is important that maritime training institutions encourage specialisation.**
6. • **The interface between seagoing and shore-based jobs should be improved to help seafarers building up transversal competences and skills in the maritime sectors, i.e, software development, technology-based sales and marketing.**

Figure 17: Key future skills of seafarers and expectations from the industry

8 Future of learning technology and methods

This chapter briefly presents the rationalities and outcomes of the research activities to assess the future developments of the programs and courses offered at institutions providing maritime education and training, including those offering programs in the closely related fields (for example, Maritime business and Logistics).

The research activities included the following steps:

- literature search and review,
- identification of commonalities and drivers, particularly those enforcing changes,
- assessment of consequences, particularly those affecting learning and teaching methods,
- appraisal of the impacts on the MET institutions' educational models and associated challenges.

The facts, estimations and expectations are presented as concise as possible to keep the length of the text manageable. Further explanations and rationalisations can be found in the attached references.

8.1 Introduction

As emphasised in previous chapters and associated reports, the training of seafarers was traditionally based on empirical knowledge acquired during shipboard work. Due to challenges imposed by emerging technologies, firstly in the 19th century and then more intensely during the 20th century, the training of seafarers gradually developed into a fully-flagged education process, eventually becoming a part of the national vocational or university education process. Today, the providers of maritime education and training (MET) are:

- Higher Educational Institutions (HEI), i.e. institutions delivering coherent STCW-related study programmes, primarily those leading to Certificates of Competency at management level, but also non-STCW study programmes.[77]
- Maritime Training Centres (MTC) as private, profit-oriented institutions offering courses delivering skills required by the STCW Convention and leading to Certificates of Competency or Certificates of Proficiency (operational or support level) offered mainly dealt with safety, security and pollution prevention.
- Specialised MET Establishments (SME) as institutions or establishments providing specialised or high-level education, mainly for those already working on board ships or ashore, offering more in-depth knowledge, usually beyond the STCW level.

These institutions, particularly those offering programs leading to the Certificates of Competency at the management level, so far carried out their activities within the stable and well-known milieu. The main characteristics of the environment are the following:

Regulating authority. The activities are regulated predominantly by authorities responsible for maritime affairs, particularly those responsible for safety, security and pollution prevention (i.e. authorities responsible for implementing the international maritime instruments). In the case of institutions offering STCW-related programs leading to Certificates of Competency at the operational or management level, in most EU countries, the authorities responsible for the national education system have recognisable regulating power. The level of academic autonomy, particularly at institutions offering post-secondary or university-level programs, may be reasonably high, thus permitting flexibility in operations, particularly in respect of their research activities and cooperation with the most important stakeholders.

Framework. MET institutions carry out their activities within a highly regulated and formalised framework, regarding minimal requirements. The institutional structure and programs delivered, even in different

[77] In several EU countries, there are schools at a secondary level offering programs leading to Certificates of Competency at the operational level. Although a part of the national vocational system, these schools are not considered as key players in future, i.e. they are not expected to deliver state-of-the-art knowledge and skills. However, all comments regarding e-learning methods and associated educational models apply to these schools as well even they are not expressly stated.

countries, are alike regarding subjects, sequence, delivery methods, minimal requirements for teachers and instructors, duration, etc. It is especially the case regarding programs leading to the Certificates of Competency or Certificates of Proficiency at all levels. Even in the case of programs not explicitly regulated by the STCW Convention, the programs are highly alike (for example, due to standard industry procedures; the example of such approach is the vetting requirements in the tanker shipping). Consequently, frameworks in different countries are quite similar and comparable.

Funding. Two distinctive sources provide financial support to the MET institutions: directly from the owners (either government or industry) and end-users (seafarers, shore-based employees). For state-owned institutions (primarily those offering programs leading to Certificates of Competency at operational or management level), the governments provide almost all required incomes via a national educational funding scheme. Consequently, funding is stable and institutional development can be planned for several years ahead.

For privately-owned institutions, the funding depends on the market they are serving. If there is a steady supply of end-users and reliable quality of education and training provided, income is stable and provide conditions for further continuous development.

Students. In most European countries, the MET institutions provide education for the student population originating from nearby areas. In other words, the pool of prosperous students is relatively stable, with minor changes over the years. The regions providing the major part of the student population are most commonly oriented towards maritime industries and usually well-known. The percentage of those coming from other regions or other countries is relatively minor. It is also the case for cross-border education.

It may be concluded that the European maritime education and training system, although developed in different socio-economic surroundings, particularly after World War II, has evolved to a relatively consistent system, sharing numerous similarities and closing. Differences are caused mainly by different development paths.

8.2 Reasons to change

In recent decades technology development in all human activities has exceedingly accelerated. MET institutions are not exempted. The changes can be noted during the last twenty to thirty years. Firstly, at a reasonably modest pace, but then more and more accelerated. Probably the most prominent single disruption has been caused by the COVID-19 pandemic in 2019. It caused an abrupt abandon of traditional teaching and almost overnight switch to distance learning methods in most EU countries. However, the pandemic is not the only driver causing the switch; numerous other drivers, probably more influential, prepared the scene for change.

The following paragraphs briefly discuss the most influential drivers and resulting challenges the EU MET institutions recently faced.

Communication and control technologies. Modern communications started in the 1960' with the invention of satellite technologies. New communication means provided those operating in distant areas to be (more or less) continuously connected to the communication network, at the beginning to the message exchange network and later on to voice and data networks. For the shipping industry, new communication means enabled close cooperation between shipboard crews and shore-based personnel, causing redesign of the communication network previously used by the shipping industry. The next leap forward took place with the miniaturisation of the processors, sensor and control components. It enabled extensive personal communications (smartphones) and made it possible to automate the most critical processes. Together with the sensor optimisation and miniature communication devices, computerised control components paved the road to the extensive implementation of automation, including highly complex processes and the use of artificial intelligence, even in routine operations (Internet of Things).

For MET institutions, new communication and control technologies imposed substantial changes in curricula, programs, subject areas and modes of operation to develop new skills.[78] For example, radio officers have been disembarked from ships by the end of 1999, and deck officers were assigned new duties. At the same time, the participation of the shipboard crew in the shipping business diminished, causing gradual abandonment of the related courses from the standard maritime curricula. Educational tools have become highly computerised, and local data networks have become the most critical part of the institutional infrastructure. Once the institution's heart, libraries become interconnected and, in some cases, even moved to the cloud.

Globalisation. New technologies opened up numerous possibilities, both in professional as well as private activities. On the global scale, a process of ever-increasing worldwide interaction and integration among people, companies and institutions (providers and end-users) and governments, has been recognised and labelled globalisation. Although recognised for centuries, the speed up noted in the last forty years has never been noted before.

According to the International Monetary Fund (IMF),[79] there are four essential aspects of globalisation: trade and transactions, capital and investment movements, migration and movement of people, and the dissemination of knowledge. Globalised processes affect many other human activities, such as business and work organisation, national and international economics, and socio-cultural and the natural environment. Today, the three most essential aspects of globalisation are economic, cultural, and political globalisation.

Globalisation significantly affected all aspects of the shipping industry.[80] Thanks to globalisation, the shipping industry has become the lifeblood of the world economy. Accordingly, it affected the EU MET institutions, causing, for example, a substantial decline in the student numbers, particularly in developed countries (highly prominent in specific periods due to a large number of low-wage seafarers employed from non-EU countries), or higher focus on academia-industry cooperation. On the other side, it forced MET institutions to step out and seek partners from other countries, not necessarily European. It was a significant step forward. Before, the MET institutions were primarily oriented to the home region or nearby regions.

One aspect of globalisation should be particularly emphasised. It is a considerable increase in mobility, both within the countries and internationally. And it is particularly significant for the EU countries. As a result, EU MET institutions significantly enlarged their scope of interest, looking for the students, besides their traditional area of interest, internationally and even globally. Most successful institutions become real global players, inviting students from all over the world or offering programs in many countries.

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[78] See for example Kadir Cicek, Emre Akyuz, Metin Celik, *Future Skills Requirements Analysis in Maritime Industry,* Procedia Computer Science 158, 2019

[79] "Globalization: Threat or Opportunity?". International Monetary Fund. 12 April 2000. Archived from the original on 18 August 2017. Retrieved 28 November 2019.

[80] See for example Burke, R., Clott, C., *Education & Professional Development of Engineers in the Maritime Industry*, Technology, Collaboration, and the Future of Maritime Education, Singapore, 2016

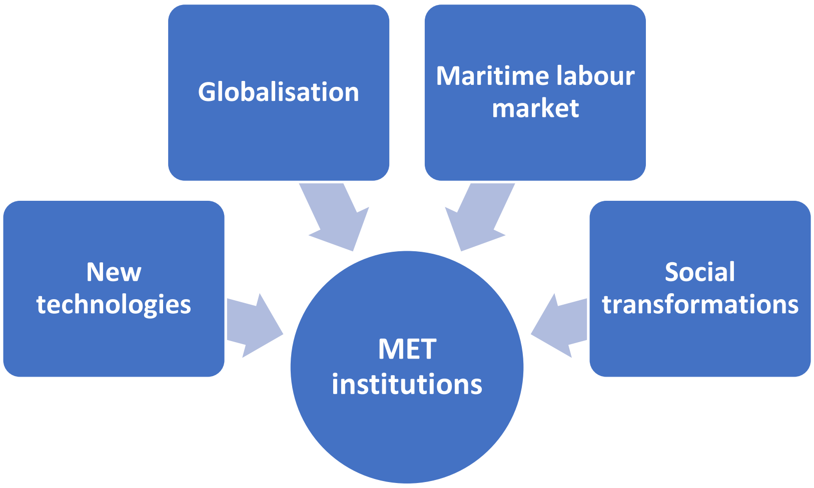

Figure 18: Drivers affecting maritime education and training institutions

Labour market dynamics. Thanks to the processes previously mentioned, significant changes have been recognised across the global maritime labour market. In many countries, the structure of seafarers significantly changed. For example, countries offering predominantly ratings now also offer officers, or countries traditionally maintaining a large slot of seafarers at the international market now employ their citizens only on ships sailing within national waters.

Accordingly, many studies (such as the BIMCO ICS Seafarer Workforce Report[81] 2005, 2010, 2017, 2021) indicated a significant lack of seafarers, predominantly officers. BIMCO/ICS report 2021 estimates the shortage of seafaring officers to 89,510 by 2026. These reports attracted a lot of attention and considerations, although there are no clear pieces of evidence that such a shortage in reality occurred[82]. In any case, these reports provoked MET institutions and shipowners to react and approach each other to ensure a sufficient number of seafarers and an appropriate level of education. Accordingly, efforts to encourage the young people to maritime schools followed, and the numbers of European seafarers seem steady in recent years.

It is important to note that the maritime labour market changes are not over. Emerging technologies are expected to disturb not only the numbers but all other characteristics of the maritime labour market.[83] At present, the scope and extent of the forthcoming disruption are not easily predicted.[84]

Social transformations. New technologies affect not only those who are directly implementing those technologies but also all others. The central mechanism causing social transformation is new media, causing widespread drive toward increasing individualism.[85] The widespread availability of not-easily verifiable information, limited time to absorb content and its meaning and consequences (increasing orientation to peers, relationship breadth, and choice) significantly change the end-users attitudes. Understanding how new media and cultural traditions interact with globalisation and social shifts and affects changes in human development, particularly regarding the student population, is a highly

[81] Previously BIMCO/ISF Manpoer Report

[82] The SkillSea project has not been able to find hard evidence in the form of ships being laid up or routes disrupted over shortage of seafarers. It seems this is more a question of access to qualified seafarers as in seafarers holding all the necessary additional competencies to take on a seafaring position. The shortage could potentiall result in positions being given to margianally qualified seafarers rather than well qualified ones and whether such situations have occurred are not investigated by the project.

[83] See Gholam Reza EMAD, *Shipping 4.0 Disruption and its Impending Impact on Maritime Education*, Proceedings of the AAEE2020 Conference, 2020

[84] See *Transport 2040: Automation, Technology, Employment - The Future of Work*, World Maritime University, http://dx.doi.org/10.21677/itf.20190104

[85] See „New Media, Social Change, and Human Development from Adolescence Through the Transition to Adulthood“, Adriana M. Manago, Shu-Sha Guan, and Patricia Greenfield, The Oxford Handbook of Human Development and Culture: An Interdisciplinary Perspective, Edited by Lene Arnett Jensen, 2015

challenging task for policy-makers at all levels, including those responsible for MET institutions[86] (and not only them).

One of the fundamental issues caused by recent social transformations is the question of knowledge management in new circumstances. A relatively recent phenomenon called '*just-in-time learning'* or '*knowledge on demand*' allows one to find the information when needed. Rather than engaging in long, methodical educational sessions, a provider (formal or informal) creates repositories of information, on less long-lasting media (pdf, wikis, presentations) or use general purpose repositories (e.g. Wikipedia, Youtube) that those interested can access as and when they need it. As a behavioural trait, it evolved thanks to advances in technology and the Internet. Such behaviour is becoming a norm among young people, thus colliding with traditional, more systematic knowledge acquisition. Availability of information is, as a rule, highly beneficial if such approach is considered and found appropriate (for example, when introduced by a company to support its employees). However, in other situations, it may disturb the education process, particularly if effects on cognitive abilities and their development (judgement, critical assessment of situations, social abilities) are not properly addressed. It is worth noting that this behavioural trait is not the only one caused by new media that may degrade the education process. However, this one seems the most influential.

Tendencies outlined in the previous paragraphs may significantly affect the effectiveness of the processes carried out in the MET institutions. MET institutions relatively recently started adopting new technologies and improving learning methods in the education and training field. One may conclude that a need for change is undoubtedly recognised and most EU MET institutions are undertaking or preparing for substantial changes.[87] These changes will inevitably affect all activities carried out at the MET institutions. Yet, although new technologies and resulting new education environments seem promising in many areas, their final benefits could be appraised only after acquiring the experience.

8.3 Consequences

A new environment in which MET institutions are expected to carry on their tasks is characterised by several topics where new requirements and possibilities are primarily visible. These areas may be divided in:

- emerging teaching and learning methods,
- new educational models.

These topics are discussed in detail in the following paragraphs.

8.3.1.1 Emerging teaching and learning methods

Learning methods may be defined as a structured activity deliberately undertaken or resources provided to help the learning process at the individual, team or organisational level. Consequently, e-learning methods are teaching and learning activities delivering content using electronic devices and Internet technologies. These methods, in general, enable teachers and instructors to more actively involve students in the learning process. Briefly, new technologies in education, commonly known as e-learning, provide teachers with an extended set of learning methods.

These methods, as was the case with traditional methods, may be divided into three main groups: 1) expositive methods, aiming to ensure the 'absorption' of new information, 2) application methods, aiming to demonstrate the active processes, i.e. the processes learners are expected to accomplish when carrying out procedural and principle-based tasks and build new knowledge, and 3) collaborative

[86] See Sohyun Jo, Enrico D'agostini, and Jun Kang, From Seafarers to E-farers: Maritime Cadets' Perceptions Towards Seafaring Jobs in the Industry 4.0, MDPI Sustainability, 2020

[87] See Vincx, M. et al, Training the 21st Century Marine Professional: A new vision for marine graduate education and training programmes in Europe. Future Science Brief 2 of the European Marine Board, Ostend, Belgium, 2018

methods, emphasising the social dimension of learning and promoting knowledge sharing and a collaborative work environment.

Recent developments provide MET institutions with many e-learning methods. Their implementation may take immense forms, depending on the characteristics of the curricula, subjects to be delivered, available resources, teachers' competencies, etc. Consequently, MET institutions are urged to use different learning management systems (LMS), i.e. software applications for the administration, documentation, tracking, reporting, automation and delivery of programs, courses and training. As a rule, they provide a set of e-learning methods that teachers can use as building blocks for their courses.[88] The essential capability of the learning management systems is that they empower multiple end-users to access online courses and instructions simultaneously, regardless of their geographical or time zone. Also, they empower an institution to centrally manage educational resources, deliver content in an efficient, consistent and timely manner, automate and optimise processes related to training delivery and administration, and monitor learners' progress and performance. It is assumed that an efficient education process based on e-learning methods need to be supported by adequate LMS.

Consequently, the emerging teaching and learning methods will enable MET institutions to provide:

- Blended learning, i.e. a much closer integration of classroom and online teaching, where classroom time is reduced but not eliminated, with substantial time being used for online learning.[89]
- Collaborative learning, i.e. acquiring knowledge through questioning, discussion, sharing perspectives and sources, analysing resources from multiple sources, and instructor feedback, including the use of social media, thus developing associated social skills.[90]
- Increased student control, selection, and independence in respect of timetable, sources, sequences, etc.
- Objective assessments, including questionnaires and other assessment methods, aiming to ensure fair and objective assessment in all phases of the process (for indicative assessment, as a teaching method and for summative assessment).
- More effective accomplishment of the intended learning outcomes.[91]

For MET institutions, improved experiential learning methods are highly respected due to the nature of the profession. The methods include simulations,[92] virtual reality systems,[93] and augmented reality systems[94] or combinations, and their value is verified beyond any doubt. So far, MET institutions and maritime simulator manufactures have focused on high-end full-mission simulators in which hardware and software are used to replicate realistic, high-fidelity working environments at sea. Although offering high fidelity, there are several significant constraints, the most important being significant resources needed, demanding facilities and maintenance procedures, and limited capacities. It is assumed that new, promising e-learning methods could supplement the simulators and minimise the effects of these limitations.

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[88] See for example https://moodle.org/ or https://www.instructure.com/en-gb/canvas.

[89] See Evangelos Boulougouris et al, Developing multidisciplinary blended learning courses for maritime education with cross-European collaboration, WMU Journal of Maritime Affairs, 2019

[90] See Pedro Manuel Geada et al, *Future of maritime education and training: blending hard and soft skills,* Multidisciplinary Scientific Journal of Maritime Research, 2020

[91] See Robert Kidd, Elizabeth McCarthy, Maritime Education in the Age of Autonomy, WIT Transactions on The Built Environment, Vol 187, 2019

[92] See Steven C. Mallam et al, Rethinking Maritime Education, Training, and Operations in the Digital Era: Applications for Emerging Immersive Technologies, Journal of Maritime Science and Technology, 2019

[93] See Serhii A. Voloshynov et al, *Application of VR technologies in building future maritime specialists' professional competences*, 4th International Workshop on Augmented Reality in Education, 2021

[94] See Baldauf, M.; Dalaklis, D.; Kataria, A. *Team training in safety and security via simulation: A practical dimension of maritime education and training*. In Proceedings of the International Technology, Education and Development Conference, Valencia, Spain, 7–8 March 2016

In addition, e-learning methods provide significant opportunities to effectively improve lifelong learning,[95] particularly in the case of seafarers who are a significant period of time away. They may considerably promote seafarers' career evolution professionally and personally, enhancing productivity, employability, and social stability. E-learning platforms enable more flexible lifelong learning, making it accessible from ships, homes or while away, whether at sea or ashore.

Finally, it has to be stressed that e-learning methods are not a cure-all solution. Proper implementation requires much more rigorous considerations, preparation, and assessment compared with a traditional approach and learning methods. Although options seem infinite and use looks trouble-free, the target learning outcomes are ensured only if the selected e-learning methods are consistent with the course structure, learning objectives, outcomes and assessment methods. Therefore, it is assumed that MET institutions will need to invest substantial resources[96] to bring their courses to the level where e-learning methods and associated technologies will guarantee the effective achievement of the learning outcomes across all courses and programs offered.

8.3.1.2 Emerging educational models and associated challenges

Thanks to the new methods and mainly due to the industry demands, the traditional education model, i.e. the model requiring students to be exposed to the prescribed set of learning methods and associated assessments within the given timetable, has been scrutinised. Most regulatory and industry comments ask for a more effective educational process, more flexible timetables and assessments, and more focus on recent technologies. Although some of the proposals may be opposed,[97] the majority are justified and should be considered in the future.

In the following paragraphs, several approaches that may adequately respond to mentioned issues are discussed.

Individualised education and training.[98] Individualised education and training mean a course or a program individualised according to the needs of the person or a smaller group. The minimum requirement for such an approach is a set of knowledge units, in a considerable part based on e-learning methods. These knowledge units represent a thematic grouping of the content that encompasses multiple and mutually related topics. The units should include all the necessary parts, such as presentations, demonstrations, associated media files, checklists, assessments, etc. Although not necessary presented to the students, each unit should have assigned learning outcomes. Knowledge units may, if necessary, include traditional classroom lectures or other face-to-face activities if so required by the nature of the knowledge and skills encapsulated.

If the program or the course is segmented as required, individualised education or training can be designed. In case of demanding programs or courses, the institution's representative should propose the knowledge units, considering the specific needs of the individual or a group. The goal is to create the program or course in cooperation with students and to adjust it to their needs as much as possible.

The students are commonly required to follow a course outline where self-study sections are interlaced with various active e-learning methods and assessments in a coherent and structured way. The sequence of sections to be mastered are more or less fixed, mainly imposed by their interdependencies. The degree of freedom left to the students mostly depends on the complexity of the subjects. Probably the most demanding part is estimating the student's previous knowledge and experience and how it will fit within the program agreed upon.

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95 See Jeannette Edler and Virginia Infante: Maritime and Other Key Transport Issues for the Future – Education and Training in the Context of Lifelong Learning, Trans. marit. sci. 2019

96 See Ally, M. *Competency Profile of the Digital and Online Teacher in Future Education*. International Review of Research in Open and Distributed Learning, 20(2). 2019

97 See, for example, *Innovation in Maritime Education and Training*, Reza Ziarati, Ergun Demirel. Taner Albayrak, IMLA Conference 2010

98 This should not be confused with individualised education and training for primary and secondary schools for students who need specialised instruction and related services.

One should note that such an approach is time-consuming and demanding on the side of the institution. The approach requires that the institution has an extensive list of more or less independent but connected knowledge units to offer. In the case of specialised equipment required (for example, simulators) or activities requiring face-to-face delivery, the organisation of such programs or courses may become very demanding[99] and may be considered the main obstacle for broader implementation. Another obstacle may be fulfilling the minimal conditions for accreditation according to the national qualification framework if it is required.

Extended scope of the specialised subject areas. Implementing e-learning methods and demands for specialised (and individualised) education requires institutions to invest more resources into developing knowledge units. In such a case, its market position is improving, but the level of organisational complexity may also increase.

Institutions willing to serve several industrial or professional sectors will have to establish and maintain a broad set of knowledge units. Some of them are part of the main educational programs, and some may be delivered as standalone units, offering specialised knowledge and skills to the industry and interested individuals.

In the case of units offering specialised knowledge and skills, support from the industry (subject matter experts employed with interested companies) would be highly recommended. Such support will relax the burden of permanent staff and enable the transfer of knowledge between the institution and industry. Such cooperation will also support the joint development of research and development projects.

For most EU MET institutions, the available resources limit the number of such knowledge units and associated courses, thus stimulating specialisation in a few subject areas.

Training as a service. Courses delivering standardised knowledge, i.e. based on the knowledge units, not mandating face-to-face learning, may be delivered as a fully online course. In this case, direct (synchronous) interaction between students and teachers is minimal or not supposed.

In this case, if courses are correctly designed and developed, the staff workload is minimal, thus allowing relatively large enrolment. One should note that a specific workload is always required, no matter how perfectly the course is designed, developed and delivered. The total workload and costs may be minimised if external providers are involved. In that case, academic staff is responsible for development and design while subsequent maintenance and communication with students may be outsourced, requiring the academic staff to step in only in case of issues going beyond the capabilities of the external provider.

It is worth noting that such an approach could be hardly implemented in the STCW subjects and courses. Also, in the case of specialised knowledge and skills, such an approach in particular subject matter areas may not be applicable (for example, in all areas where hands-on experience is required). Contrary to this, in some areas, such an approach is highly recommended. For example, specialised knowledge and skills required in Maritime Business, Maritime Law and related subject matter areas can be easily transferred in online, distance-learning courses.

Competition and cooperation. After World War II, education in Europe was mainly considered as a specialised area, as a rule, within the government umbrella. Although there were fully private institutions, many institutions (not only MET) were funded and regulated by respective governments. New technologies and globalisation undeniably changed the picture.

The most important consequence is much higher students' mobility than ever before. In a Europe without borders, with the highly developed road, rail and air connections, and efficient and cost-effective communications with relatives back home, enrolling at an institution in another European country has

[99] Md Golam Jamil, Zakirul Bhuiyan, Deep learning elements in maritime simulation programmes: a pedagogical exploration of learner experiences, Int J Educ Technol High Educ, 2021

never been as trouble-free as today. A strong push in that direction has been made with the EU Erasmus mobility program, providing institutional support to students, teachers and institutions.

As a result, institutions offering programs in the English language are emerging every year. As a consequence, institutions are now exposed to much broader competition. The same applies to MET programs, although their number is relatively modest, comparing with other programs commonly found at higher education institutions. It may be concluded with certainty that this trend will continue in the future, benefiting those who deliver more developed programs and penalising those lagging. In that respect, well-developed e-learning courses and an overall orientation to blended learning as the primary delivery methodology will make the difference.

While the mainstream professional education will, beyond any doubt, remains under the government umbrella, the parallel educational system, mainly offering high-level knowledge and skills, is emerging. The drivers are recent technological developments and globalisation, on the one hand, and the ever-increasing demand for new knowledge and skills mainly developed due to the use of new technologies, on the other. As a rule, these programs are:

- highly specialised, in most cases closely related to complex software or sophisticated products,
- offered as a part of the consultancy, mainly to the companies and much less to the interested individuals,
- delivered by software or equipment manufactures or entities closely connected with manufacturers.

A notable example of such an approach is the DNV Academy,[100] offering a broad range of courses, some of them built upon extensive knowledge their experts collected over the years, in addition to many low-level courses that do not require particular expertise.

After all, even the shipping companies and crewing agencies are beginning to offer educational programs to seafarers they are contractually or otherwise related. As a rule, these entities consider such activities only if a sufficiently large number of seafarers may be attracted, thus making the whole venture economically viable. The notable examples of such ventures are the Maersk Training[101] and Maersk Procurement Academy.[102] Both institutions are a part of the large shipping company, thus targeting its seafarers and employees. In addition, they also provide services to other interested individuals or partner companies.

It may be concluded that such ventures will continue to develop and eventually even extend their services. One can easily imagine that such institutions may reach the point when they can compete with traditional MET institutions. Even in this case, the advantage would be given to the institutions providing more effective learning, i.e. more attractive and more affordable education. And even in this case, it will depend on the overall quality of education and more effective implementation of the e-learning methods.

Both trends, discussed in the previous paragraphs, clearly indicate that increased competition in forthcoming years will beyond any doubt impact the way present MET institutions are operating. Bearing in mind that resources available to the MET institutions being a part of the national education system will remain limited, and in any case, not comparable to resources available to competing institutions established by the industry, the only viable strategy[103] is to promote cooperation among different institutions[104] delivering MET programs at various level. By closer cooperation,[105] not only with institutions

[100] See https://www.dnv.com/maritime/maritime-academy/index.html.
[101] See https://www.maersktraining.com/b2c-course-category/maritime/.
[102] See https://www.maersk.com/procurement-academy/course-catalogue.
[103] See Jack Harris, Peter Sunley, Future Skills Requirements for a Global Centre of Maritime Training and Education: Skills Challenges for the Solent, University of Southampton 2021
[104] See for example Oral Erdogan, Ergun Demirel, *New Technologies in Maritime Education and Training, Turkish Experiment*, Universal Journal of Educational Research 5(6): 947-952, 2017
[105] The idea is not new. It was scrutinised in 1990' during METNET and METHAR projects and promoted by Günther Zade from WMU.

in the same country but also across the EU,[106] all institutions will benefit and use the available resources more effectively.

8.4 Conclusions

The most important conclusions are the following:

1) Future learning technologies, particularly learning methods, will depend extensively on e-learning methods and learning management systems.
2) The predominant form of maritime education and training in the future will be blended learning. Future programs and courses are expected to promote transitional skills by the more extensive use of collaborative learning.
3) Programs leading to Certificates of Competency and Certificates of Proficiency will preserve substantial parts of knowledge and skills to be delivered using face-to-face learning methods, although even those subjects may contain parts delivered using e-learning methods.
4) When developing or re-developing MET programs, MET institutions must consider the effects of new technologies, globalisation, labour market changes and social transformations. Although these drivers, as a rule, positively change the learning environment, some aspects may become pretty challenging and may put the forthcoming transformation and its effectiveness at risk.
5) New learning methods and associated educational models will require more effort to design and develop knowledge units, particularly ensuring a coherent structure of programs and courses delivered using e-learning methods. In that respect, particular attention should be paid to the selection, implementation and management of the learning management systems since they will become a core part of the learning technology used at the MET institutions.
6) MET institutions will be required to reconsider their development policy with particular attention to the scope and depth of the knowledge and skills they will provide. In that respect, the additional mechanisms to promote cooperation among MET institutions across the EU should be considered, and a cooperation strategy in respect of other providers of educational content, mainly those closely connected with the industry, should be developed.
7) Since significant milestones are still not defined (e.g. IMO and regulations on autonomous vessels[107] [108] [109]), the MET institutions development policy should be regularly re-examined and adjusted if required.

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[106] See Evangelos Boulougourisa*, Leonidas Chrysinasa, Georgios Vavourakisa, Panagiotis Mizythrasa, *Maritime Education in EU: Strengths and Challenges,* Proceedings of 7th Transport Research Arena, 2018, Vienna, Austria

[107] See for example Baldauf, Michael & Kitada, Momoko & Mehdi, Raza & Dimitrios, Dalaklis. *E-Navigation, Digitalization and Unmanned Ships: Challenges for Future Maritime Education and Training*. 12th International Technology, Education and Development Conference, 2018

[108] See M. Baldauf & S. Fischer, M. Kitada, R.A. Mehdi, M.A. Al-Quhali & M. Fiorini, *Merging Conventionally Navigating Ships and MASS - Merging VTS, FOC and SCC?* Transnav, Vol 13(3) 2019

[109] Wang Deling aet al, *Marine Autonomous Surface Ship - a Great Challenge to Maritime Education and Training*. American Journal of Water Science and Engineering. Vol. 6, No. 1, 2020

9 Future working environment and skill needs

9.1 Future skills

In this chapter we have combined findings from key trends, labour market, digitalisation, green shipping, demographics, and voices of maritime experts.

All views have a common understanding of aspects as the ships will be smarter, data driven, connected, greener and the role of innovation.

The maritime experts also highlight the importance of transversal skills, sea-land mobility, and innovation.

The future maritime activity will integrate people and digital technology in a way that transform how we operate and interact. A new operation paradigm needs to be created to meet these challenges.

We have therefore divided the digital transformation into two subjects, skills needed to master the digital technology and skills needed to master operations in a digital world. The second subject was focused by the maritime experts but is challenging to define. More research is needed to fully understand the opportunities.

9.1.1 Green shipping

A continuous stream of new technologies is being introduced in the shipping industry to ensure that it meets new operational limitations set by environmental regulations. For example, leading shipping companies (Maersk CMA CGM, MSC and Hapag-Lloyd) team up to drive emission reductions faster than regulators. The CO_2 reduction targets, and new sulphur emission limits are key drivers of these technology developments. As part of regulatory compliance, several technologies are likely to be improved - for example, hydrodynamics, new fuel and energy sources, logistics, and methods for effective harbour operations.

Currently, then only technically applicable alternatives fuel for this are liquefied natural gas (LNG) and sustainable advanced biofuel. In addition, systems to reduce emissions and particulate matter in harbours and the proximities to cities will be important. See figure 19 for a list of key skills to master.

9.1.2 Digital technology

Ships will be smarter, data driven and connected to the rest of the world. We are facing a stream of new digital technologies and we will see new solution in the years to come. It is a precondition to master technologies as digital communication and teamwork, sensors, IoIT, networks, Ship 4.0, cyber security and so on.

In depth skills to understand complex systems, onboard and onshore, is needed to be able to serve the needed redundancy of all systems. Skills to update, service and repair of digital systems is also needed.

Seafarers should know how to interact with the computer systems to respond to challenges in the operation of automatic systems, such as when routes are changed, or ships are in hazardous waters. See figure 19 for a list of key skills to master.

9.1.3 Operations in a digital world

Seafarers are become system managers. In depth skills to understand complex systems, onboard and onshore, is needed to be able to serve the needed redundancy of all systems.

Distributed maritime capabilities where knowledge and competence are increasingly distributed to technology, procedures and regulations will change role of the individual seafarers. Vessel positions, manoeuvres, speed, fuel consumptions, cargo condition and so on may for example be monitored in control centres. Fleet managers will then be able to analyse this data, enabling them to advise the captain and crew on navigation, weather patterns, fuel consumption and port arrival. We will have distributed maritime capabilities as well as dispersed ship crew with other roles and responsibilities than we can see in present operations. Soft skills are needed to master communication throughout the value chain.

The fixing of malfunctions on-board often requires outside expertise from the suppliers. While ships were traditionally autonomous organisational systems that the seafarers on board mastered alone, ships are now increasingly part of large networks of ships, several internal and external IT systems, control centres, yard, certification agencies and regulations. Common broker platforms and e-commerce will simplify and secure the supply chain and reduce the amount of paperwork in the value chain under the heading of block-chain technology. These advances enable integration of the business process and reduce transaction costs.

The complexity of sociotechnical systems into which ships are increasingly woven requires increasingly complex control systems. We have coined this transition distributed maritime capabilities and use of dispersed teams.

Also, sensor data from onboard integrated machinery systems is being increasingly transferred to shore centres. Digital twins enable real-time data analytics by use of AI and machine learning tools to support a rich management and operational view of the entire supply chain. This technology will enable a high degree of streamlining of operations from ship control centres. See figure 19 for a list of key skills to master.

9.1.4 Innovation

Regions with good maritime education and training combined with surrounding industrial clusters of advanced companies will have a precondition to develop new competencies for the maritime industry's future workforce.

Maritime professionals (seagoing and land-based professionals) have for decades contributed with operational maritime experience and knowledge to companies in the maritime sector, and they are still crucial for realising much of the maritime industry's innovation potential. Close interaction between maritime professionals and researchers provides a faster and more precise path to new innovations. See figure 19 for a list of key skills to master.

9.1.5 Sea-land mobility and talent attractiveness

A key finding from the expert group is the importance of transversal skills within future maritime competences. These skills are vital to move from one value chain to another. Lifelong learning programmes are needed to enable seafarers to work across industries and services in the maritime shipping sector.

Mobility and **possibilities** to enter a variety of occupations are needed to attract young talents. See figure 19 for a list of key skills to master.

Green shipping

- Measurement, calculation and documentation of emissions, EU and international legislation
- Operation of complex hybrid and zero emission machineries
- Environmental economics, performance management systems
- Logistics and optimisation methods to achieve high vessel utilisation
- Advanced routeing, considering factors such as wind, current, and waves
- How to handle a variety of fuels (toxic content, explosion etc.)

Digital technologies

- Basic digital technology skills as for example
  - Sensors
  - IoIT
  - Networks
  - Connectivity and
  - Cyber security
  - Ship 4.0/ Industry 4.0
- Advanced analytics and use of data in optimisation of the fleet
- Deep understanding of the complex systems onboard and systems connected to the ship to be able to serve the needed redundancy of all systems
- Updating, servicing and repairing digital systems

Operations in a digital world

- Seafarers are become system managers. They need deep understanding of complex systems.
- Seafarers should know how to interact with the computer systems to respond to challenges in the operation of autonomous ships, such as when routes are changed, or ships are in hazardous waters.
- The future fleet will be continually communicating with its managers that is continually monitoring vessel positions, manoeuvres and speeds. Fleet managers will be able to analyse this data, enabling them to advise the captain and crew on navigation, weather patterns, fuel consumption, and port arrival. We will see distributed capabilities and use of dispersed teams
- Distributed capabilities and dispersed teams. Sharing of work tasks due to shore-based control centres supporting ships and remote operations.

Innovation

- Understanding of business development taking advantage of digital technology (for example: cargo tracking, cargo and machinery condition monitoring, logistics in digital connected value chains, smart port operation, fleet management, e-brokerage, smart commerce with blockchain)
- Good maritime education and training located in strong industrial clusters will have a precondition to develop new competencies
- Close links between education institutions and industrial clusters can foster innovation as knowledge creation and strength of R&D

Sea-land mobility and talent attractiveness

- Transversal skills needed to move from one value chain to another
- It is a need to establish suitable lifelong learning programmes that enable seafarers to work across industries and services in the maritime shipping sector
- Maritime clusters with a variety of job opportunities and career paths are a key to talent attractiveness
- Improved interface between seagoing and shore-based jobs can help with building up transversal competences and skills in the maritime sectors.

Figure 19: Future of working environment and skill needs

9.2 Recommendation for training

9.2.1 Current maritime training

The IMO STCW standard of training provides a common level of competence for seafarers worldwide. It is used by all MET academies when creating curricula that constitute seafarer occupational profiles. The A section contains the requirements for both general certificate levels, specific ship type competence requirements, and sailing area and type competence. As such, a student graduating with, for example, a D3 navigators' certificate has completed training towards the same requirements regardless of which MET is attended.

In addition to the common requirements, there are additional requirements that are not compulsory unless you are sailing a type of ship or in an area requiring this type of competence. Examples of this are IGF training for LNG-fuelled ships, Polar Code training for sailing in Arctic or Antarctic regions, Dynamic Positioning training for DP class ships, High Speed Craft training for passenger vessels exceeding 20 knots and 20 passengers. These are only some examples of the additional training programmes that are defined in the STCW A section.

The B section describes model courses that if implemented by a MET will meet the corresponding requirements in the A section. For example, in the B section there is a Model Course for the Polar Code, which consist of 40 hours Basic training and 40 hours Advanced training, 80 hours in total. By implementing this course, a MET academy is in line with what IMO sees as a sufficient to fulfil the Polar Code requirements in the A section. It is not the IMO that approves, but the National Maritime Administration (NMA) in each IMO member country. The IMO STCW training also caters for the need of coastal and smaller ship types for limited certificates that typically require only one year or less of education (D5) and are limited to, for example, the North Sea and Baltic Sea, for ships below 500dwt. Now, each NMA may issue or approve different ways (as compared to Model Courses) of complying with IMO certificate requirements. For the example above, this means that Norway's and Sweden's NMAs have approved 20 hours Polar Code Basic training and an Advanced training programme of 20 hours to comply with the Polar Code requirements (40 hours total instead of 80) based on national considerations.

A seafarer that graduates by only fulfilling the minimum certificate requirements will soon need to take additional training at or outside of a MET academy. Depending on trade and market conditions, this additional training is covered by the employer, by the seafarer or by a third-party sponsor or public funding.

9.2.2 Future maritime training

As we look at the findings, it is relevant to look at what relates to the IMO and what is independent of IMO requirements. STCW is mainly about the safe navigation of ships and less about being efficient and economical. But such requirements are emerging through IMO. For example, the sulphur cap on Heavy Fuel Oil (HFO) introduced in 2020. Those ships who choose to install scrubbers as a solution to achieve the emission goal of less than 0.5% of sulphur will need to adapt to a lot of new scrubber technology.

Training programmes proposed for seafarers and shore-side employees as a result of our investigation into future skills needs will fall into the categories of training that fit with the purpose of STCW or are independent of STCW. By offering specialised training (module courses) in addition to STCW, we provide an opportunity for maritime professionals to gain a higher competence[110]. This will help maritime professionals to enhance their skills and employability. Such specialised training will act as a 'dynamic system' to help to close the gap between current and future needs, as well as an extra aid to respond to the ongoing changes of IMO STCW.

The drivers for change are already present and influence the maritime shipping industry. With time the drivers themselves will change. Most certainly sustainable development will increase in strength,

[110] More details about future training can be find in D1.2.1 and D 1.3.

collaboration of clusters is likely to continue but may temporarily decline due to ongoing trade wars, digitalisation is growing stronger day by day, and lifelong learning has just started and is set to increase. What is the best way to adapt and react to the drivers in order to be a successful maritime professional in Europe? We can say for sure that competence in new technology, new equipment, especially in digital and sustainable technologies, leadership and people skills, as well as transversal skills, must be fulfilled. We also acknowledge that the above cannot be fulfilled at the time of basic training, as those who have already been trained need to catch up and stay updated until retirement. And although basic training most likely can deliver competence in line with industry needs, it is certain that with time technology and operational methods change and maritime professionals need to adapt through training.

Thus, we have a suggestion for the possible future development of maritime training in Europe. We suggest a module course package in between current training and future development. The purpose is to establish an opportunity to build up new knowledge for maritime training without intervening in the STCW Convention but to respect worldwide trends in digitalisation, sustainability, collaboration of clusters, education and training. In such a module course package, we suggest new courses to fulfil the industry's needs, *such as digital, language, and social literacy, as well as ship finance, law, insurance and management competence*. In terms of digital skills, we suggest utilising VR, AR, simulator-based learning and other techniques as a means to support the development of future skillsets. However, it should be borne in mind that member countries should only take our suggested module course package as a framework. Thus, for specialisations in present occupations, each country could develop module courses that fit the context of their countries in various formats, such as degree-oriented (i.e., BSc or MSc) and non-degree oriented training (i.e., certificates).

For cross-functional skills and soft skills, each country can decide itself which comes first in model course package. The fundamental is to provide more training paths for seafarers to broaden their skills, both on land and at sea. In that case, we fully address maritime training initiatives with additional focus on the internationally agreed training of seafarers regarding IMO standards, while also offering new chances for seafarers towards knowledge-based industry, such as:

- Training on domestic and other European ships, including management skills, foreign language as a second language, and culture
- Training in home nation and other European METs, including management skills, foreign language as a second language, and culture
- Training with respect to multiple cultures and nationalities in team operations in computer-based environments, using simulators as an example.

9.2.3 Opportunities in new learning technologies

In the future, the skillset of maritime professionals should give flexibility to individual learning paths. With e-learning and simulation-based training, lifelong learning becomes more available and enable those who work at sea to expand their knowledge and acquire transversal skills.

Seafarers who have transitioned to land could shape future skills with their seagoing experience and competence to help the development and innovation of ship technology.

Then Covid 19 totally disrupt the classical learning methods and the privilege of close physical interaction. MET, colleges and universities responded very quickly, and training program turned into partly digitally and partly physical sessions. We have seen a tremendous development in tools allowing cooperations as MS Teams and Zoome as well as introduction of many new learning management platforms.

On-line education has seen a massive development within the last year. In many ways, the 21 century begins in 2021, the true digital transformation. On-line education is growing, and it will not disappere.

Simulation-based learning has traditionally been used to train navigational competence and engine engine room competence. It is becoming increasingly available for more demanding scenarios that are too dangerous or too expensive to rehearse in real life. This allows maritime education and training to prepare seafarers for new technology while also assisting maritime professionals in validating their new developments. The ships of the future will be based on advanced technology at all levels and will require different and more technically advanced knowledge and expertise than today's shipping.

The simulator helps seafarers learn the highly contextualised/situated knowledge of the maritime work environment and provide opportunities to work together in a team, practising qualities such as critical thinking and leadership.

Advanced tools using Virtual Reality and Augmented Reality will enable maritime professionals to explore, understand and train operations, procedures, technologies and tasks at a conceptual, operational and detailed level. This has the potential to reduce the need for practical training. Similarly, the availability of simulation through cloud computing is enabling remote access and remote participation in training, reducing the need for travelling.

9.3 Occupational profile

Occupational profile should respond to the global and education trends of shipping and new requirements for the industry. However, education-driven occupational requirements now are slow to change and this leaves METs with insufficient competence for the technological innovation in the workplace. Our interviews with key players in the shipping industries identified a consensus that occupation is not isolated from technology, finance, port and logistics, and more. Not only these experts, seafarers also hope to gain cross-function and soft skill competences (D1.1.2) in the future. This requires us to assert that the professionals the shipping industry employs have a rounded understanding of all aspects of maritime operations, as well as the capability to transition to onshore businesses, such as ship financing, maritime law, logistics and so on. This forces both METs and industry to seek an extra aid to widen STCW-based occupations in the future.

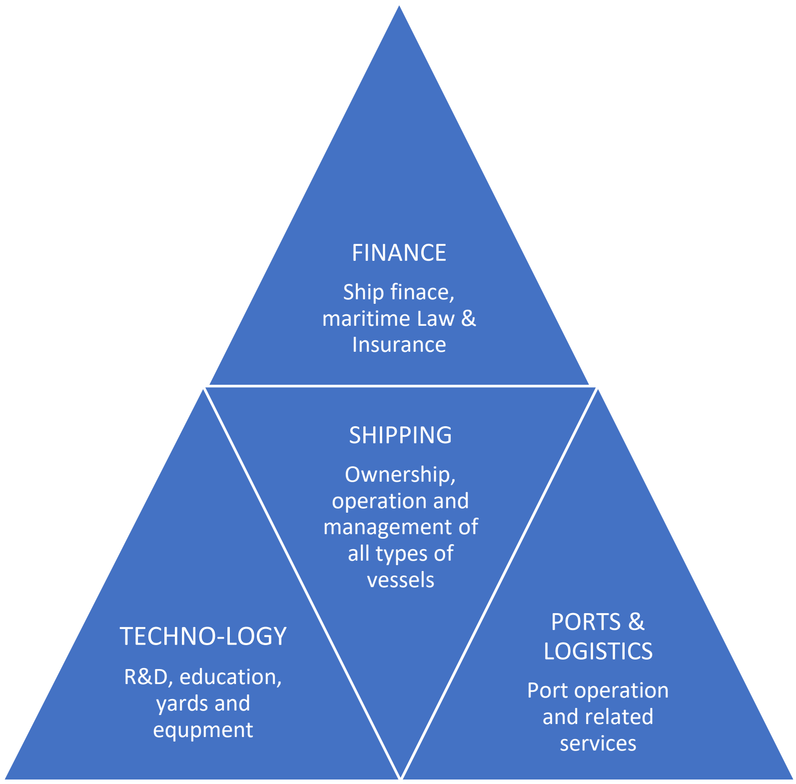

Figure 20: From shipping to land based positions

9.3.1 Mobility

With additional modular training courses on e-learning platforms, maritime professionals, in particular seafarers, will able to gain new knowledge and competence which is greatly needed in the future shipping industry. This competence will be their new profiles which can be seen as 'brands' to attract youths to enter the maritime industry and promote maritime professionals who are willing to shift positions from sea to land. Also, the new competence will encourage land-based professionals increase their interest and willingness to work at sea[111]. Moreover, the dynamic system with modular courses will increase mobility to help to shorten the distance between the gap of current and future skills. The mobility, in that case, also goes beyond the sea-land jobs and allows multiple choices for flexibility and in-demand career paths.

[111] The future occupations at sea might very different than today. No one knows what it will look like. We assume people who are curious to work at sea will be attracted.

10 Appendix 1 - Interviews of experts in the maritime shipping business

In this section, we provide our qualitative research analysis of the interviews with experts in the shipping industries in Europe. There are two sub-reports in this section, part A and part B.

10.1 Interview analysis – Report A, Scandinavian countries

D1.1.3 NTNU team (Alphabetical order)

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10.1.1 Data collection and analysis

The data collection took place from the beginning of May to the end of September 2019. In total, 12 interviews were conducted, including shipbuilder, university educator, technology provider, shipping company, workers' union, consultancy, bank, and insurance company representatives. A student assistant was hired to collect data. However, all data were transcribed, analysed, and represented by the researchers. Since coding is a highly personal skill, the code and memos followed personal coding paradigms [3, p.27-28]. Struss defines coding as

the general term for conceptualising data; thus, coding includes raising questions and giving provisional answers about categories and about their relations. A code is the term for any product of this analysis (whether category or a relation between two or more categories). (3, p.20)

In this vein, it is clear that coding and analysing are intertwined. To collect the code and memos, researchers linked patterns from different notes to derive themes and meanings from the interviews. Analysis began early in the research process, focusing and refocusing on the research aims and questions. In this way, the researchers could phase and address any issues with specific people. This also helped to answer the questions the interviewer raised; for example, what are people trying to accomplish now to meet future needs? What specific means and/or strategies do they use? How do they characterise the future and understand what the future will be? Is it any different with current needs in the maritime domain? What assumptions are they making? All of these led the interviewer to reflect: what do I see going on here? What did I learn from these notes? [3]. Particular attention was given to categories such as education, technology use, digitalisation, skills, operations, offshore, onshore, digital competence, future, now, strategy, policy, green and sustainability, rights, role of university and industry, and the combinations of such. In doing this, the researchers conducted thematic index analysis. Interesting events were marked or boxed in with different colours. These colour marks were accompanied by comments, explanations, and references to related events of interest. All of these were written in the margins or on blank back pages of the researchers' field materials. Sometimes, the researchers made notes on the cover of a piece of field material to indicate thematic events in a given context. The researchers also wrote coding memos and comments for self-use. In addition, there was no video recording, and neither personal nor corporate information was gathered. Given that some of the interviews were audio recorded, an oral agreement between the interviewer and interviewee was made to ensure that transcripts would be rephrased with regard to ethical considerations. Furthermore, particular emotions and body movements were noted during conversations. This vitally assisted the researcher in identifying those parts of the transcripts where particular attention is needed in cases of sensitive and personal expressions and/or perceptions and should not be identified outside this report. Thus, the material presented in this report (see Findings section), as an aggregation of the various materials collected during the interviews, has been rephrased.

10.1.2 Findings

Capital flows, human skills and dreamland

As main onshore players, banks and insurance companies invest in and shape the shipping and technology industries in a significant way. These financing entities are not just concerned with where to invest; they are also highly interested in how to prevent loss. To this end, they invest capital into new technologies that could help them to monitor the daily operations of shipping companies, including the health status of the seafarers in shipping. According to a senior advisor at one of the leading banks in Nordic countries:

> *Knowledge within surveillance of ships from ashore will be important in the future, for on-board safety reasons.*

In this manner, the bank needs talents from the industry who have seagoing knowledge to build up those technologies and know how to use that technology. As the bank's senior advisor stated:

> *We hope universities can help to build skills for people to monitor ships and their location at sea or in ports using new technology. In such a manner, seafarers must know how to collect data, understand data, and use the data.*

However, we acknowledge that the seafarers mentioned by this senior advisor probably do not speak the same language that most nautical people do. The interviewer then continued with questions to address collecting data for, as the advisor states:

Banks' investment evaluation. People in shipping companies should be able to show how data and technology can impact a company's safety cost. It will also be important to request seafarers to care for their ships.

The advisor hopes that people could obtain some inputs onboard, and that someone could analyse those inputs for the bank, because the bank also provides insurance for shipping companies. In this way, banks could be responsible for the environmental and sustainable activities in the maritime domain. To this end, the bank currently hires professional companies, rather than asking seafarers, to collect data on every ship they finance. They then compare these data to a scientifically trajectory kind of emission reduction line to meet IMO goals. These professional companies analyse the data for them. More data analysis skills are required of data analysts. The advisor expressed the following wishes:

> *University lecturers should have updated skills to train seafarers to obtain some financial forecasting skills. Shipowners should think about their responsibilities for shaping future skills, such as data analysis.*

However, she clarified that hiring seafarers is not possible due to their lack of financial background. Another bank officer wants seafarers to play a key role in the development of technology at the operational level, contributing their experiences at sea to shape technology development. An insurance company that works for shipping industries clarified how they make contributions in shipping:

> *The only way in our insurance company is not to directly hire seafarers. We do not need them all the time, but we need a few of them to indirectly work with us, for example, to report safety manners to ship managers. In that way, our loss prevention handlers can get a basic idea before entering the field for inspection. For example, we have collaborators working on estimating whether the energy use on ships is sustainable, as well as how to improve on pollution and reduce fuel emissions.*
>
> *We are all in the same boat. We do not know what the future is. Technology drives it. We do have certain products for which we are partnering with technology companies in the design*

process, for example, AIS. We are now able to monitor where the ships are and what potential loss preventions could be if the ship is entering into what we know to be a challenge area. We know better the situation; we know better how to prevent loss.

Although there seems to be no room for seafarers in current shore-based financing jobs, the researcher could say that there is little room for seafarers. The insurance officer provided an interesting statement:

Interdisciplinarity is very important. We do not need purely seafarers, lawyers, bankers, and insurance brokers in the future. Most things could be done using technology. The realistic way is to find a place where you could deepen your competence.

In this vein, we could conclude that, if seafarers wish to shift from seagoing jobs to onshore banking and insurance work, they must learn a wide knowledge of other disciplines, such as law, economics, technology, science, and engineering.

10.1.3 Technology development and use

Although technology plays an important role in the shipping industry, it deviates from what people who develop technology and then offer them to external users, like the shipping industry. Although plenty of research addresses technology use and design, for unknown reasons, the maritime domain has little interest in adopting it. When technology providers say they need seafarers, it does not mean that they need seafarers in their business activities. Seafarers are needed only when technology is in the design and testing processes, because they have experience at sea and may be good test subjects. As one of the main technology providers in Norway stated:

We are a technology provider. We hope all ships can be connected to us. In that way, it will be a big opportunity for our business. We do not own any ships. However, we hold a deep understanding of technology. We are not only selling software and hardware. We hope people coming to us could produce and maintain our product. We do not hire a lot of seafarers, but a few of them could share their sea experiences that are important to us. We need young people who have the knowledge to translate those experiences so we could better develop our products for seafarers.

It is now clear that technology providers need people who could understand the language of seafarers and the technology they provide. Unfortunately, those people are outside the shipping industry and are, at least in Norway, slowly being trained in academic fields. Thus, it is reasonable to guess that when autonomous ships come, technology providers will need seafarers to play a role in controlling the ships on land. When they say, ‘humans in control’, they mean a new role of seafarers who can interact with computer systems, understand data, analyse the data, and even know how to intervene with computer applications to supervise autonomous ships if necessary. As the participant from the technology company stated:

Autonomous technology is not what you can learn as a seafarer. The control happens on land. However, I still believe the users of the autonomous technology are seafarers. Seafarers should know how to interact with the computer systems to respond to difficulties of autonomous ships, such as when routes are changed, or ships are in dangerous waters. Land workers [future seafarers, authors emphasized] need to know how to re-control the ships manually and know relative international and national law to safeguard the company’s profits. Human will always be in the centre when developing autonomous ships. The important thing is to understand their new roles and new abilities for the future, such as communication abilities in different languages, information security knowledge – how to secure and safeguard ships; negotiation ability – knowing specific cultures and laws in specific areas; and data analysis ability – analysing data from different data resources, such as GPS, lasers, radars, and other systems and devices. Like other study programmes at universities, people could choose one specific area to dive into.

This raises the question of who will be able to do these tasks in the future? There is no systematic educational route. As the technology provider envisions:

> *We need to distinguish between different educations. Using technology and developing the technology are very different. For us, using technology fully depends on how technology is developed. So, we think seafarers' education can be developed more diversified – that means, if you only want to know how to use, then spending many years at a university might not be necessary. Technology use could be trained for everyone in vocational school. But there should be another way that can allow seafarers to continually study general basic science at the bachelor level, then continue other specific programmes as the master's and PhD levels, such as the abilities mentioned before; they could choose IT, communication, sociology, data science, law, financing, and so on.*

This vision is confirmed by one of the LNG shipping companies; the interviewee reflected that:

> *People need to know in what conditions LNG operation is safe, such as temperature and its demanding operations. Take estimating energy as an example; seafarers do not think that is within their ability, because it is optimised and planned by computer applications. However, the computer is not always accurate, and the seafarer has great potential to make changes in this field. This requires requesting educators to think carefully about what is going on in current maritime education.*

The same applies to current trends of digitalisation within the shipping industry; as one of the interviewees stated:

Digitalisation gives more opportunities for training. We could train people every day for every skill that person needs. Thanks to digitalisation progress, we are able to provide more flexible training around the world. People can be trained at home, on vessels, at rigs, and so on. That requests not only gaining skills for use, but, as a shipping company, we must expend effort to lead the technology to survive. Blockchain is an example, and it is now coming to our company, but we have no further comments on it. It is a secret. All I can tell you that the shipping industry will also change to a technology company in the future.

When addressing who will introduce new technologies, the interviewee stated:

> *There should be a license as an instructor or navigator in schools, just like a certificate. You need a doctorate to teach students, master's to assist students the same in maritime training, we need best captains to train captains, and high-end seafarers to teach other seafarers, supported by high-tech facilities. Danish education systems have now changed with small success. The same also applies to the Netherlands. Interdisciplinary skills are important, but seafarers do not need to master all skills at the same time; they could take it step by step to different fields but still focus on shipping, such as to be a mechanical engineer.*

The ball is being kicked to education. Currently, seafarers are trained in schools, either vocational school or university, to gain basic practical skills. That might be enough for shipping industries at the current stage; however, this will be dramatically changed if there is a failure to respond to the ways in which technology will change the shipping process.

Our competence evaluation is supported by our external partner, who makes standards about evaluation with assisting digital tools (energy companies). Seafarers, of course, will have to complete the STCW training at college. Then, they will have pre-sea time and sea time. They will build up their competence in specific types of vessels. This is a fixed procedure for everyone. If they change work from one type of vessel to another type, they will have to go through the procedure again to gain specific competence. Since their competence could be standardised through education and evaluation tools, it would be desirable for people to have high-end soft skills, such as communication, leadership, and management, among others (energy shipping). Also, skills not introduced to seafarers' education, such as electrical work or programming? These now become basic knowledge; for example, programming is introduced in primary school. This is the future of energy companies, because we do not need people who can do manual operations as much; skills from other fields become vital.

10.1.4 Consultancy and political constraints

If the shipping industry changes its mind about the future due to rapid advances in technology, consulting companies and trade unions control the future. Consulting companies might have their own strategy for markets. Utilising big terms and leaving room for imagination in annual reports could be a good strategy for maintaining unpredictable markets. For example, when a consulting company discussed the topic of digitalisation and sustainability, strategy seemed to be the main goal. A few details could be told by consultant. Nonetheless, the following describes how seafarers will find their way to contribute:

> *We collaborate and communicate with our customers [shipowners] and do data consolidations across entities [technology companies, in particular] from different sensors [technology company provided]. In that case, we could use AI technology to guide our customers to find their position in commercial markets.*

However, when questioned on who will benefit, the consulting company candidly said, *we*. It is noteworthy that all technical work is supported by both internal and external teams, consisting of both IT and management figures. They are sensing what is now happening in academic conferences, including what new terms are used – such as the Internet of Things, blockchain, data mining, machine learning, and big data – then innovating with several business models to use those technologies. The researchers must emphasise that none of these are new technologies, but are instead ontologies in information science field. They could be used as business model; however, the consulting company uses them as different strategies to benefit their business. On the one hand, the consulting company keeps telling shipping companies and shipowners that new technology will improve the future. Thus, it is important to digitally transform the maritime industry. On the other hand, the consulting company tells shipping companies and shipowners that if they apply these new technologies, their people will gain new skills, such as data analysis. However, a loose discussion about who needs such skills and through what routes they will gain such skills is dismissed or stifled. Although one of the CEOs said:

> *I cannot see a better way to increase our safety and profitability than to make sure we base our processes and discussion on correct data. [To have] the ability to collect the correct data through the crew onboard.*

The researchers have enough reason to doubt that prioritising business will damage the future of seafarers. They likely contribute from one side, but the responsibility to lead the future mainly rests on education. Trade unions that represent workers' rights can also contribute in the field.

With that said, to expect consulting companies to act on environmental and climate change is unrealistic:

> *It is the crew who should know how to better use energy. This should be trained before they work on the vessel, regarding current IMO standards. If they do so, the company [takes] a sustainable [approach to] business.*

However, shipping companies likely take such business advice, which is why they exert much effort on training people in regard to green operations. Sustainability, as a given and unquestioned concept, might not be able to contribute an understanding for educators and policy makers regarding in what ways they can practise sustainability. Through what inquiries, methods, or technical approaches could we weave a sustainable future? A poor mapping in current maritime education has led the politician at the trade union to a self-contradictory belief that seafarers do not need to learn any digital skills, but that they must know how to make sense of digital data:

> *Young people sit in front of computers and only press buttons, such as [for the] engine. If something happens, they have to know how to fix it. They need to have the*

ability to go to the engine room, disconnect computer systems that control the engine, then move the ship safely to the quay. This is only briefly mentioned in STCW; it could be done differently and deeply.

To disconnect computer systems is not just to physically remove the cables. It requires education on telematics, communication, electrical engineering, control engineering, and so on. It is not as the trade union might be told by the consulting company:

Seafarers should see examples of data analysis and translation. They need to know how to read data and how to use the data. This can be done in simulator training.

The researchers then investigated what data was meant, for whom, and how it might be analysed, to which the interviewee responded:

I mean, for example, you must act as who you are onboard. If you have the wrong vibration on a ship, how do you deal with it?

The data, in this sense, means ***situation***. It is not how one can analyse the data like a data scientist or analyst. Only the situation could be duplicated from simulator training into real life. However, this concept is misinterpreted and mixed with data analysis for autonomous vessels, as well as with data use. Interacting with data is not the same as making sense of the data. Making sense of data is for specific contexts and purposes, such as development. As the politician [from the trade union] stated,

Autonomous is coming. It is the future. Crew will be reduced, but there will always be humans onboard. But they will not control the vessel. An onshore centre will do. In that case, women will be attracted, since they could build a stable family. Also, young people will join because it is high tech. People who work onboard should have some experience as seafarers and certificates in management and could be electricians.

It is about how people can interact with the data. This is different from the technology provider's use of data. Thus, when the politician links sensor data with infrastructure and questions the responsibility of the autonomous, many academic fields must be combined to investigate the answers regarding policy making, design of technology, environmental engineering, and pedagogy. There are no other ways around it.

10.1.5 Bellwether is lost in tutoring

If the university has no clear view on what the future holds, there will be no direction to make progress to face the future and its needs. Skills are deeply rooted in daily life as work.

The university is driven by society. We build the expertise that will continue into society. Universities and colleges have the power to influence the students' competence and what kind of knowledge and expertise they will gain after graduation.

The director believes that education plays a role in shaping the future. However, the director is not sure what competences and expertise are expected in the future. Although the university has introduced study programmes to cover digital competence, the director adds that such skills relate to teaching, rather than to students. While the university generates a large number of engineers in Norway, the greatest engineering faculty still believes that the university must provide students with necessary skills that are not affected by changes in studies, such as physics and maths. The reason is that the university should not take sole responsibility for foreseeing the future; we quote:

For future skills, companies and industries demand them, rather than universities. They can demand many different competences, but the university must consider what to provide to both students and teachers, rather than request extra work for the teachers. Thus, in the current stage, attempting to train and test the use of digital tools *within engineering studies, students will be able to develop their future with some competence in programming – software development, for instance.*

However, as another educator stated:

Most Norwegian industries have very little interest in commercial and social aspects in regard to shaping a better maritime industry, which differs from a purely technical-driven field. If we do care, we will not waste money and energy on useless technology development, such as ship design. And the topic you discussed here, future skills, is highly relevant to technology. No other way around [it].

Technology should have some purpose. Our people in the university are trained too narrowly and too procedurally based, and they lack basic critical thinking ability to scope social responsibilities, such as environmental and climate changes. In a dilemma, the educational structure is too fixed and [there is] little room for change, because people have limited time for education at school. Industries have less ability to lifelong educate their employees. A clear education framework must be created in response to this big question.

He continued:

Technology development must be negotiated with other actors too, such as trade unions, from the local to the international level. Autonomous, for example – how to maintain it, how safe it is. We need a safe solution to operations. How can education back up this question? How can we educate people to gain this skill? If this can be achieved, seafarers might become less and less. But I agree that we still need them, but at what skill level? We do not have answers! Most people say, data analysis skills, IT skills in general. But I would argue that all of these are not seafarers' jobs. We have data analysts, we have IT admins, we have Jacks, Mikes, and many others who are trained in other professional fields. But can seafarers be one of them? This is a question we can spend many years figuring out. This is a challenge that our society does not think through carefully.

What is the future?

There are many potential answers to what sets of skills are necessary for the future, and there is no clear answer for future seafarers. Regarding the interviewees, should we simply call future European workers in the maritime domain seafarers? Yes, we still think so. Galam [4] argues that, to get a job as seafarers in the global maritime industry, thousands of 'male Filipino youths' work for free as 'utility men' for manning agencies that supply seafarers to ship operators around the world. During this time, they take on many different tasks, including cleaning, washing, ironing, and looking after the children of the agency owners and their families. Many others scout for seafarers that their agencies urgently need or liaise with embassies on the transit visa applications of seafarers hired by their manning agencies. Although the shipping industries have not directly pointed out hidden wage differences between local seafarers and 'male Filipino youths', it is a crucial factor that can affect the skills that we believe will be important in the future. If technology investment is more expensive than cheap labour, the skills of seafarers can be prolonged until there is potential to use old ships. However, to our knowledge, there are many old ships sailing around the world.

Another important issue is the decreasing numbers of seafarers in the Western maritime world [5], which, arguably, may be unproblematic from a socio-economic perspective [6]. Aside from foreign seafarers [6], technology is another factor that is replacing the skills of European seafarers. According to the interviews, data collection, analysis, and representation (understanding) are the most important skills in the digital world. However, it is worth asking whether well-established skills in other fields, such as statistics, computer science, and electrical engineering, are relevant to seafarers. As one of the educators argues, there are already too many courses for a student to take in a limited number of years. Seafarers already study navigation, ship operation technology, ship stability, collision prevention, chart work, and ship maintenance and operation in their nautical studies, even though there are other courses that might be more theoretical and fundamental, such as 'non-applied sciences'. Other scientific fields do contribute to the shipping industry and make significant changes, and may likely develop huge contributions, just as shipping industries shifted to digital shipping after the oil crisis, and in the same way as law, policy making, energy, and financing players quickly find their roots to collaborate with technology companies to profit from the maritime sectors.

The future is unpredictable for seafarers. However, the future skills of seafarers depend on how well they can find their own ways to co-build maritime studies to be an interdisciplinary field. As Dan Coward, a maritime historian from the Australian National University, reflected on his working experiences with other disciplines in a maritime project:

Not only were we all trying to get to know more about each other – warts and all – but we were struggling to give coherence and meaning to 'interdisciplinary' academic studies. Personality and age differences were inevitably tangled up with different viewpoints between disciplines and between natural and social scientists. We had to learn to put our egos aside: in the 'in-house' seminars, criticism was of the work, not of the person. …I suppose we all thought we knew what to do when we applied for our jobs. In practice, it turned out to be a difficult task to steer our different disciplines in the same direction [7].

A true interdisciplinary study for seafarers is necessary and urgent. It might be unrealistic to ask other disciplines to involve courses from nautical science. But, at least, it is time for nautical sciences to make changes to keep up with a rapidly changing, technology-driven maritime world. Educators must understand that current programmes for seafarers' education might be dated. To prepare seafarers for the future, new courses and teaching methods must be introduced. For example, seafarers should learn how to obtain different types of data and make analyses, as well as to make sense of their analyses. These data do not need to be the same as in the data science field, where people make large efforts to understand and visualise them. Data for seafarers could be related to cultures, experiences, operations, and their daily work activities. Seafarers, more than anyone else, could make these data meaningful to guide technology development.

10.1.6 Policy-supported changes to grasp the future

Since the interviews were mainly conducted in Norway, we use Norway as an example in this report. Currently, there is no policy to support seafarers' further education in Norway.[112] The Norwegian Parliament requested the creation of a maritime policy to declare Norway as a maritime nation in May of 1994 [8]:

> *The Storting requests the government to submit a white paper on Norwegian shipping policy and maritime activity. In it, maritime business activity in Norway should be discussed in a broader industrial and international perspective in order for the prospects of increased value creation and employment to be assessed. [9, p.3927-32]*

On the one hand, the request referred to 'shipping policy' as an established policy field for state authorities; further, the requested white paper was in line with a debate in the wake of the shipping crisis in the mid-1970s. On the other hand, it is clear from both the wording of the resolution and the debate preceding it that shipping was no longer to be considered in isolation from other lines of business in a policy context. Shipping is about:

> *sustainable growth and value creation, including trade area limitations for NIS-registered vessels, environment, maritime administration, competence and education, research, development and innovation, international regulatory frameworks, blue growth, and the high north.* [10]

[112] We discuss, in the following section, that the national joint PhD programme in Norway is not designed to bridge the gap between nautical operations, engineering, and management as skills expected from society.

In a lengthy discussion, this governmental strategy reveals several policies to guide the country to be, maintain status as, and be a leader of maritime nations. Among these polices, practical experience from the sea, linked with research-based knowledge, is key to technology development and innovation throughout the value chain. The policy foresees that:

> *The industry depends on qualified labour in anything from banking, trade, consultancy, manufacturing, technology development, finance, shipping, stockbroking, classification, research, and teaching. [10]*

This policy does not exist in a vacuum. There are a number of maritime education programmes in Norway to support high-quality education in the maritime domain. For example, the University of South-Eastern Norway, Western Norway University of Applied Sciences, Norwegian University of Science and Technology, University of Nordland, University of Tromsø, and the Norwegian Naval Academy in Bergen all offer nautical or maritime studies. In addition, The Nordic Institute of Maritime Law at the University of Oslo offers research and training in maritime law. Further, maritime studies are offered at 21 upper secondary schools and 13 maritime vocational schools, as well as 103 safety centres in Norway. All of these schools can provide shore courses, training, and consultancy in fields relating to health, environment, and safety based on IMO conventions. This means Norway could continue to enrich their education at all levels in and around maritime studies.

However, we should not forget that seafarers and their representatives (the trade union) should participate in policy making to guide technology development, consultancy on technology development, and capital flows to help shape the future skills. Maritime education is equipment intensive. This equipment does not exist in a vacuum either. Equipment can be a waste if no seafarer experience is utilised to make the technology of the equipment useful. In such a case, all investments will be wasted. Although the government has increased the student funding system [10], it is important to note that collaboration between the business community and the research-based universities is still weak. As this report indicates, most skills now requested of applicants/employees are beyond the scope of the maritime education in Norwegian universities, such as data science, data analysis, economics, computer science, mechanics, energy, stochastic modelling, statistics, and risk analysis. The Nordic Institute of Maritime Law at the University of Oslo is an exception, since law is their only concern. It is also important to note that maritime industries require professionals who have deep knowledge in their own fields and could apply their knowledge to the maritime business. In turn, this logic does not hold. Although seafarers can be indirectly used, such as in insurance agencies and banks, that does not mean that seafarers will be hired in these industries. The employers only require intensive use of seafarers for some specific tasks.

Foreseeing future skills is not the same as manpower planning. It would make no sense to predict how many seafarers will be needed in the future. However, foreseeing the future requires examining how labour markets are developing and, consequently, how jobs, skills, and learning are changing. Thus, we must touch a challenging segment – education. As the Shipowners' Association states:

> *Norway needs a flexible, scalable educational system. It is important that maritime educational institutions are well-rooted in the local business community. Costly infrastructure requires a large degree of co-location. This is essential for creating strong academic environments and good cooperation, and to encourage specialization. [11]*

Such specialisation, as this report illustrates, encourages the educational system to 1) focus on digitalisation and sustainability, 2) integrate and finance practical training in maritime education, 3) link researchers and university lecturers to create strong interdisciplinary environments, and 4) establish effective transfer schemes between academies and maritime instructors.

10.1.7 Optimising skills systems

Currently, Norwegian maritime education consists of three main venues: vocational education (fagskole), training companies, technical colleges (høgskolen), and universities. Along with several training companies across the country, these three educational systems contribute to disequilibrium. For example, vocational education and technical colleges primarily focus on utilising simulators to train seafarers from the novice to the proficient level. After that, course certificates are awarded to students who later achieve some experience at sea, then acquire certificates from the maritime authority of Norway. Certificates are primarily papers that describe a position in the maritime industries. Alternatively, training companies also offer training programmes to seafarers, as well as diplomas or certificates if the companies are approved by the Norwegian Maritime Authority [12]. On the other hand, universities instruct technicians on how to design maritime simulations. There is no overlap between seafarers and technicians. In addition, technicians have less experience working at sea, while the seafarers have less knowledge of the simulators' capabilities and limitations. Altogether, the relationship between competences of individual labourers and the aforementioned missing links among organisations create a gap in which unavoidable fundamental questions are raised over the long term: who has competence, who defines it, who evaluates it, and which relevant simulators are equivalent to in-situ knowledge and skills of which people in the work setting? Simply put, the usefulness of scenarios created by simulators is uncertain and unstable. This, in turn, presents an obstacle to the future skills of seafarers.

Currently, Norwegian seafarers could choose to be educated in both vocational schools and technical colleges. Due to the merging of some technical colleges and universities (for example, Ålesund University College was merged with NTNU), seafarer education has become a part of university education as well. However, to be part of university education is neither a merging of programme structures nor adapting each other's education component. For example, nautical studies at Ålesund is a three-year bachelor programme focusing on general programmes (mathematics, physics, electrics, computer networks [basic course], maritime law, maritime medicine, HSE, work management, cultural understanding, maritime English, ocean environment, and basic safety courses), as well as navigations, basic ship technology, and philosophy. Marine technology in Trondheim is another five-year engineering programme (equivalent to a master's degree), focusing on marine structures, control systems, hydrodynamics, safety and asset management, engineering, systems design, marine resources and aquaculture, and subsea engineering. Though information technology and programming courses are introduced, both are rather basic and technology oriented [13]. There are a few overlaps in educational components, such as mathematics, physics, and philosophy. However, a large gap exists in our own university. When comparing the nautical studies programme of NTNU with that of vocational schools (specialised in deck officers and engineers), it is evident that overlaps exists in navigation and safety courses. Furthermore, they both use the simulator as an educational tool.

In current VET systems [14], students who are passionate about becoming seafarers are offered the opportunity to continue their studies until the Ph.D. level. There are two realistic routes in this regard: management and engineering [15,16]. These two options have their own merits to offer contributions to the shipping industry, as well as surrounding businesses. However, as our report indicates, the gaps between societal demands and education are not fulfilled. Society requires particular skill sets in between nautical studies, engineering, and management. These include skills in information technology, data science, environmental science, law, and financing. Although NTNU and its partners have relevant educational programmes within and outside of maritime education (including joint PhD programmes), a combination of automation and mechanics, sensor technology, human factors, machinery, logistics, and management does not satisfy the requirements of society (see Figure 1). A new framework that satisfies these requirements must be addressed by education towards a digitalisation[113] to offer benefits to seafarers, the shipping industry, and society. Such a framework, on the one hand, would generate qualified seafarers for the future. On the other hand, the new framework would bridge the gap between current education systems in Norway.

[113] Digitalisation must not be confused with digitising, as the former refer to transformation of organisations, markets, and society – and not only the digitising technologies as such. In this regard, Gartner views digitalisation as different from the application of novel technologies as such, underscoring that «Digitalization is the use of digital technologies to change a business model and provide new revenue and value- producing opportunities; it is the process of moving to a digital business. » However, digitising technologies like blockchain, Internet of Things, machine learning, big data analytics, and digital platforms are important building blocks in understanding the phenomena.

10.1.8 Making matching more sustainable for future skills

As an important contributor to society, educators must create new programmes for seafarers to study, ranging from natural science to social science. Further, educators need to wisely manage the time limitations of seafarers' education. Should sea experiences occur before and during seafarers' education? As of yet, there is no clear answer. However, creating new programmes or adding a new framework into current education systems would require a long-term plan and would likely be time consuming. However, we are obligated to set out the key takeaways from the present future skills analysis before we conclude this report. Remember that they are only temporarily stratagem rather than solutions. We believe topics urgently needed in current maritime education include, but are not limited to, the following:

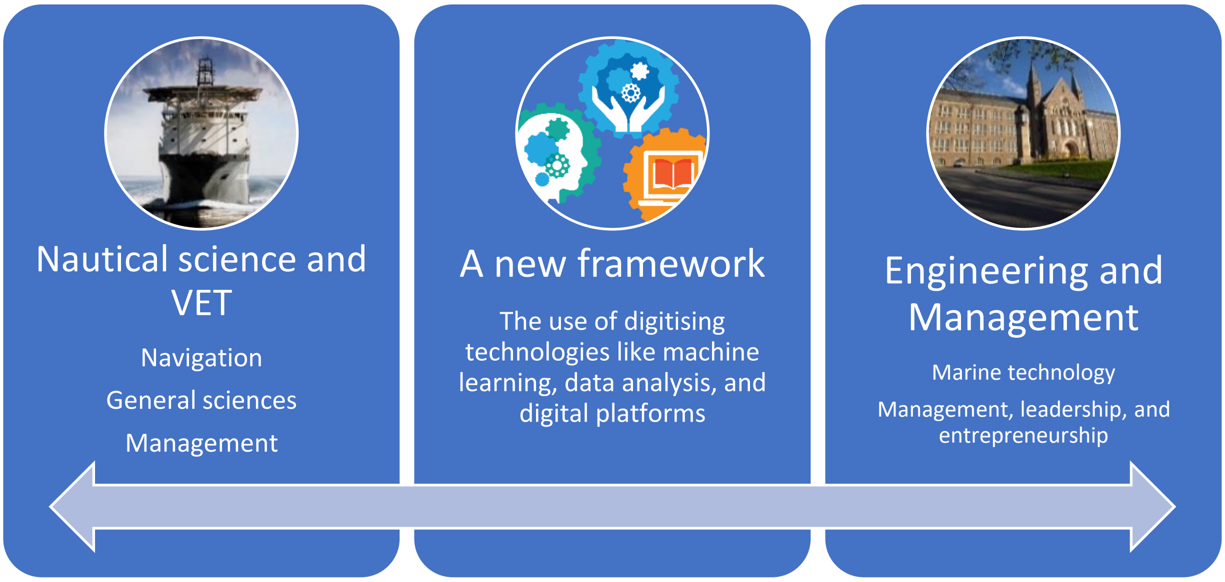

Figure 1: A new framework for the future education of seafarers.

Photo-/video-visual literacy: the ability to read and deduce information from visuals.

- Advanced knowledge of searching, locating, assessing, and critically evaluating digital data and knowledge of how to present findings to technology providers
- Advanced knowledge of remotely de-bugging problems with technology providers

Reproduction literacy: the ability to use digital technology to create a new piece of work or combine existing pieces of work together to make it one's own.

- Advanced knowledge of calculation as a back-up skill when automation fails, as well as basic statistics and risk analysis for safety operations
- Basic human factor and HMS (health, environmental, and safety work) knowledge in the working context. Knowledge of how to keep healthy onboard

Nautical literacy: the ability to successfully navigate within the non-linear medium of digital space.

- Advanced knowledge of energy emission
- Advanced knowledge of electricity
- Advanced knowledge of manually operating autonomous vessels, including dynamic positioning

Information literacy: the ability to search, locate, assess, and critically evaluate information found on the web and on library shelves.

- Advanced knowledge of ocean geography – remote control in foreign waters
- Advanced knowledge of IT security and safety. Guidelines and procedures should be trained

Social literacy: the social and emotional aspects of being present online, such as through socialising and collaborating.

- Advanced knowledge of workers' rights and duties
- Basic knowledge of different cultures, regions, and domain knowledge. E.g. remotely navigating a vessel in foreign waters.

Management skills: the ability to obey basic national and international law, company policy, and regulations.

- Maritime law – basic knowledge of the law in various locations that are inside of companies' businesses
- Specific North Sea energy law – advanced knowledge about energy emissions and policies in the North Sea

Economy and finance – basic knowledge of economics and the consequences it has for daily operations.

- The ability to work with bankers and insurance officers on providing accurate information regarding daily work, while simultaneously preventing the loss of the company

Environment – the ability to adhere to the company's policies to manage daily environmentally friendly operations.

- The ability to work with the technology providers on presenting requirements for new technologies based on current experiences with existing technology.
- Basic product design knowledge
- Basic skills to write requirements

Digital tools use – the ability to use technology as a tool to organise, evaluate, and communicate information in international and local languages (Norwegian and English languages).

- Word processing
- Spreadsheets
- Database software
- Presentation software
- Internet and email
- Improving productivity using digital tools

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Interview guide

The interview is semi-structured. The guide only provides a frame for the interview; however, the interviewer could add other questions outside of this guide, which are relevant to the answers from the interviewees.

A. General

Introduce myself:

Name, researcher/professor/officer at institution/organisation in Norway. I have worked for many years the maritime sector. Became interested in how digitalisation will influence on skills in the maritime sector.

Introduce my research

Explain purpose of my research. Request consent to participate in interview and ask permission to use the information gained in the interview in my research

Always ask:

1. Name
2. Function
3. Contact information
4. Can you describe your work and your daily responsibilities in your own words.
5. Particular interests
6. Anonymity (if yes; ask name or organisation; purpose alias)
7. On the record/off the record (partly anonymous)

B. Guiding questions (ship operators, worker unions): Ask if they can give a demonstration of their work

Ask if applicable, about options, categories, knowledge organisation, languages, and if they know, since the maritime jobs have their own terminologies.

1. What is your work, in your own words.
2. How can ICT support your work.
3. How they got involved with your work.
4. What is specific to the technology supported work in your current position.
5. Is the technology solution a good solution for supporting your work.

6. How has your work changed since the introduction of ICT.

7. Do you see the differences between ICT support work and tradition work? What are the differences?

8. In your understanding of ICT supported work, what is then maritime knowledge/skills and how is it different from current job position.

9. How has your work changed since economic changes.

10. How has your work changed since environmental changes.

11. How you forecast the future skills for seafarers?

B. Guiding questions shore side shipping industries (Classification societies, consultancies, recruiting department, financial, legal, protection and indemnity associations, worker unions, research bodies, training and recruitment, ship-owners, shipyards): Ask if they can give a demonstration of their work

1. How long have you been doing this work. Has your knowledge changed since you involved in the shipping industries. How your work affected by maritime skills? How does it benefit by digitalisation.

2. What is skills for development careers in the shipping industries.

3. What maritime skill is needed in your work? In your own words. What is so important about it.

4. How can ICT support skills sharing

5. How long have they been involved in skills sharing, what are the most visible or important changes?

6. Understanding, and differences between current and future skills. Examples!

7. What is good future skill. Examples!

8. In your understanding of future skill, what is then knowledge and how is it different from information.

9. How has your work changed since economic changes.

10. How has your work changed since environmental changes.

11. Have you hired seafarers before? How you work with seafarers?

Interview analysis – Report B, the UK

D1.1.3 LJMU team (Alphabetical order)

Ian Jenkinson

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Introduction

The economic contribution of the Maritime Sector to the UK economy – based on data for 2017 for Scotland, Wales, the Liverpool City Region and Solent LEP (Local Enterprise Partnership) region, stands at £47bn (€55) in business turnover, £17bn (€20) Gross value Added (GVA), and 220,100 jobs for UK employees (Maritime UK, 2019). In the UK, the Maritime Sector is defined as shipping, ports, leisure marine, marine engineering and scientific (MES), and the Maritime Business Services Industry. Shipping industries and MES are the largest constituent industries in terms of economic activity, supporting 59,400 and 81,900 jobs respectively, and contributing £6.1 (€7.1bn) and £5.1bn (€6bn).

This report aims at analysing the future for seafarers who may transfer ashore within the UK Maritime Industry to investigate how to harmonise and collaborate on the development of standards for associated shore-based roles, as well as to facilitate the transition from seagoing roles to shore-based roles and vice versa.

Research Method

Data sources include face-to-face and telephone interviews, observing and participation in debate while in attendance at relevant sessions as part of London International Shipping Week, secondary sources; namely industry discourse as recorded in the trade press, as well as the consideration of relevant reports produced by key stakeholders.

Data collection and analysis

Primary data collected through interviews, discussion and observation includes viewpoints of stakeholders from the education and training sector, as well as those from key individual industries of the UK Maritime Sector:

- Shipping

Operations (2)

Management (1)

- Maritime Business Service Industry/Finance:

Banks, brokers and financial services (2)

Maritime law (3)

Insurance (2)

- Technology & Manufacturing:

R&D and education (2)

Classification societies (1)

Ship building & repair (1)

Equipment production, including IT (4)

A similar interview guide was followed to that of the NTNU researchers in Norway. Prior to the interviews, participants were informed of the basis of the interview and the relationship with the European Key Competence and the key pillars of the UNESCO Education for Sustainable Development (ESD) frameworks. All interviews were conducted in an anonymous and off the record basis. Prior to each interview, participants were asked to consider their organisation in light of the following areas, as prescribed in the common interview guide. In addition, participants were asked to rank each key competency area as low, medium and high priority for their future skills development strategy and vision for the future of their organisation in order to guide discussion.

As part of the interview process, clarification was offered to respondents in relation to each of the seven EU Key Competencies, and the three pillars of ESD. This was necessary to enable a level of consistency with the interpretation of each competence area by each respondent.

EU Key Competencies for Lifelong Learning:

- Literacy
- Multilingualism
- Numerical, scientific and engineering skills (previously STEM)
- Digital and technology-based competences
- Interpersonal skills, and the ability to adopt new competences
- Active citizenship
- Entrepreneurship
- Cultural awareness and expression

Three Pillars of Education for Sustainable Development (ESD):

- Environmental
- Global economy
- Social inclusivity

As per the definition contained within the Brundtland Report (WCED 1987:23) ‘Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs’. The United Nations refers specifically to 17 sustainable development goals (Table 1).

Table 1 – UN Sustainable Development Goals

GOAL 1: No Poverty	GOAL 2: Zero Hunger	GOAL 3: Good Health and Well-being	GOAL 4: Quality Education	GOAL 5: Gender Equality	GOAL 6: Clean Water and Sanitation
GOAL 7: Affordable and Clean Energy	GOAL 8: Decent Work and Economic Growth	GOAL 9: Industry, Innovation and Infrastructure	GOAL 10: Reduced Inequality	GOAL 11: Sustainable Cities and Communities	GOAL 12: Responsible Consumption and Production
GOAL 13: Climate Action	GOAL 14: Life Below Water	GOAL 15: Life on Land	GOAL 16: Peace and Justice Strong Institutions	GOAL 17: Partnerships to achieve the Goal	

Both interview notes and secondary data were coded using NVivo software in order to store and organise, categorise and analyse, and in order to visualise connections between the data sources in a rigorous manner. The coding focussed on the EU Key Competencies for Lifelong Learning and UN Sustainable Development Goals.

Primary data collection and analysis were subject to Code of Practice for Research of Liverpool John Moores University. Data storage and analysis followed this code of practice and ethical approval sought from the University Research Ethics Committee (UREC) (Reference number 19/MME/011). Thus, in this document, all individual and company names have been removed and the findings presented remain anonymous. Interviews were not recorded and notes made by the interviewer replaced full interview transcripts.

This provisional analysis will be incorporated into the evaluation of impact on occupational profiles (D1.2.3 Impact on occupational profiles (M15)), and primary data collection expanded where necessary.

Stakeholder industry sector outline

Shipping

Ship management and ship operation deal with the process of operating or managing the operation of a ship. This includes the narrow technical management of ships, registration of vessels, operations, servicing, technical maintenance, as well as management of crew. It can also include the business and commercial management of a vessel, such as its chartering and financial administration. The term *Shipping Company* is used to describe a vessel-owning operator of cargo and passenger carrying ships, as well as a company that manages and operates cargo-carrying ships without necessarily owning them. The latter can also be within the remit of a shipbroker as a function of *post-fixture* commercial management of a ship (see below).

The *Ship Operator* is a technical management position within a shipping company. The role of the ship operator is to ensure that all technical tasks in relation to the operation of a vessel are performed in accordance with the company's procedures. A ship operator could be employed by the actual ship owning company, or may be employed by a company who contracts out this technical role to a ship management company. A ship operator is often called upon to provide technical support within other areas of ship operations such as crew management, logistics related to vessel operations, service and maintenance of the vessel.

According to the EU enterprise size definition, the two shipping companies representing this stakeholder group in this analysis of the UK maritime shipping industry sector are large enterprises (more than 250 employees).

Maritime Business Service Industry

Stakeholders represented in this section are brokers and financial services, maritime law, and insurance professionals.

Shipbrokers are specialist intermediaries (i.e. brokers) between shipowners and charterers who use ships to transport cargo, or between buyers and sellers of vessels. Shipbrokers represent the interested parties in commercial management of a ship as an asset - pre fixture for chartering, and in the context of sale and purchase (‘S&P’) - ship operations (post fixture), port agency and market research intelligence. Because of this varied operating model, the learning and development needs of firms vary across the shipbroking firms dependent on the services offered. For the purposes of this report, and for subsequent stages of the analysis, all of these services are packaged under the heading of *Shipbroking* as a financial service.

According to the EU enterprise size definition, the shipbroking firm representing this stakeholder group in this analysis is a large enterprise (more than 250 employees).

Maritime Lawyers, and other legal and insurance personnel within the maritime business service industry are represented in the analysis of the UK maritime shipping industry sector by three stakeholder organisations. Working within the maritime business service industry sector as a legal and insurance professional will often require someone who is a fully qualified shipping lawyer. Most employers will be looking for substantial experience of working within a law practice. Other roles include risk management advisors, claims handlers, loss adjusters. These roles do not necessarily require a law qualification and may attract former seafarers. Protection and Indemnity (P&I) is another common area of the marine insurance sub-sector that attracts personnel with seagoing experience. Insurance personnel will work together with qualified shipping lawyers on a variety of cases on behalf of the organization. According to the EU enterprise size definition, the three maritime law and insurance related firms representing this stakeholder group are large enterprises (more than 250 employees).

Technology & Manufacturing

According to the EU enterprise size definition, the two education related organisations representing this stakeholder group are small enterprises (10-49 employees). In this context they represent the ‘education’ stakeholder group. One of these organisations is responsible for awarding vocational qualifications to seafarers, while the other is responsible for setting the syllabus to meet the requirements of the STCW.

One classification society features in this analysis. This company has a worldwide operation with employees into the tens of thousands. A classification society establishes and maintains technical standards for the construction and operation of ships and offshore structures. Classification societies are non-governmental independent organisations that issue a certificate to confirm that the construction of a vessel complies with relevant standards. In addition, they carry out regular surveys of a vessel or structure when it is in service to ensure ongoing and continuous compliance with the standards.

Shipbuilding and repair is a major contributor to the marine engineering and scientific (MES) industry sector, and this industry sector is represented in the primary analysis. The shipbuilding industry builds different kinds of ships for transporting goods and people. Specialist research icebreaker, barges, and tugboat build and repair are carried out at the shipyard in questions, as well as the constructing offshore structures. Besides building ships, shipbuilders outfit ships and repair them. While there are fewer shipyards in the UK than in the past, they focus on specialist purpose vessels and repair contracts with the Ministry of Defence. The shipbuilding industry stakeholder represented in this analysis is classed by the European Union as a large enterprise.

Research and Development, equipment production (including IT) are industry sectors represented by small and micro enterprises, highlighting the start-up nature of these firms. Crew management and education providers are also represented in this stakeholder group.

Findings

The following is an outline of the competencies in order of importance for the future skills development needs, according to stakeholder views interviews, observations and secondary sources that have been analysed. Firstly, each of these skills competence areas is provided, as was used when interpreting the findings for the maritime shipping industry sectors represented in the UK analysis. Secondly, evidence is provided from the analysis to provide further detail on the anticipated future need for each key competency. This provisional analysis will be incorporated into the evaluation of impact on occupational profiles (D1.2.3 Impact on occupational profiles).

EU Key Competencies for Lifelong Learning

Literacy (High) and Multilingualism (Medium)

'Defining literacy as a key competence has to take note of the fact that literacy can be developed in the mother tongue, in the language of schooling and/or the official language in a country or region and that these languages can be different. The key element here is that a good level of literacy needs to be ensured in at least one of these languages to allow for further competences development.'

(EU Commission, 2018:45).

Under this heading, focus is on communication in the mother tongue and communication in foreign languages. In the case of the UK *Literacy* relates to communication in English as mother tongue, and communication in English as a foreign language, as this is the working language for the stakeholders represented. English is the working language of all of the organisations making up the maritime business service industry sector in the UK. It is also the working language of ship operation and management firms.

While other languages are of importance, and there is an increasing trend and need for employees with foreign language skills, mastery of the working language of the company in question is the priority. This is seen as unlikely to change in the future. Specific foreign languages are becoming more desirable e.g. Chinese and Arabic, but this is of more relevance to the Cultural awareness and expression competency than an increasing demand for skills and competency [multilingualism].

Shipbroking

Numerical, scientific and engineering skills (previously STEM)

This refers to mathematical competence and basic competences in science, technology engineering and mathematics. This may include the use of structured thinking to solve problems, understanding and applying mathematical terms, knowledge of the basic principles of the natural world, scientific concepts and processes. At a more advanced level, this may include demonstrating the capacity to evaluate scientific arguments based on evidence and to apply conclusions from such arguments in an appropriate manner (European Commission, 2018).

Brokers will need to acquire new talent with a strong data and analytics skillset.

Shipbroking

Problem solving and decision making using scientific argument is of increasing importance today and as we move forward. It is not always possible to provide this as operational sea training. There is some use of simulation to aid this kind of active training. One opportunity we would like to see is linked simulation between the Bridge and Engine Room so that teams can simulate decision making in this replica setting and train for situations e.g. equipment failure, in an active [as opposed to passive] way.

Ship Operations/Management

There is already a lot of discussion about the use of VR in the near future for many training and professional aspects of cadet training. There is also increased emphasis on the use of simulators and even discussion of simulator training replacing a short part of training usually completed at sea.

R&D and education

The role of the vessel is anticipated to change and this will open the market to new competitors to emerge. Analysis of activity in the global startup scene allows us to understand how the industry may innovate in the years to come.

Technology & Manufacturing (MES)

‘Once something can be represented in ones and zeros – from containerised trade to smart materials – it becomes an information-based technology that can chain react with other technological progressions and disrupt existing industries and business models, as well as unlocking new layers of untapped potential. We argue that the business models of asset owners and ship operators are as likely as those of integrated shipowners (i.e. who run a business where either technical management, commercial management or both are managed internally) to be disrupted, but for very different reasons.’

Danish Ship Finance and Rainmaking (2018:6)

The role of the Marine Engineering officer may be expanded to align with Electro Technical officer. However, we don’t see that there will be a move toward combined certificates of competency, as they see IT and Engineering support will come from shoreside.

R&D and education

Digital and technology-based competences

With respect to digital and technology-based competence, several frameworks define a specific 'digital competence' with some variation in the terminology used (digital competence, ICT competence, digital literacy, citizenship and digital creativity). Instead of 'IST' (Information Society Technology) and 'ICT' (Information Communication Technology) that were used in the 2006 EU definition, 'digital technologies' is considered the most appropriate term to refer to the full range of devices, software or infrastructure. With the increased, varied and embedded use of mobile devices and applications, references to 'computers' and the 'Internet' are removed, but are still classed under the broad term of 'digital technologies' (EU Commission, 2018).

Digital technology supports everything that we do. Staff development monitoring will become enhanced as we move towards increased electronic document support. We are currently supporting the movement to electronic cadet training record books with supporting electronic learning.

Crew Management

It is difficult to comment on what skills are needed for the future as there is no real indication of just how quickly technology will be developed within the sector.

R&D and education

DigComp is a reference framework that describes what it means to be digitally competent. DigComp sets out the 21 competences necessary to be digitally competent and maps these across 8 proficiency levels, from the most basic to advanced levels. It can be used across sectors, disciplines and systems to enable people to develop digital competence. DigComp 2.0 (European Commission, 2019a) identifies the key components of digital competence in five areas, which can be summarised as below:

1) Information and data literacy: To articulate information needs, to locate and retrieve digital data, information and content. To judge the relevance of the source and its content. To store, manage, and organise digital data, information and content.

2) Communication and collaboration: To interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity. To participate in society through public and private digital services and participatory citizenship. To manage one’s digital identity and reputation.

3) Digital content creation: To create and edit digital content. To improve and integrate information and content into an existing body of knowledge while understanding how copyright and licences are to be applied. To know how to give understandable instructions for a computer system.

4) Safety: To protect devices, content, personal data and privacy in digital environments. To protect physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.

5) Problem solving: To identify needs and problems, and to resolve conceptual problems and problem situations in digital environments. To use digital tools to innovate processes and products. To keep up-to-date with the digital evolution.

Ultimately, digitalisation will drive transformation, leading to greater operational efficiencies. Although the industry has survived 300 years on paper-based systems, the pace of innovation accelerating in the last two to three years and it is now looking to embrace opportunities from emerging technologies. Access to real-time data that empowers brokers and insurers with insights to react quickly are expected to shape the competitive advantage of firms:

> *‘To navigate today’s evolving challenges and risks, the maritime industry requires a risk management advisor with innovative technology and decades of dedicated marine expertise’.*

Marsh & McLennan (2019)

Marine Insurance

Using Artificial Intelligence (AI) and machine learning algorithms, new rating factors are being employed to understand risk. This analysis of risk 'behaviour' utilising AI allows risk to be understood by market segment, for it to be priced accordingly and to improve loss ratios. Behaviours are correlated with claims analysis datasets with inputs relating to vessels, their movements, weather, machinery information and other more traditional demographic data ***[Problem solving]****. Industry leaders operate in a digital marketplace* ***[Communication and collaboration]*** *where they can assess and transfer risk efficiently, made possible by the developers of such behaviour-based tools* ***[Digital content creation]****.*

Law and Marine Insurance

Decision making tools have been developed in-house in the form of applications to assist shipbrokers at all stages of the process of fixing a vessel from start to end. Due to the competitive nature of the industry sector, these 'apps' are developed in-house by specialist teams in order to maintain the competitive advantages over other brokerage houses, and smaller firms tapping into the same resources ***[Digital content creation]****.*

Shipbroking

Being able to write and interpret algorithms and to code are skills we are in need of more and more **[Information and data literacy]**. What we do not know is to what extent these competencies will be needed in the occupational roles as we move forward. Our officers will need to have knowledge of the organisational, ethical, and technical challenges involved in automation technology deployment, and how to effectively prepare for practical application and to guard against cyber threats **[Safety]**.

Ship Operations/Management

What is required of early and later stage employees is a level of digital literacy to work effectively with these interfaces ***[Information and data literacy]****. With the exception of staff tasked with developing such applications, the level of coding literacy required among staff performing the business' primary functions of broking (commercial management, ship operations, port agency and market research intelligence) is minimal, but there is a notable increase in the ability to code amongst the current workforce* ***[Digital content creation]****.*

Shipbroking

'51% of Insurance CEOs are extremely concerned about the speed of technological change and 81% are concerned about the availability of digital skills in the industry'

(PwC, 2018)

Law and Marine Insurance

Technology will affect the whole value chain from ship owners through to brokers, insurers, and reinsurers. The broker's role will move away from purely transactional to providing better insight on risk and exposure through analysing meaningful data. Insurers will be able to react swiftly to a vessel on the move and adapt prices and coverage in real time to manage risks more accurately ***[Communication and collaboration]****.*

Law and Marine Insurance

Ship operators are engaging with original equipment manufacturers to aid them with bridging the skills gap and equipping employees with digital competency skills e.g. for control systems.

This is a great challenge for instructors. Our Electro Technical Officers (ETOs) are trained to have the competencies required by the STCW relating to shipboard electrical systems. They are not equipped for complex digital systems. Sometimes, the classification society will influence who can maintain a control system. We already follow the lead of other sectors and the military, and go beyond STCW. This is still not enough and it is necessary to go direct to the equipment manufacturers to request their time for training in the use, and fault diagnosis of a control system, but they are not always able to provide the training requested or to spare the manpower to be available for training. With the advent of AI and increased autonomy we will be very challenged to keep up with the training need, and we have no clear strategy in place for this. Remote diagnostics will be used widely and will require a suitable skill set ***[Problem solving]****.*

Ship Operations/Management

With high levels of automation all crew would then be multi-skilled. The highest skills needed for those on board would be meta skills as those on board would only really be required to solve things when things went wrong, so would need high critical evaluation skills, decision making skills, and so these should be incorporated in all levels of training ashore **[Problem solving]**.

R&D and education

Interpersonal skills, and the ability to adopt new competences

Interpersonal skills, and the ability to adopt new competences, relates to how a learner, learns. This skills competency area is assessed by how a learner demonstrates their ability to pursue and persist in different kinds of learning, and identifying available opportunities to learn. Being a self-directed learner and demonstrating both initiative and commitment to learning as a lifelong process are key to how a learner is able to gain, process and assimilate new knowledge and skills required to attain career goals as well as being able to reflect on past experiences of learning in order to inform future progress (EU Commission, 2018).

Trust and teamwork stand out as the key skills in which we need to develop competency.

Ship Operations/Management

The industry has very progressive regulation on emissions and ballast water, which is running ahead of the current technology.

Ship Operations/Management

Some of the stakeholders represented are dealing with this demand through their intake for graduate recruitment programmes, predominately in data-related jobs.

Leadership, ambition and innovation are the key traits required for the marine insurance industry to prepare for a digital future in the short to medium term. It's vital that a leader can effectively communicate the vision of a digital future to their organisation. An organisation also needs the ambition to reinvent itself to meet higher expectations from clients in a digital era. The challenge is to find innovation that is viable and meaningful to clients and delivers growth to your business.

Law and Marine Insurance

It will be difficult to transition to integration of soft skills within training programmes while traditional elements still exist and the regulators insist on training being completed by trainers with higher levels of competence. This means that most maritime ‘educationalist’ only teach to the same structure they are used to on ships so difficult to incorporate changes. Courses such as HELM [Human Element Leadership and Management] do include these elements, but this has been a difficult course to develop.

R&D and education

Entrepreneurship competence

This skills competency relates to the sense of initiative and entrepreneurship to work effectively to create new ideas and increase both innovation and quality of work. Entrepreneurship competence describes and ability to turn ideas into action, to be creative and innovative, while having the ability to plan and manage tasks, and to be independent, motivated and determined. Rather than conforming to traditional industry structures, companies have created an ecosystem of products and services that fulfil customers’ needs globally. The potential consolidation of access to customers could happen relatively soon in the maritime shipping industry.

‘Startups are founded to meet a need, a need for which no solution yet exists. Or perhaps one does, maybe in another industry, but it is not sufficiently accessible to those who require it in the current setting. Or it is too costly or too difficult.’

Danish Ship Finance and Rainmaking (2018:9)

By their very nature, startup companies experiment with new technologies to develop solutions. Their goals is to test potential solutions that may allow them to orchestrate value creation at a much lower cost than established players. In doing so they seek to identify scalable and repeatable and models of doing business. In other words, startups play a key role in testing if a new business model can be adopted in the first instance, and if successfully can it be scaled up? In this iterative process others can learn from both their successes and their failures.

Classification Society

Working in a rule-based sector makes this challenging. Innovation is encouraged, but this should be based on experience and confidence when operational in a safety critical domain.

Ship Operations/Management

For some it will be increasingly difficult to compete as there will be significant changes to how value is created and distributed across the shipping industry.

Technology & Manufacturing (MES)

‘EntreComp’ is authored by the European Commission (2019b) and is a framework that can be used as a basis for the development of curricula and learning activities fostering entrepreneurship as a competence. EntreComp consists of three interrelated and interconnected competence areas: ‘Ideas and opportunities’, ‘Resources’ and ‘Into action’. There are five competences, which, together, constitute the building blocks of entrepreneurship as a competence. These are ultimately translated into a list of 442 learning outcomes. In order to do this, the EntreComp framework develops the 15 competencies along an 8-level progression model from foundation to intermediate, advanced and intermediate. What needs to be established is how these progression levels align with the career pathways and impact on occupational profiles analysed as part of the later stages of the SkillSea project (D1.2.3 Impact on Occupational Profiles).

‘The core services in traditional business models (i.e. transporting goods from port to port) are losing their value in a digital industry, and are being usurped by other services. Vessels will still be needed to perform the task of moving cargo from port to port, but it is the data this generates rather than the cargo that will start to be monetised not only from port to port but through the entire value chain from origin to destination.’

Danish Ship Finance and Rainmaking (2018:6)

Cultural awareness and expression, and Active citizenship

Firstly, *cultural awareness and expression* as a skills competency means to understand culture and to have a positive open minded attitude towards diverse cultural differences. Interaction, inclusion and mobility are viewed as opportunities in society for the benefit of the economy (European Commission, 2018). The second, *active citizenship*, relates to social and civic competence as a duel competence, from both a personal and social perspective (European Commission, 2018).

Trust and teamwork rely on successful relationship building. Leadership and Management training has always been part of what we have focussed on. Today, and going forward, Mental Wellbeing training – for both those at operational and management levels – is essential.

Ship Operations/Management

Crew management requires a higher level of emotional intelligence than seafaring. Some seagoing experience is useful, but there are times when the experience of being at sea creates some specific working practices not always accepted ashore. We are seeing that the shore-side industry is more willing to employ non-mariners in roles that were traditionally given to ex-seafarers.

Crew Management

Many women form part of our seagoing workforce and life on board has been diverse in terms of sexuality for a number of years. While the Royal Navy did not accommodate LGBT values until more recently, the merchant navy has been more tolerant in this respect. Diversity training is commonplace and we are very open about the topic – promoting inclusivity through all channels e.g. social media.

Ship Operations/Management

This particular comment is also of significance when exploring ESD and relates to ‘Goal 3 – Good Health and Well-being’ (*see* Table 1).

Conclusion

The maritime sector is at the beginning of a fundamental transformation. Every aspect of the industry’s operating model will change over the next three decades. This will be as a direct result of the rise of connectivity and digitalization, and the need to move away from fossil fuels. This analysis has identified the focus of the maritime shipping industry on certain key competency areas. The next phase will be developing occupational profiles for the key roles within the maritime shipping industry sector and will be informed by the output of this report (D1.1.3.).

As stated at the outset of this report section, the UK maritime industry the Maritime Sector is defined as shipping, ports, leisure marine, marine engineering and scientific (MES), and the Maritime Business Services Industry. Maritime Shipping, and associated industries, and MES are the largest constituent industries in terms of economic activity. The conclusions are based on the findings from UK primary and secondary data analysis and the emphasis placed by industry stakeholders on specific European Key Competency areas as well as the UN’s Sustainable Development Goals (Table 2 and Table 3):

Table 2 – EU Key competencies for Lifelong Learning (Low, Medium and High priority)

Low	Medium	High
Multilingualism	Literacy	Digital and technology-based competences
Cultural awareness and expression	Numerical, scientific and engineering skills (previously STEM)	Interpersonal skills, and the ability to adopt new competences
	Active citizenship	Entrepreneurship

Table 3 – UN Sustainable Development Goals (Low, Medium and High priority)

Low	Medium	High
GOAL 1: No Poverty	GOAL 3: Good Health and Well-being	GOAL 4: Quality Education
GOAL 2: Zero Hunger	GOAL 5: Gender Equality	GOAL 9: Industry, Innovation and Infrastructure
GOAL 6: Clean Water and Sanitation	GOAL 8: Decent Work and Economic Growth	GOAL 17: Partnerships to achieve the Goal
GOAL 7: Affordable and Clean Energy	GOAL 10: Reduced Inequality	
GOAL 11: Sustainable Cities and Communities	GOAL 13: Climate Action	
GOAL 12: Responsible Consumption and Production	GOAL 14: Life Below Water	
	GOAL 15: Life on Land	
	GOAL 16: Peace and Justice Strong Institutions	

According to the report authored by Danish Ship Finance and Rainmaking (2018), the Digital 2030 vision for the shipping industry presents a number of possible future directions:

Table 4 – Maritime Shipping Industry Trends

Industry innovation	Industry Transformation	Industry Redefined
The introduction of new technologies is causing existing business models to be upgraded.	New business models will begin to transform value creation in the shipping industry.	Most of the traditional business models will find it increasingly difficult to compete with ecosystem players who fundamentally change how value is created and distributed across the supply chain.

Recommendation one: the proposed SkillSea toolbox (D1.1.3) needs to align itself with the eight progression levels contained within the DigComp framework foundation, intermediate, advanced and expert.

Recommendation two: the proposed SkillSea toolbox needs to align itself with the eight progression levels contained within EntreComp framework, intermediate, advanced and expert.

Recommendation three: the development of occupational profiles should focus on knowledge, skills and attitudes for both current and future roles in the maritime shipping industry sector (D1.2.3 Impact on Occupational Profiles).

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Appendix 2 - Number of ships - Europe

NUMBER OF SHIPS: MERCHANT FLEET BY FLAG OF REGISTRATION AND BY TYPE OF SHIP,

SHIP TYPE	Containers							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
BELGIUM	4	4	..	..	..	..	..	..
BULGARIA	1	2	..	..	..	..	..	..
CYPRUS	209	212	217	201	201	181	182	184
DENMARK	98	97	97	99	110	117	116	123
ESTONIA	1	1	1	..	..	..	..	..
FAROE ISLANDS	3	3	3	2	2	2	2	3
FINLAND	1	1	1	1	1	1	1	1
FRANCE	25	28	27	24	24	24	24	24
GERMANY	272	295	273	198	157	133	117	107
GIBRALTAR	38	39	40	49	36	34	32	26
GREECE	37	37	35	18	17	9	7	6
IRELAND	..	1	..	..	..	..	..	..
ITALY	24	18	16	13	12	10	10	10
LATVIA	..	..	..	..	..	..	..	..
LITHUANIA	1	1	1	2	2	2	2	3
LUXEMBOURG	7	9	8	20	27	24	20	9
MALTA	101	117	115	160	204	274	290	283
NETHERLANDS	63	74	61	51	49	46	40	41
NORWAY	4	3	2	1	..	..	..	..
POLAND	..	..	..	1	1	1	1	1
PORTUGAL	6	9	8	25	75	133	188	236
ROMANIA	..	..	..	1	..	..	..	..
SPAIN	6	6	3	2	1	..	..	2
SWITZERLAND, LIECHTENSTEIN	2	3	3	2	2	..	..	..
UNITED KINGDOM	177	197	188	134	119	112	108	109
TOTAL	1080	1157	1099	1004	1040	1103	1140	1168

NUMBER OF SHIPS: MERCHANT FLEET BY FLAG OF REGISTRATION AND BY TYPE OF SHIP

SHIP TYPE	Bulk carriers							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
BELGIUM	19	22	22	20	17	15	15	18
BULGARIA	26	19	16	3	5	2	2	2
CROATIA	20	22	22	19	19	15	17	16
CYPRUS	250	268	277	289	294	300	307	311
DENMARK	3	3	3	5	10	7	7	7
FINLAND	3	5	6	6	7	7	7	7

FRANCE	2	2	2	0	..	..	..	..
GERMANY	7	9	7	1	1	1	1	1
GIBRALTAR	2	3	6	10	11	9	8	11
GREECE	240	255	258	250	250	232	204	191
IRELAND	7	8	8	10	11	11	9	8
ITALY	78	103	104	104	75	73	67	59
LITHUANIA	5	5	5	5	5	5	..	..
LUXEMBOURG	3	3	3	9	5	6	3	4
MALTA	475	542	539	568	617	658	656	645
NETHERLANDS	2	9	13	18	19	16	11	13
NORWAY	86	94	98	102	97	104	98	102
POLAND	..	..	..	..	..	..	..	1
PORTUGAL	3	1	5	14	22	37	52	68
SLOVAKIA	1	..	..	..	..	..	..	..
SPAIN	..	1	1	1	1	1	1	1
SWEDEN	1	1	1	1	..	..	..	..
SWITZERLAND, LIECHTENSTEIN	16	20	21	22	24	27	30	28
UNITED KINGDOM	88	105	117	128	123	109	117	129
TOTAL	1337	1500	1534	1585	1613	1635	1612	1622

NUMBER OF SHIPS: MERCHANT FLEET BY FLAG OF REGISTRATION AND BY TYPE OF SHIP

SHIP TYPE	General cargo							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
BELGIUM	17	23	23	17	18	17	15	18
BULGARIA	23	22	20	19	17	19	20	18
CROATIA	54	54	52	43	41	40	39	38
CYPRUS	184	174	166	165	174	176	166	177
DENMARK	104	91		77	75	73	73	77
ESTONIA	5	8	5	5	3	6	7	8
FAROE ISLANDS	29	29	32	44	42	42	43	42
FINLAND	99	91	98	92	88	93	93	88
FRANCE	74	74	75	75	72	70	70	73
GERMANY	93	103	91	78	84	89	89	92
GIBRALTAR	131	142	140	125	127	112	101	81
GREECE	199	186	182	145	132	132	133	136
ICELAND	5	5	5	5	5	5	6	5
IRELAND	27	28	29	29	27	27	28	34
ITALY	150	151	150	145	143	142	145	142
LATVIA	11	9	8	11	12	17	15	18
LITHUANIA	35	34	35	33	29	27	27	28
LUXEMBOURG	17	16	21	19	15	11	4	6
MALTA	391	397	367	323	308	296	303	288
NETHERLANDS	505	581	602	622	607	601	596	586
NORWAY	304	293	291	237	233	232	245	249

POLAND	18	16	17	16	13	12	13	13
PORTUGAL	47	46	40	39	38	47	67	84
ROMANIA	18	14	14	13	13	13	13	13
SLOVAKIA	16	11	10	..	..	1	1	..
SPAIN	49	46	45	44	43	43	43	41
SWEDEN	92	96	85	81	80	74	69	66
SWITZERLAND, LIECHTENSTEIN	9	9	9	12	12	12	12	4
UNITED KINGDOM	226	243	241	203	181	177	174	162
TOTAL	2932	2990	2944	2717	2632	2606	2610	2587

NUMBER OF SHIPS: MERCHANT FLEET BY FLAG OF REGISTRATION AND BY TYPE OF SHIP

SHIP TYPE	Oil Tanker							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
BELGIUM	13	10	10	15	20	20	20	20
BULGARIA	10	9	9	8	8	8	8	8
CROATIA	16	20	18	15	15	19	19	19
CYPRUS	108	96	80	80	74	68	57	51
DENMARK	127	92	94	89	73	81	79	75
ESTONIA	7	7	7	5	5	5	5	6
FAROE ISLANDS	3	1	1	1	1	1	1	1
FINLAND	12	7	7	7	5	5	5	4
FRANCE	40	32	28	31	28	29	30	29
GERMANY	39	35	36	34	34	35	35	36
GIBRALTAR	58	15	15	19	22	32	29	27
GREECE	444	434	439	421	423	410	407	405
ICELAND	1	1	1	1	1	1	1	1
IRELAND	1	1	1	1	1	1	1	1
ITALY	186	162	159	149	143	135	133	128
LATVIA	8	9	8	8	8	8	8	8
LITHUANIA	1	1	1	2	2	2	2	2
LUXEMBOURG	10	8	8	4	4	2	2	2
MALTA	390	271	261	282	298	318	345	391
NETHERLANDS	26	18	18	16	16	21	21	21
NORWAY	117	78	79	77	74	71	79	81
POLAND	9	8	8	7	7	7	7	7
PORTUGAL	7	4	6	4	6	6	8	11
ROMANIA	10	10	10	7	7	7	7	8
SPAIN	36	30	31	28	28	27	28	28
SWEDEN	56	29	28	24	24	23	23	22

SWITZERLAND, LIECHTENSTEIN	4	..	..	..	1	2	2	1
UNITED KINGDOM	218	213	204	169	170	163	171	177
TOTAL	1957	1601	1567	1504	1498	1507	1533	1570

Appendix 3 - Number of ships, 2011-2018

SHIP TYPE	Oil tanker							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
WORLD N.E.S.	118	114	112	134	163	178	158	168
DEVELOPING ECONOMIES	6878	5912	6097	6343	6723	6945	7220	7353
TRANSITION ECONOMIES	452	430	453	486	497	500	504	503
DEVELOPED ECONOMIES	3161	2382	2371	2278	2312	2312	2334	2396
TOTAL	10609	8838	9033	9241	9695	9935	10216	10420

SHIP TYPE	Bulk carrier							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
WORLD N.E.S.	10	12	8	9	13	5	3	10
DEVELOPING ECONOMIES	6702	7330	7861	8366	8670	8897	9067	9279
TRANSITION ECONOMIES	49	38	32	27	27	27	27	24
DEVELOPED ECONOMIES	1467	1621	1667	1760	1799	1818	1795	1812
TOTAL	8228	9001	9568	10162	10509	10747	10892	11125

SHIP TYPE	General Cargo							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
WORLD N.E.S.	363	364	343	367	494	457	390	476
DEVELOPING ECONOMIES	14048	13364	13376	13036	12973	13184	13280	13069
TRANSITION ECONOMIES	1372	1290	1292	1274	1237	1236	1221	1218
DEVELOPED ECONOMIES	5307	5291	5271	4987	4862	4821	4820	4841
TOTAL	21090	20309	20282	19664	19566	19698	19711	19604
SHIP TYPE	Container							
YEAR	2011	2012	2013	2014	2015	2016	2017	2018
ECONOMY								
WORLD N.E.S.	3	6	3	4	11	12	11	19
DEVELOPING ECONOMIES	3771	3817	3903	3979	3946	4005	3892	3853
TRANSITION ECONOMIES	18	19	14	10	11	13	14	17
DEVELOPED ECONOMIES	1174	1254	1187	1108	1143	1197	1241	1275
TOTAL	4966	5096	5107	5101	5111	5227	5158	5164

NOTE: Transition economies - Albania, Armenia, Belarus, Bosina and Herzegovina, Georgia, Kosovo, Macedonia, Moldova, Montenegro, Serbia, Ukraine, Russan, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan, Cambodia, China, Laos, Vietnam, Botswana.

Appendix 4 - Number of seafarers

Appendix

	Country	*# of Seafarers*
1	Philippines	252.392
2	Russian Federation	198.123
3	Indonesia	143.702
4	China	134.294
5	India	113.474
6	Ukraine	76.442
7	United States	59.586
8	Malaysia	35.000
9	Vietnam	34.590
10	Italy	34.486
11	United Kingdom	33.743
12	Myanmar	33.290
13	Poland	31.222
14	Greece	30.507
15	Turkey	28.587
16	Korea, Republic of	27.919
17	Brazil	26.631
18	Denmark	26.159
19	Nigeria	25.610
20	Japan	25.458
21	Panama	25.141
22	Spain	24.487
23	Norway	22.887
24	Bulgaria	22.762
25	Sri Lanka	21.793
26	Croatia	20.495
27	Cambodia	20.067
28	Romania	17.708
29	Iran, Islamic Republic of	17.654
30	France	15.914
31	Thailand	15.682
32	Antigua and Barbuda	15.663
33	Sweden	12.527
34	Germany	12.234
35	Pakistan	12.168
36	Canada	11.652
37	Belize	11.072
38	Finland	10.011
39	Netherlands	9.667

40	Sierra Leone	9.586
41	Ecuador	8.942
42	Taiwan, China	8.268
43	Georgia	8.171
44	Latvia	8.088
45	Morocco	8.081
46	UAE	7.987
47	Australia	7.704
48	Egypt	7.021
49	Chile	7.017
50	Mexico	6.971
51	Saudi Arabia	6.456
52	Singapore	6.000
53	Cuba	5.356
54	Bangladesh	5.147
55	Belgium	4.980
56	Venezuela	4.735
57	Estonia	4.498
58	ST. Kitts and Nevis	4.483
59	Tanzania	4.365
60	Comores	4.189
61	Mongolia	4.055
62	Barbados	3.946
63	Korea, DR	3.901
64	Tuvalu	3.384
65	Bahrain	3.330
66	Lithuania	3.106
67	Colombia	3.061
68	South Africa	3.030
69	Luxemburg	2.991
70	Cyprus	2.926
71	Peru	2.824
72	Qatar	2.591
73	Moldova	2.526
74	Trinidad & Tobago	2.305
75	Argentina	2.222
76	Cameroon	2.193
77	New Zealand	1.889
78	Guyana	1.760
79	Turkmenistan	1.666
80	Solomon Islands	1.502
81	Kazakhstan	1.482
82	Gabon	1.470

83	Algeria	1.434
84	Paraguay	1.306
85	Ireland	1.242
86	Portugal	1.238
87	Fiji	1.221
88	Domenica	1.168
89	Tunisia	1.069
90	Angola	1.055
91	Uruguay	1.042
92	Maldives	1.006
93	Libya	996
94	Azerbaijan	975
95	Honduras	901
96	Albania	836
97	Jordan	831
98	Togo	828
99	Hong Kong, China	824
100	Jamaica	817
101	Vanuatu	786
102	Papua New Guinea	782
103	Mauritius	763
104	Capo Verde	709
105	Liberia	662
106	Equatorial Guinea	650
107	Montenegro	649
108	Malta	628
109	Djibouti	586
110	Lebanon	576
111	Sao Tome et Principe	557
112	Israel	546
113	Seychelles	512
114	Senegal	489
115	Madagascar	476
116	Kiribati	474
117	Oman	470
118	Niue	434
119	Slovenia	374
120	Irak	367
121	Syria	323
122	Mozambique	312
123	Yemen	294
124	Ethiopia	275
125	Micronesia	266

126	Iceland	237	
127	Tonga	203	
128	Guinea Bissau	196	
129	Dominican Republic	192	
130	Kenya	185	
131	Bahamas	124	
132	Congo	122	
133	Slovakia	112	
134	Suriname	106	
135	Sudan	99	
136	Ghana	98	
137	Guinea	89	
	Total	1.920.516	
	Total EU	270.443	14,08%

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