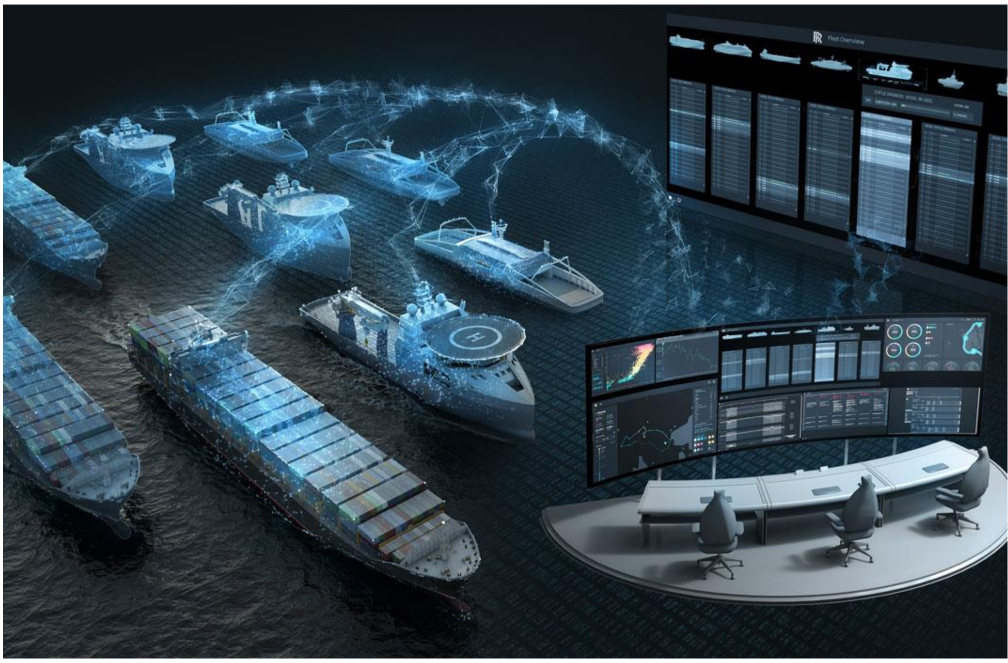
FUTURE SKILL AND COMPETENCE NEEDS



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AUTHOR: A. Oksavik, H.P. Hildre, Y. Pan, I. Jenkinson, B. Kelly, D. Paraskevadakis, R. Pyne

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MAIN EDITOR(S)	Arnfinn Oksavik, Hans Petter Hildre, Yushan Pan
CONTRIBUTERS	Arnfinn Oksavik, Hans Petter Hildre, Yushan Pan, NTNU, Norway {arnfinn.oksavik;hans.p.hildre;yushan.pan}@ntnu.no Ian Jenkinson, Barbara Kelly, Dimitrios Paraskevadakis, Robyn Pyne, LJMU, UK {ian.jenkinson;barbara.kelly;dimitrios.paraskevadakis;robyn.pyne}@ljmu.ac.uk
REVIEWER(S)	University of Rijeka, Svendborg International Maritime Academy, ECSA and HSBA
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Future-proof skills for the maritime transport sector

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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.

In this report we have reviewed **outlook** 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 professionals1** 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. In line with these trends, and endorsed **through our interviews, one of the rational solutions** for improving current maritime professional education and training is simulation-based learning, with lifelong learning attribution. Three areas could be addressed:

1. Developing maritime professionals' competence and skillsets in response to the rapid development of onboard technologies such as ICT and sustainable technologies.
2. Improve seafarers' soft skills in leadership and management with new training programmes aimed at both furthering their onboard career and supporting the transition to an onshore career.
3. Establishing bridging programmes that complement the IMO certificate-based education towards occupational profiles **with a wider reach in the areas of digital, sustainable, transversal and leadership skills**. The aim is to help bridging the distances between shore-based and seagoing profiles. We envision these programmes can be established as **module courses** to attract maritime professionals for the future shipping industry.

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 maritime 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 work and new initiatives to drive mobility.

Acknowledgements

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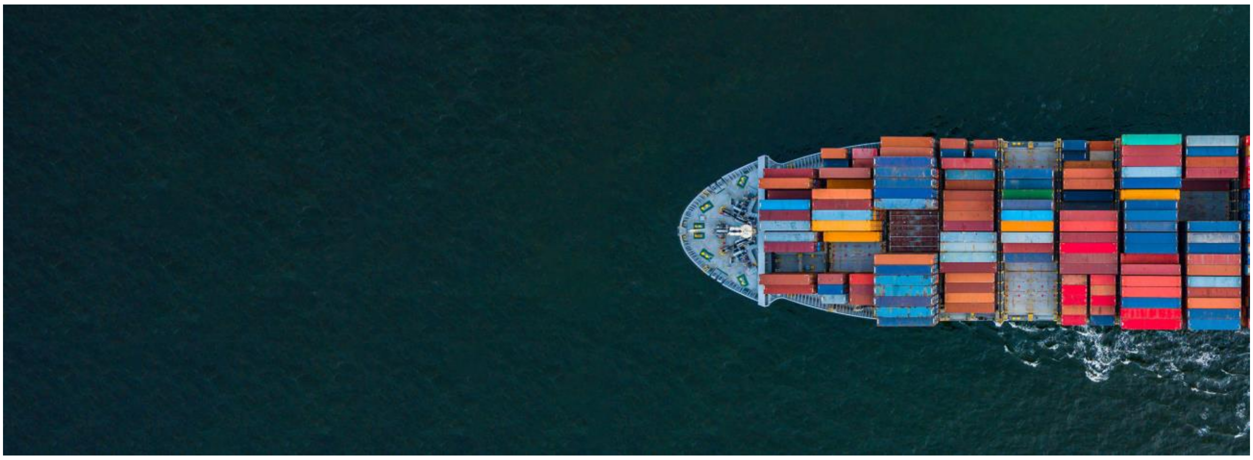
1. Introduction



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.

Maritime 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. Maritime professionals can give concrete innovation suggestions to shipping, ship design and equipment manufacturers, finance and port operations, as well as to researchers who know the challenges presented by specific maritime innovations. Research and product development are thus more targeted. Close interaction between users and researchers provides a faster and more precise path to new technology and solutions. If the European maritime industry is to continue to be a world leader, good education and research institutions, as well as the right competencies, are crucial.

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 and 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.

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. The maritime domain is defined in this report as all companies that own, operate, design, build or deliver equipment or specialised services to all kinds of ships and other floating units. The maritime industry is divided into following four areas:

1. Shipping
2. Finance
3. Ports and logistics
4. Technology and manufacturing

Within shipping, the following segments are included: conventional (such as dry bulk, containers, tankers); industrial shipping (such as gas, car carriers, chemicals); offshore (such as seismic, platform support vessels, anchor handling, subsea construction); and operations.

We include all skills related to areas 1, 2 and 3, but port operations and offshore oil and gas are excluded from the study. In the area of technology (4) the skills needed to adapt technological innovations to shipping operations are included. For occupational profiles we include bridge, deck, engine, and shore-based maritime jobs.

In the following, we highlight a most important figure that is relevant to this project: numbers of European maritime professionals (seagoing). The data resources come from UNCATD Statistics – United Nations Conference on Trade and Development[1]. All in all, this report provides an outlook for the future skills of maritime professionals (both seagoing and shore-based) in relation to four important indicators – sustainability, collaboration of clusters, digitalisation, and education trends. The report also presents our interviews with experts from shipping businesses in Europe.

[1] UNCTAD is a permanent intergovernmental body of United Nations since 1964. https://unctadstat.unctad.org/EN/

SKILLSEA

Table 1 Key numbers illustrating the size and development of the maritime sector

	Europe		*Globally*		*Comment*
	2011	*2019*	*2011*	*2019*	
Number of ships	*39,000*	*43,000*	*85,000*	*91,000*	*Ships greater than 1,000 DWT*[2]
Employees in shipping - *Officers*[3] - *Ratings* -		*234,000* *194,000*	*1,647,500*[4]*, of which 774,000 are officers, and 873,500 are ratings*[5] *13.08% are Filipino seafarers: Officers 9.37%, ratings 16.37%*		
Investment and market share	*The top 9 financing and insurance companies in Europe represent ca. 20% investments around the world*[6]*.*		*The rest of world share increases from ca. 16.87% to ca. 36.15%, as of 2018.*		As of October 2019, the European share of the ship finance and insurance market has dropped to 58.7% [7].
Ports & logistics	*280,000* [8]	*110,000* [9]	*Ca. 1,200,000* [10]		*Employees in ports, logistics and related services*
Technology & manufact. - *Shipbuilding & rep.* - *Classification* - *Equipment prod.* - *R&D & education*		*272,000* [11] *83,301* [12] *451,000* [13] *33 universities* [14]	*1,900,000* [15] *95,000* [16] *1,635,000* [17] *66 universities*		*Roughly, 88% of classification societies' personnel work in European-owned companies.*

[2] The figure in the table includes cargo, fuel, and stores, e.g., Containers, bulk carriers, general cargoes, oil tankers.
[3] Officer refers to deck officer, engineer officer, telecommunications personnel holding certificates of competency issues by competent authorities
[4] United Nations. https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=157422
[5] International chamber of shipping. https://www.ics-shipping.org/shipping-facts/shipping-and-world-trade/global-supply-and-demand-for-seafarers
[6] Data source: https://www.poseidonprinciples.org/
[7] Ship financing down to its lowest level since 2008 as banks continue to exit the sector. https://www.hellenicshippingnews.com/ship-financing-down-to-its-lowest-level-since-2008-as-banks-continue-to-exit-the-sector/
[8] Employment trends in all sectors related to the sea or using sea resources. https://edz.bib.uni-mannheim.de/daten/edz-kr/gmf/06/Exhaustive_Analysis_Main_report_en.pdf
[9] Europe's seaports 2030. https://ec.europa.eu/transport/sites/transport/files/modes/maritime/ports/doc/2014-04-29-brochure-ports.pdf
[10] Estimated data. Data source: Eurostat, OECD, National Statistics and BALance TC calculations, 2017.
[11] Euroststat data 2017.
[12] Data are not registered from Croatian Register of Shipping and Polish Register of Shipping.
[13] Competitive position and future opportunities of the European marine supplies industry. European Commission. Final report. http://ec.europa.eu/DocsRoom/documents/4233/attachments/1/translations
[14] Members of IAMU https://iamu-edu.org/about-iamu/members/ as of April of 2019.
[15] International labour organization. https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_617086/lang--en/index.htm
[16] Data are not registered from Croatian Register of Shipping, Polish Register of Shipping, and ClassNK (Japan).
[17] Data source: Eurostat, OECD, National Statistics and BALance TC calculations, 2017.

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In Figure 1, Russian Federation has the highest numbers of seafarers and officers, 49,000 and 48,000, respectively. Ukraine is second-placed, with 30,000 and 39,000, respectively. Norway is in third place, with 19,000 seafarers and 15,000 officers. Data for other countries can be found in the appendix. Note: *Officer* refers to deck officers, engineer officers, electro-technical officers holding certificates of competency issued by competent authorised. The next update is expected in 2021 with data for 2020.

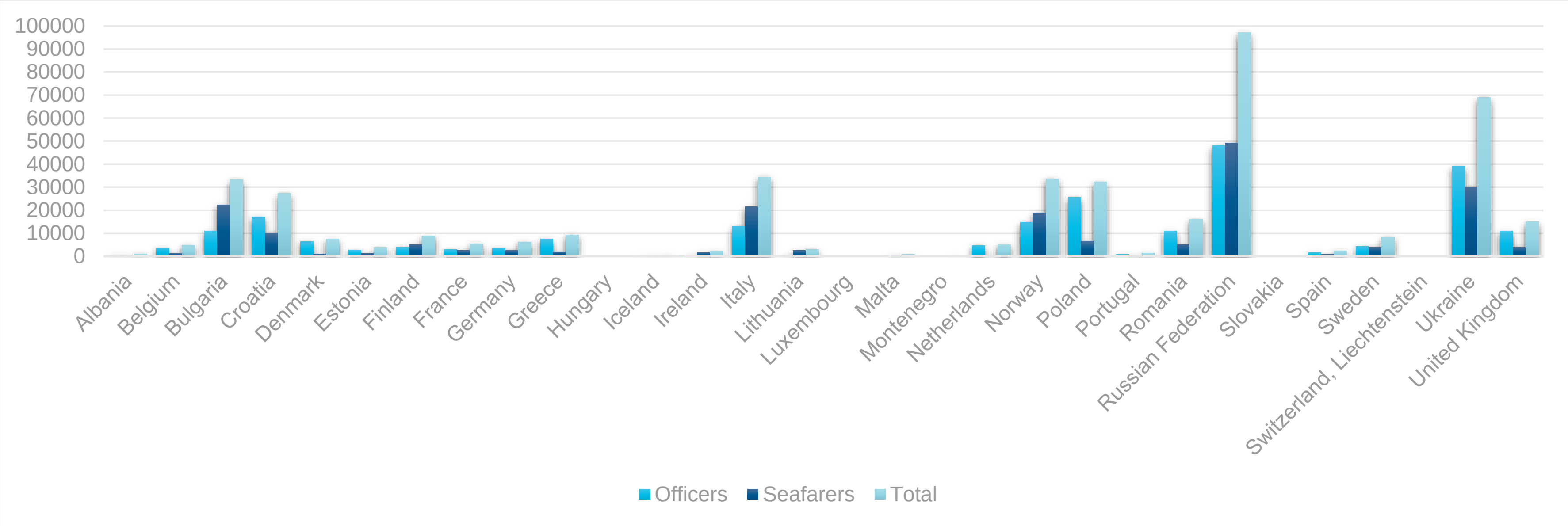

Figure 1: European ratings supply numbers, quinquennial 2015, ref: UNCTAD.

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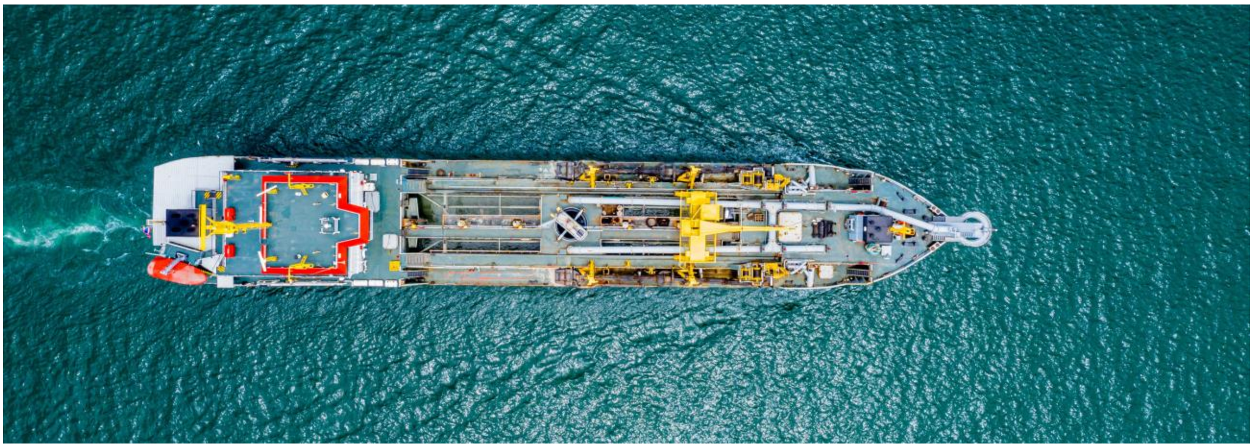
2. Outlook based on global trends



The energy transition from fossil fuel to renewable technologies requires a substantial shift in priorities[18.] The shipping industry's goals for CO_2 reduction are set by the International Maritime Organisation (IMO) and will cause major technological developments and raise demand for more effective and efficient ship operations.

More than half the world's population lives in cities and it is predicted that two-thirds of the world population will be living in urban areas by 2050[19]. The importance of cities and surrounding regions will strengthen. Centres are a core for innovation, knowledge, education, research and specialised services and the world's leading maritime centres will be those that attract the most talented people and start-ups.

Digitalisation is another global trend transforming industry and society. This shift also opens scope for new value chains and technologies to increase safety, increase automation, and enhance efficiency.

We will therefore in this chapter study the effects of the following trends[20]:

- Sustainability
- Collaboration of clusters
- Digitalisation

[18] Shipping sector proposes UDS 5 billion R&D board to cut emissions https://www.hellenicshippingnews.com/shipping-sector-proposes-usd-5-billion-rd-board-to-cut-emissions/
[19] Two-thirds of global population will live in cities by 2050, UN says. https://www.cnbc.com/2018/05/17/two-thirds-of-global-population-will-live-in-cities-by-2050-un-says.html.
[20] We acknowledged in this report that transversal skills are the results from the three trends that are affecting on current occupational profile.

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2.1 Outlook based on sustainability trends

The ocean is the highway for international trade and transport and 90% of all transport by mile-tonnage is by sea[21].The International Transportation Forum (ITF) report, ITF Transport Outlook 2019[22], predicts significant trends and development towards 2050. A reasonable assumption, according to ITF, is that the present growth of 3.6% annually will continue. Global transportation will then have a growth of 300% from 2015 until 2050.

The DNV-GL analysis, Energy Transition Outlook 2018[23], assumed annual growth of 2% until 2030 and then growth of 0.2% until 2050, giving a total growth of 37%.

The IMO has reached an agreement on a strategy for the reduction of CO_2 emissions from shipping. Its Marine Environment Protection Committee[24] (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[25]. 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[26], EEDI).

An increase of transportation of 37% until 2050 will require a 70% reduction of CO_2 from transportation in order to reach a total reduction of 50% by 2050. To achieve such a reduction will mean major improvements in logistics, hydrodynamics, machinery and fuel. Within fuel we will see a number of sources as LNG/LPG, electric systems, biofuels, synthetic fuel and hydrogen. 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. We believe a reduction of speed from 25 to 15 knots will typically reduce the fuel consumption by 60% but can only be effective if delivery obligations are maintained. Further reductions can be achieved by optimisation of the operations. For example, some ships are sailing longer distances as a result of the high costs of using the Suez Canal. The average waiting time[27] to get into a port is reported to be up to several days and many ships are sailing without utilising their full cargo capacity.

Both the EU and the IMO have established two similar regimes to control CO_2:

- EU MRV – EU Monitoring Reporting and Verification of CO_2 emission (started 1 January 2018)

[21] Global Marine Trends 2030, Lloyd's Register, https://www.lr.org/en/insights/global-marine-trends-2030/
[22] ITF Transport Outlook 2019, OECD Library, https://www.itf-oecd.org/itf-transport-outlook-2019-0
[23] Energy Transition Outlook 2018, DNV-GL, https://eto.dnvgl.com/2018/
[24] http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-%28MEPC%29/Pages/default.aspx
[25] International Chamber of Shipping.
[26] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Technical-and-Operational-Measures.aspx
[27] Park N.K. and Suh, S.C. Tendency toward Mega Containerships and the Constraints of Container Terminals. J. Marine Science and Engineering. 7, 131.

- IMO DCS – IMO Data Collection System on fuel consumption (started 1 January 2019).

Both the EU MRV and IMO DCS requirements are mandatory and the first step towards the collection and analysis of emissions from shipping.

In addition to reducing CO_2 emissions, considerable attention is being paid to the reduction of soot and particulate matter at a local level, as in harbours and cities.

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

- Maritime Forecast to 2050, Energy Transition Outlook 2018[28], DNV-GL
- Global Marine Fuel Trends[29], 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 executive summary 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. That means the optimum operating speed will be one of the most important skills for seafarers. Regarding factors, such as ship's age, the ship's type and size, as well as the designed speed, seafarers will be required to have new knowledge to determine the optimum operation of the ship to ensure maximum sustainability.

DNV GL'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. It also places a focus on safety in cyber-risks, autonomy, and control systems. The ongoing digital transformation will, through automation and adaptive manufacturing, have an impact on global value chains. It will also advance the design and operation of ships and create new competencies and skillsets for seafarers to master. If clean fuel is an example, then electricity and new technologies will be other vital drivers in shipping industries. Seafarers must be able to gain knowledge on the safe use and storage of carbon and LNG, as well as battery packages, and even retractable wind turbines, solar panels, and sails. All these are beyond current IMO conventions and require new thinking in maritime education and training. 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.

[28] DNV GL https://eto.dnvgl.com/2018/maritime
[29] Lloyds https://www.lr.org/en/insights/global-marine-trends-2030/global-marine-fuel-trends-2030/

Conclusions with respect to energy

There is generally a demand for specialised technology and equipment in the maritime industry to achieve improved efficiency at sea, as well as to address new operational limitations and ambitious goals due to recent environmental regulations.

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:

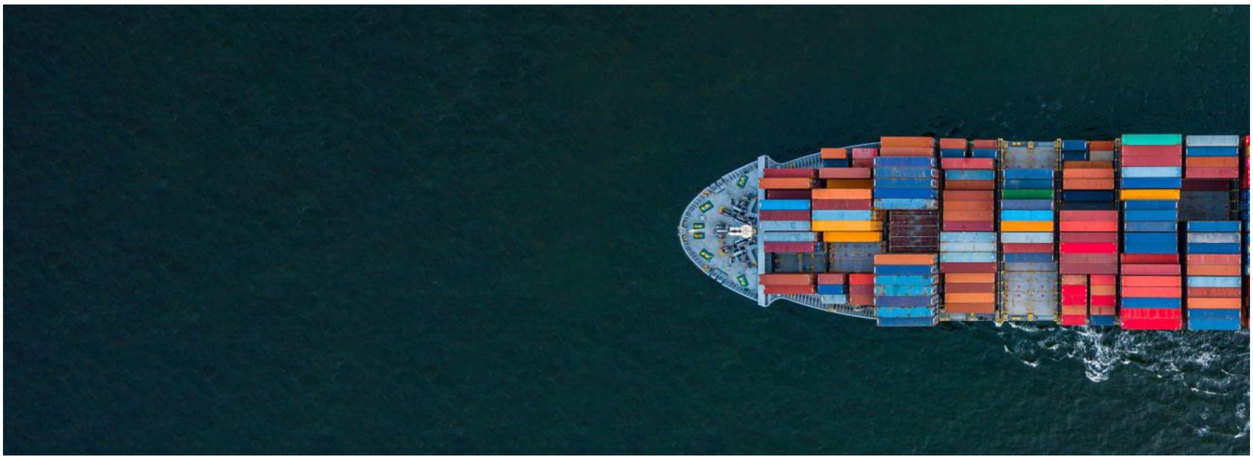
- Logistics: reduction of speed, ship size, utilisation of ships, reduction of waiting times, optimum routeing
- Hydrodynamics: optimum design of hull, hull fouling and cleaning
- Machinery: use of surplus heat, optimisation of machinery, batteries, etc.
- Fuel and energy sources: LNG/LPG, batteries, biofuel, synthetic fuel, hydrogen, etc.
- System for effective harbour operations.

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. Thus, the following capabilities of seafarers are needed:

- **Logistics and optimisation methods to achieve high vessel utilisation**
- **Advanced routeing, considering factors such as wind, current, and waves**
- **Operation of complex hybrid and zero emission machineries**
- **Measurement, calculation and documentation of emissions**
- **Control centres supporting ships with optimisation services, remote control and autonomy**
- **Performance management systems**

2.2 Outlook based on collaboration of clusters



Collaboration of clusters 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 collaboration of clusters is relentless. Cities already generate 80% of global GDP 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.

For decades, the world economy has become increasingly integrated. 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[30].

[30] https://www.forbes.com/sites/billconerly/2020/03/10/rolling-recessions-are-the-likely-economic-impact-of-new-coronavirus-and-covid-19/#33c282fd1320

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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 [31] 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.

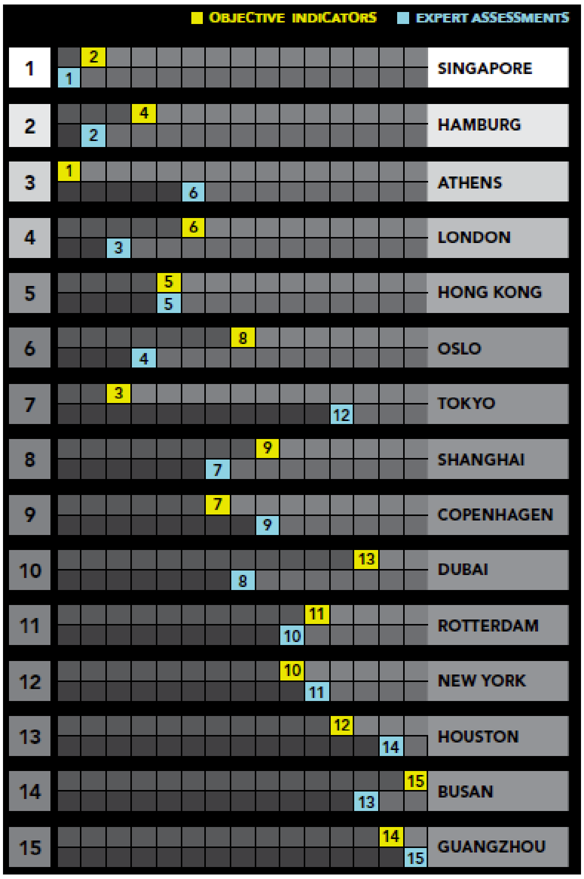

Figure 2 Ranking of maritime cities, Menon ref 32

When combining the objective indicators and expert judgments equally, Singapore[32], Hamburg and Athens take the top three positions in the total ranking of the leading shipping centres, see figure 2. 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.

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

[31] https://www.menon.no/wp-content/uploads/2017-28-LMC-report.pdf

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

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. 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.

Conclusions with respect to collaborated clusters

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 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 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. This not only will offer benefits to Europe, the world will be able to connected.

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.

2.3 Outlook based on digital transformation and innovation

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 and create new opportunities.

How digitalisation will affect the industry and the speed of this change is hard to predict. Actors in the value chain are trying to adapt new technologies. At the same time, digitalisation will have a disruptive effect on the industry.

Connectivity

Digitalisation is not a new force. The personal computer as a mass market electronic device gained popularity in the 1970s. Internet capabilities were also developed in the 70s and commercial internet service providers began to scale late in the 1980s. Speed and capacity have been continuously developed and new software with improved performance and functionality have been launched continuously. What is new? What is the key technology driving this digital transformation? Connectivity.

Advancement in wireless communication, sensor technology and advanced analytics are fuelling the digital transformation. In just a few years the price of 5G-connected sensors will be very low, and the availability very high. The low power consumption of the Internet of Things (IoT) devices also enables a long lifetime without the need for replacements. Data will be available at the fingertips everywhere. This development opens opportunities for data-driven industrial activity on a huge scale. Analytics will be a key to optimise business and operations.

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.

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The challenge has been to establish high-speed internet access to and from ships everywhere. Existing satellite communications offer low bandwidth at high cost. Elon Musk's SpaceX[33] has launched a pair of test satellites into orbit, and now, for the first time, it has been possible to see 60 of the final versions loaded up and ready to launch. The long-term plan is to fill the sky with 7,000 satellites transmitting high speed internet to every point on the globe – truly disrupting technologies.

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[34].

Digital twins integrate the internet of things, artificial intelligence, machine learning and software analytics with spatial network graphs to create living digital simulation models that update and change as their physical counterparts change, see also figure 3.

A digital twin continuously learns and updates itself from multiple sources to represent its near real-time status, working condition or position[35]. 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.

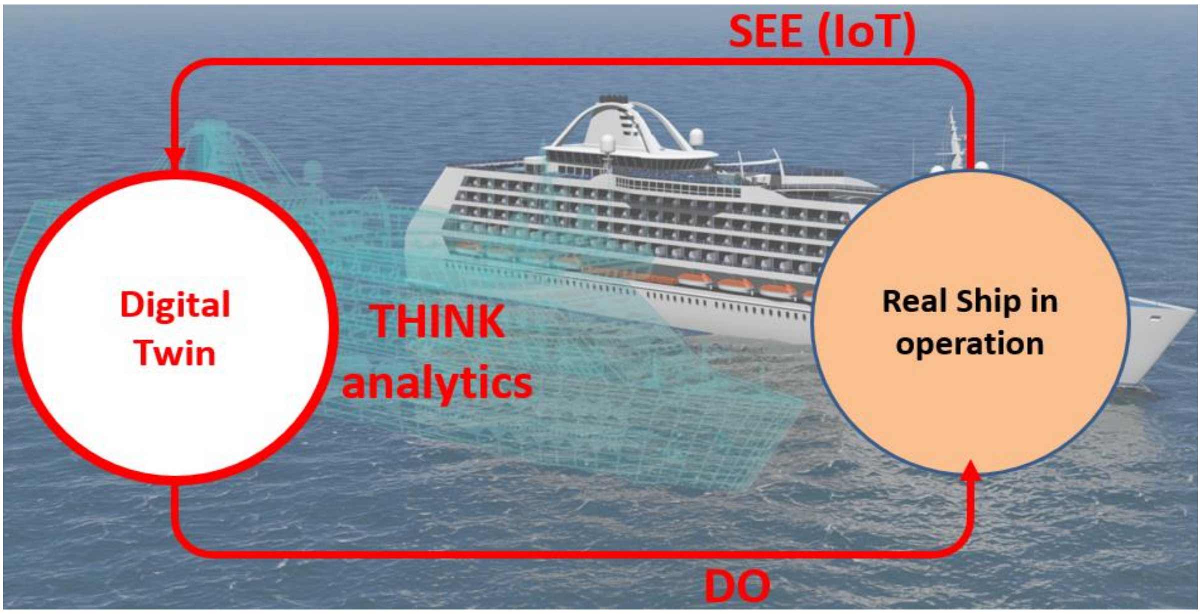

Figure 3. Digital twin

[33] https://www.spacex.com/
[34] "Minds + Machines: Meet A Digital Twin". Youtube. GE Digital. Retrieved 26 July 2017.
[35] "Introduction to Digital Twin: Simple, but detailed"Youtube. Retrieved 27 June 2017

Opportunities in shipping

Autonomy. Autonomous ships are new concepts that will challenge the conventional methods for designing, testing and operation of ships. Autonomous ships do have some form of self-governance, such as the ability to select between alternative strategies without consulting humans. This does not necessarily mean that no human is present (unmanned).

Interest in autonomous shipping is growing fast and it is a popular topic in research communities. 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.

In recent years, complete systems onboard ships such as power packages, propulsion packages and more, have been installed motivated by the desire to integrate and streamline ship operations. As an additional effect they have (unintentionally) added a level of autonomy to the ships, since these integrated packages are designed to work with little or no crew maintenance and are designed as 'black-boxes' with only key control input and output.

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.

Dispersed crew and remote operation: 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.

Remote-operated functions include both operations on the bridge and in the engine room. A precondition for this organisation is to have effective dispersed teams that perform as a fully integrated crew team.

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.

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 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[36].

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

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

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

Anticipatory shipping: Amazon is developing capabilities to build predictive analytics around consumer shopping behaviour. Amazon wants to ship products even before the consumers know that they want them. The strategy is to send deliveries to areas and get the products as close as possible to its consumers and then, in-transit, complete the address and route to the one who has placed the order.

Blockchain: The impact of blockchain technology is expected to provide a broader reach to track right from the order initiation by the customer to shipment details, creating an unprecedented transparency within the entire supply chain system and allowing the parties concerned to access real-time status that is accurate from anywhere and at anytime.

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.

Conclusions with respect to digitalisation

The digital transformation and distributed technologies change our societies and the maritime business. The gap between common practice, competence 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.

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. **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.**

3. Voices of maritime experts

As part of our study into future skills, we asked five shipping industry 'champions' about their ideas on the way in which the sector is changing and of the necessary future skills. We also interviewed[37] 12 experts from 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.

In the following section, we present the views of champions in section 3.1. In section 3.2 we present the data analysis approach. And results of the 12 interviews are presented in section 3.3.

[37] we use a 'folk explanation' approach. This approach allows researchers to study and discuss people's everyday lives, their work, and their experience with new technologies in the workplace. A semi-structured interview guide was used (see Appendix 1). In addition, secondary qualitative data were used to outline and categorise the particular knowledge, skills, and attitudes perceived as necessary for the relevant occupational roles to compare 'what people believe in now' in the interview. The majority of these data sources were in the form of published written materials, including CEDEFOP, academic papers, and the World Economic Forum. This differs from a literature review in that the sources were coded to identify and capture significant information from the data, with the outcome shaping our understanding of shipping industry. The data collection and analysis were reported to the Norwegian Centre for Research Data (NSD). Data collection was approved by the same authority. Data storage and analysis followed the rules of the NSD. In this document, details of individual identify, and company names have been removed and remain anonymous except four key persons from the shipping industry.

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3.1 Views of champions

In this section, five shipping industry ‘champions’ have expressed their opinions regarding future skills of maritime professionals.

Five shipping industry ‘champions’ are:

- DNV GL – Knut Ørbeck-Nilssen, CEO
- Compagnie Maritime Belge – Alexander Saverys, CEO
- Kongsberg Maritime – Egil Haugsdal, President
- Clarkson PLC – Andi Case, CEO
- Skuld – Trude S. Husebø, Chief Human Resources Officer

DNV GL

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.

- Knut Ørbeck-Nilssen CEO DNV GL Maritime

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

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

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. ***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.

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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.

- Alexander Saverys, CEO

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)

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.

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.

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Kongsberg 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.

- Kongsberg Maritime, Egil Haugsdal, President

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 (2018 consolidated figure)

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. 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.

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Clarkson PLC

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[38].

- Andi Case, CEO, Clarksons

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)

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.

[38] This is an authorised extract from the 2018 annual report by Andi Case and Clarksons.

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Skuld

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

- Trude S. Husebø, Chief Human Resources Officer, Skuld.

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

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3.2 The interviews

The interviews took place from the beginning of May to the end of September 2019. In total, we conducted **12** interviews. To collect the code and memos from our qualitative data, we linked patterns from different notes to derive themes and meanings from interviews. Analysis began early in the research process, focusing and refocusing on project aims and questions. In this way, we could phase and address any issues with specific people. This also helped to answer the questions the interviewers 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 interviewers to reflect: what do I see going on here?

In the interview, particular attention was given to categories such as, education, technology, use, digitalisation, skills, operations, offshore, onshore, digital competence, future, now, strategy, green and sustainability, role of university and industry, and the combination of these. In doing this, the researchers conducted thematic index analysis. Most of the material presented in this report as an aggregation of the various materials collected in the interviews has been rephrased regarding NSD policy on anonymity. However, as mentioned, four key persons from the industry agreed that **SkillSea** is a good opportunity to highlight their visions of the maritime professionals' future.

Results of 12 interviews

In this section, we briefly present our analysis outcomes from the interviews in Europe. Detailed analysis could be found in Appendix 1.

The major impact of educational recommendations in the context of shipping industry currently sits at the international level, with IMO member states agreeing to comply with the the international standards of training, certification, and watchkeeping (STCW) Convention. These requirements are mainly for seagoing personnel but also heavily influence competence requirements for shore-based job roles. In Europe, there are less common regional standards, such as the NORSOK standard or OPITO standard[39], which can help European countries to collaborate on the development of standards for seagoing jobs. They can also apply to shore-based jobs but here the core criteria will be 'knowledge of', rather than

[39] Norsok Standard R-003N, Safe use of lifting equipment. 2004

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simply possessing certificates of competence (CoCs). It is also important to consider the challenges to facilitate the transition from seagoing roles to shore-based roles and vice versa.

However, with the progression of digitalisation, globalisation, and sustainability in shipping, maritime professionals face new opportunities to expand their skills and competencies. That means new knowledge of simulation-based training and, for example, the use of IoT, running sustainable operations, gaining advanced knowledge through simulator-based training, enhancing personal management skills in teams, and expending transversal competence in the context of lifelong learning programmes. Even without recognising the above trends, future uncertainties increasingly require maritime professionals to develop their competence. This presents a challenge for the training in Europe – particularly in the maritime domain – due to differences among countries, including the structure of training programmes, the technologies used, educational content, cultural differences, and member state policies.

The opportunity and necessity for making changes in training is not easily seen by policymakers. The interview outcomes reveal some significant opportunities, using Scandinavia as an example. Many industries could be considered as contributors to shipping, including those non-maritime industries, like Yara and ASKO (grocery wholesaler) in the value chain.

Complying with STCW minimum standards only?

Responses from the interviewees confirm that compliance with the IMO certificate requirements is a priority. IMO competence is organised in mandatory training towards certificate levels, so compliance follows technology, ship types, sizes and sailing areas. As such, IMO certification requirements seek to ensure a level playing field globally.

However, the nature of IMO decision-making results in a cycle of adaption to current technology that lags behind maritime technology development – in some cases by decades. **Seafarers** therefore need to advance the updating of their competence accordingly to further their carrier at sea and on land.

The interviews demonstrated that gathering and understanding data are becoming important digital skills. Finding time for learning these new skills during basic maritime training competes with current curricula and puts pressure on minimising the STCW training length. Learning new skills after graduation is expensive in terms of time and money, whether paid by the shipping industry or the individual. However, the future skills of maritime professionals depend on how well we are able to help them to find their own ways to co-build maritime studies in an interdisciplinary field. 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.**

Establishing new programmes towards future skills

Some European governments' strategies reveal the importance of linking practical experiences from the sea with research-based knowledge for technology development and innovation. Maritime is an equipment-intensive industry and this equipment needs competent employees during development and use. Investment in equipment can be wasted if there is a failure to ensure that maritime professionals are properly trained to make the most effective and efficient use of the technology.

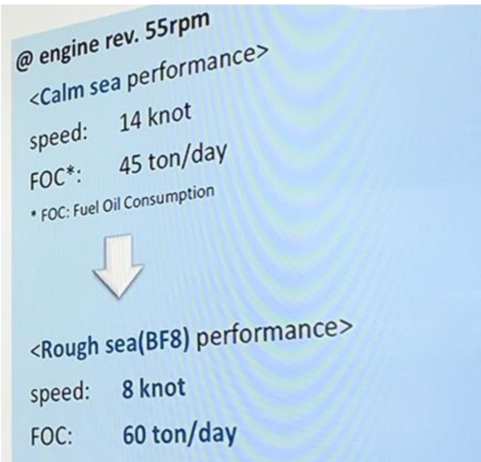
In addition, to support new programmes in seafarers' training, the collaboration between the business community and research-based universities should explore new methods and new technology. Most skills required in the future, as our interviewees forecasted, are beyond the scope of current training courses and cover areas such as: advanced data analysis, operational economics, future onboard power and energy production, developing and using statistics and risk analysis. This requires educators to establish 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, foreseeing future skills is not the same as manpower planning. 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. **We need a flexible, scalable training system, and it is important that maritime training institutions encourage specialisation.** For example,

1. integrating sustainable skills and digital skills in maritime training **to enhance the competence and skills of maritime professionals**
2. Integrating maritime law, business finance, remote operation and other new technology-based skills in maritime training **to expand STCW training**
3. uplifting instructors' knowledge of the future **to be able to update training programmes**
4. 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**
5. Establishing effective transfer schemes between academies and companies to address **mobility and culture issues**

Lifelong learning, transversal competence and skills sustainability

"Charterers don't buy the boat; they buy the crew" - Knut Steinar Dyrkorn. This signifies that in some segments of shipping the ship is part of the basic requirements, and the crew is the competitive advantage. During a recent visit (to NTNU) from a shipping line which employs a large number of European officers, it became clear just how significant an impact the onboard crew and its competence makes for the operational cost of the ship. It was revealed that a voyage in calm vs rough sea differed in fuel per mile efficiency by a factor of more than two. In this context, knowledge of the strategies and capability to exploit the fuel-saving opportunities are all-important and rest entirely with the crew. This shift also applies to the shore-based positions. **Through lifelong learning (LLL), an improved interface between seagoing and shore-based jobs can help with building up transversal competences and skills in the maritime sectors.**



Digitalisation, globalisation, and sustainability now provide a new chance for LLL to break the barriers between different disciplines around the training of maritime professionals. The new opportunities will not end for maritime professionals after they finish their training in nautical studies. Instead, according to our interviewees, interfaces can be used to further develop seafarers to help the technology-driven maritime world further, such as:

1. **A programme (module courses) that leads seafarers to gain knowledge in both the onshore and seagoing sectors**
2. A framework between maritime education, training, and research is necessary. **To use maritime professionals' experience and competence to help researchers to shape technology development and innovation; in turn, to help maritime professionals gain the most up to date and relevant knowledge of technology**

To make progress step by step, in the appendix 1, we list topics which are urgently needed in current maritime education - including, but not limited to, nine literacies.

4. Outlook based on education and training trends

As a starting point, we provide an overview of how the maritime education and training process is set up in European member countries.

Each country's METs develop their own training programmes that comply with IMO certificate requirements and apply to the National Maritime Administration (NMA) for approval. Such programmes can either be an implementation of an IMO model course or an implementation different from the model course, but still approved by the NMA. These training programmes go into the curriculum and make up a study programme, leading to, for example, navigator, ship's engineer, electrician, able seaman, oiler, etc. If the MET adds sufficient content to the IMO curriculum, the study programme can contain enough study points that it will also be a BSc degree. This set-up results in all MET curricula being different in composition but all achieving the same goal, an IMO certificate.

Furthermore, when a **seafarer** needs to complete additional training, as required by - typically - a new IMO requirement or going to a different ship or trade, the **seafarer** almost always must do this in his/her home country. This is the case since the MET institutions that provide the training need to be approved by the certificate holder's home country. This has the following effect: there is virtually no student mobility for parts of the study programme, such as one semester or one year, since no two METs have curricula that are similar. There is very little **seafarer** mobility[40] since seafarers and ship-owners are reluctant to cover the cost of returning to the home country for additional training. For this reason, the way maritime training is implemented in European countries severely restricts mobility.

Although MET academies are strongly focused on complying with IMO requirements, there are existing solutions which contribute to promote mobility between METs and **mobility of seafarers between seagoing and onshore sectors.**

(i) E-learning which makes learning more distributed, flexible and adjustable, with multiple training and assessment methods

[40] Mobility of other maritime professionals is more open than seafarers.

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(ii) Use of new computer technology such as VR and distributed computing (simulators) allow seafarers to participate and be examined remotely, making it easier to conduct exchanges even if the training is not perfectly aligned

4.1 Trends for the future of learning and development in shipping

Utilising simulators, virtual and augmented reality for assessment of maritime training

Simulator-based learning in maritime is booming, even though it is a bit late compared with other similar disciplines. For example, Sharma et al[41] use simulators as an intervention for maritime education and training. They state that the maritime domain is one of the most high-risk industries and it predominantly employs simulator training as a means to train prospective operators. Thanks to the computer-based learning environment, maritime instructors can train students who will become future sharp-end operators and interact in a highly safety-critical environment no matter where they are.

Simulators will help seafarers not only to learn the highly contextualised knowledge of work settings but will also provide them with the ability to work together in teams to demonstrate qualities such as critical thinking and leadership*. *Moreover,* *technology also enables* ***part-time and distributed learning for seafarers even they are at sea.

Similar studies could also investigate the influence of educational technology in maritime education and training[42], virtual and augmented reality for the maritime sector[43], and simulator user conference, focusing on maritime training[44]. It is important to mention that virtual and augmented reality is not a recent invention. Scientific research has been working in this field for decades, having recognised it as a very powerful tool for creating more natural and intuitive human computer interactions (HCIs). VR can be described as an interactive, computer-generated three-dimensional (3D) environment with which users can interact using specialised peripherals such as 3D displays, data gloves and haptic/force feedback devices. VR is also interpreted as a natural extension to 3D computer graphics, with advanced HCIs that

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[41] Amit Sharma, Salman Nazir, Camilla Wiig, Charlott Shellberg, Marius Imset, Steven C. Mallam. 2018. Conference on Advances in Human Factor in Training, Education, and Learning Sciences. Springer.
[42] Rani Unnab Aziz Khan. 2014. The influence of educational technology on affective education in maritime education and training. Master thesis. World Maritime University.
[43] Uwe Freiherr von Lukas. 2010. Virtual and augmented reality for the maritime sector – applications and requirements. IFAC proceedings 43, 20, 196-200.
[44] Kongsberg. 2017. A digital revolution for maritime training explored at Kongsberg simulator user conference. https://www.kongsberg.com/digital/news-and-media/news-archive/2017/a-digital-revolution-for-maritime-training-explored-at-kongsberg-simulator-user/.

simulate a functionally realistic environment. As the technologies of VR evolve, the applications of VR become literally unlimited. **VR will reshape the interaction practices between seafarers and computer technology by offering new approaches for the communication of information, the visualisation of processes and the creative expression of ideas**. Most important is the use of computers as a mediating artefact in shared workspace ***for peer-to-peer interaction***. This provides more support on several challenge levels of operations **which cannot be practised in reality** [45] such as mirroring, meta-cognitive support and guidance, as well as enabling both students and lecturers to be proactive, reactive and passive in **dangerous operations** and in **distributed team performance**.

Simulation-based research for supporting maritime education and training

In order to support the above-mentioned maritime training in simulators, VR, and its assessment, maritime studies have been of interest to design simulators or similar digital environments for some time. Perhaps the earliest work was that discussed in a G-7 ministerial conference, held in Brussels on 25-26 February 1995, along with the European Commission. This resulted in a decision to launch 11 pilot projects, one of which was to build up intelligent manufacturing systems, through global cooperation[46]. The project was embraced within the scope of computer systems, including interactive computer-aided design, manufacturing systems, and exchanging information on design[47] to demonstrate the potential benefits of the information society and to stimulate its deployment. After that, a few maritime studies appeared in the maritime field. Mainly, these studies could be divided into two categories: technology development to support cooperative maritime operations[48,49,50,51,52] ; and empirical study of the use of technology in maritime operations[53,54,55,56,57,58,59] . The empirical study in maritime has intensified in recent years, paying attention to end users' work practices in technology use. In their mobile computing study, Kristoffersent and Ljungberg conduct ethnographic studies on how maritime surveyors use mobile technologies in their daily work[51,52]. They argue that the use of computer technologies is very different outside the office. They found maritime surveyors have difficulty in using both hands to type in during

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[45] Charlott Sellberg and Hans Rystedt. 2015. Temporal and material conditions for instruction in simulation-based maritime training. Conference on CSCL 2015.
[46] European Commission. 2014. IS-G7-MARIS C-G-7 Information society pilot projects - Maritime information society, 1995-1998. European commission.
[47] Bangemann, M. (*1995)* MARIS -Maritime information society. Brussels.
[48] Detken, K.-O., Kaufmann, U. and Muffler, K. 1997. 'EIES -New applications for an efficient co-operation in/between harbour areas.' In European workshop on advanced communications for the maritime world.
[49] Godøy, Ø. (2009) i-Nord: A holistic information system for monitoring of maritime security, marine environment and marine resources of the Nordic Seas and Arctic Ocean.
[50] Scott, S. D., Allaven, A., Cerar, K., Franck, G., Hazen, M., Shuter, T. and Colliver, C. 2010. 'Investigating tabletop interfaces to support collaborative decision-making in maritime operations.' *ICCRT 2010*
[51] Larsson, M., Coppin, G., Poirier, F. and Grisvard, O. 2012. 'A framework for a priori evaluation of multimodal user interfaces supporting cooperation.' CHI'12.
[52] Franz, J., Malloch, J., Reilly, D. and Nedel, L. 2017. 'More Than Blips on the Radar: Exploring Immersive Visualization for Maritime Decision Making. Immersive Analytics Workshop at VIS
[53] Kristoffersen, S. and Ljungberg, F. 1999. '`Making place' to make IT work: Empirical explorations of HCI for mobile CSCW.' ACM GROUP
[54] Kristoffersent, S. and Ljungberg, F. 1998. 'Representing modalities in mobile computing: A model of IT-use in mobile settings.' Interactive applications of mobile computing.
[55] Aoki, P. M. 2007. 'Back stage on the front lines: Perspectives and performance in the combat information center.' CHI 2017.
[56] Haavik, T. K. 2014. 'Sensework: Conceptualising sociotechnical work in safety-critical operations.' CSCW.
[57] Pan, Y. 2016. 'Design of Digital Environments for Operations on Vessels.' COOP 2016.
[58] Pan, Y. 2018. From field to simulator: visualizing ethnographic outcomes to support systems developers. UiO.
[59] Hontvedt, M. and Øvergård, K. I. 2019. 'Simulations at work - A framework for configuring simulation fidelity with training objectives.' CSCW.

their work on board and they normally face challenges in finding a place to position their pocket digital device. Another example is Aoki's empirical study on the combat information centre[53]. Aoki studies both social and technical aspects of naval tactical coordination, trying to understand the social relations and interaction in and beyond the tactical command, control and communication environments that might offer useful design insights.

Hontvedt and Øvergård[77] identify that technical, psychological and international fidelities may contribute to ***link the fidelity of simulation to increase the levels of professional expertise without separating the learning activities from cooperative work performance from a trainer's perspective.*** They argue that whether the level of fidelity is sufficient for effective training depends on the learning objective. ***Learning objectives, then, can follow the institutional standards and formal classifications of learning outcomes in maritime training***[60].

[60] International Maritime Organization. 2010. *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*. IMO. [Online] [Accessed on 24th September 2019] http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx

4.2 Conclusions with respect to education and training trends

Technology changes maritime education and training towards more flexible and on-demand paths. In line with the rapid technology changes, maritime education and training must seek effective training methods to meet the needs of the shipping industry. Training courses should be accessible from anywhere and at any time.

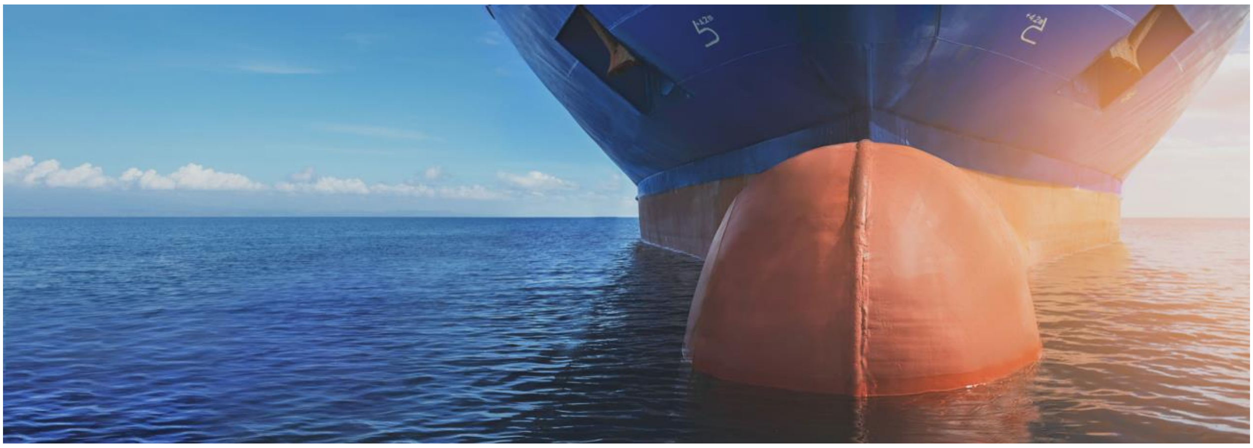
One example is the combination of simulation-based training, including VR, AR and the use of computer-generated models such as digital twins, which are key technology ingredients to meet the emerging competence needs of the wider maritime shipping sector. Although simulators are identified as important contributors, the human will still take centre stage. The use of digital tools listed above are mainly utilised as enablers for seafarers to develop their competence:

1) Learn to interact through technology in teams onboard, between ships and between ship and shore

   Further, the following competences will be key:
2) Leadership and project management through simulation-supported cooperative work
3) Establish capability to estimate sustainable and green skills while training in simulators
4) Develop digital skills to extend the personal value chain in the shipping industry, such as using IoT, blockchain, big data to work on logistics

In line with the above training module courses, we can create this opportunity for enhanced mobility. The above courses could be designed such that seafarers have access to **flexible training paths** and **training methods** in line with the shipping industry's needs. In the meantime, **seafarers** will have many more opportunities to master new technologies as well as good seamanship in terms of **mobility** and **lifelong learning,** along with **specialisations**. **Their experience and competence will be carried back to technology development and innovation, both at sea and ashore**. Such a strategy will ensure that training, shipping industries, maritime professionals and - most importantly - technology development and innovation, will progress towards new achievements in a more structured, coordinated and collaborative manner.

5. Recommendations for future education and training



5.1 Future skills

Future skills with respect to environmental regulations

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 (Maesk 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, a number of technologies are likely to be improved - for example, hydrodynamics, new fuel and energy sources, logistics, and methods for effective harbour operations.

In addition, systems to reduce emissions and particulate matter in harbours and the proximities to cities will be important.

As a conquence of the above changes, the following competences and capabilities will then be needed:

- **Logistics and optimisation methods to achieve high utilisation of ships**
- **Advanced routeing, considering wind, current, and waves**
- **Operation of complex hybrid and zero emission machineries**
- **Calculation and documentation of emissions**
- **Control centres supporting ships with optimisation services, remote control and autonomy**
- **Performance management systems**

Future skills with respect to cluster approach

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

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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.

Future skills with respect to digitalisation

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 under the heading of block-chain technology. These advances enable integration of the business process and reduce transaction costs. **Skills that support business development in taking advantage of technology will be important.**

Autonomy and advanced support systems onboard will continue to be developed. We do not think ships without crew will be a reality on a large scale in the next few decades. However, technology development will cause challenging interaction between complex autonomous systems and the crew. **Skills required to interact with computer systems that respond to difficulties in autonomous systems will be a core competence.** The crew need in-depth understanding of the complex systems onboard to be able to support the necessary redundancy of all systems.

Vessel positions, manoeuvres, speed, fuel consumptions, cargo condition and so on will be monitored in control centres. 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. **Advanced skills in analytics and use of data in optimisation of the fleet will be necessary.**

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. **One possible outcome will be to transfer tasks from the ship to the control centre and be supported by highly advanced tools for optimisation of the entire fleet.**

Future skills with respect to innovations

Maritime 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. Maritime professionals can give concrete innovation suggestions to shipping, ship designers and equipment manufacturers, finance and port operations, as well as researchers who seek to understand the challenges one faces in specific maritime innovations. Research and product development are thus more closely related to ship operations. Close interaction between users and researchers provides a faster and more precise path to new technology and solutions. **Establishing a habit and a process for such close cooperation is a key competence to deliver successful innovation in maritime clusters.**

Maritime professionals also need transversal skills to enable them to move from one value chain to another and thereby contribute to innovation. Such skills are also of vital importance to allow smooth transition to other positions in the maritime industry.

Examples of transversal skills are logistics competence (transportation of heavy structures, warehouse management, supply chain management, etc.) and construction and repair of ships' steel sections. The purpose is to draw links in between these competences to enable seafarers to move from one value chain to another.

Future skills with respect to sea-land mobility

A key finding from the expert group is the importance of transversal skills within future maritime competences. These skills are vital in order to move from one value chain to another.

Seafarers onboard ships work in a structured hierarchy where higher ranks have authority over lower ranks and for a large part the ships' crew is confined to staying together 24 hours a day. The ship's voyage and the maritime environment serve as a strong common motivator to accomplishing tasks or face collective wrath. Transitioning to shore means working in looser hierarchies and leadership competence such as motivating team members become more prominent, as well as only being available during work-hours. For this reason, leadership and managing people, which are associated with management in the maritime sector, will be one of the most important career development paths to widen seafarers' skillsets. In turn, it will be another important part of their transition to shore-side careers.

The development of new courses to help maritime professionals (including seafarers) and shipping industries in the future (for example, open communication, team-working, awareness, leadership, and choice-making) is of critical importance.

Notably, the cultural aspect of management is changing. However, it is possible to train soft skills for maritime professionals with simulator exercises to gradually build up a 'culture' of good teamwork.

5.2 Opportunities in new learning technologies

In the future, the skillset of maritime professionals should give flexibility to individual career 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.

Simulation-based learning has traditionally been used to train standard procedures in navigation and engine management. 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.

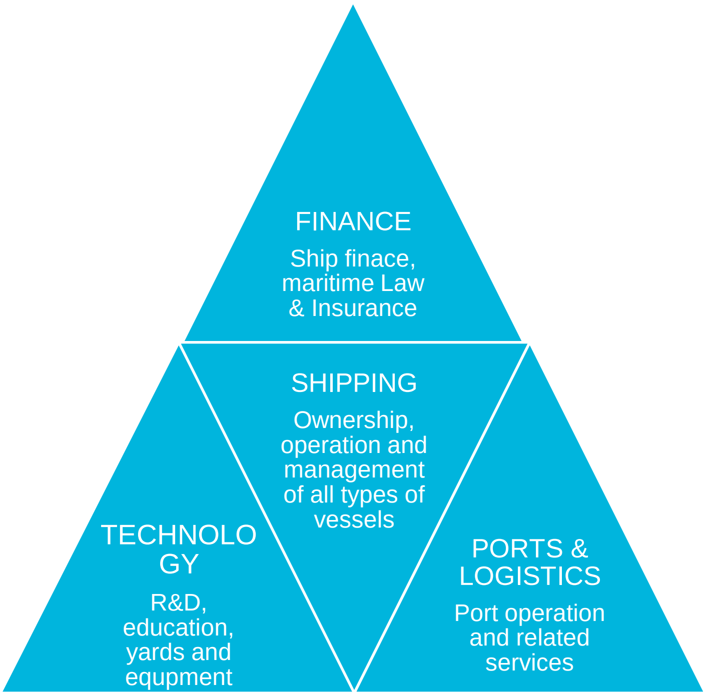
The maritime domain is inherently a high-risk industry and it employs simulator training and apprentice/cadet time on-the-job coaching to prepare the prospective operators.

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.

5.3 Occupational profile and career path

Future education of land-based skilled profesionals



The highly competitive shipping industry, drive the need for education and training both in digital and sustainable solutions. These developments add to the need for maintaining and improving the core skillsets necessary to keep global trade moving. The development of knowledge ashore comes from innovation, industry champions and entrepreneurs that shape it. In the future, insights from seafarers are required to combine with the competence of shipping industries to develop new and advanced solutions. To make this happen, some seafarers must be encouraged to make the transition to land-based occupations by acquiring transverse skills. Currently, the majority of maritime education and training is aimed at furthering the seagoing career and there is little availability of transitional training programmes. Reflecting the changes going on in the maritime industry, we are committed to being open and accessible to anyone who wants to build their knowledge and understanding of the maritime industry. In that case, education and training are strengthening their links to the industry, offering industries the opportunity to leverage the institutes' learning resources alongside their in-house training and development programmes. We assume 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.

Towards future and beyond

Maritime training is responding to the digital transformation of shipping and new environmental requirements for the industry that result in technological responses. However, maritime professionals' educational requirements are slow to change and this leaves them with insufficient competence for the technological innovation in the workplace. From the land side, technology providers depend on insights of current procedures and operations at sea and even more so on how seafarers interact with the new technology in order to create the solutions for the future**.**

To obtain this knowledge, technology providers need seafarers that transition to land and interact with product development experts. One way to showcase and future-proof these new technology developments is to implement them in a digital environment and train the operators before putting them in to operation.

Even though technology providers, financing and insurance systems, and shipping industries, as well as educational institutions, wish to uplift and safeguard the future of maritime professionals, there is no systematic approach to put all the players together. This, in turn, presents an obstacle to the future skills of maritime professionals.

The IMO's STCW Convention has done much to establish a minimum competence standard needed to operate. We now observe that the gap between the minimum level of high competence required to cope with rapid technology changes and the comprehensive landscape is growing. This is a huge challenge.

By using simulation-based learning, we could contribute to decreasing the gap between nautical sciences (**seafarers**) and maritime technology and other shipping industries. Our interviews with key players in the shipping industries identified a consensus that technology is designed to assist maritime professionals, rather than to diminish their ability in their workplaces. Skills are not isolated from technology, economics, policy, and education. To reduce the gap between current skillsets and the upcoming skill requirements, we suggest that policy influencers, including policy makers, trade unions, technology providers, and relevant businesses, closely collaborate to shape the future – the future is in their hands.

In this manner, simulation-based learning could provide fast, economic, and advanced technology support for maritime professionals' education. Together with simulator-based training, technology providers will be much more engaged with maritime professionals to acknowledge that seagoing knowledge, maritime operations, as well as the social aspects of maritime technology use, help to contribute to the most effective and advanced simulation-based learning environment. In turn, this will enhance the provision of well-prepared future maritime professionals in Europe, with positive occupational profiles that will be more transversal, technology-based and deeper than today**.**

5.4 From present to the future maritime training

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.

Future maritime training

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, 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 can not 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.

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.** 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.

Suggestion of implementation

At the end of this report, 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 **simulator-based learning 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).** However, our focus on technical skills should include, but is not limited to, the following:

- Knowledge of logistic and optimisation methods
- Advanced routeing planning
- Operationally complex hybrid and zero-emission machineries
- Calculation and documentation ability for sustainable operations

- Remote control training regarding optimisation services for vessels, and remote control of autonomous vessels
- Advanced skills to interact with computer systems and to respond to difficulties with autonomous systems
- In-depth knowledge of complex systems onboard
- Advanced skills in analytics and use of data in optimisation of the fleet
- Ability to transfer knowledge from one value chain to another in both seagoing and shore-based jobs, including using knowledge to make technological innovations.

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.

Mobility

With additional modular training courses, maritime professionals, in particular seafarers, will able to gain new knowledge and competence which is greatly needed in the future shipping industry. The training courses will be able to attract maritime professionals who are willing to shift positions from sea to land. Also, the training courses will encourage land-based professionals increase their interest and willingness to work at sea[61]. 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.

[61] 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.

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.

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Interview analysis – Report A, Scandinavian countries

D1.1.3 NTNU team (Alphabetical order)
Anette Jacobsen Aspelund
Arnfinn Oksavik
Hans Petter Hildre
Yushan Pan

Summary

This is not a scientific paper, but rather a report that aims at analysing and discussing the multi-faceted future of seafarers within the shipping industry. If seafarers are to work successfully in the future as they do now, they must understand that different forces within the industry are actively changing the landscape of future work. The proposed argument is that seafarer education must change and develop true 'inter-disciplinary' dimensions to expand the skill profiles of seafarers in preparation for the future, rather than waiting for training as a 'unit' within technology-driven operations in the shipping industry. The primary data were obtained through face-to-face interviews, maritime newspaper articles, maritime journal articles, and social media. The secondary data were drawn from qualitative methodologies. From this, we suggest 1) a short-term aid for seafarer education to meet societal demands and 2) a long-term policy to support educational changes in developing the 'inter-disciplinary' dimensions.

Introduction

The major influences of education policy in the context of the shipping industry currently sit at the international level, with member states being required to comply with the international standards of training, certification, and watchkeeping requirements for seagoing job roles. At the level of the EU and other Schengen Area countries, there are less common regional standards which can help member countries to harmonise and to 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. However, with the progression of digitalisation in shipping, skills and competences of seafarers are required to catch up and keep pace with with new technologies, continuously updating technical operations and personal skills. At the same time, seafarers today need to hold competences that reflect future uncertainties. This presents a challenge for the education policy in Europe – particularly for the maritime domain – due to the differences among countries, including the structure of education programmes, the use of technologies, educational content, and policies.

In addition to differences in education level, the opportunity for making changes in shipping is hidden from society. To use Norway as an example, many industries could be considered as contributors to shipping, because Norway is an oceanic nation. Although most industries could also be categorised outside of the maritime domain due to their generic roots in other well-defined industries, such as banks, technology companies, consultancies, and insurance agencies, they play active roles as the shore-based hubs for shipping.

Thus, this report uses the example of Norway, focusing on both offshore and onshore industries as potential knowledge hubs, 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*.

Methods

To study future skills, we use a 'folk explanation [1]' approach. This approach allows researchers to study and discuss people's everyday lives, their work, and their experience with new technologies in the workplace. No assumptions or property measurements were made while conducting this study. Furthermore, no oppositions, conflicts, or contradictions were observed in the in-depth analysis [2]. A semi-structured interview guide was used. In addition, secondary qualitative data were used to outline and categorise the particular knowledge, skills, and attitudes perceived as necessary for the relevant occupational roles to compare 'what people believe in now' in the interview. The majority of these data sources were in the form of published written materials, including CEDEFOP, academic papers, and the World Economic Forum. This differs from a literature review in that the sources were coded to identify and capture significant information from the data, with the outcome shaping our understanding of shipping industry.

The data collection and analysis were reported to the Norwegian Centre for Research Data (NSD). Data collection was approved by the same authority. Data storage and analysis followed the rules of the NSD. Thus, in this document, all individual and company names have been removed and remain anonymous.

Data collection and analysis

The data collection took place from the beginning of May to the end of September. 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.

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 on land will be important in the future market, for on-board safety reasons.*

In this manner, the bank needs talents from the industry who have 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 up skills for people to monitor ships and the location of the 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.

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.

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.

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.

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.[62] 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]

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,

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[62] 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.

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.

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[63] 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.

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

[63] 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.

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:

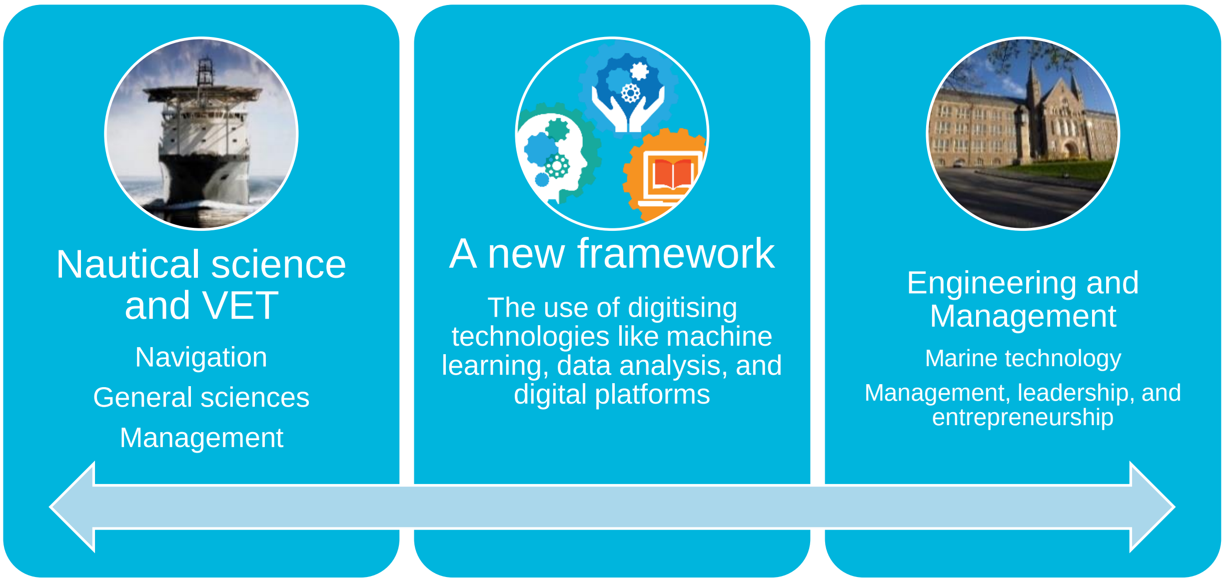

Figure 1: A new framework for the future education of seafarers.

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*

Conclusions

In this report, we analysed the conditions in which we could predict the skills required of seafarers in the future. By interviewing 12 key players in and around the shipping industry in Scandinavian countries, we discussed some key factors which dramatically influence the skillsets of seafarers. We found that skills are not isolated from technology, economics, policy, and education. To reduce the gap between current skillsets and the upcoming skill requirements, we suggest that policy influencers, including policy makers, trade unions, technology providers, and relevant businesses, closely collaborate to shape the future – the future is in their hands. Technology is designed to assist seafarers, rather than to diminish their abilities in their own workplaces. In the short term, we suggest adding new competences and courses to match the skills that will be necessary in the near future. In the long term, we suggest optimising skills systems to be more sustainable for seafarers' future skills by establishing a framework to bridge the gap between nautical studies and engineering and management programmes.

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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
Barbara Kelly
Dimitrios Paraskevadakis
Robyn Pyne

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	89	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 – Global, 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 maritime personnel

YEAR	2015					
MEASURE	Absolute value			Percentage of total world		
SEAFARER TYPE	Officers	Seafarers	Total	Officers	Ratings	Total
ALBANIA	445	519	964	0.057497	0.059413	0.058513
BELGIUM	3665	1259	4924	0.473545	0.144125	0.298878
BULGARIA	10890	22379	33269	1.407069	2.56186	2.01937
CROATIA	17183	10063	27246	2.220172	1.151973	1.653784
DENMARK	6432	1026	7458	0.831063	0.117452	0.452688
ESTONIA	2703	1158	3861	0.349248	0.132563	0.234356
FINLAND	3819	4979	8798	0.493443	0.569976	0.534023
FRANCE	2915	2446	5361	0.37664	0.280008	0.325403
GERMANY	3708	2527	6235	0.479101	0.289281	0.378454
GREECE	7451	1874	9325	0.962725	0.214528	0.566011
HUNGARY	55	35	90	0.007106	0.004007	0.005463
ICELAND	198	251	449	0.025583	0.028733	0.027254
IRELAND	564	1602	2166	0.072873	0.183391	0.131472
ITALY	12988	21498	34486	1.678147	2.461007	2.09324
LITHUANIA	424	2479	2903	0.054784	0.283786	0.176207
LUXEMBOURG	0	0	0	0	0	0
MALTA	151	594	745	0.01951	0.067999	0.04522
MONTENEGRO	110	116	226	0.014213	0.013279	0.013718
NETHERLANDS	4708	348	5056	0.608309	0.039838	0.30689
NORWAY	14768	18933	33701	1.908136	2.167375	2.045592
POLAND	25586	6603	32189	3.305903	0.755886	1.953816
PORTUGAL	851	590	1441	0.109956	0.067541	0.087466
ROMANIA	11000	5000	16000	1.421282	0.57238	0.971172
RUSSIAN FEDERATION	47972	49089	97061	6.198341	5.619516	5.891433
SLOVAKIA	0	0	0	0	0	0
SPAIN	1546	842	2388	0.199755	0.096389	0.144947
SWEDEN	4266	3972	8238	0.551199	0.454699	0.500032

SWITZERLAND, LIECHTENSTEIN	4	2	6	0.000517	0.000229	0.000364
UKRAINE	39000	30000	69000	5.039092	3.434282	4.188179
UNITED KINGDOM	11010	3945	14955	1.422574	0.451608	0.907742
TOTAL	234412	194129	428541			

NOTE: DATA RESOURCE WILL ONLY UPDATED EVERY 5 YEAR. THE NEXT UPDATE IS EXPECTED IN 2021 WITH DATA FOR 2020.

Appendix 5 - Executive summary from DNV DL and Lloyd's register

Lloyd's register Marine – Global Marine Fuel Trends 2030

Executive Summary

Global Marine Fuel Trends 2030 central objective is to unravel the landscape of fuels used by commercial shipping over the next 16 years. The problem has many dimensions: a fuel needs to be available, cost-effective, compatible with existing and future technology and compliant with current and future environmental requirements. In a way, one cannot evaluate the future of marine fuels without evaluating the future of the marine industry. And the future of the marine industry itself is irrevocably linked with the global economic, social and political landscape to 2030.

Rather than looking for a single outcome, we use scenario planning methodologies. This is why we are making the connection with Global Marine Trends 2030, through its 3 different scenarios: Status Quo, Global Commons and Competing Nations.

> One cannot evaluate the future of marine fuels without evaluating the future of the marine industry

These scenarios represent alternative futures for the world and shipping in 2030, from business as usual to more globalisation or more localisation. Our assumptions are fed into probably the most sophisticated scenario planning model that exists for global shipping, GloTraM, developed as part of the Low Carbon Shipping Consortium. The model analyses how the global fleet evolves in response to external drivers such as fuel prices, transport demand and technology availability, cost and technical compatibility. Tonnage replacement and design/operational speeds are adjusted to ensure a balance between transport demand and supply. The decision-making algorithms in the model are based in the principles of regulatory compliance and ship-owner profit-maximisation, very much aligned to the dimensions of the future fuel challenge.

GMFT 2030 boundaries are wide but not completely inclusive: we examine the containership, bulk carrier/general cargo and tanker (crude and chemical/products) sectors, representing approximately 70% of the shipping industry's fuel demand in 2007. We include fuels ranging from liquid fuels used today (HFO, MDO/MGO) to their bio-alternatives (bio-diesel, straight vegetable oil) and from LNG and biogas to methanol and hydrogen (derived both from methane or wood biomass). Engine technology includes 2 or 4 stroke diesels, diesel-electric, gas engines and fuel cell technology. A wide range of energy efficiency technologies and abatement solutions (including sulphur scrubbers and Selective Catalytic Reduction for NOx emissions abatement) compatible with the examined ship types are included in the modelling. The uptake of these technologies influences the uptake of different fuels.

> We examine the containership, bulk carrier/general cargo and tanker sectors, representing approximately 70% of the fuel demand in 2007

Regulation is aligned with each of the 3 overarching scenarios to reflect business-as-usual, globalisation or localisation trends. They include current and future emission control areas (ECAs), energy efficiency requirements (EEDI) and carbon policies (carbon tax). Oil, gas and hydrogen fuel prices are also linked to the Status Quo, Global Commons and Competing Nations scenarios.

So what does the marine fuel mix look like for containers, bulk carriers and tankers by 2030? In two words: decreasingly conventional. HFO will still be very much around in 2030, but in different proportions for each scenario: 47% in 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 space left by the declining share of HFO will be filled by low sulphur alternatives (MDO/MGO or LSHFO) and by LNG, and this will happen differently for each ship type and scenario. LNG will reach a maximum 11% share by 2030 in Status Quo. There is also the entry of Hydrogen as an emerging shipping fuel in 2030 Global Commons, a scenario which favours the uptake of low carbon technologies stimulated by a significant carbon price.

Contrary to common perceptions, containerships are not the segment with the highest share of LNG - in fact it is the chemical/product tankers, with LNG making up 31% of its fuel mix by 2030 in Status Quo. In contrast, containerships will see a maximum 5% LNG share in Global Commons. This can be explained considering that the fuel mix represents the entire fleet, so tonnage age and renewal are as important as technical compatibility and cost-effectiveness of different fuels.

> HFO will still be very much around in 2030, taking 47%-66% of the fuel mix

Segments with the higher proportion of small ships see the highest LNG uptake. It is also a matter of perspective: from a non-existent share of the marine market in 2010, LNG will have 5-10% share in 20 years. We are not saying that LNG will not be the fuel of the future. But that seeing new ships built with LNG today (many of which in niche markets/short-sea shipping) and overturning the marine fuel landscape in less than a ship's lifetime are two entirely different discussions. Methanol does not appear in the fuel mix in any considerable quantities by 2030. It may be that this timeframe is too short or that it is not a cost-effective solution making it, again, appropriate for a niche market not represented by the 4 main ship types we examined.

While the fuel mix indicates a declining share of HFO, filled by alternative options, in 2030 the demand for HFO will be at least the same (In Status Quo) if not 23% higher (in Global Commons) compared to its 2010 levels. But, with the overall fuel demand doubling by 2030, other fuels will see a higher rate of growth to meet this demand.

The fuel choice and scenarios are shown to create differences in energy efficiency technology take-up, design and operating speed. Low technology take-up occurs in Status Quo and Competing Nations, although installed power reduces due to reductions in design speed. Greater installed power reduction occurs in Global Commons, due to the combination of design speed reductions and greater efficiency technology take-up.

> LNG will reach a maximum 11% share in 2030. Segments with the higher proportion of small ships will see the highest LNG uptake

Typically, the installed power in Global Commons is operated at higher engine loads, resulting in marginally higher average operating speeds when compared with the other scenarios. This is due to the greater technical efficiency of the Global Commons fleet. As the most profitable fuel and machinery change over time and between scenario, this in turn impacts the optimum operating speed, with higher fuel prices and less energy efficient (e.g. older) ships operating at lower speeds when compared with the newer ships of the same ship type and size.

> In Status Quo, shipping emissions will double by 2030. Carbon policies result to a downwards trajectory in Global Commons

The fuel mix may be a central output to this study but it is not the only one. GloTraM can predict shipping emissions and these are very much affected by the same drivers that we already discussed plus the marine fuel mix itself. Despite improvements in design and operational efficiency and current/future policies, CO_2 emissions from shipping will not decrease in 2030. Status Quo will see its emissions doubling, due to the increase in trade volume combined with the moderate carbon policy and the low uptake of low carbon fuels. Global Commons is following a similar trend but then decreasing post 2025, thanks to carbon policy and the uptake of Hydrogen. Competing nations will see the smallest growth in emissions.

Despite the lack of carbon policy, the smaller trade volume, high energy prices and, predominantly, the high uptake of bio-energy, result in the lowest increase of CO_2 emissions than any other scenario (56%).

The lower emissions associated with this scenario seem attractive but come at the cost of lower growth in the shipping industry, higher operating costs and less global trade. Furthermore, in 2030, in Competing Nations and Status Quo, emissions remain on an upwards trajectory and the global fleet remains similar to the fleet in 2010 with the industry poorly positioned to weather any policy or macroeconomic storms in the period 2030-2050. In contrast, in Global Commons the sector's emissions peak (in 2025) and are starting a downwards trajectory that should assist in a more stable and sustainable long-term growth in shipping, trade growth and global economic development.

When discussing future policies and shipping CO_2 emissions, it is worth considering our assumptions for calculating them, which is that GHG emissions come from the CO_2 released in fuel combustion activities of the vessels during their operation. However, if LNG, bio-fuels and hydrogen take a greater role in the shipping, it would be important to consider emissions associated with upstream processes and for non-CO_2 emissions, for example methane slip. This could show that fuels which, on the basis of operational emissions alone, appear attractive have significant wider impacts. This is important when developing mitigation policies.

Having looked at a variety of fuels, technologies, economic and regulation scenarios, all resulting in different future outcomes, what is perhaps the main take-away from GMFT2030? We often talk about tipping points but what we anticipate is an evolutionary process rather than any instant shift. 16 years is less than a ship's lifetime and a dramatic overturn of the marine fuel landscape may not be realistic. On the other hand, it is also a matter of perspective: we may not see an immediate revolution but we will certainly experience some changing trends.

> If alternative fuels take a greater role in shipping, it is important to consider upstream emissions beyond the point of operation

> In Status Quo, shipping emissions will double by 2030. Carbon policies result to a downwards trajectory in Global Commons

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> If alternative fuels take a greater role in shipping, it is important to consider upstream emissions beyond the point of operation

- The crude oil fleet will decline by 30% by mid-century, peaking in 2030 at about 20% larger than today, then shrinking
- Today's product tanker fleet will decrease by 8% by 2050.

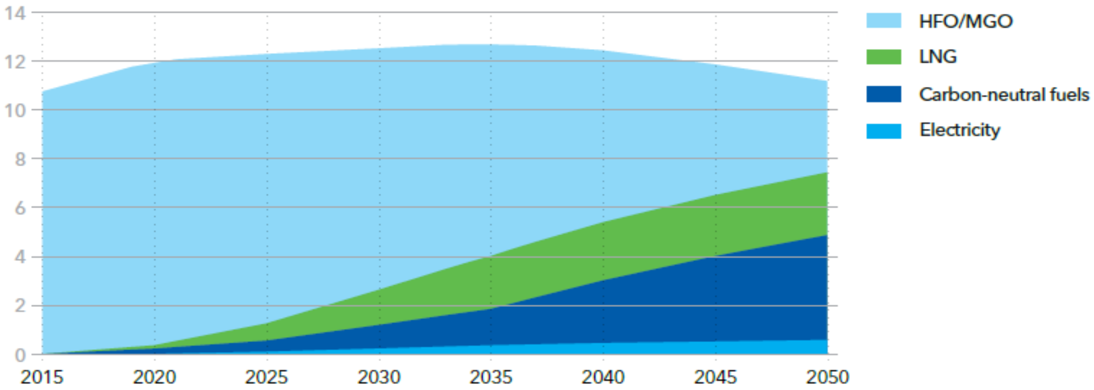
One of our key assumptions is that IMO GHG reduction targets will be met. Beyond 2035, we will see the full impact of gradually improving the energy efficiency of new ships and the shift to alternative fuels. Fuel consumption per tonne-mile will decline by, on average, 30% by 2050. We find that total energy use in international shipping will increase from about 11 exajoules (EJ) to 13 EJ during 2016-2035. It will then decrease to 11 EJ in 2050, which equates to nearly 270 million tonnes of oil equivalent (Figure 2).

Our model finds that by 2050, 39% of shipping energy will be from carbon-neutral fuels, which will have overtaken the 34% share of liquid fossil fuels, such as heavy fuel oil (HFO) and marine gas oil (MGO). Liquefied natural gas (LNG) and liquid petroleum gas (LPG) will, together, have a 23% share. Electric batteries will be an energy source on one third of all ships from mid-century, providing about 5% of the total energy for shipping. We have not evaluated which carbon-neutral fuels will be preferred, as this will depend on future production costs, availability, and infrastructure. Short-sea and non-cargo shipping will use 40% of the total energy; and, in these segments, electricity will constitute more than a tenth (11%) of energy use.

FIGURE 2

Shipping energy mix

Units: EJ/yr



Maritime Forecast to 2050, DNV-GL

Maritime Forecast to 2050, DNV-GL

EXECUTIVE SUMMARY

A global transition towards greater use of renewable energy and less use of fossil fuels is underway and will progress towards mid-century. There is also rising interest in sustainable development, and action to establish circular economies to reduce consumption of virgin materials.

The ongoing digital transformation will – through automation, robotization, and adaptive manufacturing – have a large impact on global value chains. It will also advance the design and operation of ships, and create new business models. For shipping, there is increasing pressure to decarbonize and to reduce emissions to air. This will impact asset value and earning capacity more significantly than in the past. It will shape the future fleet in important ways, particularly in the choice of fuels and technologies.

This publication is one of DNV GL's new suite of Energy Transition Outlook (ETO) reports. It provides an independent forecast of the maritime energy future and examines how the energy transition will affect the industry. Trends and drivers factored into our long-term projections are outlined in the integrated approach to forecasting. Our focus this year is the challenge of decarbonization facing the maritime industry. Our intention is to provide guidance for stakeholders coping with increasing uncertainty, risk, and opportunities.

SEABORNE TRADE OUTLOOK TOWARDS 2050

Based on the updated model for the DNV GL Energy Transition Outlook 2018, we forecast a rise of nearly a third (32%) in seaborne trade measured in trillion tonne-nautical miles per year for 2016–2030 (see Figure 1). We see increases in tonne-mileage over the forecast period for all trade segments except crude oil and oil products. The largest relative growth in trade is for gas and container cargo, for which we see a tripling and doubling, respectively, by 2050. We predict only 5% growth in trade over the period 2030–2050.

For bulk, there is sustained growth in tonne-miles for grain and minor bulk throughout the forecast period. For iron ore, we expect strong growth until 2030, more than offsetting an expected decline in coal transport. The total bulk trade increases by 39% over the period, maintaining bulk as the largest ship segment; however, most of this growth is expected in the first 20 years of the forecast period.

REGULATORY AND STAKEHOLDER OUTLOOK

To ensure compliance and to make the right business decisions, it is crucial to understand the existing and future regulatory framework, and the expectations placed on shipping from external stakeholders.

Over the past decade, shipping has seen a surge of environmental regulations. Impact on shipping in the next five years will include:

- The global sulphur limit for ship fuels, as set by the International Maritime Organization (IMO)
- IMO Tier III requirements for limiting nitrogen oxides (NO_x) in Emission Control Areas (ECAs)

Maritime Forecast to 2050, DNV-GL

FUEL AND TECHNOLOGY OUTLOOK

Fuels that could contribute to meeting the IMO targets include ammonia, biofuels, electrification, electrofuels[1], hydrogen, and nuclear power. In each case, it is important to take a lifecycle perspective to ensure that energy used to produce the fuel is from renewable sources or from fossil sources using carbon capture and storage.

The selection of fuel will be based on a compromise between the benefits and drawbacks of the various fuel options being compared. The cost associated with machinery, as well as the expected fuel prices and availability of bunkering infrastructure, will be key barriers. Safety will be a primary concern. It can be translated into monetary terms once a design has been established and the necessary safety measures identified.

The many alternative fuels, and their diverse characteristics, make it difficult to identify 'winners and losers' clearly. This is why we introduce a concept for the 'ranking of alternative marine fuels', as an important new feature in this latest Energy Transition Outlook report. It describes a multi-objective approach focused on the environment, economics, and scalability, to evaluate promising fuels.

Operational and technical energy-efficiency measures complement the fuel options. Reducing vessel speed is an especially effective operational measure, with a large fuel-saving potential. Substantially reducing speed will impact the transport system and require the industry and related stakeholders to collaborate to realize this potential. However, our Automatic Identification System (AIS) -based study of the world cargo fleet reveals how it spends much of its time at anchor or in port. Resolving this inefficiency, perhaps through emerging digital technologies, could contribute to reduced sailing speed and thereby lower fuel consumption.

Technological developments in batteries, drag reduction, energy efficiency, materials science, and propulsion will provide the basis for key specifications of new ship concepts to reduce energy losses and improve overall performance. Only a fraction of the fuel energy going into a ship's main engines ends up generating propulsion thrust; the rest is lost as heat. Exergy (or useful work) analysis reveals insights about the energy losses in a ship's energy cycle and assists the prototyping of novel mature and immature technologies to improve the energy efficiency.

The concept of hybridization is a promising ongoing development, where the benefits of two or more configurations for saving fuel are combined. A hybrid electrical ship could contain alternative diesel engine configurations, marine fuel cells, battery packages, and even retractable wind turbines, solar panels, and sails.

FLEET OUTLOOK

Integrating our knowledge of future trade demand, regulatory developments, and technology and fuel advances, we have modelled the uptake of a wide range of alternative fuels, energy-efficiency measures, and other emission-reduction technologies.

Measuring in deadweight tonnes (DWT), we predict:

– The fleet size will increase by more than a third (35%) by 2050

1 Electrofuels is an umbrella term for carbon-based fuels, such as diesel, methane, and methanol, which are produced from CO_2 and water using electricity as the source of energy.

THE CARBON-ROBUST SHIP

Fleet forecasts, as presented in this report, contain inherent uncertainties and depend heavily on assumptions. Regulations on CO_2 are poised to shape the future fleet. Developments in fuels and technologies are rapid, with potential game-changing consequences. Add in 'traditional' concerns over market cycles, trade demand, and supply, there are many aspects to consider when, investing in new tonnage. How can a shipowner wanting to invest today, handle this uncertainty and associated business risks to make the right decisions?

In this study, we present a further and significant development of the carbon-robust ship concept that we introduced in 2017. A new model now evaluates fuel and technology options by comparing the break-even cost[2] of a design to that of the competing fleet of ships (see Figure 3). The cost structures of competing fleets are compiled on the basis of scenarios, including, for example, regulations, fuel prices, and technology developments.

We showcase the model here to gain insights into what a carbon-robust bulk carrier would be like under possible future CO_2 regulations. We use the model for exploring key questions for three design alternatives for a ship designed today and built in 2020. The design alternatives are a standard ship, an LNG-powered ship, and a fuel-effcient option.

The study shows significant differences in competitiveness over the life of a vessel, depending on different scenarios. One striking finding is that investing in energy efficiency and reduced carbon footprint beyond current standards seems to increase competitiveness over the lifetime of the vessel. The study also suggests that owners of high-emitting vessels could be exposed to significant market risks in 2030 and 2040 in scenarios where low-emission vessels attract premium rates or avoid CO_2 taxes or levies.

In this report, we have explored the maritime implications of a global transition towards an increased use of renewable energy and a diminishing use of fossil fuels, which is underway and will progress towards mid-century. As discussed, uncertainty is high. However, we believe that this uncertainty is manageable. By applying a structured, knowledge-based approach, supported by modelling tools, stakeholders can stay ahead of industry developments and remain competitive moving forward.

> "One striking finding is that investing in energy efficiency and reduced carbon footprint beyond current standards seems to increase competitiveness over the lifetime of the vessel.