Seafarer Market – Challenges for the Future

Zvonimir Lušić, Mario Bakota, Mirko Čorić, Ivica Skoko

In today's seafarer market, one of the key problems is the lack of seafarers, especially experienced officers. Although the global supply of officers is increasing steadily, the demand is still higher than the supply. An additional problem is that an increased demand may lead to a decreased quality of education. Ships and shipping technology in general have become more advanced and require well educated and trained personnel. In addition, over the next several decades it is expected that partially or fully autonomous vessels will be in commercial use, and this will require significant changes in the education and training of crew members. So, regarding the education of seafarers, the main future challenges include the ways of ensuring sufficient supply of seafarers, especially well-trained officers, and adapting the education systems for the upcoming introduction of autonomous ships. This paper analyzes the present situation of the seafarers and shipping market, and provides forecast for the near future. Also, the main challenges in the education and training of seafarers will refer to observing the recommendations for improvement and adaptation to future demands.

KEY WORDS
~ Seafarers
~ Vessels
~ Ship officers
~ Education and training
~ Autonomous ships

University of Split, Faculty of Maritime Studies, Split, Croatia
e-mail: zlusic@pfst.hr

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1. INTRODUCTION

Minimum knowledge, familiarization and skills required for obtaining specific certificates of competence on board merchant sea-going ships have been laid down by the International convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). The last significant amendments to this Convention were introduced in 2010 and entered into effect on 1 January, 2012 (STCW 2010 Manila Amendments). These have been the first major changes since 1995. However, although substantial new competence requirements related to leadership, teamwork, and managerial skills for deck and engine officers were added, the amendments have not yielded spectacular effects. As a whole, STCW remains a set of minimum knowledge and skill requirements which individual states, i.e. their administrations, use as a reference framework for granting relevant certificates, and their education institutions as a groundwork for creating curricula and syllabi. Generally speaking, STCW is a useful and necessary prerequisite for the standardization of knowledge and skill acquisition, but its content remains too general and allows education institutions for arbitrary interpretations of the guidelines. In addition to the general sections and the ones dealing with more specific aspects, the STCW Convention provides tabular specification of minimum standards of competence, e.g. Competence, Knowledge, Understanding and Proficiency, Methods for demonstrating competence, and Criteria for evaluating competence (STCW, 2017). Given the fact that the STCW does not define executive curricula, many education institutions and training centers rely on additional recommendations and model courses provided by the International Maritime Organization (IMO): IMO Model Course 7.01 (unlimited) for future Masters and Chief Mates, IMO Model Course 7.03 (unlimited) for future Chief Engineer Officers and Second Engineer Officers, etc. However, both the STCW guidelines and IMO Model Courses change very slowly and it is clear that their specifications of standards have not been efficiently following modern trends and demands in the maritime transport. This is proved, for instance, by the numerous non-STCW training courses that the seafarers at various shipping companies have to attend. When all these issues are considered within the context of maritime staff shortage, where many employers tend to fill position gaps as soon as possible, it seems that the degradation of quality is inevitable. This forecast is additionally supported by the trend of shortening formal periods of education and training in certain countries, and outsourcing of the education processes from the higher education institutions. On the other hand, methods and technologies related to maritime shipping have been developing very fast, thus presenting new challenges and requirements to the seafarers, particularly seafaring officers. These requirements are much higher than the minimum requirements as described by the current international regulations. Moreover, it is expected that the following decades will experience a gradual introduction of autonomous vessels and other technologies that would significantly change the ways the ships are managed and handled at sea. It is therefore necessary to start adjusting the education and training systems to be able to cope with the impending challenges in a timely and efficient manner.

2. WORLD MERCHANT FLEET AND WORLD TRADE

The world merchant fleet has been growing steadily over the past few decades. In 2017, the world fleet reached 93,161[1] vessels (of which around 50,155 above 1,000 GT), with 1.9 billion dwt, twice the size it had 12 years ago (Figure 1). Today, bulk carriers account for 43 % of the fleet, followed by oil tankers (29 %) and container ships (13 %). LNG and other gas carriers recorded continued high growth (9.7 %). Growth was also experienced in other trades: oil tankers (5.8 %), chemical tankers (4.7 %), and container ships (0.5 %). By contrast, a long-term decline has continued in the general cargo segment, which experienced a fall by 0.2 %; its share in the world's tonnage is currently 4 %, down from 17 % in 1980 (UNCTAD- Review of Maritime Transport, 2017).

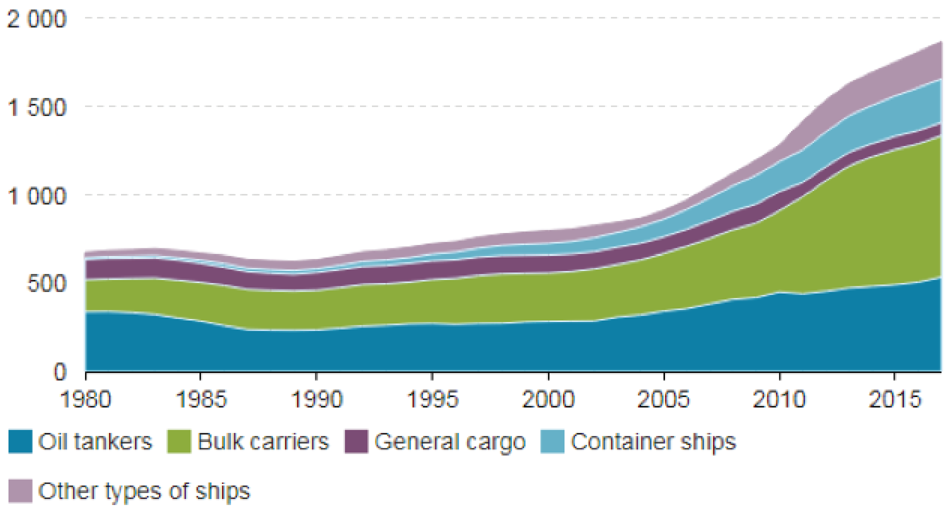

Figure 1.
World fleet by principal vessel type (mill. of dwt) (e-handbook of statistics-Merchant fleet, 2017).

When taking into consideration the overall number of merchant vessels, general cargo ships are ranked as the most common type of vessel in the global merchant fleet (18 %), followed by tankers (15 %), and bulk carriers (13 %) (Table 1) (Equasis Statistics, 2016). If we take into account the vessels above 1,000 GT, general cargo ships are ranked first, accounting for about a third of the fleet, followed by bulk carriers, crude oil tankers, and container ships (Statista-The Statistics Portal, 2018).

At the end of 2016, the top five ship owners included Greece, Japan, China, Germany, and Singapore. Together these ship owners had a market share of 50 % in dwt. The top five flag registries were Panama, Liberia, the Marshall Islands, Hong Kong SAR, and Singapore. It is worth noting that in 2016, 92 % of world tonnage was built by only three economies, namely the Republic of Korea, China, and Japan (UNCTAD- Review of Maritime Transport, 2017).

1. *Propelled seagoing merchant vessels of 100 gross tons and above.*

Table 1.
World fleet – total number of ships, by type and size (Equasis Statistics, 2016).

Ship Type	Small(1)		Medium(2)		Large(3)		Very Large(4)		Total	
General Cargo Ship	4,374	13.1 %	11,830	30.3 %	229	2.0 %			16,433	18.3 %
Specialized Cargo Ships	8		225	0.6 %	64	0.6 %	4	0.1 %	301	0.3 %
Container Ships	18	0.1 %	2,253	5.8 %	1,507	13.0 %	1,329	22.9 %	5,107	5.7 %
Ro-Ro Cargo Ships	31	0.1 %	641	1.6 %	592	5.1 %	223	3.8 %	1,487	1.7 %
Bulk Carriers	309	0.9 %	3,792	9.7 %	5,830	50.2 %	1,683	28.9 %	11,614	12.9 %
Oil and Chem. Tankers	1,902	5.7 %	6,912	17.7 %	2,629	22.6 %	1,779	30.6 %	13,222	14.7 %
Gas Tankers	38	0.1 %	1,126	2.9 %	337	2.9 %	420	7.2 %	1,921	2.1 %
Other Tankers	364	1.1 %	605	1.6 %	9	0.1 %			978	1.1 %
Passenger Ships	3,894	11.7 %	2,674	6.9 %	272	2.3 %	171	2.9 %	7,011	7.8 %
Offshore Vessels	2,685	8.0 %	5,402	13.8 %	120	1.0 %	201	3.5 %	8,408	9.4 %
Service Ships	2,537	7.6 %	2,554	6.5 %	26	0.2 %	6	0.1 %	5,123	5.7 %
Tugs	17,196	51.6 %	1,003	2.6 %					18,199	20.3 %
Total	**33,356**	100 %	**39,017**	100 %	**11,615**	100 %	**5,816**	100 %	**89,804**	100 %

(1)GT<500; (2)500≤GT<25,000; (3)25,000≤GT<60,000; (4)GT≥60,000

Figure 2 shows the change in the number of vessels for the three main types: tanker, bulk carrier, and container/multipurpose ship over the period 2000-2016. It is likely that the tendency of growth will continue.

It is expected that the number of vessels will increase even further in the years to come, given the forecasts of the world economy growth and, consequently, the increasing amount of goods handled by maritime shipping.

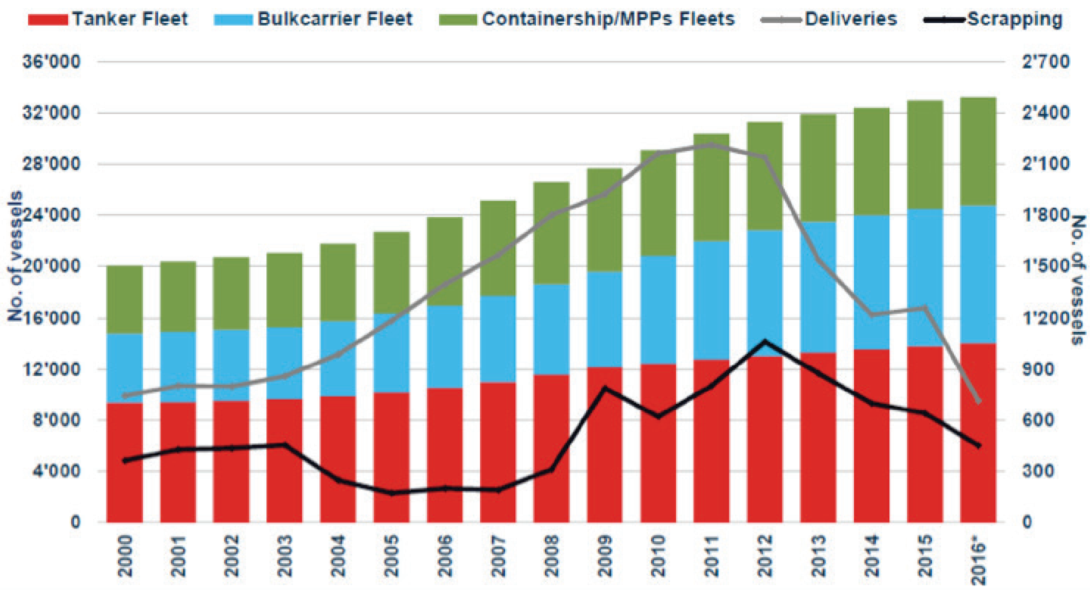

Figure 2.
Tanker, bulk carrier, container ship and multipurpose fleet (Kern Ferretti, 2016) (all vessels above 100 GT).

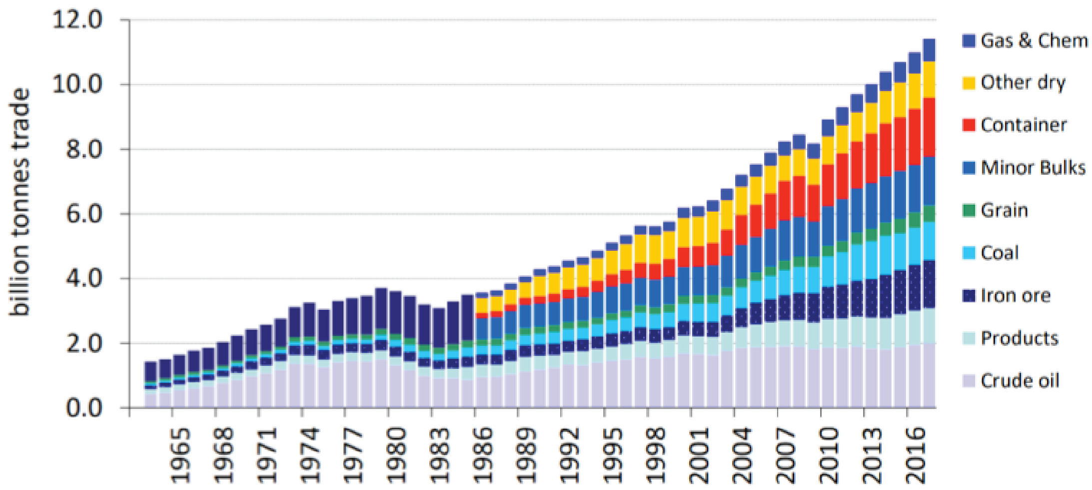

Figure 3.
Seaborne trade by commodity [Stopford, 2018].

The total volume of the seaborne trade reached 10.3 billion tons in 2016. Forecasts for the following mid-term periods indicate a continued expansion, with volumes growing at an estimated compound annual rate of 3.2 % between 2017 and 2022 (UNCTAD-Review of Maritime Transport, 2017) or 1.8 % until 2035 (Sea Europe, 2017). In the year 2017, the world industry was growing at the rate of 4.3 %, the trade increased up to 3.9 %, and the merchant fleet increased by 3.5 % (Stopford, 2018). While experiencing a slightly slower growth rate compared to the longer-term historical average, the global sea-borne trade is forecast to rise to an excess of 15,000 million tons in 2035 (Sea Europe, 2017). Figure 3 shows the sea-borne trade from 1965 to 2017, while Figure 4 presents a forecast of the sea-borne trade until 2066 (between 16 and 46 billion tons) (Stopford, 2017).

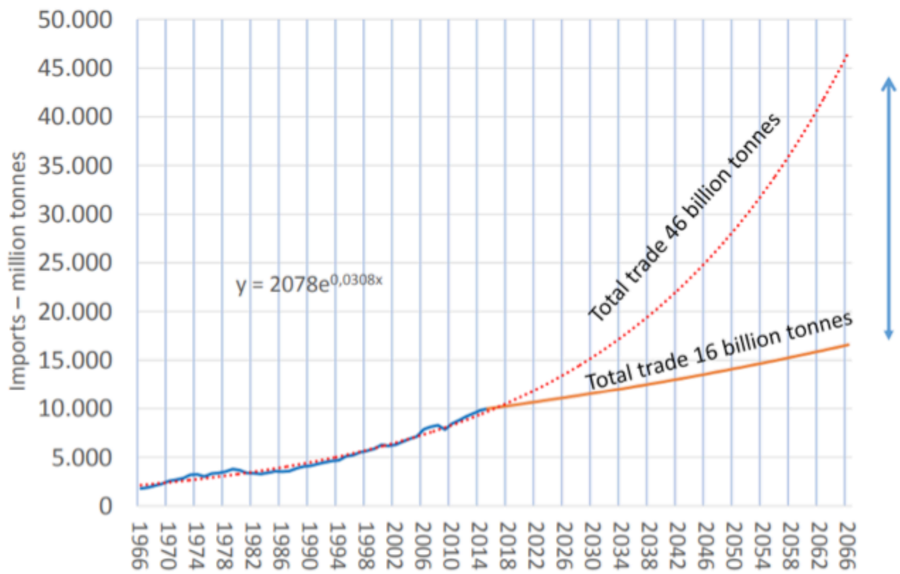

Figure 4.
World seaborne trade [Stopford, 2017].

The DNV-GL analysis forecasts that trade measured as tonne miles will experience 2.2 % annual growth over the period 2015-2030 and 0.6 % per year thereafter. The merchant fleet will grow somewhat more slowly than trade, but the crude oil fleet will start to decline after 2030, also the bulk fleet but after 2035. An assumption is that a better utilisiation of ships and larger ships will reduce the deadweight tonnage needed. The average size of deep sea vessels will rise 40 % for LNG tankers, 30 % for containers and other cargo, and 10 % for bulkers (Maritime Forecast to 2050, 2017). Most authors predict positive trends in the maritime transport, but there are threats that can disrupt these projections. At present, the greatest threats arise from potential trade wars and national protectionism (UNCTAD/press/pr/2018/030, 2018); however, there is always a risk of the emergence of large scale war conflicts, large natural disaster, changes in the global political scene, etc.

3. GLOBAL SUPPLY OF SEAFARERS

The global supply of seafarers in 2015 was estimated at 1,647,500 of which 774,000 were officers and 873,500 were ratings. This represents an increase of about 66 % in officers and about 21 % in ratings over the last ten years (see Table 2) (BIMCO, 2015). At sea, 1 per cent of seafarers are women (UNCTAD-Review of Maritime Transport, 2017).

Table 2.
Estimated supply of seafarers (BIMCO, 2015).

Rank	2005	2010	2015
Officers	466,000	624,000	774,000
Ratings	721,000	747,000	873,500
Total	1,187,000	1,371,000	1,647,500

Five countries with the largest number of seafarers are listed in Table 3. Ten years ago the major seafarer supply countries for officers where the Philippines (12 %), China (9 %), and Russia (5 %), while most of ratings came from the Philippines (22 %), Indonesia (8 %), and China (6 %) (Galić et al, 2012). Today, China is thought to have overtaken the Philippines as the largest single source of seafarers.

Table 3.
Estimated five largest seafarer supply countries (BIMCO, 2015).

	For all seafarers	officers	Ratings
1	China	China	Philippines
2	Philippines	Philippines	China
3	Indonesia	India	Indonesia
4	Russian Federation	Indonesia	Russian Federation
5	Ukraine	Russian Federation	Ukraine

The global demand for seafarers in 2015 was estimated at 1,545,000 seafarers, including approximately 790,500 officers and 754,500 ratings (Table 4).

In 2015, the global shortage of officers was estimated at 16,500 (2.1 %), while the total number of ratings was in surplus of 119,000 (15.8 %), resulting in the total number of extra seafarers of 102,500 (BIMCO, 2015). An especially pronounced shortage referred to engineer officers at management level and officers needed for specialized ships such as chemical, LNG and LPG carriers (World Maritime News, 2016).

The 2015 report completed by the Baltic and International Maritime Council (BIMCO) indicates that the world merchant fleet will grow over the next ten years and the anticipated demand for seafarers will likely continue, as will the trend of an overall shortage in the supply of seafaring officers. It has been forecast that additional 147,500 officers will be required by 2025 to serve the world merchant fleet (Table 5). Unless seafarer training capacities are increased significantly, the growing demand for seafarers could generate a serious shortage in the total supply of officers. This can be prevented only through continuing efforts in promoting careers at sea and by improving levels of recruitment and retention (Safety4Sea, 2018).

Table 4.
Estimated global demand for seafarers (BIMCO, 2015).

Rank	2005	2010	2015
Officers	476,000	637,000	790,500
Ratings	586,000	747,000	754,500
Total	1,062,000	1,384,000	1,545,000

Table 5.
Estimated supply-demand balance for officers (BIMCO, 2015).

	2015	2020	2025
Supply	774,000	789,500	805,000
Demand	790,500	881,500	952,500
Shortage/Surplus	-16,500	-92,000	-147,500
%	2.1 %	11.7 %	18.3 %

4. SHIPPING TECHNOLOGY DEVELOPMENT AND AVERAGE CREW SIZE

When observing the development of the shipping industry over the last several decades, it can be noticed that the world merchant fleet has been growing steadily, with the average size and number of ships getting bigger and bigger. Recently, the growth has been particularly generated by the increasing capacities of container ships whose average size (in dwt) increased by 90 % through the period 1999-2015. For the sake of comparison, the average size of bulk carriers increased by 55 % over the same period, while the tanker size increased by 21 %. Ro-ro and passenger ships did not experience significant changes in size, whereas the size of general cargo ships decreased (Figure 5) (International Transport Forum, 2015).

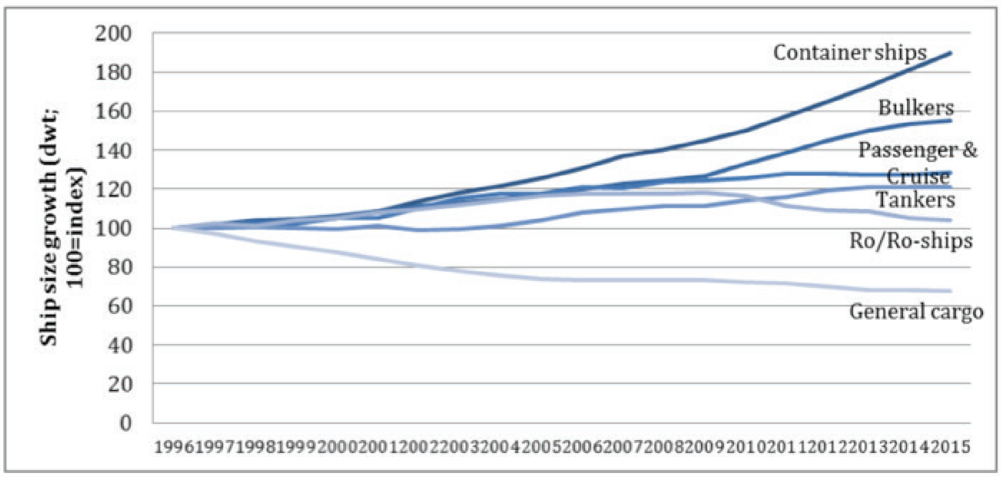

Figure 5.
Ship size development of various ship types 1996-2015 (International Transport Forum, 2015).

When discussing the containerization phenomenon, it should be noted that it took 30 years for the average size to grow to 1,500 TEU, and then only 10 years to reach 3,000 TEU. In 2015, the average new-build size was around 8,000 TEU, while today's largest container ships have a capacity of over 21,000 TEU (around 200,000 dwt and 400 m in length) (International Transport Forum, 2015). The trend of increased ship capacities can be justified by a simple fact that the increase in ship size reduces the average freight rates per cargo unit. However, the size of ships has not been accompanied by the crew size; on the contrary, the manpower has been decreasing so that fewer crew members operate vessels that get ever larger. A long time ago, an average crew size amounted to 40-50 members, while today even the largest ships carry about 20-25 crew members on the average (Berg et al., 2013). For instance, the minimum manning requirements for operating the largest container ships (200,000 dwt) amount to only 13 crew members, i.e. 19 crew members for operations under normal conditions (Martin, 2011). Although the crew size is greatly affected by the ship size, the essential factor remains the type of the vessel. Figure 6 presents average crew sizes for various tanker sizes.

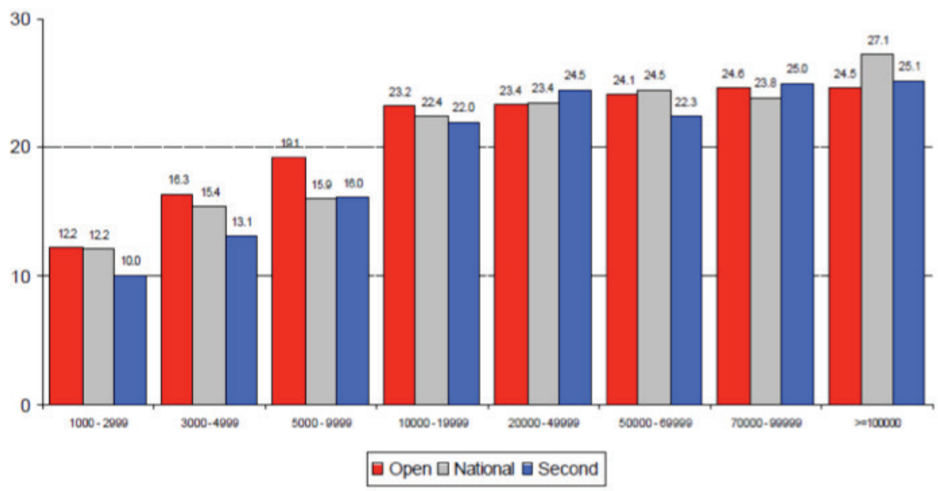

Figure 6.
Mean number of crew (tankers) (Winchester et al., 2006) (Open Registers Flag, National Registers Flag, Second Registers Flag).

As the operation costs are directly affected by the size of the onboard personnel, a further reduction in crew size can be expected. A rapid development of technologies is likely to facilitate the process. Here is a short list of several innovations that considerably affected ship management and crew reduction in the second half of the 20th century (King, 2000):

- introduction of the autopilot enabled the potential crew reduction of one and a half able seamen,
- introduction of radar was not accompanied by any decrease in manpower, but undoubtedly contributed to a more efficient surveillance and collision avoidance,
- remote monitoring and control of the main engine resulted in the development of the unmanned machinery space operation,
- reorganization and redefinition of work at sea,
- introduction of the Global Maritime Distress and Safety System (GMDSS) made the service of the Radio Officer redundant on board ships,
- satellite and communications systems, Electronic Chart Display and Information System (ECDIS), Integrated Bridge Systems, surveillance and monitoring systems, etc., indirectly affected the number of deck officers,
- communications technology brought the ship into direct contact with people on shore, so that it could no longer be regarded as a completely independent unit as it used to be,
- highly automated systems, etc.

The size of the ocean-going cargo ship crews has been decreasing steadily over the past 250 years (~1860: 250 men; ~1880: 140 men; ~1900: 100 men; ~1950: 40 men (diesel propulsion); ~2000: 16 men (container ship); ~???: 0 men [Bertram, 2013].

In addition to the reduced manning over the past 30 years, there have also been essential changes in the role of the ship crews. For instance, cargo handling has been reduced to monitoring loading/unloading operations; hold washing has become impossible without shore crew assistance; shorebased personnel is occasionally also required for major repairs; maintenance work has been reduced to basic tasks; complex navigation tasks are completed by pressing a button; the master's role is changing due to the fact that ships are no longer independent units that are isolated from the rest of the world, etc.

Nowadays we can see various investments around the world which may totally transform shipping business. Technologies that could shake the maritime industry and have already been here for some time include artificial intelligence, Internet of Things (IoT), Augmented reality (AR), Virtual reality (VR), Drones, Robotics, Cyborg crew, Autonomous vessels, etc. [Wingrove, 2018]. One of the special technological novelties is the autonomous ship, i.e. autonomous surface vessel. Building of such vessels will present a revolution in shipping, although their use will be initially limited to short sea shipping. In 2018, Lloyd's Register (LR), along with QinetiQ and the University of Southampton, released The Global Marine Technology Trends 2030 report (GMTT 2030) (Global Marine Technology Trends 2030, 2015). The GMTT 2030 identifies two main areas of change: one will transform ship design and building, the other will impact safety, commercial, and operational performance. The GMTT 2030 also focuses on 18 specific technologies that will potentially transform the shipping industry: robotics, sensors, big data analytics, propulsion and powering, advanced materials, smart ship, autonomous systems, advanced manufacturing, sustainable energy generation, shipbuilding, carbon capture and storage, energy management, cyber and electronic warfare, marine biotechnology, human–computer interaction, deep ocean mining, human augmentation, and communication.

Given all these efforts and possibilities to reduce the number of crews on ships. it is difficult to believe that the shortage of seafarers will increase in the years to come. As mentioned before, BIMCO predicts shortage in the total supply of officers of 18 % for the year 2025. These numbers can be justified by the positive trends of maritime transport, the forecast growth in the world merchant fleet as well as the slow introduction of highly sophisticated vessels, i.e. autonomous vessels. Prediction is that the merchant fleet will reduce its growth, or even begin to decline (in some sectors) somewhere between 2030 and 2035 (Maritime Forecast to 2050, 2017). Regarding autonomous vessels, about the year 2025 the first commercial remote-controlled unmanned coastal vessels are expected, about 2030 remote controlled unmanned ocean-going ships, and about 2035 autonomous unamanned ocean-going ships (Rolls-Royce-Autonomous ships, 2016). Also, autonomous ships will eventually reduce the jobs on board but will increase the number of 'crew' on shore in the supporting functions. By 2025, in a very optimistic scenario, some 1,000 ships will be fully autonomous and some further 2,000 vessels semi-autonomous; this may possibly reduce the demand for seafarers only by 30,000 – 50,000. However, at the same time the need for highly skilled remote-operators, pilots of a new kind, and "special crews" will be needed to keep these ships operational [Seafarers and digital disruption, 2018]. According to all of the above, a lack of seafarers, especially experienced officers, at least in the next decade is imminent.

5. EDUCATION OF SEAFARERS

In the past, a seafarer's career usually started at sea, where people were sent to work on board ships at a very early age. Over time, the development of different ships, specialization of ships, technological advances, etc. resulted in the demand for a higher level of education and training. Nautical education started to be provided at schools on shore, combined with the onboard training. One of the most important steps in the development of the seafarer's education system was the adoption of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers. The shipping market is inherently international by nature and cannot reach its full potential without effective onboard personnel. The STCW Convention has set minimum qualification standards for masters, officers, and watch personnel on seagoing merchant ships. The Convention was adopted at the International Maritime Organization (IMO) conference in London in 1978 and entered into force in 1984. It was significantly amended in 1995 and 2010. This was the first convention to establish the minimum basic requirements on training, certification, and watchkeeping for seafarers at a global level. Before that, the minimum standards of training, certification, and watchkeeping of officers and ratings had been established by individual governments, usually without reference to practices in other countries, which caused large differences in the minimum standards and procedures as well as discrepancies in the process of certification in general.

5.1. The Existing Problems and Challenges

Although the STCW Convention defines the minimum levels of knowledge and skills required for specific qualifications, national and international education systems have not been harmonized in terms of learning contents, ways the curricula have been designed and performed, and the time required for acquiring specific qualifications. Generally speaking, education systems can be divided into two categories: the traditional education system combines theory and learning through practice, while the other form of education is performed through formal national education systems (gradient system and university system) (Ćorović et al, 2012). The traditional system consists of several stages which individually last 2 or 3 months, while the whole system takes between 5 and 7 years to complete.

This system is typical for Asian and African countries, but it is also under way in some West European countries (e.g. the UK). A gradient system usually includes formal education over 3 to 4 years and navigational practice lasting from 6 to 12 months, after which the candidate acquires a BSc degree (Bachelor of Science) and the STCW Certificate Officer of the Watch (Deck/Engine). For obtaining the Chief Officer / Master license, additional education is required. It usually takes 2 to 4 years at the university (master degree study). However, some countries also recognize special courses in duration of approximately 3 to 6 months, without formal education degree. If the above discrepancies are transferred into man-hours, it results that the total time of a ship master formal education, not including primary education, may vary from 1,500 hours [Model Course 7.03 & 7.01, 2014] to 7,000 hours (4 years of secondary school + 4 years of university). These values are incomparable. It is rightfully expected that a more formal (gradient) type of education will produce a far better quality of personnel. This quality is particularly reflected in increased abilities to acquire new knowledge and to adapt to new technologies over the entire working life. Potential problems may occur if the education is performed under inadequate conditions, i.e. with poor material, technical, and teaching support or if an attendant leaves the system at an older age and without onboard practice. More man-hours spent in education, i.e. more extensive curricula, imply that the future seafarers may attend a variety of courses that extend beyond minimum requirements as described by the international regulations. As every national administration is free to design education programs, the acquired competences inevitably vary among countries and institutions.

Table 6.
Years of education for a maritime officer degree in some countries.
Source: (Berg et al, 2013); for Croatia – the authors

	Level of education		
Country	**Compulsory**	**Maritime**	**Total**
China	12	1.5-2	13-14
The Philippines	10	4-5	14-15
Finland	9	7 (3+4) Vocational lower maritime + officer programs	16
The Netherlands	12-14	1-4 years of vocational training for lower ranks 3-5 years of university / polytechnic	13-19
Croatia	8	4 (for lower ranks) + 0.5 vocational course or 3 years of university	12.5-15
	12	3-5 years university	15-17

Another major issue that the seafarer market has been coping with is the corruption and issuance of counterfeit certificates. Some shipping companies require additional compulsory training for the seafarers arriving from the countries that are not efficient in dealing with the above problems (Berg et al., 2013).

Finally, it should be emphasized that the two main global challenges the seafarers' profession faces today and will continue to face in the future even more profoundly are the shortage of skilled seafarers and prediction of future skill needs due to digitization and automation. These days it is evident that the workforce shortage directly affects the ways of maritime officer education as there is a trend to produce as many officers as possible within the shortest possible education time-frame. In some countries, there is a tendency to switch from the gradient system to the training system, to reduce the minimum time-frame within the gradient system, or to abandon the university level altogether. This approach may result in a lower quality of maritime personnel, particularly in terms of their ability to adjust to cutting-edge technologies. Some analyses indicate that the seafarer market does not lack seafaring personnel, but it does lack high-quality seafaring personnel. It is expected that 1 out of 12 seafarers completes STCW tests with just 40 % achievement (IHS Markit-The maritime world, 2017). The problem is even more serious when those who fail the tests eventually find employment at other companies, i.e. shipping companies that have no other choice.

The application of new technologies in maritime shipping industry should be observed in two ways. On the one hand, the new solutions make work easier or even eliminate the need of performing routine chores, thus making some of the traditional skills redundant. On the other, new technologies require new knowledge and additional competences in operating complex systems and devices, processing of large amounts of data, developing new communication skills, and responding fast to new solutions and regulations. Moreover, one cannot overlook the sociological aspects, familiarization with new environments and acting within complex relationships between man and man, and man and machine. Some of the expected specific education features in digital maritime industries include (Nguyen, 2018):

- simulator-based and computer-based training,
- use of 3D simulation and gamification, which also allow seafarers to train and practice on board,
- training that is absolutely tailored to the individual needs,
- training provided for the seafarers should be, to a certain extent, similar to the training provided for nearly all other technical industries, in particular STEM competences (science, technology, engineering and math),
- advance knowledge in leadership and managing people, associated with management in the sector,
- preparing the young for the life at sea,
- education of personnel who will control future autonomous ships and their driving systems, whether from on board or remotely, whether as deck officers, marine engineers, or electro-technicians.

Education systems will have to respond to these challenges by producing the workforce with adequate competences and capacities to meet further training needs. Taking into consideration the existing education systems that are implemented globally as well as the very nature of onboard work that implies life-long learning, it is clear that some of the seafarers will turn out to be under-qualified while others will become over-qualified, and that the higher-quality workforce will gravitate towards "better" companies, i.e. the companies offering better salaries and working conditions. Once a good seafarer enters the payroll, however, the question will be how to keep him or her and how to maintain his or her loyalty and commitment.

5.2. Education System for Partly or Fully Autonomous Ships

The introduction of Maritime Autonomous Surface Ships (MASS) and, in particular, those which are fully autonomous, presents a huge challenge to all the parties engaged in the future education of officers. MASS is defined "as a ship which, to a varying degree, can operate independently of human interaction." The degrees of autonomy of MASS are organized (non-hierarchically) as follows (IMO MSC 99, 2018):

- Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.
- Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location, but seafarers are on board.
- Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
- Fully autonomous ship: The operating system of the ship is able to make decisions and take actions by itself.

Automated ships will be commanded from a shore operating center, where shore masters (or MASS operators) will be monitoring and controlling their navigation and performance through detectors, sensors, cameras and advanced communication systems. The first question concerns the source of the future operators of fully autonomous vessels. Will they be requalified deck or engine officers holding the highest seafaring ranks, graduate technical or information engineers who will run through supplementary requalification in line with STCW requirements, or people holding adequate professional degrees who will complete specialized formal training for autonomous ship management (Figure 7). Similarly to unmanned aerial vehicles, the best way of educating the required personnel is perhaps within specialized university studies designed for this purpose. However, such studies are in their early beginnings and will require an appropriate time for realization. Accordingly, it may be expected that the operators of the first autonomous vessels will be the existing onboard officers, i.e. experienced masters, who will have to complete adequate training programs. However, recruitment can also be feasible from the staff primarily specialized in remote control processes and who have completed adequate STCW programs.

The MASS vessels will be controlled by ship masters, shore masters, and MASS operators, depending on the degree of vessel autonomy (Figure 8). Given the possible variants of future autonomous, semi-autonomous, and remotely controlled vessels, it will be a great challenge to design education programs covering the needs and requirements of the future MASS operators. In addition to minimal STCW competences, future MASS operators will have to acquire specific competences, i.e. knowledge and skills in a variety of fields, including computer science, robotics, communication theory and skills, legislation, math, and science in general.

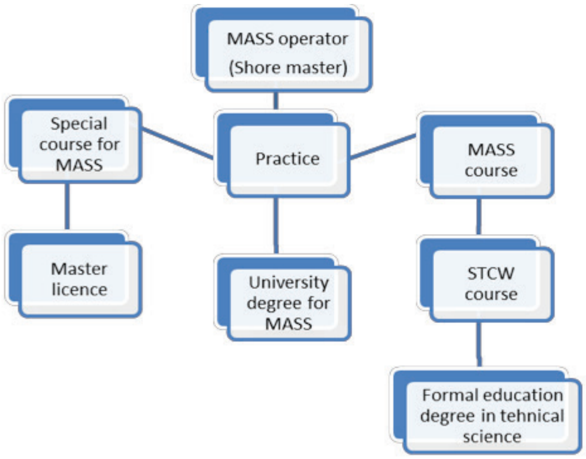

Figure 7.
Training process of the operator for the fully autonomous ship.

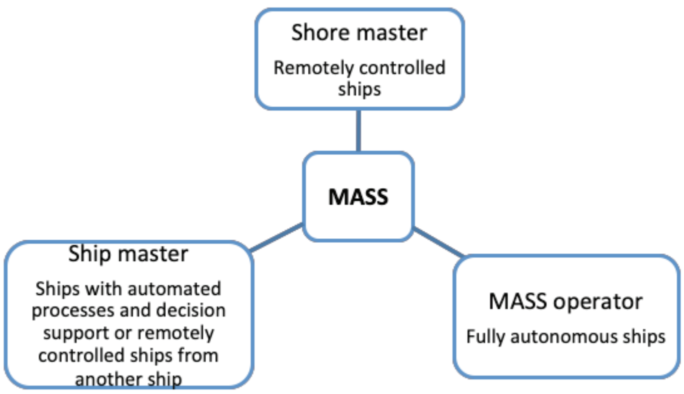

Figure 8.
MASS operators in a Shore/Ship Control Centre.

6. CONCLUSION

It is expected that the demand for maritime shipping and seafaring personnel will continue to grow in the near future. For some years now, the global market has been experiencing a lack of seafaring officers, and it is forecast that the shortage will be even more pronounced in the years to come. The increased demand for onboard officers is likely to result in a lower quality of work performance as the future officers will not be able to deal with constant technical and technological developments. Although the STCW Convention provides a standardized framework for the education and training of seafarers, the relevant schools and centers have diverse approaches to designing and performing the teaching and learning processes. The minimum knowledge and skills required for specific qualifications have been clearly defined, but the differences and problems arise from the non-standardized periods of schooling, education within or out of higher education institutions, various ways of performing the required practice, different human and material resources that are available at educational institutions, corruption, etc. By all means, a formal education system at a higher education institution is preferable and has more advantages over other systems, provided that adequate human, material, and technical resources are available.

The development of science and technology has significantly changed the features of seafaring: directly, through making certain tasks easier and through replacing human workforce by automated systems and indirectly, through the development of communication systems that have changed the relationships between the master and the crew, and between the onboard personnel and their principals ashore. As a consequence, the size of the crew has been continuously reduced, and the trends may eventually result in unmanned automated vessels. However, this is surely not going to happen in the next decade; most analyses forecast shortage of seafarers in this period, especially of experienced officers.

Education institutions have been recently facing difficult challenges. As the demand for onboard officers is growing, it is expected that efforts will be made to produce the maximum seafaring personnel while maintaining the level of quality or even enhancing it, given the development of new technologies and the modern market demands. A particular focus should be on the education and training for the future work on (or with) the highly sophisticated vessels, including autonomous vessels.

Although the use of the autonomous vessels in the first phase will be limited in many ways, education system should respond in time. In order to timely respond to the new challenges, maritime education and training centers have to develop adequate curricula and syllabi, and start implementing them as soon as possible, according to the market requirements.

The tasks and duties onboard ships related to ship operations are very complex and prone to constant changes. Accordingly, they require constant and life-long learning and requalification. Educational and training institutions, together with the companies employing seafarers, must constantly invest into supplementary training of the crew members, and create long-term plans and strategies in order to ensure sufficient high-quality workforce on the seafarer market, particularly at the management level.

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