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# Maritime education development for environment protection behaviour in the autonomous ships era

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**Abstract.** Shipping is the last sector of the global transport chain, where the autonomy of the transport is at a very early stage. During the second decade of the 21st century, we have been actively involved by powerful corporations in the process of creating an autonomous ship to solve problems of design, economic, environmental and social nature. In this process, huge financial and research resources have been attracted, which assures that a long-lasting and sustainable effect is sought.

Research on autonomous vessels are diverse – structural, navigational, infrastructural, communicational, environmental, social. Many of them are based on the current state of shipping and a very small proportion uses actual achievements. Education in the field of environmental protection and the needs of the future management and operation of autonomous ships are some of the shortcomings in human knowledge today. The article analyses the current state of education and qualification of seafarers through the prism of the new realities. The authors present the experience of Nikola Vaptsarov Naval Academy in the introduction and development of new maritime specialties that form the competencies of future seafarers.

## 1. Introduction

Today a real revolution is taking place in shipping. It takes place in the scientific sphere as a whole and in all correspondent branches of science as well. Its influence can change both the nature of shipping and the strategic thinking in shipping.

Maritime education is an integral part of the global strategy for the development of world shipping. The seemingly peaceful area of the International Maritime Organization's agenda faces the challenges of the new era - the gradual realization of the idea of building and using autonomous ships.

Today our perceptions of the use of autonomous vessels are still limited by the traditional ways of transporting goods and people by sea. Significant is the fact that shipping is the last transport sector to introduce the idea of autonomous transport. The traditional approach to solving system problems, as well as numerous regulatory bodies, often hinder or lead to a slowdown in the development and application of new technologies in the industry. Practice logically raises the question of whether today's seafarers and their theoretical and practical training are adequate enough to modern shipping technologies. This rhetoric is evident in the IMO's "Procedures for Port State Control" (2017), which instructs inspectors to strengthen the control of seafarers' competence at all levels of responsibility [1]. Despite the introduction of new technologies through modern communication tools, ECDIS, integrated navigation systems that facilitate bridge operations, navigational accidents continue to occupy a significant place in marine statistics [2].

The second question, which finds its natural environment in the maritime community, refers to the place of autonomous ships in modern shipping. The skepticism of more than half of the participants in

an interview conducted by the author among students and trainees of Nikola Vaptsarov Naval Academy shows that the idea is making its way with difficulty. Similar sentiments are also seen in the comments on the article by blogger Wolf Richter published on September 1, 2018 on his website "wolfstreet.com". Within five days, from 01.09.2018 to 06.09.2018, the eighty-two participants in the discussion showed polarized views on the introduction of autonomous vessels [3].

Why is there such a contradiction between the beliefs about the need for modern shipping technologies to replace much of human activity and the inadequate skills to use them in the right direction? Why are we still afraid of emerging technologies and we prefer to reject them rather than try to control them? What is the role of maritime education in this process?

## 2. Impact of autonomous vessels on the work on board the vessels and the maritime environment.

Contemporary scientific achievements push us beyond the traditional educational approaches and programs to the exotic theory of self-organization and adaptation. New trends in scientific research that have emerged over the last thirty years suggest that the structure of maritime education follows shipping developments and is even lagging behind. This finding makes it necessary to carry out a permanent staff training cycle [4].

Over the last four years there has been increased activity among the research community in the field of autonomous vessels. At this stage, publications mainly analyze the current state of shipping and the restrictions on the use of autonomous maritime transport on international voyages [5, 6, 7, 8]. Other large-scale publications present the problems dealt with by large consortia such as "Mitsui O.S.K. Lines, Ltd. - Nippon Yusen Kaisha", "Rolls Royce - Kongsberg", "Yara", "DNV GL". The authors mainly cite the definitions of the concept of "ship" presented in the IMO conventions and resolutions, as well as the role of the crew and its physical presence on the ship. Autonomy criteria have been proposed and adopted, according to which the classification of ships and their positioning in the respective level have been made (Fig. 1) [9, 10].

Ship category	Level of autonomy	Acquisition of information	Analysis of situation	Decision	Action
Conventional ship	0	Human	Human	Human	Human
	1	System/Human	Human	Human	Human
Smart ship	2	System	System/Human	Human	Human
Autonomous ship	Lev.1	System	System	System/Human	Human
	Lev.2	System	System	System	System/Human
	Lev.3	System	System	System	System

Fig. 1. Autonomy levels of modern ships

It is important to note that each of these documents requires the performance of certain duties by the crew on board. One of the most important shipping conventions, the STCW Convention, in Article IX of the latest edition of 2017, allows the application of local rules that can be interpreted as facing the needs of unmanned ships:

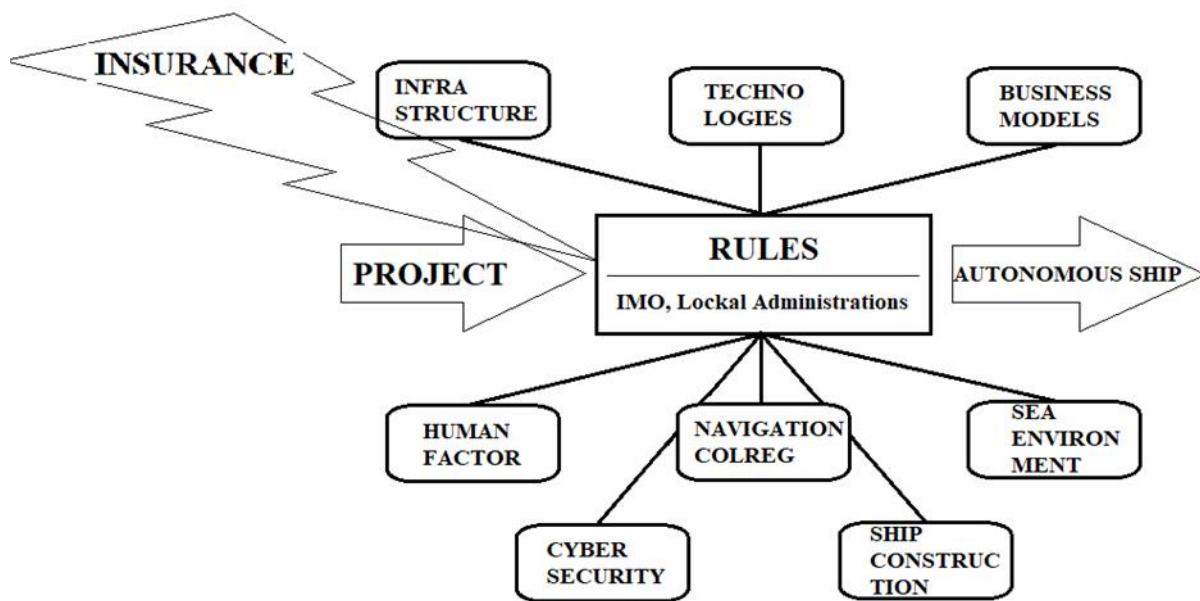
„The Government shall not prevent an Administration from retaining or adoption other educational and training arrangements, including those involving sea-going service and shipboard organization especially adapted to technical developments and to special types of ships and trades, provided that the level of sea-going service, knowledge and efficiency as regards navigational and technical handling of

ship and cargo ensures a degree of safety at sea and has a preventive effect as regards pollution at least equivalent to the requirements of the Convention” [6].

Other authors concentrate on the legal barriers in existing local and international legislation. In his study "All hands off deck?" Lucy Carey makes a detailed analysis of all the international documents adopted by IMO, focusing on the possibility of reducing crew and the use of autonomous vessels together with those currently existing in international shipping [11]. But this and other quoted publications seem to raise more questions than give answers to the concerns of the entire maritime community.

Autonomous ships are already a fact. On December 3, 2018, a demonstrative voyage was carried out between the Finnish ports of Parainen and Nauva on board the “Falco” ferry [12]. Thus, analysts' forecasts for the start-up period of 2020 came true two years earlier [11, 13]. The rapid development of work projects requires the immediate response all parties concerned. But the skeptical researchers, who are more than a few, define the lack of changes in international legislation as a priority obstacle, as well as the most important argument in terms of the commercial operation of ships - the insurance companies' opinion about the level of responsibility [14, 15].

The circumstances that are identified as current barriers to the use of autonomous vessels on international voyages are shown in Fig. 2.



**Fig. 2. Barriers to the use of autonomous vessels for international voyages**

The figure sums up a basis for solving the problems, faced by autonomous vessels, which has been presented to the maritime community, including all the followers of the processes under consideration. Through the proposed scheme of relations between the various components, we focus on the rules that need to be developed primarily for the benefit of autonomous and unmanned ships. International rules will have to be written, developed and updated. A sign of goodwill was given by IMO at MSC's 99th (May 16-25, 2018) and 100th (03-07 December 2018) Sessions. The issue of the future implementation and use of Maritime Autonomous Surface Ships (MASS) was included in the agenda of the two forums [16].

The International Maritime Environmental Protection Committee (MEPC) also included autonomous and unmanned ships in its agenda. At the 73rd session of the Committee, it was decided

to wait for MSC's decisions after the following sessions to synchronize the actions of the two Committees [24]. This fact is indicative of the global responsibility of the international maritime community and the increased interest in environmental protection.

The issue of establishing local rules for the operation of autonomous and unmanned ships is an entirely different issue. Changes in the coastal states' national legislation depend solely on the will of local maritime administrations. Within the territorial sea under their jurisdiction, rules not contradicting the international ones can be established in order to support and stimulate the process. The Norwegian Forum for Autonomous Ships established on 04th of October 2016 was initiated by the Norwegian Maritime Administration, the Norwegian Coastal Administration, the Federation of Norwegian Industrialists, and more than 30 organizations and 110 individuals [17]. Through NFAS, the state authorities make it possible to realize YARA's project for the commissioning of the YARA Birkeland autonomous ship.

The company publishes detailed information on its official website, which shows that at first the ship will be manned and will become fully autonomous in the middle of 2020. The authors of "YARA Birkeland" focus on environmental protection, using only electric power to propel her. Thus, the project will become the first to produce no harmful emissions.

From a societal perspective, autonomous ships present a number of different and great potentials:

- An environmental advantage due to fuel savings and new means of propulsion
- Enhanced safety both in open waters and in ports
- Significantly increased cost-efficiency and productivity
- Optimization of the logistics chain via IT solutions
- Improved infrastructure for, inter alia, transport to and from islands as well as for densely trafficked routes.

From the above analyzes, it can be concluded that the process of construction and subsequent operation of autonomous and unmanned ships is high-tech and ecological. Successful implementation requires specialists with adequate education, qualifications and skills to meet the demands of time. To this goal, amendments to the STCW Convention are necessary which, together with local legislation, will fill the gaps caused by technology.

### **3. Marine Environmental Education in the Age of Digital Navigation.**

The rapid development of technology requires adaptability in the professional environment. A number of studies have shown strong dynamics in the education sector, which is heavily influenced by economy needs. The technological boom has formed nonlinear dynamics in the labour market, which is evidenced by the emergence of new professions and skills, as well as the phasing out or the complete demise of existing ones. A report by the European Center for the Development of Vocational Training CEDEFOP entitled "Skills forecasting trends and challenges for 2030" states that changes in employment are the result of a combination of two main factors [18]:

- continuing structural change in the economy in terms of its sectoral mix;
- technological and other changes that influence the patterns of skill demand within sectors.

The study notes that the need for highly qualified specialists will increase and that the share of low-skilled workers will decrease. "Most of the increase in employment in recent years has been concentrated in higher-skilled jobs, with usually higher formal qualifications, such as university degrees. These include areas such as management, professional and associated professional positions. This model is expected to continue" [18].

The conclusion is logical considering the fact that highly educated specialists are those who can adequately meet the high demands of the new realities. Among shipping managers in this sector, new specialists will be formed who will make decisions from a distance in order to solve the following problems:

- Technical problems related to the ship and the cargo;
- Ship management problems;

- Problems in selecting a sailing route related to environmental features;
- Problems related to the communications and communication equipment of ships;
- Cyber security issues;
- Conflicting situations in case of impaired stability and danger of losing the ship.

Today, human imagination is limited by the existing reality in shipping. From this point of view, we can hardly imagine the needs of tomorrow. Therefore, a number of authors, institutions and projects are trying to forecast the future of the labour market in shipping. As this issue is new to the industry, all research is based on the experience of autonomous management and the digitization of activities in other industries.

We are witnessing a revolution that can change strategic thinking not only in shipping, but also in areas related to it like ancillary human activities such as education, research, environmental protection, material science, etc. Contemporary scientific achievements have made many researchers turn to labour market statistics. These new trends of research have been emerging for the last 10-15 years as a result of the rapid implementation of automated systems into the industry. Naturally, a parallel is drawn between transport sectors such as aviation, automotive and road transport, rail transport, urban transport and shipping. The labour market trends in the above-mentioned economic sectors are naturally interrelated and influence each other. The studies by Frey and Osborn [19], Nedelkoska and Quintini [20] outline the picture of employment in the near future. They predict a reduction in the need for a human involvement in professions such as administrators, sellers, agricultural workers, transport operators and drivers, and others. Although not directly, this researches and models for predicting the future also apply to shipping.

There is no such research in the maritime sector. Statistics on the insufficient numbers of seafarers at all levels of responsibility in shipping are periodically published, and these statistics data seem to give comfort and the feeling of indispensability of crews [21, 22]. Undoubtedly, current maritime professions, such as those directly related to ships and those related to ports and coastal services, will undergo changes. Probably some of the traditional ship jobs will require additional skills and qualifications. Such a conclusion can be found in a number of studies [10, 23]. The authors point out that current and future seafarers have no reason to worry about their work. Autonomous ships will not cause job cuts, and will even help to find new ones.

Nikola Vaptsarov Naval Academy (NVNA) is a leader in marine education in the Republic of Bulgaria. The management and the academic board closely observe the processes in world shipping and respond adequately to the new challenges. A look into the future makes an attempt to describe the new skills that will be needed for the upcoming hybrid environment - the simultaneous navigation of autonomous ships at all levels of autonomy. Since 2014, a curriculum and syllabi for a Master's degree in Cybersecurity have been developed by the Department of Informatics. In 2018 the education of the first master's degree course began. The aim of the program is to prepare specialists to upgrade traditional maritime education and qualification to achieve management of ships in a hybrid environment. The specialists who will obtain this master's degree are expected to lay the foundations of a system of knowledge and skills to solve the problems in a cyber-environment in which data and signals to autonomous ships will be transmitted.

Another innovative educational project is the launch of the specialty Mechatronics with a focus on the requirements of modern shipping and environmental protection. Mechatronics is a relatively new interdisciplinary specialty, which in recent years has been intensively introduced in a number of world universities. Over the past 35-40 years, all highly industrialized countries have been paying great attention to machine building and its automation. Mechatronics is not just a combination of its constituent disciplines, it is mutual permeation and fusion of mechanical, electronic and computer structures to achieve a complete, functionally full product called the "mechatronic product". Such products appear to be the autonomous ships that are currently being built, their operation and their compatibility with the environment.

Along with the educational initiatives, the Nikola Vaptsarov Naval Academy is actively involved in projects under the European Commission's "Blue Economy" strategy. As a member of the Maritime

Cluster Bulgaria, the NVNA representative was nominated and elected an expert at the Directorate-General for Maritime Affairs and Fisheries (DG MARE) and he participated actively in the meetings of the Working Groups "Lifelong Learning, Mobility, Education Programs" and "Industry- education cooperation". In a special printed and electronic edition, good practices and practical ideas for successful cooperation between the maritime business and the maritime education were summarized and presented to users in the Member States of the European Union, particularly in the field of environmental protection in the context of new realities [25].

#### 4. Conclusion

Modern shipping has demonstrated a serious technological progress over the last two decades. The development of the industry has led to the search for new ways and means of intensifying the transport of goods and passengers across the world. Creating autonomous vessels of the highest levels of autonomy and their simultaneous operation with existing ships is a serious challenge to educational systems in the countries providing maritime education. The combination of new and existing technologies is also reflected in the attitude towards the environment. The adaptation of maritime education and the competences covered by it is the first step in mastering the intricate processes in today's complex environment. The joint work of the two major committees at the IMO, MSC and MEPC, promises to continue the policy related to energy efficiency of ships and environmentally friendly shipping.

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