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Sustainable Reaction of the Maritime Education Sector to Marine Technology Development including Autonomous Surface Shipping

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ABSTRACT: In the last two, three decades we can observe revolutionary development of technology, including global shipping industry. The Author, as the chairman of the Poland Branch of The Nautical Institute, a member of several expert groups of International Maritime Organization (IMO), rector of Gdynia Maritime University, one of the leading Maritime Education and Training (MET) institutions in the World, as well as the chair of the International Association of Maritime University (IAMU), tries to discuss how the maritime education sector can adapt and respond effectively to technological development, including Maritime Autonomous Surface Shipping (MASS). Key considerations cover a balance between traditional maritime skills and the integration of new technology in education. New technology requires digital literacy and advanced system management. Shift is needed from manual operations to supervisory roles over automated systems. Automation may reduce demand for traditional seafaring roles but create new tech-based roles. Legal frameworks and certifications need to catch up with tech developments. The author argues that a balanced approach is needed, combining new technological education with traditional maritime skills. The education sector must be proactive, working closely with industry to stay up to date. Preparing the workforce for hybrid roles is essential for the future of the maritime industry.

1 INTRODUCTION

1.1 *Context – Objective – Key Considerations*

The maritime industry is rapidly evolving with the advent of new technologies. Main objective is discuss how the maritime education sector can adapt and respond effectively to technological changes. Key considerations cover balance between traditional maritime skills and the integration of new technology in education.

1.2 *The Maritime Industry's Importance*

The maritime sector is essential for global trade, responsible for transporting around 90% of the world's goods. With technological advancements, this industry is evolving to become more efficient, safer, and environmentally friendly.

Objective is:
- to examine how the maritime education sector is adapting to the evolving demands brought about by new technologies, particularly in Maritime Technology Development,
- to explore how a balanced approach can prepare professionals for a rapidly changing industry while preserving traditional expertise.

We must realize that we solve the following problems [Weintrit, 2024a]:
- skill gaps:

  - New technology requires digital literacy and advanced system management,
  - Shift from manual operations to supervisory roles over automated systems;
- job displacement:
  - Automation may reduce demand for traditional seafaring roles but create new tech-based roles;
- regulatory lag:
  - Legal frameworks and certifications need to catch up with tech developments.

1.3 *Anticipating the Future-Skills and Certification*

Current transitions lead to evolving skill sets and certifications needed for the future of maritime professionals [Weintrit, 2024b].

Experts from maritime education, regulatory bodies, and certification authorities should begin a broad discussion on updating training programs to meet technological advancements and sustainability goals as well as the need for international alignment on certification standards to ensure a skilled, globally competitive workforce.

According to International Maritime Organization World Maritime Theme 2024 is "Navigating the Future: Safety First!".

If we are talking about the future … the most important is the time horizon: the situation next year, in 5 years, 10 years, or an unspecified future.

2 THE FUTURE IN MARINE SHIPPING

2.1 *What Does the Future Hold for Shipping?*

In 2023 the Author has been noticed seven magnificent trends in international shipping [Weintrit, 2023]:
- Alternative Marine Fuels (LNG, Hydrogen, etc.);
- Green Propulsion (e.g. Wind, Solar);
- Smart Shipping Technologies:
  - Internet of Things (IoT) applications, advanced sensors, and big data for real-time operational monitoring,
  - Predictive maintenance to prevent mechanical failures, 3D printing;
- Digitalization (e.g. Electronic Charts/ECDIS);
- GNSS/PNT;
- e-Navigation, and
- Autonomous Ships.

Figure 1. The most important question: Are e-Navigation and Autonomous Navigation heading in the same direction? Really? Are you sure?

2.2 *Reducing Greenhouse Gas Emissions: Decarbonization and Sustainable Energy in Maritime*

Commercial shipping is committed to using renewable or alternative fuels to reduce the industry's current environmental impact. Shipping experts suggest the need to change the fuel on ships for two main reasons: to reduce pollution to meet requirements, and to reduce climate change and reduce greenhouse gas emissions.

2.3 *Copying "Tri-Transformation" of International Shipping*

On 8th July 2024 there was organized in Shanghai DSH International Shipping Innovation Conference in Shanghai themed „Digitalization and Decarbonization: Empowering Shipping for a Shared Future" The DSH Conference:
- aimed to seize new opportunities in the global shipping industry's digitalization, intelligentization, and decarbonization transformation – "Tri-Transformation" of International Shipping,
- accelerate the filling of gaps in high-end shipping services, and
- enhance global allocation capabilities of shipping resources.

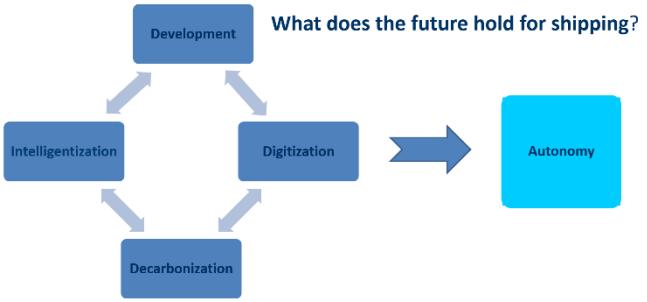

Figure 2. What does the future hold for shipping? Technology development, digitalization, intelligentization and decarbonization inevitably lead to autonomy of international shipping

2.4 *Comparison of Both Lists*

Comparing these two sets from items 2.1 and 2.3 we can see that the Chinese and Polish observations are almost identical. Well, after all, alternative marine fuels and green propulsion are nothing more than a decarbonisation. Smart shipping technologies, digitalization (e.g. Electronic Charts / ECDIS), GNSS / PNT, and e-Navigation – it is more less digitalization. As the maritime sector continues to digitalise, actionable intelligence matters to maritime professionals more than ever. Various Digital Patforms are a comprehensive collections of tools that enhance data comprehension, driving performance, profitability and progress, while assisting with decision-making and reducing risk.

And finally e-Navigation and autonomous shipping it is intelligentization.

Figure 3. Comparison Chinese and Polish observations on future of shipping [Weintrit, 2024a]

2.5 *Current Marine Technology Developments*

Technology is present in almost every sphere of human life; it is also present in the shipping industry. Smart ships and autonomous technologies are examples of solutions used in the modern maritime sector.

Improvements in ship construction (megaships), advanced materials, smart shipping, propulsion, robotics, big data and sensors are making it easier to work in the waters of the Earth. Companies and marine engineers should be aware of these technologies to improve their workforce.

With technological advances, the maritime sector can be safer for the environment and continue to decide on the escalation of the global market.

The following technologies are in focus:
- Automation in vessel operations;
- Artificial Intelligence (AI) and machine learning in Navigation;
- Digital twins and real-time monitoring systems;
- Advances in sustainable energy (e.g., electric/hybrid vessels);

We can observe the trends on increased reliance on data analytics, remote operations, and autonomous ships [Weintrit, 2021].

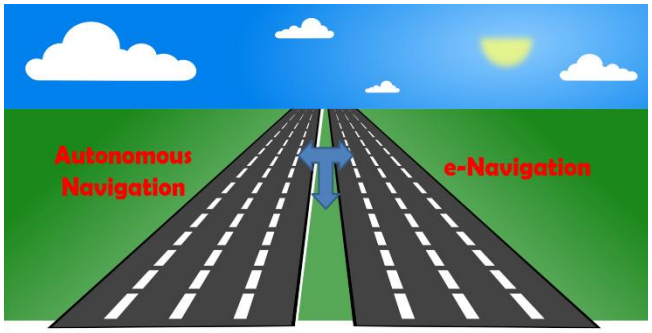

Figure 4. Is such parallel, simultaneous and mutually complementary progress of two very different approaches to technology development: e-Navigation and Autonomous Navigation, even possible? [Weintrit, 2024a]

2.6 *Expanding Navigation Application, Empowering the Future of Humanity*

The 17th IAIN World Congress 2024 organized by China Institute of Navigation (CIN) from October 28 to 30, 2024 in Beijing, with the theme of "Expanding Navigation Application; Empowering the Future of Humanity" was to share and discuss the knowledge, opinions and technical navigation issues all over the world. It has been noticed, among other things, that Artificial intelligence (AI) is reshaping humanity's future, and the Conference like this provides a comprehensive exploration of its implications, applications, challenges, and opportunities. The revolutionary potential of AI is investigated across numerous sectors, with a focus on addressing global concerns. The influence of AI on areas such as marine transportation, navigation applications and maritime education was revealed through insights and conversations on different AI systems in global shipping. Ethical considerations and the significance of responsible AI development were addressed. Furthermore, provided discussions investigated AI's involvement in addressing global issues such as climate change, safety and security. The conclusions will serve as a resource for policymakers, researchers, and practitioners understanding the complex link between AI and humans.

3 A BALANCED REACTION OF THE MARITIME EDUCATION SECTOR TO TECHNOLOGY DEVELOPMENT

3.1 *Maritime Education and Training (MET)*

As modern shipping becomes more sophisticated, highly skilled seafarers are as essential today as ever. Despite modern means of communication, ships' crews must still be able to diagnose faults, so a minimum global standard of competence for all shipboard personnel is essential. Provided by the International Maritime Organisation (IMO), this framework is known as the Standards for Training, Certification and Watchkeeping for Seafarers (STCW).

To facilitate and standardize maritime training, the IMO has developed other tools:
- IMO Model Courses are designed to help implement the STCW Convention and, further, to facilitate access to the knowledge and skills demanded by increasingly sophisticated maritime technology. Maritime institutes and their teaching staff can use them in organizing and introducing new courses or in enhancing, updating or supplementing existing training material;
- IMO e-Learning. IMO has developed a number of e-Learning courses with the purpose of increasing the capacity of Member States to effectively implement IMO instruments.

The manual published by The Nautical Institute regarding maritime education and training is still worth recommending [Syms, 1997].

3.2 *STCW Convention and Its Milestones*

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, was adopted by the International Conference on Training and

Certification of Seafarers on 7 July 1978 with major revisions in 1995 and 2010.

The 1978 STCW Convention entered into force on 28 April 1984. Since then, amendments thereto have been adopted in 1991, 1994, 1995, 1997, 1998, 2004, 2006, 2010, 2014, 2015, 2016 and 2018.

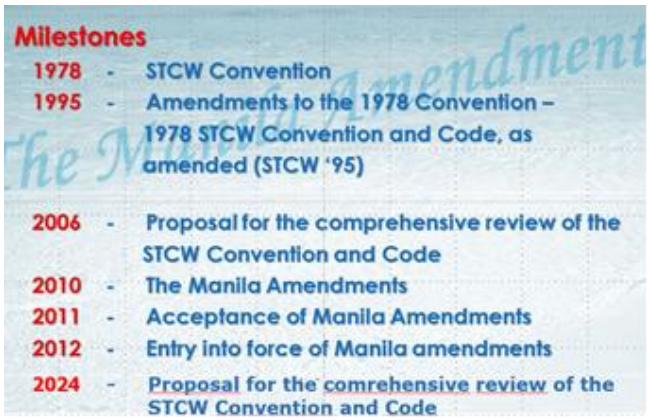

Figure 5. The IMO Milestones in STCW adoption [Weintrit, 2024a,b]

A comprehensive review of the STCW Convention and Code is currently underway. Unfortunately, due to the dynamic technological progress, the text of the convention, once adopted, becomes outdated almost immediately with subsequent amendments.

Figure 6. The subsequent versions of the STCW convention text are like a photo snapshot of the current state of technological development [Weintrit, 2023]

Therefore, there is a need for continuous revision of the Convention with constant changes and additions to the text or a general change of the previous approach. The Convention could contain only the main framework, and other documents, updated on an ongoing basis, would contain detailed requirements and explanations

3.3 *Active Cooperation between IAMU and IMO*

The IMO strategy outlines four key areas that IMO will focus its efforts over the decade from 2021 to 2030, which comprises the following four work streams (WS) [IMO, 2021]:

- WS 1 - Reform and streamline IMO's internal organization for delivery of technical assistance;
- WS 2 - Support Member States in maritime development;
- WS 3 - Enhance the Regional Presence Office (RPO) Scheme; and
- WS 4 - Strengthen the global training and development network.

In 2023, the IAMU submitted a document to the IMO [IAMU, 2023] outlining the IAMU's commitment and capacity to work with the IMO in achieving the objectives of the Capacity-Building Decade Strategy 2021-2030. In this document, the IAMU outlines the activities undertaken by the International Association of Maritime Universities (IAMU) and highlights the Association's support for Assembly resolution A.1166(32) [IMO, 2021] and its commitment and capacity to partner with the IMO to achieve the objectives of this long-term strategy.

The International Association of Maritime Universities (IAMU) was founded as a not-for-profit organization in 1999, with a shared recognition of the significance of maritime education and training in the context of the rapid globalization of international shipping. IAMU aims to be the global leader in maritime capacity-building through networking and excellence in maritime education and training as well as research in that field. The Author have a honour to be chair of IAMU in term 2023-2025.

To accomplish its mission, IAMU has implemented several academic research and developmental projects and activities to reinforce the global network of member universities and to promote capacity-building for the sustainable supply of qualified maritime personnel, both on ships and shore, including academic staff at maritime universities.

To set out a common target/goal regarding the outcomes of education, training and research emanating from member universities, IAMU has sought to formulate a vision for a Global Maritime Professional (GMP). The GMP Initiative is intended to meet the envisaged needs of industry and a rapidly evolving educational and career context while catering for the professional development aspiration of individual seafarers.

To address the educational needs IAMU analysed key professional and academic knowledge, skills and attitudes, set out a number of broad Intended Learning Outcomes, as input to curriculum development in all member universities. IAMU, through the GMP Initiative and other efforts, consistently emphasizes sustainable development in maritime education and training, particularly at the level of tertiary (higher) education. This focus acknowledges the current transitional phase heavily influenced by the rapid advancements in digital technology and further requirements for decarbonization, including the adoption of alternative fuels on ships.

To inspire the younger generation to pursue careers in GMP and to create a network of well-informed young maritime professionals, IAMU and IMO jointly organized the "IAMU Student Forum" at IMO Headquarters in 2017 and 2023 in which students from member universities discussed contemporary issues relating to maritime affairs with facilitators drawn from the academic staff of IAMU member universities as well as maritime experts from the international shipping industry.

Figure 7. Active cooperation between IAMU and IMO – IAMU Student Forum 2023 in the IMO headquarter [Weintrit, 2023]

IAMU's member universities fully recognize that the sustainable supply of qualified academic staff, who are key to the education and training of students aiming to be a GMP, is a crucial factor for the sustainable development of maritime education and training at the tertiary/higher level of education. Such academic staff need higher academic qualifications, including research capacity, as well as practical knowledge and experience as officers on the management level.

3.4 *Challenges for the Maritime Workforce*

There are growing skills gaps among today's seafarers. New technology requires digital literacy and advanced systems management. There is a need to move from manual operations to supervisory roles over automated systems.

Due to the appearance of concept of Maritime Autonomous Surface Ships (MASS) and the commencement of legislative work in this area by the IMO, it is not difficult to predict the need to change the workplace, initially of some and ultimately of all today's seafarers. Automation may reduce the demand for traditional maritime roles, but it may also create new roles based on new technologies. Regulatory lags are becoming increasingly apparent. Legal frameworks and certification frameworks must absolutely keep up with technological developments. This is the need of the hour.

3.5 *Degrees of Autonomy According to IMO*

The degrees of autonomy identified by IMO experts are the following [IMO, 2024]:

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

3.6 *Response of the Maritime Education Sector*

All of these previously outlined changes, and especially the advanced work on MASS, require a strong response from the maritime education sector in the form of:

- Evolution of the curriculum:
  - Inclusion of activities in the field of digital navigation, AI, data management and cybersecurity.
  - Hands-on training in simulators and technology applications.
- Blended learning: combining advanced skills (sailing, navigation) with technical courses (robotics, AI and automation).

It is necessary to develop not only new training courses with brain new and fresh curriculum, but also new certificates. It is necessary to use of new certificates and certificates for emerging technologies.

3.7 *Balancing Traditional and Modern Training*

There is a clear need to balance traditional and modern training through:

- Soft skills: leadership, teamwork, and decision-making remain key, especially in emergency situations;
- Technical expertise: the need to balance understanding of both traditional and advanced navigation systems.
- Practical experience: using simulators and technology labs to provide immersive learning environments, including virtual reality (VR).
- Keeping the balance between theory and practice.

3.8 *Collaborative Partnerships*

There is a need for partnerships that include:

- Academic Collaboration – partnership between maritime universities/academies;
- Partnerships with marine technology companies to update curricula and internships;
- Ongoing research collaborations to explore real-world marine applications;
- Cross-sector dialogue - engage industry leaders and regulators to ensure alignment between education and real-world requirements.

3.9 *Infrastructure and Investment Needs*

Meeting infrastructure and investment needs will be critical:

- Facility modernization: investments in simulation technologies, updated labs, and smart classrooms are needed.
- Train instructors: upskill teachers to teach new technologies and digital tools.
- Cost and resource allocation: balancing budgets between traditional educational needs and new technology-related infrastructure.

3.10 *Future Outlook for Maritime Careers*

What are the prospects for future careers in the maritime sector? This needs to be anticipated today. It will not be easy at all, given the constant development of modern technologies. However, it is certainly necessary to focus on at least:

- Hybrid roles: graduates will need to have both traditional maritime skills and modern technologies;
- New career paths:
  - Cybersecurity for the maritime sector,
  - Remote operations managers for autonomous vessels,
  - Marine data analysts and artificial intelligence specialists;
- Sustainability and green technologies: growing emphasis on environmentally friendly practices, leading to new roles in energy efficiency and environmental compliance.

We must realize that in the more or less distant future none of today's navigators, mechanics and electricians will work in their learned profession.

3.11 *World Economic Forum Report*

The World Economic Forum's Future of Jobs 2023 report [WEF, 2023] finds analytical thinking, creative thinking and AI and big data will be top in-demand skills by 2027. The report covers the entire job market, not just the maritime sector. Leadership and social influence and curiosity and lifelong learning are among other skills expected to see growing demand. Six in 10 workers will require training before 2027, but only half of workers are seen to have access to adequate training opportunities, according to the report.

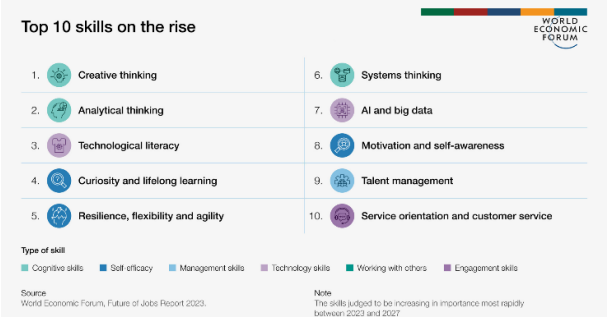

Figure 8. Top 10 skills in 2023 in job market, according to World Economic Forum – Future of Job Report 2023 [WEF, 2023]

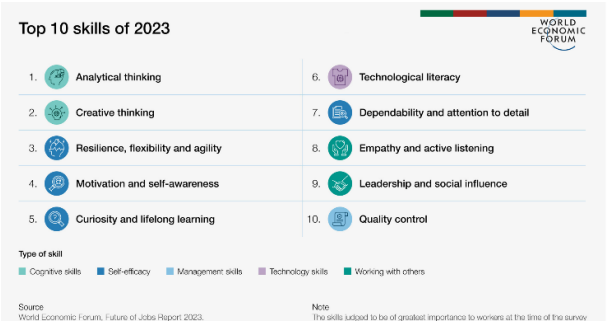

Figure 9. Top 10 skills on rise in 2023, according to World Economic Forum – Future of Job Report 2023 [WEF, 2023]

It is clear that the maritime sector is not a unique job market. The anticipated changes in global shipping apply to a similar extent to the entire spectrum of current jobs, both at sea and on land as well.

4 CONCLUSIONS

Constant observation of technological progress, especially in marine applications, is needed. Marine universities should constantly analyse and update their didactic offer and teaching programs, adapting them to technological progress along with the changing international standards. Close and active cooperation between marine universities associated under the International Association of Maritime University (IAMU) is needed. Close cooperation between IMO (MSC/HTW) and IAMU is needed. A continuous revision of the STCW Convention is needed … and the publication of a new versions of it every 10 years, as previously promised. The Convention could contain only the main framework, and other documents, updated on an ongoing basis, would contain detailed requirements and explanations.

The key takeaways that must be taken into account in the present and future work:

- A balanced approach is needed, blending new technology education with traditional maritime skills;
- The education sector must be proactive, working closely with industry to stay current;
- Preparing the workforce for hybrid roles is essential for the future of the maritime industry;
- Overview of current certification standards (e.g., STCW);
- Anticipated changes in certification requirements due to emerging technologies and practices;
- The role of continuous professional development and lifelong learning.

A what is most important just now - I the Author opinion we should urgently start working on a new convention on training future autonomous ship operators by analogy to International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) - **International Convention on Standards of Training, Certification and Watchkeeping for Operators of Maritime Autonomous Surface Vessels (STCW-MASS)** [Weintrit, 2023, 2024a]. We don't have time for pointless discussions. We need to set didactic goals and implement them urgently.

If the automated unmanned ships come to reality, the market will comprise of both manned and unmanned ships. Depending on the ship, the revenue and operating expenses will be different as well as the freight rates. Even if the freight rates remain the same, the owner of the unmanned ship will be in an advantageous position as their operating profit would be much higher in comparison to the same freight on a standard ship. Such situation will open new avenues and the market will be completely renovated.

The future skills requirements are the following:

- technological advancements (e.g., automation, digitalization) and their impact on skill requirements;
- soft skills (e.g., communication, teamwork, problem-solving) that are increasingly important;
- environmental awareness and sustainability practices;
- opportunities for innovation in maritime education and training (e.g., simulation training, remote control training, online learning).

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