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THE PROSPECTIVE POSTURE OF MARITIME EDUCATION IN SUPPORT OF SMART SHIPPING

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Abstract Maritime education covers the main seafarer's education, but after emerging of a new profession in the maritime sector it has started to cover some other aspects of the industry such as port management, fleet management, shipyard management, etc. Additionally, the exponential development of technology enforced education planners to review and revise their programs frequently to meet the expectation of new technological and management structures. Realizing this situation, academicians in the maritime field should understand the new posture of the maritime industry and define their role and missions in the light of the new requirements of the maritime sector.

This research aims to investigate the new role and the missions of maritime education institutes considering developments in science and technology in the next decade. In the first step, it is important to understand technological development affecting the maritime sector and imagine the future structure and requirements of the sector. Based on the results of this study a comprehensive study must be done to define what must be done in the education system to respond to new requirements. This research must be exhaustive and detailed. The problem areas are clearly defined and summarized as findings at the end of this step. These requirements must be adopted with academic programs. Adaptation of these corrective proposals to existing academic programs should be discussed considering how these new proposals are associated with the existing programs and/or matched with other related programs

This study will assist the academicians and researchers who work on the development of the maritime education and training system using the results of this study.

Key Words: Maritime Education and Training in Digital Era, Exponential Technologic Development, Smart Shipping and Ports, Automation, Robotics Application in Maritime Sector .

1. INTRODUCTION

Digitalization is becoming widespread rapidly in the maritime sector as in all other sectors. Smart systems are replacing classical systems not only in the technical field, but also in the operational field and, education and training methods. The development of communication facilities and IT capabilities, the commercialization of space technologies, the development of human-IT interfaces, and the development of robotic technologies have brought the definition of Smart Shipping to the glossaries.

The area of interest of maritime industry today to transform smart technologies may be resumed as:

- Cheap and uninterrupted online communication with the use of satellite communications;
- Large-scale information transfer via broadband communications;
- Using Artificial Intelligence in operations planning and risk management;
- High Computing Power in support of ship management especially in the ship and port cargo operations.

While these developments occur, new risks emerge in the maritime sector, which is a multi-risk business; Cyber Security (IT Intensive) Digital Inattention (Habit) Traditional Ability Loss, Redundancy, Autonomous Domination (Artificial Intelligence), Superiority in Technological Countries (Strategic IT), Marine Loss (Robotics).

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1.1. *Smart Shipping*

The shipping term covers all aspects of the maritime from ships to shipyards, marinas, yachts, tourism, suppliers, etc. But two key elements are the backbone of the industry which are ships and ports always are interacting.

As far as concerning smart shipping, the following subjects are under discussion in many platforms of the shipping industry:

- the new perspective of shipping operations;
- digital transformation and opportunities to support regulatory compliance;
- the future operating system of trade;
- digital shipping and trade finance convergence: easy transfer and transaction commercial, financial and official documents;
- contract management in a digital era of shipping;
- digital transformation in the management of marine assets;
- integrating ship and port operations through digitization and active collaboration;
- new perspectives on the shore-based work-force;
- new roles and duties for seafarers ;
- designing the jobs of the future, defining new professions which industry requires.

1.2. Automation

The main feature of automated systems and robotics is based on the remote control which is a combination of sensors and actuators. The combination of sensors and actuators creates a digital nervous system. Leonhard [1] explains this system with a figure below (Figure 1) [3]. Location data using GPS (Global Positioning System) sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure change.

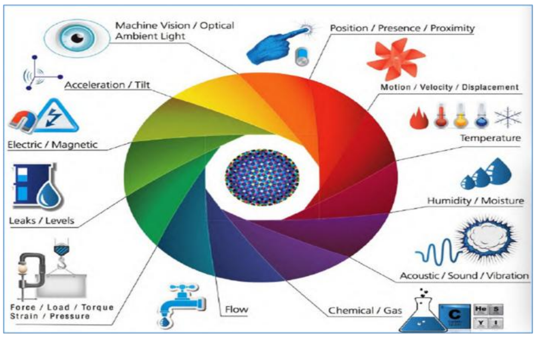

Figure 1 Sensors and actuators [3]

1.2. *1.3. Autonomous Ship*

Autonomous (unmanned) vehicles are extensively used in air space which has had more freedom of movement compared with land and sea. But the use of autonomous vehicles also started at road traffic as well as sea transportation. The use of unmanned sea vehicles for survey vessels and military purposes in constricted areas has already been started in the 1960s. Now researchers are looking for unmanned huge oceangoing vessels for maritime transportation.

The marine community, both research, and industry are working on increasing the ratio of unmanned systems, including full-size vessels, in operation at sea. The level of control differs on those platforms, from remote operation beyond the line of sight to almost full autonomy on the prototype, However, the exploitation of this kind of vessel at all control levels, requires solving several issues regarding the safety of equipment, potential cargo, and other sea users [1].

The development from Manned ship to Autonomous Ship is simply explained in Figure 2 which is introduced by MUNIN [3].

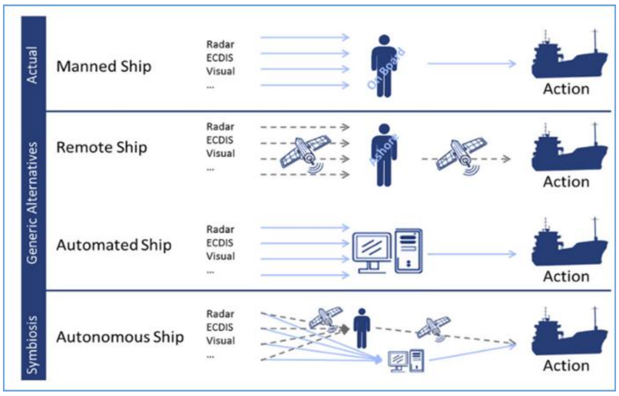

Figure 2 From Manned to Autonomous Ship [3]

3. METHOD

Maritime education was covered mainly seafarers' education, but after emerging of new professions in the maritime sector it has started to cover some other aspects of the industry such as port management, fleet management, shipyard management, etc. Additionally, the exponential development of technology enforced education planners to review and revise their programs frequently to meet the expectation of new technological and management structures. Realizing this situation, academicians in the maritime field should understand the new posture of the maritime industry and define their role and missions in the light of the new requirements of the maritime sector.

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This research aims to investigate the new role and the missions of maritime education institutes considering developments in science and technology in the next decade.

In the first step, it is important to understand technological development affecting the maritime sector and imagine the future structure and requirements of the sector. Based on the results of this study a comprehensive study must be done to define what must be done in the education system to respond to new requirements. This research must be exhaustive and detailed. The problem areas are clearly defined and summarized as findings at the end of this step. These requirements must be adopted to existing academic programs.

Adaptation of these corrective proposals to existing academic programs should be discussed considering how these new proposals are associated with the existing programs and/or matched with other related programs

This study will assist the academicians and researchers who work on the development of the maritime education and training system using the results of this study [4].

3. RESEARCH AND DISCUSSION

3.1. Role and importance of education

Education and learning is an important part of all aspects of our life. Challenging economic, technological, and socio-cultural development increased the importance of education and learning. Enhanced delivery methods facilitate to reach education sources even from distance places, Lifelong Learning applications assisted the professionals to update their knowledge, skills, and competencies to enable them to follow rapid changes in technology.

Mainly the vision of education is adding value to world cultural heritage and economy for the prosperity of the human being. The mission of education is to provide covers a large spectrum; preparing qualified people for all job sectors, assisting the development of the individuals to be ornamented with values of modern society, having a modern culture in a continuously improving learning environment, enabling them to conduct research and produce innovation to get maximum advantage from the rapid development of technology.

In the light of this vision and mission, the expectation of the society from education may be defined in the following paragraphs:

- Development of the education and learning methods and content to provide qualified human resources to fulfil the requirement for existing and developing professions necessary to create sustainable social, cultural, and economic life on both national and international scale,

- Achievement scientific research in support of continuously developing technology to provide better opportunities to get the maximum benefit from all available sources,

- Creating a suitable environment for innovation to provide scientific data which requires producing knowledge for all communities of the world to provide a better living condition for humankind.

The role of education, in particular for higher education is to prepare the people not to meet today's requirements but also for the requirement of foreseen future of the world. The content of the education program was changing in the decades but now we need education systems that are flexible, open the modification, and continuously observe the technologic developments.

The technological developments caused new formations in the education institutes. The specification of these formations may be summarised in the following headlines.

- University networks for innovation in particular in Technology and Engineering fields
- Digitally supported cross-campus and cross-disciplinary teaching activities
- Transcending traditional engineering education with an entrepreneurial mind-set
- Cooperation between education institutes and public and private sector and citizens
- Using International cooperation between education institutes to create a 'great muscle' to facilitate data flow and transfer of best practices
- Creation of inclusive alliance of entrepreneurial, change-focused education institutes

Universities are the most important and fertile places for research. To follow developments in the other part of the world, a network to connect the universities and research centres is required to accelerate the technologic development as well as coping the industrial requirements and research objectives of the universities.

3.2. Technologic development

Futurist Gerd Leonhard [3] explains "disruptive technology" which has a significant impact on the five essential elements of digitalization as follows:

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- Automation of knowledge work
- Advance Robotics
- Autonomous vehicles
- The internet of Things
- Mobile internet

It is clear that all the above-mentioned elements are directly related to the maritime industry, and all are applicable on board and change the ship operations at sea and port. Leonhard also summarizes the main characteristics of the digital era has as; change is gradually then suddenly, exponential, combinatorial, and interdependent.

All these characteristics of the digital era enforce us to take speedy action to catch the benefits of the digital era and do not miss its advantages. More importantly, the growth of technology and its impacts are not linear but exponential in the era we live in. The disruption between linear and exponential growth is identical and this requires us to take immediate action in all areas of our life (Figure 3)[4]. The systems onboard, at shipyards and ports are quickly changing and this trend will continue.

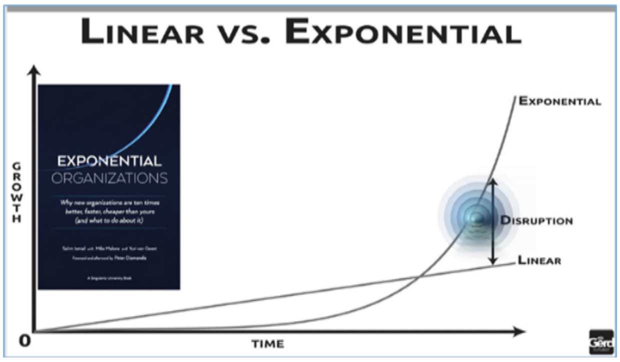

Figure 3 Linear versus Exponential [4]

Salim Ismail [4] has estimated "Likely Breakthrough Technologies" in their famous book, Exponential Organization:
- Sensors and Internet of Things (IoT)
- Artificial Intelligence (AI), Data Science & Analytics:
- Virtual & Augmented Reality
- Bitcoin and Blockchain- Neuro-Feedback

Ismail has also introduced Likely Meta-Trends as:

- Perfect Knowledge:
- Neuro-Feedback, and satellite systems
- Virtual
- Virtual Worlds
- 3D Printing
- Exponential Payment Systems:
- Autonomous Vehicles

The idea of a futurist is important for suggesting the future. Futurist Alwin Toffler has introduced our internet in the 1970s when the United States has only a "Bridge System" which provides low-speed connection only between some users and is available during working hours. He has also made the description of High Technology in his famous book 'Third Wave'. If we make "second-guessing- using the other's opinion for the future, we can imagine requirements for the near future. These are commonly agreed on the posture of the future.
- Spread of use of Internet of Things (IoT)
- Broad use of Artificial Intelligence (AI)
- Interaction through Blockchain in trade
- Simulators and laboratories equipped with virtual systems
- Broad use of satellite-based communication and observation systems
- Use of more capable automated systems and robots assisted with AI
- High speed and a large amount of data transfer
- Automated vehicles

The education system should consider all these improvements and take revise its programs to overcome requirements for future systems. The reflection of these developments will enforce us to review and revise our existing education system, such as:
- Data mining to get sufficient and suitable data from huge information sources
- Use of AI for search and innovation not for basic sciences but also social sciences
- Understanding automation theory including its capabilities and limits
- Use of virtual world in education in particular simulators and laboratories
- Use of improved command-control-communication systems to handle automated vehicles
- Application 3-D printing and nanotechnologies to facilitate material development.
- Development of modular/easily revisable academic programs to follow exponential technologic advancement

3.3. Maritime Industry in transformation

This rapid change will also cause continuous and rapid changes in the overall education system. The following Figure 5 shows close relations between education and technological improvements. The important steps start from the internet to robotics have already been outreached. There is a continuation between the technologic developments which each one triggers the other and speed up the improvement Technologic developments and application of these developments in our life are interlinked. As it has been seen in Figure 4, 3-D Printing, Renewable Energy, IoT,

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and Nanotechnology directly affect the emergence of qualified and more capable Autonomous vehicles.

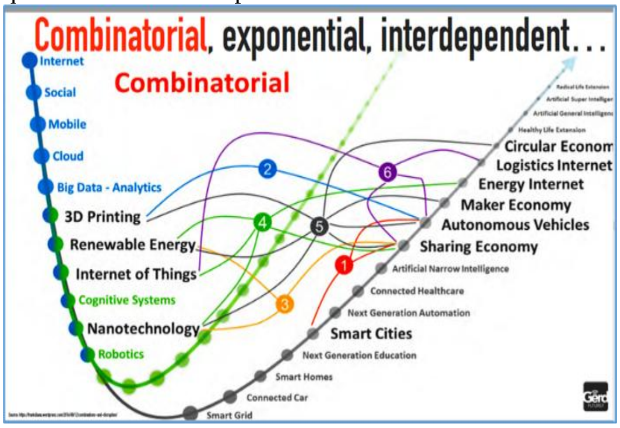

Figure 4 Technologic improvements and their effect on our life [1]

The maritime industry is in close relations with technology needs to consider this development continuously and rapidly. Technological improvements do not affect only manufacturers but also system users/operators. For that reason, the individuals responsible to operate these systems should understand the basic philosophy, capacity, and limitations of the new technologies to refrain from any causalities during operations.

3.4. Seafarer Training

Traditional seafarer training has always focused on the acquisition and use of practical skills. The prevailing view is that, while this approach addresses a degree of cognitive skills, it focuses on and gives much more emphasis to the acquisition of hands-on practical skills for the performance of specific tasks. On the other hand, academic education has been seen to be much more focused on the development of in-depth analytical and critical thinking skills; cognitive skills that are less reliant on hands-on task-oriented training, but stress critical reading and discussion. The global trend in maritime education and training is increasingly to link an essentially vocational education that provides specific and restricted competence outcomes with more general or deeper academic components leading to an academic qualification [5]. Considering technological developments and their reflection on maritime business, it is clear that the new generation of marine professionals requires deeper academic knowledge to understand the operation of state of art systems they handle.

Most of the maritime professions are multi-disciplinary professions and composed of such as mechanical engineering, industrial engineering, electric/electronics engineering, business management, management science. In the beginning, mariners started with foundation science to conduct navigation and cargo works using mathematics and geometry, physics, and chemistry. After application of the steam-powered systems mechanical and electronics engineering are included in their background a new profession namely marine engineering has emerged. After the emergence of radar, wireless, automated pilots, electronic navigation equipment electronics gained importance and were included in programs. The wide use of computers lies behind the inclusion of computer science and automation in limited content.

Being an international business International maritime Organization (IMO) regulates maritime education and training by STCW (Standards for Training, Certification and Watchkeeping Standards) Code [5]. STCW is first published in 1978, changes were made in 1995 and 2010, and a forthcoming change is likely will be made soon to cover new requirements as a result of technological changes.

One of the major problems in education is late adaptation and transfer of newly developed industry into education institutes. Manuel [6] explains his solutions to this subject for the maritime industry. “It allows for easier migration of seafarer experience and talent to other parts of the maritime industry. At the national level, it has significantly enhanced the exposure and reputation of MET (Maritime Education and Training) and seafaring as a career option as it aligns more with the main expression of higher education in many jurisdictions. Furthermore, with the enhanced role of technology in the world, such education allows for the industry as a whole to have more versatile professionals in place for future changes in ship operation.

To correct these misconceptions, the experts at CrewConnect Global [7] agree that better education is the key to showing what seafarers’ lives can be after their time at sea. Education can give them a goal to aspire to and in return, their aspirations will have an impact on what skills they want to nurture to be ready for the future. Mentoring, training courses, and work placements are all opportunities where seafarers can have a taste of a potential career in maritime.

To deliver up-dated information to the people will be use of Continuous Professional Development (CPD) Courses. Considering the condition of the workers in the maritime sector, in particular, working onboard the best method will be the use of distance learning with electronic resources.

According to Makashima [8], the criteria used in the evaluation of electronic resources, required for distance education are:

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– Ease of access to resources.
– Affordable cost of network materials.
– Ability to assist users and training of users.
– Stability of network resources.
– The possibility of obtaining long-term access to network resources.
– Facility of license agreements.
– Delays in access to materials due to congestion.
– Determination of the degree of reliability of the seller and the possibilities of further co-operation with them.
– The degree of potential use (based on numbers of users and frequency of access to materials);
– Easy computer interface for users, etc.

Seafarers, in particular, seafaring officers are key personnel in the maritime sector, they can be deployed not only as workers on board but also in the following professional areas having a perfect background in the maritime business.

- Auditors/inspectors
- Marine Surveyors (Port State Control, Classification Societies, Insurance Companies, Draft and Cargo Surveying, Average adjustors,
- Lecturers/Instructors in Maritime Education Institutes
- Logistics Expert (Planning, Routing, Cargo Operation, Warehouse Management)
- Port Management/Operation (Stevedoring, Lashing, Cargo Handling Systems)
- Coast Guard Officer
- Quality and OHS (Occupational Health and Safety) Managers
- Engineers at Ship Yards (Repair and Maintenance Planning, Ship Liaison Officer)
- Sea Trail, Test and Acceptance Officer
- Management, Technical and Commercial Branches of Shipping Companies
- Adviser/Consultants in their field
- Business at Harbour Master offices

Seafaring officers having an opportunity to be deployed to other professions in the maritime sector, should be educated not as ship operators but also in managerial roles. As far as concerning cargo operation the ports and ships are integrated and the level of success of this integration will provide a great economic value. Inclusion of port management subjects into Maritime Transportation Management (Deck Officer) programs and inclusion of shipyard management and ship construction subjects into Marine Engineering programs is considered beneficial.

3.5. Change of Business Methods and Competencies in the Digital Era

Following significant changes in technology, business methods in the high technology-dependent sectors have been drastically changed starting from the last two decades of the 20th century. The main factors which cause this change are as follows, Development of communication facilities, Increased IT capabilities and Interfaces, Development of Robotic Technologies, Reflection of Space technology in the classical industry.

The following Figure 5 helps us to understand the technological developments in the last 40 years and expectations for the near future.

1980	1990	2000	2010	2020	2025 - 2030
Personal Computers Electronic based Automation in many sectors Cellular Phones	**Growing up us of internet Wide spread of Automation Unmanned vehicles and Drones**	**Enhancement of capable robots in the industry Born of the internet supported Social Media Nano Technology Speedy and cheap internet**	**Emerging IT platforms for education, business and trade etc. Data Mining and Artificial Intelligence Advance Satellite Communication Robotics Genomics**	**Quantum Technologies Big Data Internet of Things Blockchain applications Advanced Robotics Genomics for animal and agriculture Nano Technology applications**	**Introduction of Metrology, Sensing, Computing in different fields of life Easy access of Big Data and Advance Artificial Intelligent applications Improved Internet of Things application for automation and robotics Developed Blockchain application in the trade and industry Intelligent Robots and drones Genomics for medical science Growing Nano Technology application for space and oceans Advance Integrated Communications systems Smart vessels and production lines**

Figure 5Technologic developments in the last 40 years and expectations for the near future

This figure is based on the opinion of different futurists and any argument on this figure is acceptable. This table aims to reverberate the past improvements in technology and following consequences of achievements to create a possible posture in the next decade. Finally, it is intended to proposals based on the possible developments to respond to future requirements. Not only the business methods but changed but also some new jobs have appeared as some jobs disappear or change their formation to meet new requirements. During this transition new jobs in particular at shore facilities raised.

If we look at common characteristics of digitalization, these are availability of huge data; data mining to use huge data banks; artificial intelligence to

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facilitate decision making; a high level of automation; high speed online data transfer.

These applications the expectations of the business from the human being at work. Most of the researchers have described the most important human competencies needed soon are as follows:

• Leadership
• Expressing himself well
• Processing large amounts of data from various human-machine interfaces
• Focus on critical issues rather than details.
• Working with teams in remote locations
• Understand automation and its limitations
• Manage change
• Continuous learning
• Coping with increased stress
• Ability to communicate effectively

The seafaring officers should be prepared as a high technology system user, able to work in a group(s), bear to increased stress, capable to communicate in different levels of people from different nations as well as a leader. All these expected competencies should be considered when arranging MET.

3.6. Automation and avoiding accidents related to automation failure

The application of automated systems has facilitated the management and operating functions of transportation systems. They have reduced the workload of the users and provided better control of the management and operation activities as well as simplifying record keeping and establishing more sensitive and automatic fault warning alarm and control units. But not having a common sense which is only a human being, still, these highly improved systems are reliable. As a result, automation systems must always be under the supervision of the human element to ensure safe and reliable operations. Any failure on automated systems navigation and/or command control systems may cause serious accidents even the total loss of a ship as well as ships and port facilities.

Although these systems are products of high technology, unfortunately, operators are not equipped with sufficient information on the working principles and specifications. This weakness will reduce their reaction capability to avoid any mishaps in case of failure in the autonomous system.

Application of automation technology is emanating in all parts of shipping, and rapid change of technology brings new automation applications and develops existing automated systems. This improvement also reflected operation procedures and processes as well as training methods. It is time to revise our training systems to meet the new requirements introduced by automated systems.

These systems require employees to be donated with engineering skills to fully understand the automation philosophy, the limitation of automated systems, and the role of the human being to supervise these systems. An employee equipped with sufficient engineering skills would be more suitable to operate these state-of-art systems. Additionally, it is needed to revise our existing education and training programs to cover new technologies, especially automation-related subjects. Not now but shortly, we will see the deployment of robots in the shipping sector, and our education and training system is to be revised to cover robotics applications.

The main aim of the SURPASS, a European Union Leonardo Project [9] is to fill this gap created as the result of the emergence and application of the automated systems in the education and training of seafarers by the provision of a training course enabling them to have a full understanding of automated systems, and these systems' weaknesses and limitations.

The research has shown that the older generations who received their education and training two or three decades ago are less familiar with the new technology than the younger generations who have become familiar with computer systems in their everyday life. But even for the younger generations, it is important to provide an education that introduces the subject of automation, operation, and management of automated systems used onboard ships and, the use of safety-critical systems [10].

We get benefits from the CPD (Continuous Professional Development) methods to introduce new developments in the industry and provide new technology applications to the people at work. CPD covers a large spectrum of delivery methods that may fit people working in different environments and different types of works.

3.7. Developed Management Systems

Developing information and communication technologies provided distance-controlled management information systems for the maritime industry enabling online transactions between the ships and management offices at the shore.

Figure 6 shows an example of a developed management system incorporating four parties of shipping; ship, shipping company, manufacturer, and

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overseas repair and shore storage facility. The control and alarm system of the ship generates ship records which include information about main and auxiliary engine activities. Manufacturer generates stock control and maintenance information and, overseas repair and shore storage facility generates stock control and repair/maintenance information.

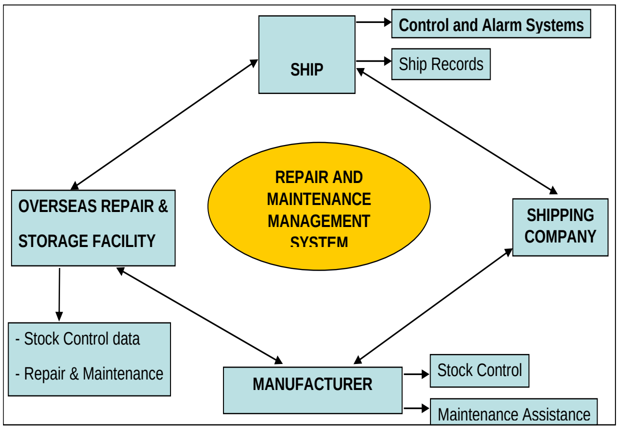

Figure 6 Initial (proposed) Model for Shipping Company

IoT (*Internet of Things*) application is embedded in the system to provide direct communication between systems that need no human interaction. All management systems are interfaced with by computerized communications. The ship and shipping company management system is integrated with manufacturer and overseas repair and shore store facility to provide connection promptly, and they can communicate and interact with each other through the interfaced ICT system.

It is clear that the workforce onboard, at shipping companies, ports and shipyards should have sufficient background on the IT systems to fully understand and sufficiently use the technical equipment under their responsibility.

3.8. Robotics and Automation and Autonomous Vessels

- *Robotics*

By and large, the study of the mechanics and control of manipulators is not a new science, merely a collection of topics taken from “classical” fields. Mechanical engineering contributes methodologies for the study of machines in static and dynamic situations. Mathematics supplies tools for describing spatial motions and other attributes of manipulators. Control theory provides tools for designing and evaluating algorithms to realize desired motions or force applications. Electrical engineering techniques are brought to bear in the design of sensors and interfaces for industrial robots, and computer science contributes a basic for programming these devices to perform the desired task [11]

- *Automation*

Automation means “the technique of making an apparatus, a process, or a system operate automatically.” ISA [12] definition for automation is "the creation and application of technology to monitor and control the production and delivery of products and services.”

Automation is used in monitoring and controlling the production and delivery of products and services. More common areas using automation are manufacturing, defence, safety and security services, modes of transportation, energy production, and transfers, Operation management. Automation is also a tool for integration, interfacing, and interoperation of the different but compatible systems.

- *Autonomous Vehicles*

An autonomous vehicle is a tool that can operate itself perform necessary functions without any human intervention and have the ability to sense its operating environment.

An autonomous vehicle utilizes a fully automated driving system to allow the vehicle to respond to external conditions that a human driver would manage. There are six different levels of automation and, as the levels increase, the extent of the driverless car’s independence regarding operation control increases [13]. By MASS (Maritime Autonomous Surface Ships) UK Code of Practice, these levels are Manned, Operated, Directed, Delegated, Monitored, and Autonomous [14].

Developing technology will provide monitoring and control functions of ships both onboard and from the shore using speedy and reliable communication facilities as well as advanced decision support systems.

This description implies two generic alternatives that are combined in an autonomous ship (see also Figure 1) [2]:

- The remote ship where the tasks of operating the ship are performed via a remote control mechanism e.g., by a shore-based human operator and

- The automated ship where advanced decision support systems onboard undertake all the operational decisions independently without the intervention of a human operator.

The main reason for most accidents at sea and ports is because of the automation failure which subsequence may cause total loss or fatal damages. The user of the

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robotic systems and automated systems requires sufficient knowledge to fully understand the main system philosophy, ability, and limitation of automated systems as well as robotics theory.

3.9. Autonomous Ships

There are many discussions on the suitability, reliability, and acceptability of autonomous ships as well as some discrepancies on insurance and legal issues. Another issue, which seems to be crucial for the safety of unmanned vessels operation, is a robust and reliable self-diagnosis system on the unmanned vessel to provide the operator with performance quality indicators and an alarm regarding any malfunctions, loss of input data, and unforeseen behavior of specific devices or unexpected changes in positioning, speed, heading and attitude measurements systems data [15].

Ships are the largest vehicles and any failure in the propulsion, communication, command control or cargo handling systems may cause serious, even fatal accidents. The application of automation onboard propulsion and steering systems is now expanding. And any automation failure may cause unacceptable accidents with damage to human life, the environment, the ship(s), port facilities, and the goods being transported.

Automated systems facilitate ship management functions and are comparably more effective than manual systems, but they do not have the decision-making capability. What this means is that automation systems must be controlled by the human element at all times. These systems are products of high technology and users should be aware of their working principles, specifications, and limitations of them to be able to avoid any accidents in case of failure in such systems [16].

An ITF Study showed that 80 percent of seafarers voiced their anxiety about possible job losses with the advent of automation. This view shows that automation is very likely to face opposition from seafarers and their unions who believe if introduced in a manner that focuses primarily on the rush to be first and cost-cutting for the sake of cost-cutting that it will affect livelihood and safety if changes are not communicated properly [17].

The autonomous ship is a reality, and they are navigating in non-confined waters. There are many studies to solve major problems involving safety and legal issues, doubling with operator control, monitoring, and supervision of autonomous ships. Considering the lack of “common sense” of the autonomous system the community still has some negative concerns. Until solving these problems, we may assume that we will need some monitor and supervision crew to secure autonomous ship operation. To this end, we should educate our cadets on robotics and automation to prepare them for future unmanned autonomous ship operations.

3.10. Smart Ports

The use of up-to-date technology is an essential part of the management and running of a port/terminal efficiently. A wide variety of technology applications available are available to support port and terminal management. Nowadays products and IT systems are continuously upgrading to optimize cost and operational effectiveness.

The role of the management information systems (MIS), its quality and content are improving as well as IT expenditure of ports. The coverage of IT technology is now empowering providing integrity, interface and interoperability thorough different elements serve different purposes. The role of Information Technology in ports varies to cover all aspects of functions.

- Management of the Business
- Administrative system support
- Financial Systems
- Human Resource Systems
- Sales and Marketing
- Material management
- Argo Operation management
- Warehouse management
- Overall cargo planning and running
- Safety and Security Control
- Serving and supporting vendors
- Resource management
- Enterprise planning
- Knowledge support centre.

To command and control, such a huge IT system following issues should be determined.

- Information Requirement and Information Exchange matrixes
- Architecture design study to define IT infrastructure (core-intermediate-final)
- The level of the technology requires (not best, not minimum but optimum)
- Cost and efficiency assessment
- Vendors for software and hardware considering support of an open-end system.

Park et al [18] made a comparative study on ‘*Port Management Information System towards Privatization*’. This research covers the following information systems: PORT-MIS of Busan port, DAKOSY of Hamburg, PACE (Port Automated Cargo Environment) of London, PORTNET of Singapore, HIT of Hong Kong (Hong Kong International Terminals). The PORT-MIS of

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Busan before 2004 was a typical information system among many state-run ports. The researchers have also taken into account a previous study made by Partridge et al [19] which shortly explains PSA (Port of Singapore Authority)'s success factors.

- A business-cantered system should be developed.
- IT system has to be compatible with its business.
- Infrastructure is required to be flexible and expandable.
- Creativity and reformation are critical factors.

By applying PSA success factors to BPA (Busan Port Authority) information system, Park et al [18] propose the following reconstruction directions:

- As BPA's management goal is to be a hub port in Northeast Asia, its information system should correspond to the management goal.
- To be a hub port in Northeast Asia, BPA must improve customer services. To this end,
- It is to build up a community information system and e-business information system. Instead of VAN (value-added network) -based EDI (*Electronic Data Interchange*) system, Internet-based network infrastructure should be established.
- To pursue creativity and reformation in the IT sector, CIO (Chief Information Officer) system should be organized directly under the CEO.
- To enhance software function and to build a business-oriented system, a combination of outsourcing and in-house development is desirable.
- For long-term system development, the following three-stage plan is recommendable:

(1) 1st stage: stabilization stage- The stage to mirror PORT-MIS to stabilize overall business of BPA

(2) 2nd stage: cooperation stage - Introduction of a cargo inventory system just like PACE of PLA and PORTNET of PSA

(3) 3rd stage: e-business stage

- Introduction of PSA's customer-oriented e-commerce system and portal system

- Customer-centred tailored services and specialized services toward each individual & group.

Korea Logistics Network Corp. published an introductory report on "Port Management Information System in Korea" [20]. Integrated Data Network for Port network is comprised of two parts:

- PORT-MIS (Port Management Information System)
- EDI Network for Logistics (Electronic Data Interchange)

Port Management Paradigm (*Past and Future Port*) is also explained to highlight the future requirements and expectations in this report. Figure 7 extracted this report explains 'Port Management Paradigm (Past and Future Port)'. The characteristic of future ports is defined as High value-added activities, Integrated Logistics center, Hub Port, Transhipment Cargo handling, Business profit-oriented, Aiming service quality. Advanced information and automation, high productivity will support the transformation to the future (Figure 7)[20].

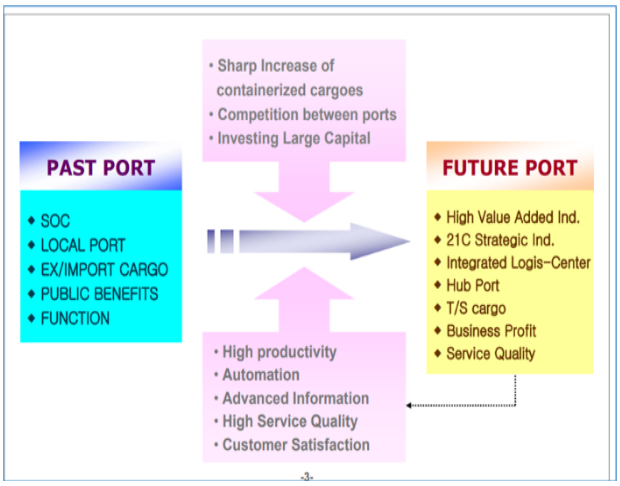

Figure 7 Port Management Paradigm (Past and Future Port) [20]

In the same report, there is a figure that shows the relations between 'Requirements of Terminal' and Features of ATOMS (Advanced Terminal Operation & Management System)' which connects all the ports in Korea. The ATOMS consists of three elements to meet requirements: Planning, Operation, and Management system (Figure 8)[20].

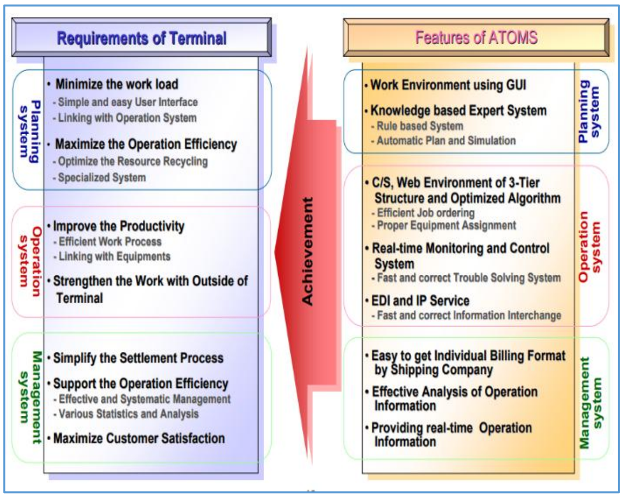

Figure 8 Port Management Requirement and Features [20])

In the light of the above-mentioned facts following are proposed.

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- All the ports require an MIS connected with other respective authorities/parties to handle their planning, operation, and management system effectively. This system should be open-end which permits modification on a required basis.
- All ports should establish their own MIS, Hardware, and Software support systems. MIS of ports in a country should be connected in some cases as well as contiguous ports in the neighboring countries.
- The management level should be eligible to understand IT applications. In particular content of IT Courses delivered to Maritime and Port Management programs should be revised and enhanced to ensure that the students fully understand IT applications.
- The cargo handling equipment used in the ports are now huge electrical, hydraulic, and mechanical systems supported with electronic and IT systems. The port management programs should be supported with basic engineering science courses to enable understanding the fundamentals of engineering.

3.11. Quantum Technologies

European Commission [21] has published a Strategy document on Digital Single Market, namely 'Quantum Technology Flagship Program Final Report'. In this document, it has been stated that "Supporting research and innovation in advanced computing is key to the development of the computing systems of tomorrow, which will go beyond the limitations of today's technology in terms of speed, reliability, and efficiency".

The QT Flagship program should be structured in five domains, each of which should be reflected in a call for proposals. Four vertical domains (not necessarily of the same size in terms of allocated resources) address vital application areas of a future knowledge-driven industry (Figure (9)[21].

- Communication, to guarantee secure data transmission and long-term security for the information society by using quantum resources for communication protocols.
- Computation, to solve problems beyond the reach of current or conceivable classical processors by using programmable quantum machines.
- Simulation, to understand and solve important problems, e.g., chemical processes, the development of new materials, as well as fundamental physical theories, by mapping them onto controlled quantum systems in an analogue or digital way.
- Sensing and Metrology, to achieve unprecedented sensitivity, accuracy, and resolution in measurement and diagnostics, by coherently manipulating quantum objects.

This gives us a clear understanding of the main features of education and training for the future. Communication, Computation, Simulation, Sensing, and Metrology will be included in the programs related to engineering and management professions to enable students to understand and apply quantum technologies. And the importance of basic science will always continue.

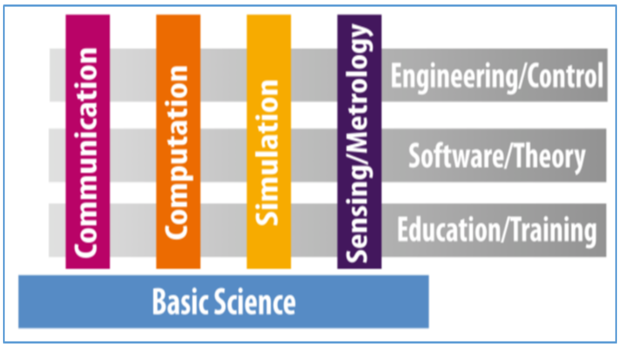

Figure 9 Structure of the Strategic Research Agenda [21]

Related to the area of interest and modus operandi of each profession, the following subjects should be added,

- Engineering and Control: If the profession is covering design, control, construction, and use of new technologies to make the transition

- Software and Theory: If the profession is related to developing quantum algorithms, protocols, and applications, and connecting to tools for control.

- Education and Training: If the profession is embracing training programs for the new generation of skilled technicians, engineers, scientists, and application developers in Quantum Technology, as well as to enable senior managers to understand QT and their benefits.

We should always address Education and Training to prepare the maritime community to understand QT which is the raising concept of the near future.

4. CONCLUSION

The role of education, in particular for higher education is to prepare the people not to meet today's requirements but also for the requirement of foreseen future of the world. The content of the education program was changing in the decades but now we need education systems that are flexible, open the modification, and continuously observe the technologic developments.

Universities are the most important and fertile places for research. To follow developments in the other part of the world, a network to connect the universities and research centers is required to accelerate the technologic development as well as coping the industrial requirements and research objectives of the universities.

The disruption between linear and exponential growth is identical and this requires taking immediate action in all areas of our life The systems onboard, at shipyards and ports are quickly changing and this trend will continue.

The education system should consider all these improvements and take revise its programs to overcome requirements for future systems. The reflection of these developments will enforce us to review and revise our existing education system for the development of modular/easily revisable academic programs, such as Data mining, use of AI, innovation, virtual laboratories &simulators, 3-D printing, and nanotechnologies.

The maritime industry is in close relations with technology needs to consider this development continuously and rapidly. Technological improvements do not affect only manufacturers but also system users/operators. For that reason, the individuals responsible to operate these systems should understand the basic philosophy, capacity, and limitations of the new technologies to refrain from any causalities during operations.

Seafaring officers having an opportunity to be deployed to other professions in the maritime sector, should be educated not as a ship operator but also in managerial roles. As far as concerning cargo operation the ports and ships are integrated and the level of success of this integration will provide a great economic value. Inclusion of port management subjects into Maritime Transportation Management programs and inclusion of shipyard management and ship construction subjects into Marine Engineering programs is considered beneficial. The seafaring officers should be prepared as a high technology system user, able to work in a group(s), bear to increased stress, capable to communicate in different levels of people from different nations as well as a leader. All these expected competencies should be considered when arranging MET.

The research has shown that the older generations who received their education and training two or three decades ago are less familiar with the new technology than the younger generations who have become familiar with computer systems in their everyday life. But even for the younger generations, it is important to provide an education that introduces the subject of automation, operation, and management of automated systems used onboard ships and, the use of safety-critical systems.

We get benefits from the CPD (Continuous Professional Development) methods to introduce new developments in the industry and provide new technology applications to the people at work. CPD covers a large spectrum of delivery methods that may fit people working in different environments and different types of works.

It is clear that the workforce onboard, at shipping companies, ports and shipyards should have sufficient background on the IT systems to fully understand and sufficiently use the technical equipment under their responsibility.

The main reason for most accidents at sea and ports is because of the automation failure which subsequence may cause total loss or fatal damages. The user of the robotic systems and automated systems requires sufficient knowledge to fully understand the main system philosophy, ability, and limitation of automated systems as well as robotics theory.

The autonomous ship is a reality, and they are navigating in non-confined waters. There are many studies to solve major problems involving safety and legal issues, doubling with operator control, monitoring, and supervision of autonomous ships. Considering the lack of "common sense" of the autonomous system the community still has some negative concerns. Until solving these problems, we may assume that we will need some monitor and supervision crew to secure autonomous ship operation. To this end, we should educate our cadets on robotics and automation to prepare them for future unmanned autonomous ship operations.

All the ports require an MIS connected with other respective authorities/parties to handle their planning, operation, and management system effectively. This system should be open-end which permits modification on a required basis. The management level should be eligible to understand IT applications. In particular content of IT Courses delivered to Maritime and Port Management programs should be revised and enhanced to ensure that the students fully understand IT applications.

The cargo handling equipment used in the ports is now huge electrical, hydraulic, and mechanical systems supported with electronic and IT systems. The port management programs should be supported with basic engineering science courses to enable understanding the fundamentals of engineering. This gives us a clear understanding of the main features of education and training for the future. Communication, Computation, Simulation, Sensing, and Metrology will be included in the programs related to engineering and management professions to enable students to understand and apply quantum technologies. And the importance of basic science will always continue.

Related to the area of interest and modus operandi of each profession, the following subjects should be added; Engineering & Control and Software and Theory.

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