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A critical evaluation of potential outcomes of using modern artificial intelligence and big data analysis technology in maritime industry

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A critical evaluation of potential outcomes of using modern Artificial Intelligence and Big Data analysis technology in Maritime Industry

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): **..**

(Date): **...**

Supervised by: **George Theocharidis**

Supervisor's affiliation**.......**

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Abstract

Title of Dissertation: A critical evaluation of potential outcomes of using modern Artificial Intelligence and Big Data analysis technology in Maritime Industry
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The dissertation is a study about the potential and impact of Artificial Intelligence, Big Data and Machine Learning on lives of seafarers and the future of jobs on partially and fully autonomous vessels. The new technology, while very efficient, brings a lot of complexities and the current crews are having a tough time adapting such fast changes in short amounts of time.

A deep dive is taken into the current technological developments in shipping industry and concepts that have been researched and tested to understand the potential of current technology and the bottlenecks those tests revealed before moving forward. A brief look is taken at industries that are heavinly robotized and automated. This was done to evaluate the impact of such developments and relate those shifts to the its potential influence inshipping industry and lives of seafarers at sea.

From the analysis it's been revealed that the shipping industry, while highly modernized, it has not been using the highest of the tech that is available in industries like automotive or manufacturing. It has been concluded that since the technology is more efficient in repetitive or pattern oriented tasks, there will be a big shift on how the seafarers work since many tasts carried on board will be transferred to computers, but the need for seafarers will not vanish and there will always be a need for a crew on board for safety and maintenance reasons.

The final chapters give a brief look at the analysis and the rationale behind the conclusion which is then used to create recommendations for three main industry members IMO, Shipping Companies and Seafarers.

KEYWORDS : Machine Learning, Autonomous, Artificial Intelligence, Big Data Analysis, Internet of Things

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List of Abbreviations

3D	Three Dimensional
AC	Alternating Current
ACTUV	Anti-submarine warfare Continuous Trail Unmanned Vessel
AI	Artificial Intelligence
BDA	Big Data Analysis
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPU	Central Processing Unit
DARPA	Defense Advanced Research Projects Agency
DC	Direct Current
DP	Synamic Positioning
ECU	Engine Control Unit
FinFET	Fin Field-effect Transistor
GPU	Graphics Processing Unit
H2S	Hydrogen Sulfide
HIPAP	High Precision Acoustic Positioning System
I/O	Input/Output
IBM	International Business Machines
IMO	International Maritime Organization
IOT	Internet of Things
IT	Information technology
JD	Job Description
MARPOL	Marine Pollution, The International Convention for the Prevention of Pollution from Ships
MASS	Marine Autonomous Surface Ships
MCU	Microcontroller Unit
ML	Machine Learning
MuNIN	Maritime Unmanned Navigation through Intelligence in Networks
OEM	Original Equipment Manufacturer

OS	Operating System
P&I	Protection and indemnity (Insurance)
PC	Personal Computer
PSU	Power Supply Unit
SATCOM	Satellite Communication
SCC	Shore Control Center
SOLAS	International Convention for the Safety of Life at Sea
STCW	The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TEU	Twenty-foot equivalent
TV	Television
USA	United States of America
USD	United States Dollar
VR	Virtual Reality
VTS	Vessel Traffic System

Introduction 1

Data and AI 1.1

Data capturing and its analysis has always been an important part of maritime industry since the early ages (Osekowska, Johnson, & Carlsson, 2017) . The captain's log and engine log book are an example for that, the data captured in these logs are carefully reviewed in order to understand what has gone wrong and initiated an accident. Nowadays the shipbuilding industry has become more technology-heavy and the competition in this field-initiated adoption of automatic control systems on ships where various data is collected, analyzed and processed to create more efficient ships, optimized workflow and environment friendly engines(Min, 2008).

The trend of use of technological tools in data analysis is nothing new, according to Solnik (Solnik, 2013) IT departments use AI to predict and solve the problems before they even occur and according to Min (Min, 2008) , there are already developments made in creating artificial intelligence based predictive data analysis software for ships that will help reduce the hard work of engineers and help the companies and seamen enjoy safer seas and more reliable machineries.

In this growing technology trend, one can observe that there is a trend that is getting more and more popular and that is making the tech more intelligent. In example, Google created AlphaGo that won the GO world champion (Lee, Shin, & Realff, 2018), and what is more impressive is that this AI taught itself how to play though comprehensive procedure of machine learning, basically, learning by experience (Silver et al, 2016). This was a milestone in AI development, because before, computers were taught (coded) to be efficient and using its abilities to do things fast, but now, Google taught it to learn (Silver et al., 2016), and it learned faster than humans could teach and did faster than players can ever do.

Although, it seems like artificial intelligence is a great idea there are a lot of concerns and questions being asked, especially related to the loss of jobs. Automation in the operation of ships has reduced the number of officers needed for safe maintenance and sailing of the ship (Min, 2008). According to Frey and Osborne (Frey & Osborne, 2017a), in research that they have conducted by using 702 detailed occupations, they estimated that 47% of jobs in the USA are under high risk of being replaced by robots and AI in the next decade.

But this concern is nothing new to the industries. For example, the growth of trade and the progress of businesses created a demand that led to the first Industrial Revolution (Landes, 1969). The great discoveries like the use of steam engines, fossil fuels, coal and oil in harvesting energy met this demand for the need for faster manufacturing and modern ships are the results of this industrial milestone. These innovations have changed the role of the workers from makers, to "energy managers" or as we call them today, drivers, pilots, operators and many more depending on the type of machine that is being controlled.

Industrial revolution 1.2

While economic, environmental and safety benefits of AI combined with Machine Learning cannot be denied, the concerns about the loss of jobs should not be taken lightly either. Therefore, this study will assess how artificial intelligence shapes the future of the Shipping Industry.

In order to look and predict the development of our future, it's wise to look at the past since the present is the future of the past and development of your present from the past might give clues and patterns that can help connect the features of that development to the development that Artificial intelligence bring on the table. During the Neolithic agricultural revolution, the human muscle was the most popular energy in order to get things done and archaeological findings show that there were bone tools, grinding tools, pounding tools, polished celts used to enhance the productivity of human during that age (Perlès, 2001). Productivity increase meant fewer hours for the same job and more hours for something next in the line or, an expansion of work to keep everyone busy and getting more positive outcomes than before.

The Industrial Revolution was another big change in the way labor was distributed, while many physically intensive and time-consuming jobs got cut, the need for more intelligence and creativity demanding jobs were created (Landes, 1969). In those ages scale of economies changed drastically and businesses started expanding, and this expansion compensated and sometimes surpassed the number of jobs that were cut, the only problem was that different skills were required for them and this was solved by specialization.

1.3 Machine vs. Human

In the modern era, where Artificial Intelligence threatens to take away the number of jobs (Frey & Osborne, 2017), looking at the past it's observed that there always was a compensation for this problem and mostly it was due to the expansion of the industry which helped keep the jobs while changing the required skillset. Therefore, it is very important to predict the new potential jobs and prepare the industry for it by looking at the common features of the jobs lost and created and it can be achieved by closely observing the last 10 years of industries where AI and machine learning has drastically changed the workflow and labor demand (Frey & Osborne, 2017).

Research of Lee et al. (Lee et al., 2018) gives a very important view on the way Artificial Intelligence and Machine Learning process information, modify it's work patterns and perform an action based on those modifications in it's one and only goal of reaching the utmost perfection. This information tied with the research of Frey and Osborne (Frey & Osborne, 2017) is very important, since understanding the interaction of Artificial Intelligence without everyday tasks and its way of development is very important to understand the real capabilities of it and predict how it's advantages can be better-utilized Shipping and Maritime Industry as a whole.

It's no secret that the seaborne transportation industry is one of the most important industries that shape the economy of the world (Hoffmann & Sirimanne, 2017). However, there are a lot of concerns over its impact on environments such as pollution and very high fuel consumption (Doulgeris, Korakianitis, Pilidis, & Tsoudis, 2012) and according to the study that has been carried out by IMO (Buhaug et al., 2009), shipping industry is accountable for the 2.7% of all CO2 emissions globally. Due to the rise in the price of fuel (García-Martos, Rodríguez, & Sánchez, 2013) the shipping companies find different solutions in reducing the costs and this race of cost-saving is helping to reduce these cost savings greatly since efficiency is the solution most giant companies are opting for. Yan, Wang, Yuan, Jiang, and Negenborn (Yan, Wang, Yuan, Jiang, & Negenborn, 2018)) look into the ways the shipping industry addresses environmental and efficiency issues by the use of big data analysis and machine learning in reaching optimal speed and therefore consuming less energy.

According to Yan et al (Yan et al., 2018) the big data's biggest difference from the traditional one is "characterized by its large scale, fast evolution, and high diversity, making it rather hard to analyze" and it's advantages come with a disadvantage that there is a need for a very specialized design which consists of 4 main functional layers which are "data acquisition layer, computing layer, optimization layer, and decision-making layer". The data captured from engines, wind sensors, wave radio signals and many different sensor and calculation devices go through this cycle of data analysis and the platform, after it's analysis, sends data back to the control units to modify the speed and direction of the vessel and this system, working non-stop during the voyage, helps to reduce the emissions by using less fuel for the same distance travelled and therefore being more environment and cost-friendly(Yan et al., 2018).

1.4 Objectives, Expected Results, and Research Questions

1.4.1 Objectives

The objective of this research is to find the potential outcomes of Artificial Intelligence and Big Data analysis methods in the ships ranging from a positive impact on the environment, safety, efficiency and concerns about loss of jobs. The goals that have been set to achieve this objective are as follows:

- To analyze the capabilities and outcomes of Artificial Intelligence and Machine Learning in industries where they are being implemented and find common features that can be related to the seafarers
- To describe the challenges that the above-stated changes will put on the industry and use it to create solutions and recommendations to prepare for this change.

With above goals achieved, this research will provide information about the use of Artificial Intelligence, it's potential to improve the efficiency and environmental problems, provide insight about the potential changes that it will bring and provide solutions and recommendations for stakeholders in their efforts to stay more up to date and competitive in the market.

1.4.2 Research questions

To meet the goals and fulfill the objectives, several questions are posed:

- What and to what extent will Artificial intelligence impact ships and seafarers?
- What is the potential of modern Artificial Intelligence development and where does it stand in regards to its current use in ships?
- What have been the advantages and disadvantages of Artificial Intelligence in industries that adopted it and how can those be related to seafarers?

- How can the seafarers and shipowners be better prepared for the implementation of Artificial Intelligence and Machine Learning?
- How can AI help the shipowners in reaching the environmental goals while sustaining economic growth?

1.4.3 Scope and Limitation

This study focuses on the current state of Artificial Intelligence and Machine Learning technologies, its current use in Maritime Industry, the potential future uses, the benefits that the technology brings to reach higher standards on safety, a cleaner environment, better economic growth and the concerns that surround the use of this technology to replace human labor. The scope of the research is the use of AI in shipping transportation, the area of Maritime where safety-related issues can result in the biggest environmental disasters since the ship in the ocean doesn't have many options when a safety issue occurs.

The reviewed literature is based on the current state of the AI, Big Data and Machine Learning in the industry and concepts created by respected members of the industry that does not have full implementation as of yet. This study does not include the use of Artificial Intelligence on shipbuilding industry, port logistics, and port management.

1.4.4 Research Methodology

In this research information about Artificial Intelligence, Big Data Analysis and Machine Learning will be gathered from literature review. Literature review includes publications about Artificial Intelligence, it's future and current potential and its impact on other industries, publication about shipbuilding companies with information about the use of AI and ML in reaching higher levels of safety, reliability and environmental cleanliness. Scientific publication about the new achievements of AI will be analyzed to understand the details about its ability to learn, a feature that brings a lot of information to the table that will help better understand how can AI be used in the future.

To better predict the influence of AI and it's potential to take away the jobs, a look on the historical breakthroughs in industries will be observed and analyzed to find a common ground and better understand the threats and benefits.

Moreover, a close look will be focused on the research publications that evaluated the current state of jobs in industries that have been heavily exposed to robotization and automation. This will help understand the commonalities of the affected jobs and compare those to jobs in shipping industry. Since Artificial Intelligence is a very specialized technology, it promises to bring new jobs and change the jobs that industry already has. Therefore, there will also be a look into the jobs that have been created in various industries by the impact of AI and steps taken in those industries to fill in those specializations. After the thorough analysis, there will be recommendations and possible solutions suggested to better prepare the industry and stakeholders for this big inevitable change.

2. Background

2.1 Digitalization

The digital era is upon us and by looking at the achievements of today one can assume that most of the potential uses of digital technology have been achieved, but just a glance through the concepts of the future reassures that it is still just a start, a small step towards the massive changes that humanity will encounter. It has never been a secret that digitalization will change the way we live, interact, work and manage and one can say that with all the dependency from this tech, we are technically cyborgs, although the tech is not physically incorporated into human body, it plays a significan role on how we interact and make decision. To analyze this fascinating area more, a closer look is needed to fully understand what is happening and why is it so important.

2.1.1 Technological revolution in the shipping industry

Humans have started building ships ages ago, even though water is not the natural habitat of humans, the advantages of sailing has always been too great to pass by (Paine, 2014) . Those advantages still hold a big value and high priority in humankind's progression and therefore shipping developed to become a massive industry that serves the needs of the entire planet earth. Throughout history, ships grew stronger and larger, wood, rowing, and sails have been replaced with steel and engines and in last years, digitalization has taken over shipping opening new doors to the ship-owners and business owners all together (Paine, 2014).

The history of shipping can be divided into three separate revolutionary periods. The first revolution has happened during the shift from sail to steam in around the 1800s. The second major changed happened at the beginnings of the 20th century when the shift from steam to diesel took place. Finally, the third revolution took place during the 70s, when ships started to become computerized (Rødseth, Ørnulf Jan, Perera, & Mo, 2016). Since the 70s, computers have come a long way and in modern ships it's an industry standard to have a lot of sensors all around the vessel, touch controllers, screens that project real-time data, satellite control and communication systems and many more highly advanced tech that makes the job of seafarers easier and assist them in maintaining the ship in high quality. The technological advancements are the reason why the ships grew larger but crew numbers did not grow but instead declined.

The 4th shipping revolution is underway and it is being led by Big Data and Machine learning, which can be considered one of the biggest achievements of technology in last decades. Machine Learning has sped up the technological developments so much that one can observe a big difference between generational upgrades of cars, ships, bikes and massive cut of cost in the manufacturing of various gadgets.

2.1.2 Artificial Intelligence

Artificial Intelligence has been defined in many different forms and dimensions but when different definitions are grouped together we can safely draw a conclusion that AI is expected to think and act both humanly and rationally(Russell & Norvig, 2016). Shipping emphasizes more in the rationality of AI as a simulation of human emotions is not really much of an interest in this industry, as a matter of fact, ship-owners would rather eliminate all human-related activities if they had such a financially rational opportunity, but more on that later.

AI is expected to one day help sail the ships with minimal human intervention and handle risky and emergency situations on its own reducing the dependency on human communication and intervention which can very often be followed by distortion, lack of skill and situational awareness.

Perfect AI has always been a conceptual art in minds of the theorists and many have been skeptical about the realistic possibilities of creating an AI that is smart enough to overcome humans significantly in non-repetitive tasks that require high intelligence. Part of the reason was the 1997 chess match between IBM's Deep

Blue and the reigning champion Gary Kasparov where Deep Blue was using brute-force, calculation of all the possible steps and outcomes sometimes with 20 steps ahead and choosing the step that puts the computer in a better position out of all the combinations (Campbell, Hoane Jr, & Hsu, 2002).This can be compared to taking a 4 pin lock and trying all the combinations from 0000 to 9999, in other words, while this landed Deep Blue a historical win over Kasparov, it was not a very smart or efficient way of playing Chess. Deep blue's advantage was the speed at which it could carry on these calculations and revert back with the next step, the speed that humans can never match.

But the recent developments from tech giants like Google brought new hopes to this topic. The thing is that AlphaGo Zero, a program developed by Google DeepMind to independently play the game of Go, uses complicated AI methods to get its way around the top players and land the win. Unlike DeepBlue, AlphaGo doesn't need to calculate all the possible outcomes, it just recognizes patterns and after millions of simulations, it has learned to make a decision based on a scenario without the need to look at billion options. A fascinating thing about AlphaGo is the size of the board and the sheer number of combinations that it would take AlphaGo to play if it was to use Brute-force.

2.1.3 Big Data Analysis (BDA)

Big Data's caught popularity thanks to the heating in race for bunker efficiency (Rødseth et al., 2016). Automotive industry and Formula 1 racing need to get the credit for making it popular. The utilization of such methods has become one of the cornerstones of Formula 1 since being efficient means you can put less fuel in the car, therefore, lowering the weight of the car and making it more competitive. Once marine diesel engines and ships reached massive sizes and economies of scale hit its limits, it was time for a change. Bunker costs can be up to 60-65% of the voyage costs which means being 10% more efficient in that area can bring 6-7% more profit which in a capital intensive industry like shipping it can mean tens of millions of dollars.

Big Data is usually defined as data the amount of which is too big to manage with conventional methods, and therefore, Big Data Analysis methods come into play to find patterns that can help better understand the work of the ship and paired with AI and ML, help in optimization of the ship to get the maximum out of it.
One great example of modern Big Data Analysis can be seen within the popular engine manufacturer Wärtsilä. Wärtsilä engines benefit from a system called Eniram, a big data analysis technology made to help optimize the ship's systems, help optimize the voyage routes, lower the fuel consumption through modeling of shallow water effects, use of sensors, real-time and historical data (Eniram Studies, 2012).

2.1.4 Machine Learning (ML)

The simplest way of describing Machine Learning would be “trial and error”. It’s the way of computers modifying and adapting their actions to become more precise, consistent and in the end perfect through simulation (Marsland, 2014). Machine Learning technology depends on highly consistent and frequent data and which makes the data capture a very important process in achieving good results with it and that’s where Big Data Analysis comes in.

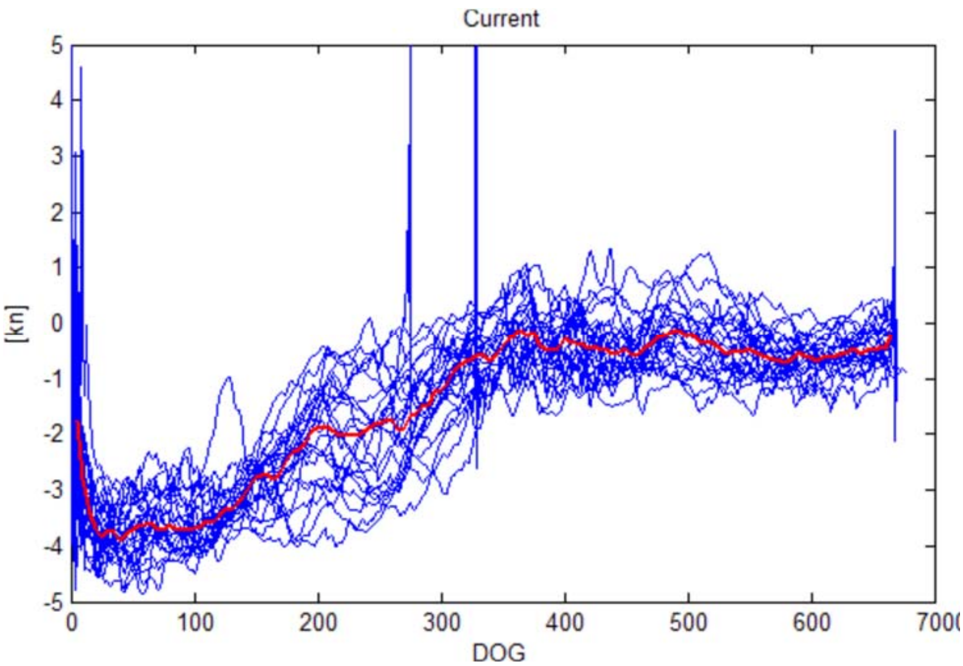

Figure 1. Amount of data captured by a single sensor. Blue line: Sensor data, Redline:Average (Eniram Studies, 2012)

Machine Learning is very special, because everyone can relate to it and it is very close to the child's development arc but unlike humans, computers can simulate a scenario billions of times in a short amount of time and find the ideal way around the problem in a fast and consistent manner. Machine learning is the next big step after big data analysis, it's utilized to combine the analysed data and start acting while optimizing by trial and error(Bishop, 2006). Information from these actions are also documented and stored in database to be analysed again and the cycle repeats until the computer finds a way to readjust its actions to every scenario(Lee et al., 2018). As mentioned before, Eniram, which is a system build upon Big Data Analysis also utilizes Machine Learning to carry out it's vital functions like fuel, voyage and vessel efficiency and helps Wärtsilä to troubleshoot the design flaws that can be used to develop better, more reliable and consistent technology.

2.1.5 Internet of Things (IoT)

A simple way of describing Internet of Things would be human body. Human body has a number of organs, fluids, proteins and, as some might argue, even a soul, that work together to achieve one or more purposes. IoT is defined as a number of "things and objects" that communicated and interact among each other to cohesively and collectively achieve common goals (Atzori, Iera, & Morabito, 2010). Nowadays, you can control all the lights, sound system, TV, security cameras, door locks, garage door, a drone and many more with just your phone and by recognizing your location, when you reach your house the door can unlock and open itself to greet you with your favorite music based on the list that you have played before and light configuration that the system recognized you using every time you get home, it can tell you the news about your favorite topics and even order your favorite food without you talking a single minute at the phone.

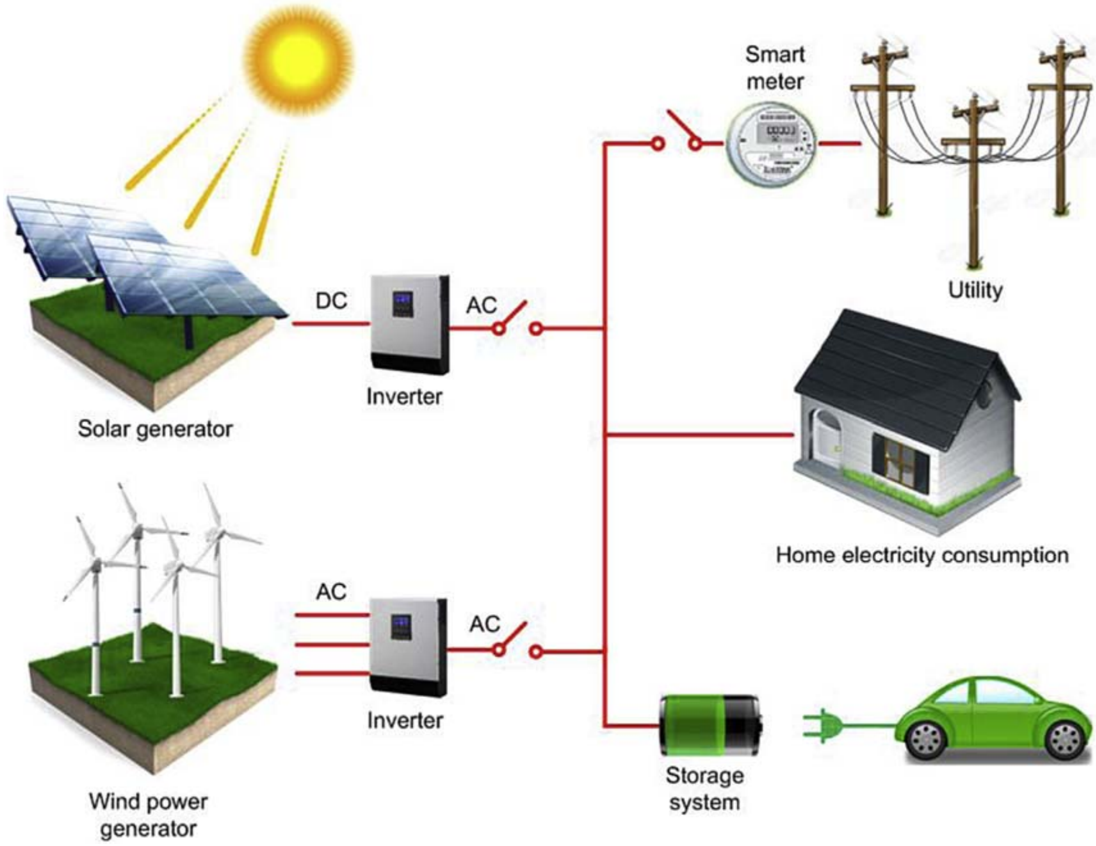

Figure 2 Internet of Things network in smart homes (Stojkoska & Trivodaliev, 2017)

Internet of Things has been a dream of all the industries for a long time but it was a luxurious technology and its boundaries were usually set in manufacturing factories, smart skyscraper buildings and military services due to the capital intensive nature of developing such platforms and limitations that the mainstream internet connection was able to provide at the time. The way it got popularized among the “regular population” is nothing short of genius. As the silicon of Central Processing Units (CPU) were reaching its limits, the Silicon Valley giants started to emphasize on convenience of the platforms they were providing, something that has become very popular after the major success of Apple Inc. (Johnson, Li, Phan, Singer, & Trinh, 2012).

IoT is something that all engine and ship equipment manufacturers are working on to achieve (Gilchrist, 2016). This can be seen on concepts built by the marine engine manufacturing giants like Rolls-Royce and Wärtsilä. The idea is to improve safety through equipment that can interact and share data among each other with AI processing the information and making decisions and at the same time Big Data Analysis tools analyzing data and Machine learning techniques being used to further optimize the state and condition of the equipment to make timely maintenance and increase fuel efficiency therefore reducing environmental footprint (Perera, 2017). IoT can be especially helpful in canals where all the ships pass the information from the center console to the port database therefore updating the information about the depth and condition in all the parts of the passage and receive information about other ships sailing in the perimeter to analyze and make computational prediction of scenarios and give advice on the course that needs to be taken to avoid collision way ahead of time.

2.2 Impact of Digital Era on Shipping Industry

2.2.1 Industry

Shipping industry has come a long way in both technical and economic aspects. Giant companies like Maersk, Evergreen, MSC are taking big steps towards improving the industry and financing researches that will benefit both them and the industry, by giving them an edge over the competition and by improving the safety, environmental footprint and economic aspects of shipping overall.
Companies nowadays utilize advanced risk hedging strategies to safeguard their finances and reduce their exposure to the risks, management software that lets them manage and measure the efficiency of their business with greater precision and applications that let them provide door-to-door, just-in-time services with higher customer satisfaction.

2.1.2 Ships

Modern ships have become a state of the art and the intense competition has pushed the companies to become more creative and responsive to the market needs and standards. Engineering and craftsmanship put into the development of modern ships perfectly represents the state of shipping and limits that companies are willing to challenge in their race for better, more efficient and green shipping practices.

Ship-owners utilize the concept called “Digital twin” whereas a ship is created with its digital twin on special software whereas the information gathered from the sensors of the vessels are fed to the software which calculates the possible degradation on the parts, therefore, letting the ship-owners know which parts of the equipment must be replaced before the dismantling and inspecting the machinery(Liu, Meyendorf, & Mrad, 2018) .

It’s common these days to see innovative projects like methanol powered ship by Stena, a ship designed to consume only methanol making it much more environmentally friendly(Stojcevski, 2014). Such projects require large amounts of financial and technical support to research, develop and build such unique technology. Apart from the financial side of this matter, it requires a bold and value-oriented company to take such a responsible step towards a better future.

2.2.3. Safety

Safety has always been a concern in shipping industry and there is a famous word among the seamen saying “regulations in shipping are written in blood' (Hetherington, Flin, & Mearns, 2006). This implies the fact that most regulations have happened after disastrous events like the Sinking of the Titanic, Torrey Canyon oil spill which resulted with the creation of SOLAS and MARPOL, 2 of the four pillar of shipping that change it forever(Curtis, 1984).

Modern vessels are equipped with satellite technology which works in parallel with vessel traffic service (VTS) that is able to help the crew with navigation and reduce the number of accidents, and if utilized responsibly, able to stop the majority of collisions(Osekowska et al., 2017).

Modern ships have all types of sensors all around the vessel to ensure the safety of the crew. Those include and not restricted to sensors that gather information about temperature, smoke, vapor, oxygen levels, Hydrogen Sulfide Sensor (H2S Sensor), CO and CO2 sensor, bilge water sensor and many more. These sensors send information to the centralized vessel monitoring system and ship own database, where the software analyzes the information and based on pre-written algorithms, is able to identify patterns that can lead to an accident, therefore, warning the crew before such an event takes place (Eniram Studies, 2012).

2.2.4. Crew

Traditionally, seafaring has included a variety of positions and ranks that vary from engineers to navigators where the duties are divided between the individuals of each profession and has been well documented by IMO's STCW convention to split the responsibilities among the crew (STCW, 2011). Modern vessels are very sophisticated and therefore depending on a ship details, a minimal crew is assigned for every ship that is built and ship operators must meet that requirement before sailing international waters (Jacks & Pendakur, 2008).

Nowadays the crew onboard are subject to rigorous training and certification procedures to ensure that they are competent to sail and work on board of a ship sailing in international waters. Such training are held to refresh the memory of the crew on safety equipment and emergency procedures onboard.

2.2.5. Longer Job Descriptions

Digitalization brought a lot of improvements to ships and the industry in general. Shipping has never been safer nor environmentally friendlier than it is now but with such improvements, it also brought a lot of challenges especially with the adaptation of the industry members to these new changes. The past generation of seamen is having a hard time getting used to the new technology that is being utilized in ships and are in need of proper training to be able to work with such technology(Kandemir & Celik, 2017). An engineer can't maintain the equipment if he doesn't know how it operates and while the engines physically have not changed much, the software of the engines have gotten more complicated and the amount of buttons in the control panel has been going up ever since the introduction of software-based engine controlling through Monitoring and Control Unit (MCU) and Engine Control Unit (ECU)(Mollenhauer, Tschöke, & Johnson, 2010). Engine rooms and bridges of modern ships have screens, buttons and touch devices all over the place(Molland, 2011).

Apart from the current seamen, the citizens of countries where computers are not as accessible were having a hard time producing crew that is competent enough to handle such technologically advanced machinery and therefore there is a big misbalance of the crew nationalities where one can see that most management requiring highly paying jobs like Captains and Chief Engineers are from 1st world countries while the working crew are from more underdeveloped countries.

The Job description of even the lowest rank workers have gotten longer and being a seaman today requires more skill to fulfil while paying the same as it was years ago and such high pace of development has made many seamen unable to compete for positions in advanced ships even if they had an amazing track record in older vessels.

2.2.6. Dreams of autonomous ship

With recent advancements in the technology world, high bunker prices and heating race for cost-cutting came the new hope for the giant companies – autonomous ships(Burmeister, Bruhn, Rødseth, & Porathe, 2014). Having an autonomous vessel brings a lot of advantages and on top of all is the benefit of cutting costs by reducing or totally removing the crew(DNV, 2017). Apart from that, theoreticaly removing the crew of the vessel and monitoring it distantly removes the safety issues caused by crew fatigue therefore also lowering risks of a collision caused by miscommunication and lack of responsibility putting everything in the hands of the technology that theoretically can better plan its movement with higher precision.

While there are several concepts of autonomous vessels, made for different purposes, there are still limitations in achieving fully autonomous ships(Burmeister et al., 2014). The main issue is obviously the fact that having a theoretically calculated perfection does not always translate as good to the practical world where external forces can jeopardize all the operations causing all kinds of mayhem.

2.2.7. Dangers of Digital Shipping

Technology has changed the way we interact and live our lives, but it never has been perfect. Too much technology is a problem, it creates dependency and when it's not there, our efficiency drops considerably. Apart from that, digitalization brought many other potential threats like loss of jobs and cyberterrorism.

As technology grew bigger and stronger, many repetitive tasks became obsolete as they were replaced by computers or robots, therefore, reducing the amount of labor needed for such tasks(Meike, 2013) . Manufacturing sites started to use robotized equipment that was able to work 24 hours and unlike humans had no problems of fatigue which is known to reduce the quality of their work. This meant that the working-class that previously did physical jobs had to find something else, therefore, creating heated arguments among politicians, tech giants, and analysts. Many analysts and scientists predict that while many jobs will be lost, it does not mean there won't be new ones(Sorells, 2018). As a matter of fact, according to the study done by Manyika (Manyika, 2011) there actually is a shortage of jobs right now in jobs that require knowledge in technology and especially data analytics and AI. While most these jobs are no on par with the skillset of working class that is used to do physical jobs, but their expertise in that field is actually important to develop the technology better and retraining the personnel with prior experience can actually contribute a lot because there will be some valuable feedback done by those workers. One great example is Stena which has high ambitions in integrating its operations with high technology and employs ex-captains to work with scientists and researchers in their development of such technology.

It’s impossible to ignore June of 2017 when cyberattacks are the topic of discussion(McQuade, 2018). That was the date when one of the most devastating cyberattacks have taken place and caused mayhem in A.P. Moller – Maersk. The malware, NotPetya, was a by-product of an exploit called EternalBlue, which was revealed earlier in April of 2017 which took advantage of a vulnerability in Windows’s Server Message Block and was able to gather valuable data like passwords and spread within the server in a short amount of time infecting everything that it could communicate with. Initially, this attack was not directed towards Maersk but just contact with an infected server was enough to spread it on their servers. This halted Maersk’s operations costing the company over 200 million USD and a lot of angry customers demanding answers (McQuade, 2018).

NotPetya was a wake-up call not for the shipping world, but to the whole world and it had raised a lot of questions and arguments from many government officials calling to reduce the dependency before something disastrous happens.

2.2.8 Impact of digitalization on other industries

Use of Artificial intelligence and Big Data Analysis has spread to all the industries(McAfee, Brynjolfsson, Davenport, Patil, & Barton, 2012). Achievement of efficient data capture and analysis and the results of such achievements in IT and electronics industry has generated a lot of interest with scientists predicting and exploring the potential use of modern techniques in various industries. Medicine, Education, Government, Automotive and many more industries have put a lot of effort to discover new grounds(Kim, Trimi, & Chung, 2014).

In the automotive industry, companies like Google, Uber and car manufacturers like Tesla, Audi, BMW, Mercedes, and Volvo have made a lot of noise in their race for fully autonomous cars achieving great success and putting many doubts to rest(Luckow et al., 2015). Nowadays, the internet is full of news about Tesla or Mercedes cars saving lives in autonomous mode, foreseeing a car crash ahead of time while there is also some news where the failure of proper data from the road has led to accidents. It’s also important to note that Tesla cars put a warning on the dash screen to remind the driver to keep their hands on the steering wheel since the “autonomous” mode is actually marketed as driver assistance, not fully autonomous.

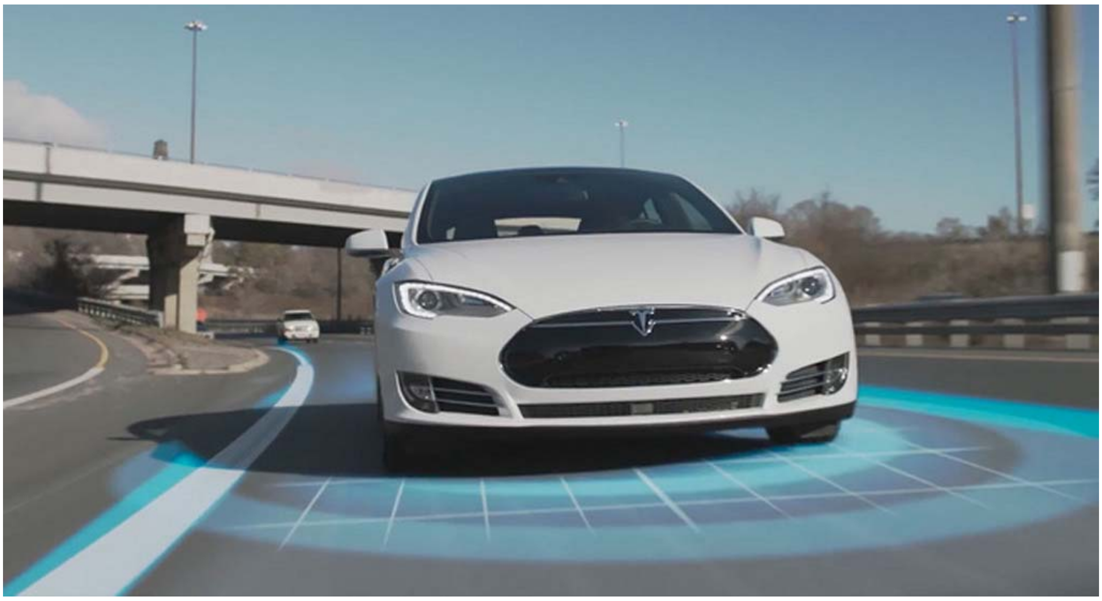

Figure 3 Road legal, Autonomous Tesla Model S. Retrieved from https://www.greencarreports.com/news/1106613_how-safe-is-tesla-autopilot-parsing-the-statistics-as-suggested-by-elon-musk

Big Data is also used in medicine, where using smart algorithms the computer analyzes the data and finds patterns to help cure cancer and other diseases or sicknesses(Obermeyer & Emanuel, 2016) . This is achieved by AI analyzing past data while trying to find similarities or differences that can help identify which tumour on body will react to chemotherapy positively and which will not therefore making the decision making more precise for further actions needed.

Government bodies started to use Big Data to integrate the processes creating a smooth customer experience and a better business atmosphere for mega corporations as well as the small businesses. Implementation of Big Data in customs processes has reduced costs therefore bringing down the fees for the bodies that wish to take advantage of it. Obviously, it has not been a smooth ride, since there is always the threat of cyberterrorism, but success so far has largely outweighed the disadvantages which is the reason why governments integrate this innovation further into their online systems (Kim et al., 2014).

3. Autonomous ships – Future with no crew

While modern equipment on vessels are heavily automatized to do certain tasks, it is still at its infancy compared to the potential ultimate end result that the industry is aiming for. The ultimate goal of Artificial Intelligence combined with full robotization is a machine that is able to do all the necessary tasks without interference of human labour or intelligence. The shipping companies have partnered with Tech giants to boost their efforts in the race for fully autonomous vessels and as a result, the idea of Marine Autonomous Surface Ships (MASS) was born. Research and development of autonomous ships have been rather diverse and different unique concepts of MASS have been developed that are focused on addressing issues like sustainability, technology, reliability or challenges with law, standardization and adaptation to current technology.

3.1 Definition – drawing the line

Understanding the difference between automated and autonomous technology is very important to go deeper towards this topic. Automated equipment, car or computer does still require human intervention in order to make key decisions in it's operation. Unlike automation, autonomous technology is usually an integrated system of automated equipment that work cohesively and does not need an operator or a driver in order to do what it is supposed to do. Initially, automation during the industrial revolution took place in order to reduce physical labour while keeping the workers on managing positions to manage such equipment.

Development of autonomous vehicles and vessels consists of different steps that needs to be addressed of which some of them still require a breakthrough in software and hardware department and therefore scientists and industry leaders drew lines to define the level of autonomy of the equipment which would also make it easier to explain to the normal public. Apart from that, discussions and arguments against full autonomy have been heating up in the automotive industry which saw the interference of law enforcement and insurance companies trying to set standards and rules regarding the tasks that are acceptable to automate and tasks that would require a human monitoring. Defining the levels for autonomy also makes it easier for the insurance companies and P&I clubs to put a price on their services when working with such vessels. Based on these considerations Lloyd's Register provided guidelines regarding the level of autonomy that is ranging from Autonomous Level (AL) 0 to 6:

Table 1. Autonomy levels defined by Lloyd's Register (Lloyd's Register, 2016) .

AL 0) Manual – no autonomous function. All action and decision making is performed manually – i.e. a human controls all actions at the ship level. Note: systems on board may have a level of autonomy, with 'human in/on the loop'; for example, pms and engine control. Straight readouts, for example, gauge readings, wind direction and sea current, are not considered to be decision support.
AL 1) On-ship decision support All actions at the ship level are taken by a human operator, but a decision support tool can present options or otherwise influence the actions chosen, for example DP Capability plots and route planning.
AL 2) On and off-ship decision support All actions at the ship level taken by human operator on board the vessel, but decision support tool can present options or otherwise influence the actions chosen. Data may be provided by systems on or off the ship, for example DP capability plots, OEM configuration recommendations, weather routing.
AL 3) 'Active' human in the loop Decisions and actions at the ship level are performed autonomously with human supervision. High impact decisions are implemented in a way to give human operators the opportunity to intercede and over-ride them. Data may be provided by systems on or off the ship.
AL 4) Human on the loop – operator/supervisory Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way to give human operators the opportunity to intercede and over-ride them.

AL 5) Fully autonomous Unsupervised or rarely supervised operation where decisions are made and actioned by the system, i.e. impact is at the total ship level.
AL 6) Fully autonomous Unsupervised operation where decisions are made and actioned by the system, i.e. impact is at the total ship level.

3.2. Development of Autonomous Ships

There are a lot of reasons why MASS is so attractive to the shipping industry. Since shippings is a commercial business, one of the main reasons is obviously the financial benefits of such technology. Money has always been the driving force behind the biggest revolutions that have changed and shaped the way we live and work including the great Industrial Revolution.

Crew costs can add up to 15% of the total costs that ship operators and owners incur. While it can seem like a small number for an innovation that will require billions to develop, but considering the extensive cost cutting measures that liner companies take to reduce their costs by 1% in order to win over customers, it makes more sense. Another point worth noting is that, while 1% cut from the costs is not a considerable amount in comparison to the all costs, it can be a decisive factor when profit is calculated. An example below is given to demonstrate this:

Profit = Revenue - Costs

If , revenue = 1.000.000, Costs = 900.000 then the profit = 1.000.000-900.000=100.000.

The 1% of Costs is 9.000. So if we reduce the costs by 1% the costs = 891.000 and Profit will be 109.000. So in this scenario while we reduced cost by 1%, we increased the profit margin by 9% (9.000 is 9% of 100.000).

If we apply the 15% here, then the costs will be cut to 765.000 increasing the profit from 100.000 to 235.000 which is a 135% increase and in a multibillion dollar industry like container liners, such a profit can provide an advantage that can endanger the survival of the competition, therefore, no major company wants to be left out of this race that can define the very future.

Another important point that makes the development of MASS so attractive is the statistics regarding the accidents at sea. Studies suggest that up to 96% of accidents at sea have happened because of human error and if there is to be a fully autonomous vessels, human interaction with it will minimize therefore reducing that risk. Apart from that, according to the Vice-president Innovation of Rolls-Royce Marine, Mr Oskar Levander, an unmanned vessel can save up to 15% of fuel that is used to sustain the life of crew at sea (Futurenautic, 2015). Considering that bunker costs can add up to 60-70% of the whole voyage, saving such a large chunk of it will make not only make the ships more efficient, but also greener.

While in commercial side of shipping, autonomous vessels are not something that has not been utilized to a full extent, in maritime sphere it has a two decades of history(Eriksen et al., 2001). The Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV) is a recent example of an unmanned autonomous vessel which was developed by U.S. Defence Advanced Research Projects Agency for military purposes(Littlefield, 2016). It is able to travel thousands of miles for months without a single crew member on board and introduces big advantages to the military especially in decision making since no one's life is on the line when something happens to the vessel(Walan, 2017).

Figure 4. ACTUV "Sea Hunter" prototype developed by DARPA. Source: https://www.darpa.mil/news-events/2018-01-30a

3.3. The race

Recently, projects that focused on autonomy started kicking off and getting a lot of traction with most notable of them being Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) and The ReVolt.

The ReVolt was an initiative made by DNV-GL, a very well respected classification society in maritime industry, and the purpose of the project was to tackle issues like congestion, sustainability and population growth that the EU, and many countries out of the EU are facing today(DnV, 2016). The main idea behind this project is to make short sea shipping sustainable and also cheap by use of battery powered autonomous vessels. Revolt is designed to sail up to 100 nautical miles in a single charge with 100 twenty foot containers (TEU) and by using renewable sources of energy, it can significantly reduce the emissions compared to a diesel powered alternative. Powering ships with battery significantly reduces the amount of moving and cooling parts throughout the vessel cutting a big chunk of cost in building of such vessel and making it driverless means that the space spared for life at sea like accommodation, human sized corridors and messroom is not necessary anymore therefore making that extra space accessible for more cargo storage(DNV, 2017).

Figure 5. Downscaled prototype of The ReVolt autonomous vessel. Retrieved from: https://www.dnvgl.com/maritime/autonomous-remotely-operated-ships/

The Revolt is an important project for a number of reasons and one of the main ones being that it is initiated and funded by a classification society like DNV GL. A classification society is a non-governmental organization that specializes in maintenance of technical standards for ships. The expertise and network of big players like DNV GL carries an utmost importance in the development of such high profile and ambitious innovations.

Another project that caught a lot of attention was Maritime Unmanned Navigation through Intelligence in Networks (MUNIN). It was a 3-year project co-founded by European Commission under the Seventh Framework programme conducted by eight research partners from industry and science communities which are Fraunhofer CML, MARINTEK, Chalmers University, Hochschule Wismar Aptomar, MarineSoft, MARORKA and University College Cork and the idea behind it was to evaluate and verify the feasibility of fully or partially unmanned merchant vessels(Burmeister et al., 2014). It was launched in 2012 and was successfully completed in 2015. The great advantage of this project was the diversity of the partners involved in the project which helped to tackle not only the technical, but also the legal side of autonomous vessels which is one of the grey areas within the industry to this day(Rødseth, Ø J. & Tjora, 2014).
The case study was conducted with a handymax sized 75.000 dead weight tonnes dry bulk carrier that was sailing between South America and Europe which speeds of 16 knots. The ship would only be autonomous while sailing in deep-seas where the risk of collision is at the very low level and an on-board crew took control of the vessel in high traffic areas like canals, ports etc. While the idea was to develop and unmanned vessel, for safety purposes there were maintenance or emergency control teams allocated to and if needed, they would board the vessel by helicopters or shuttle boats and leave after carrying out the necessary jobs(Burmeister et al., 2014).

Looking at the Autonomy Levels suggested by Lloyds list, it’s easy to understand that MuNIN project was not aiming for AL 6, the fully autonomous vessel neither was it aiming for AL 5 but rather it was to be something in between AL 3 and AL 4 or as described in the official site of MuNIN, they saw it as a "symbiosis of Remote Ship and Automated Ship" (MUNIN, 2016), which is demonstrated in the below figure:

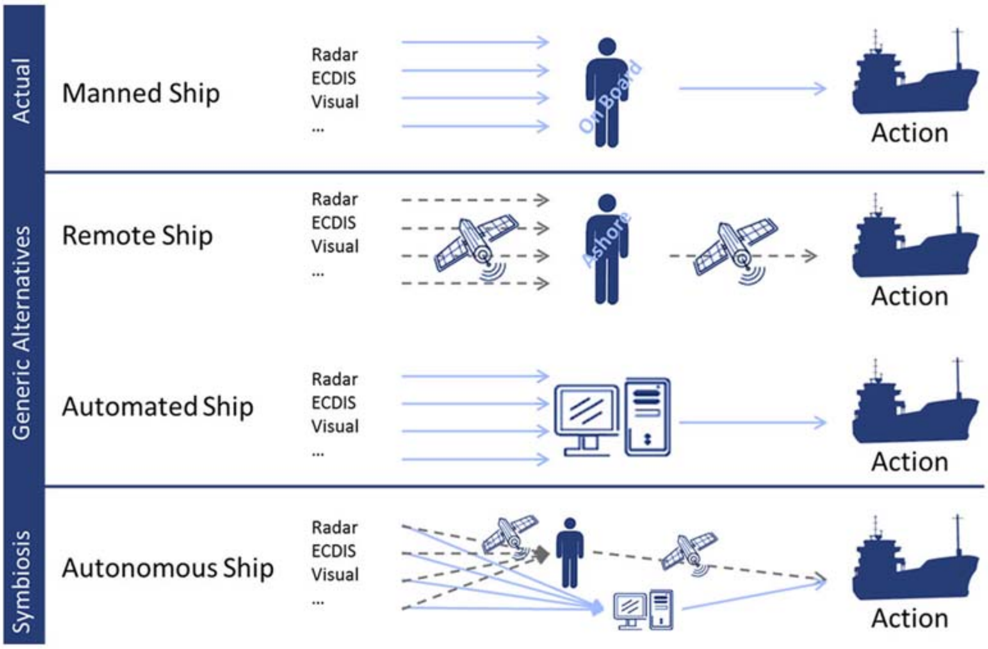

Figure 6. Visual representation of MuNIN's approach to autonomouos ships. Retrieved from: http://www.unmanned-ship.org/munin/about/the-autonomus-ship/

In this project the autonomous sailing at high seas was mostly done by the ships on-board computer systems that have been programmed to do this task to a great extent, but control and monitoring was delegated to an operator from a shore based control room called Shore Control Center (SCC) which can be easily identified in figure below(Rødseth, Ørnulf Jan & Burmeister, 2012). This means that when the ship senses a need for intervention it would do so by communicating with Vessel Tracking System (VTS) or any other ship in the perimeter(MUNIN, 2016).

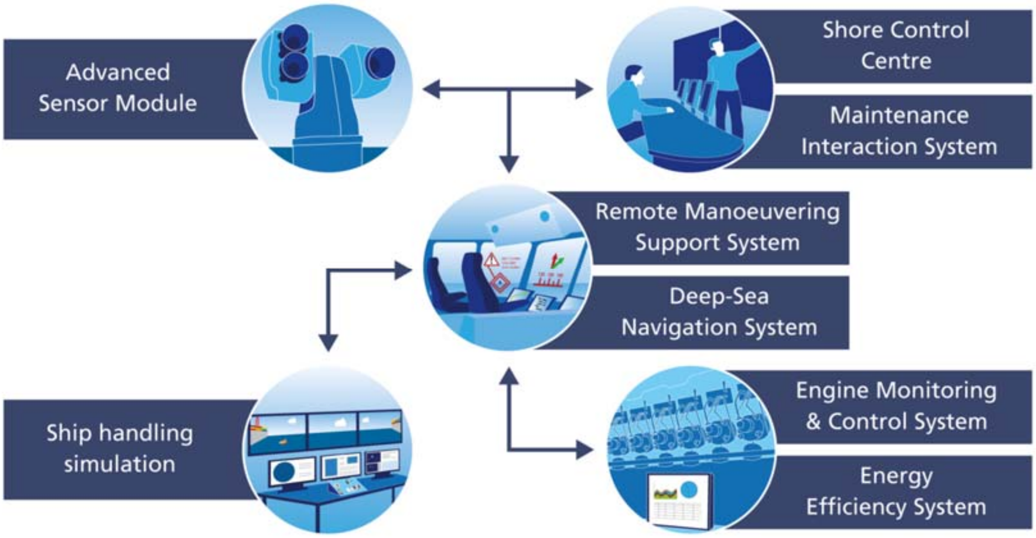

Figure 7. MuNIN Network (MUNIN, 2016)

While MuNIN does not represent the ultimate autonomous vessel of the far future, it does demonstrate that there are a lot of possibilities even with the use of current tech. One of the massive challenges of MuNIN was the availability and high cost of communication bandwidth which made remote control option unviable and brought up the idea of a partially independent ship that would only be controlled when needed therefore minimizing the amount of data needed to transmit.

Table 2. MuNIN defines those concepts as below (MUNIN, 2016)

An Advanced Sensor Module, which takes care of the lookout duties on board the vessel by continuously fusing sensor data from existing navigational systems, like e.g. Radar and AIS, combined with modern daylight and infrared cameras;
An Autonomous Navigation System, which follows a predefined voyage plan, but with a certain degree of freedom to adjust the route in accordance with legislation and good seamanship autonomously, e.g., due to an arising collision situation or significant weather change;
An Autonomous Engine and Monitoring Control system, which enriches ship engine automation systems with certain failure-pre-detection functionalities while keeping the optimal efficiency and which takes care of the additionally installed pump-jet that acts as a certain rudder and propulsion redundancy;
A Shore Control Centre, which continuously monitors and controls the autonomously operated vessel after its being released from its crew by its skilled nautical officers and engineers. It comprises amongst others the certain positions: • A Shore Control Centre Operator, who monitors the ship operation of several autonomous ships at the same time from a desktop cubicle station and controls the vessels by giving high level command like, e.g., updating the voyage plan or the operation envelope of the autonomous system; • A Shore Control Centre Engineer, who assist the operator in case of technical questions and who is in charge of the maintenance plan for the vessels based on a condition-based maintenance system ensuring sufficient reliability of the technical system for the next autonomous journey; • A Shore Control Centre Situation Room Team that can take over direct remote control of one vessel in certain situations via a shore side replica of the unmanned vessels bridge including a Remote Manoeuvring Support System that ensures an appropriate situation awareness in direct control despite the physical distance of crew and vessel.

4. Analysis

4.1. Immature hardware

In the world of IT, hardware are the physical components connected to the whole software operated system. A simple Personal Computer (PC), which can be found in most households can be drawn as an example since it contains the vital elements that can be found in most advanced computers including the vessel's computerized control unit. Almost all computers consist of Input devices, output devices which together are referred to as I/O (Input/Output), a Power Supply Unit (PSU) and the main powerhouse, the central processing unit (CPU). In a PC, Input devices are usually keyboard and mouse which we control and give commands to a computer with, and output devices are the monitor, sound device, printer or any other device that is used to get information from a PC(White & Downs, 2007).

In vessel's computer, the most important input devices are sensors, measurement devices and satellite data used to gather the data from the machinery or satellite equipment of the ship, which is then sent to the main processing unit, saved in storage and visually demonstrated on a monitor, both of which are output devices. In modern offshore vessels an advanced Dynamic Positioning (DP) system is being used to maintain the vessel position with highest precision. Dynamic Positioning is a computerized system that is able to get information from wind , satellite Vessel Tracking System (VTS), motion sensors, High Precision Acoustic Positioning system (HiPAP) and is able to maintain the heading and position of the vessel by using the ship's thrusters, counter reacting to waves and wind by propelling the vessel in the opposite direction therefore balancing the outside forces(Peng, Wang, & Wang, 2015).

Hardware has been the bottleneck of software since the early days of technology. For example, in software realm the algorithms of smart AI and Big Data analysis methods have been visualized and theorized way before the hardware for it was even available, but it should not take away any credit from the fact that the breakthroughs of last 5 centuries have been nothing short of amazing, things envisioned in 80ies to be available in 2050 are available today and the development has been faster than ever. Nowadays, companies compete in achieving perfection even in things like vacuum cleaner. In modern technology market you will find at least four well-known brands that offer a vacuum cleaner robot that is able to learn the area of your house, go around it, spot the dirt and clean it without human interference.

By observing the route technology has taken in its robotization efforts it is easy to recognize the similarity of methods that almost all tech giants are using. It's also evident that in order to fully replace a human labor, a machine must have the following four of the five basic senses: smell, touch, sight and hearing. The fifty sense, tasting, is not a commonly used sense for labor purposes. Apart from those senses, there must be a brain that is able to gather that information and based on the past memory, experience and situational assessment make a decision and perform the action.

To digitalize the sight, modern cameras or Virtual Reality (VR) camera technologies are being used with integrated depth, 3D and motion sensors which, by combining the data and using smart algorithms, allows to create video footage that can be rendered in 3D using all the data from the sensors and used for visual inspection, maintenance or security purposes(Sherman & Craig, 2018). Thermal cameras are also popularly used in engine rooms of highly advanced vessels that helps to diagnose the equipment before manual intervention.

Since modern vessels utilize all of the above, the heavily automatized vessels have made many of the engineer tasks obsolete. An engineer will not need to walk across the engine room checking temperature, pressure, flowmeters or heavy leakages as often since most of it are detected by the sensors and passed to the console in engine room from where the engineers can control pneumatic valves and most of the machinery(Molland, 2011). As long as all the machinery is maintained in good condition with timely replacement of old parts according to the recommendations of the manufacturer, engine room equipment do not fail as often, but since there is no such thing as perfect machinery, emergencies happen and must be tackled as soon as possible.

Considering all of the above it can be observed that the technology has not yet matured to be able to replace the human yet, but it’s ability to suggest corrective actions and self-troubleshoot does mean that the need for number of crew will be reduced to the bare minimum with future seamen becoming more universal and able to do tasks that are way beyond the job description (JD) of a seafarer of today. The reason is that most of the tasks in current JD of seafarers will disappear and ability to fill those obsolete tasks with new ones will mean a more efficient seafarer.

4.2. Software

While hardware does represent the physical capabilities of a computer, the software is where the magic happens. Software is a set of instructions, algorithms and data coded to communicate with the hardware of the computer and tell it what to do. The reason it is called software is because it’s not a rigid system, it lives on the memory of a drive and can be lost if the memory drive fails, therefore big data centers and highly specialized environments it is backed up to multiple drives to avoid such heavy losses(Leach, 2018).

Software can be an operating system (OS) like Windows, MacOS or Android which is acts as a platform of the smartphone or a computer which combines the operation of thousands of auxiliary features which are the secondary software within that operating system that process the data independently and OS allocates a certain amount of computational power to those secondary software to perform their tasks(Leach, 2018). Such software are often called programs. Microsoft Word, Excel, Google Chrome and iTunes are all secondary software that introduce new features for the end user.

The innovations in hardware department like the Satellite Navigation, improved sensors, use of 7 nanometre silicon nodes with FinFET design have caught a lot of attention because of the improvements they brought to the table making many unthinkable things possible, but it was the breakthroughs in software side of things that really caught the attention of the big players(Xie et al., 2015). A great example of this is the success story of Singapore as a transshipment hub, the development of Singapore as a country began with the development of the most sophisticated port system known to shipping industry at the time which enabled trade within the country in return of which the country blossomed. It was the smart software paired with its strategic location that gave Singapore the competitive edge while many other countries in the area were still perfecting what at the time would be called a "standard port system". It proves that an extraordinary thinking, brave steps, open mind and massive paradigm shifts are essential in order to excel in shipping(Chin & Tongzon, 1998).

One of such breakthroughs is the Google's AlphaGo, a software programmed to play a game, but it was the way it played and applied its past experience into game that made it stand out from all the "pre-programmed" AIs. It took an AI to play a simple game to change the mind of the industry about the potential of not just the future, but also the potential of today, something that most critics did not believe in because of the bottleneck in hardware(Chen, 2016).

Although there are a handful of examples that can show the great things achieved by modern software, there still is no software that cannot be broken into or bugged and as long as there is even a slight danger of malfunction, trusting a human life into such a system can end up with fatalities and that is exactly what happened with Boeing 737 MAX(Johnston & Harris, 2019). Those fatal crashes were a wakeup call not only for the aviation industry, but all the industries that develop any type of automation or robotization. If one thing was learned from it, then it's definitely that no automated system that can be fed misinformation should have an ultimate control over the equipment that can lead to fatalities. In usual development of such highly automated systems, the digital twins of the cars, planes or ships are used to simulate the malfunction of small parts, software or the whole system as a whole to have a clearer picture of what can go wrong(Liu et al., 2018).

Another big problem with software is the bugs. The bugs are the flaws in the software that produce incorrect or unexpected outcomes which can lead to hardware malfunctions. Bugs also pave a way to cyberattacks that take advantage of such vulnerabilities in systems and in today's globalized and international shipping market shipping companies have offices around the world therefore having malware spill to one of your international office network systems can further expand and crash the whole network system leaving nothing but dust behind. This was the lesson that Maersk learned the hard way.

4.3. New jobs

MuNIN research showed that the crew can still not be replaced and there will be the need for it for they years coming and according to Manyika (Manyika, 2011),Big data will not only change jobs, which will result in retraining the personnel, but it will also create about 1.5 million jobs in different fields especially in managerial positions. This further proves the point that while some jobs will disappear, new ones will take over. This does not necessarily mean that the job will be on board, it can be a work ashore which requires a deep knowledge of ships and skills that seamen already possess.

Manyika (Manyika, 2011) also claims that currently, the supply of workers for positions of big data analysis in the USA alone is around 300 thousand and the demand sits at around 440-490 thousand which creates a talent gap of 50-60%. Truth is, these positions must be filled and no one can fill them better than the current workers who have excelled in their workplaces. With proper retraining and transition program in place, workers who have done repetitive tasks can be transferred to work where their experience directly influences the productivity of the company. This trend creates an optimistic view for the future of the seamen who are looking for a career switch and work ashore where they can be closer to their families and kids, something that every seaman wishes for.

While most shipping companies are quite conservative towards such shifts, at the end of the day, it will take one brave company to do the first step which will threaten the business model of older, more conservative and less efficient companies which will be forced to follow, just like the Port of Singapore when they introduced digitalization into their systems. With such adjustments it will be a norm to see a data analysis department in every company employing people who are perfecting the business strategy and decision making process within the company by analysing the necessary data.

4.4. Obsolete tasks

According to this study the repetitive tasks and tasks that carried out in patterns are under threat of being replaced by computers(Frey & Osborne, 2017b) . Computers are highly efficient in repeating calculations, combinations and in case of machine learning when programmed well, they are able to recognize patterns and take the necessary action. Combined with AI they are also able to come up with better solutions or find connections between data that has never been thought about before. Such a feat is achieved by integrating the modern Big Data analysis tools into the data centers and development of tailored software for the company needs.

The ReVolt project concluded that there is still a need for improvement in some areas of technology or software development in order to have a fully autonomous vessel operating in international waters(DNV, 2017). This does not mean that maintenance of these ships will still need to be carried out by humans either physically, as it was projected by ReVolt or by controlling on board robots remotely, something that the current technology is able to achieve, but has never been tried before. In order to develop such robots, the ship design will need a drastic change. The ships as we know are designed to accommodate humans therefore having large corridors and accommodation areas, everything in a ship is designed to be within the reach of human hand and such thing won't be a need if the ship is to be redesigned for a remotely operated robot.

4.5. Human element

While theoretically possible, it's highly likely there will at least be a small amount of crew in the ships of the future for safety purposes. Ships carry huge amounts of non-eco-friendly cargo or crude that can massively hurt the ecosystem of the sea in case of an accident. If there is one thing the shipping industry has learned from Torrey Canyon disaster it is that an oil spill has to be avoided at all costs and all the necessary measures must be taken in order to prevent this(Curtis, 1984). The case with Boeing 737 MAX accidents are examples of how bad can things go sometimes and that no machine that poses threat to human life should be fully automated beyond human control. It also taught the aviation industry a great lesson, that personnel must be sufficiently trained to handle such technology, something that was not the case with the training process of Boeing 737 MAX crew.

When the disasters like the crash of Boeing 737 MAX happen, the whole world demands answers and someone or company to put the blame on and in case of a fully autonomous ship, this will be something that is not possible and in the end of the day, it's the classification societies that certified the sailing of such ships and IMO will be held accountable for such disasters therefore it's highly unlikely that such ships will ever be approved by the industry let alone enter international waters. The ReVolt project on the other hand is Acknowledgments concept as the ship does not carry dangerous liquids like bunkers and if it is to be used for the carriage of eco friendly goods, it can get green light and also serve as a testbed for the future of shipping and trial of such technology with more safety.

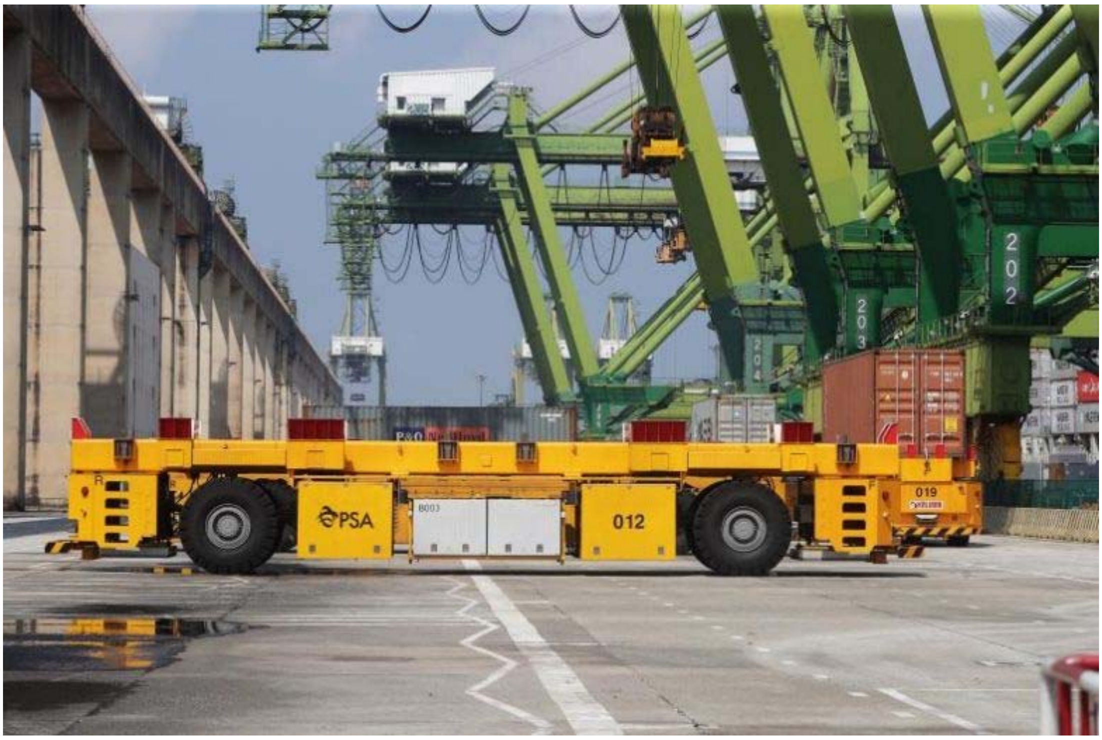

Figure 8. Driverless container carrying vehicle in Pasir Panjang terminal, Port of Singapore. Retrieved from https://www.straitstimes.com/singapore/new-automated-cranes-on-trial-at-pasir-panjang-terminal-in-boost-for-singapores-port-hub

4.6. Training – Competing With The Machines

Retraining of personnel will be a big thing in the future as the technology gets more and more integrated into our workplaces and even the process of training will create a lot of jobs for such positions. This will also be the case with shipping and the crew on board(Troshina & Mantulenko, 2019).

IMO has been very successful with the passing of the conventions like STCW, which ensures that the personnel of vessels are equipped with proper knowledge and tools to take proper action in times of crisis. STCW also covers a lot in technical side of things and regardless of the performance of the crew member, it has a minimum requirement for work on board for each position before they get promoted to a higher rank which ensures that the personnel are properly trained and experienced to take upon the work that they will be carrying on(STCW, 2011).

IMO was quick to respond for the need of training in Dynamic Positioning (DP) adding section B-V/f to STCW convention therefore ensuring that the personnel have gone through standardized training program to become an engineer or master in such vessels(STCW, 2011). DP training includes theoretical understanding of the system as well as on board, hands-on training with professionals on board of a vessel. Such training will be a must for partially autonomous vessels as the on board crew will need to learn not only which button to press, but also why and how those functions interact with each other in order to know what went wrong in time of emergency and take quick action. This was something that Boeing 737 MAX pilot have not learned, they were instructed to do certain actions but did not have a clue as to what those actions do to the plane(Johnston & Harris, 2019).

According to many studies, human age has an opposite relationship with his cognitive abilities, something that reduces the more humans age(Salthouse, 2009). This poses a threat as some of the personnel who have great experience in maintaining or navigating the more traditional, less technologically advanced ships, retraining them will not be as easy as teaching a new cadet all those computer functions of a ship. It’s no secret that older generations are very conservative towards computers and new technology, especially the shipping industry as a whole which can lead to those personnel being left with no job as those more traditional ships go obsolete. One great example of tackling this issue was done by Stena, where they hired extra personnel who would work on the technology side of things while the experience of the ships personnel was used to get the feedback that only such a qualified person can give.

5. Conclusion

The purpose of this dissertation was to analyse the technological advancements, prototypes and development of Big Data Analysis, Machine Learning and Artificial Intelligence from other industries, evaluate the impact of such developments to their respective industries and fields and evaluate their current and future use in maritime and their potential impact on the shipping industry with ship's crew in mind.
Source analysis of the ongoing developments from respectable maritime technology manufacturers and their projections regarding the future of the shipping have been analysed and advantages and potential threats of such developments have been determined. The findings highlight the possible future that is upon the industry, the changes that the crew will need to adapt and steps needed to be taken by the industry leaders and workers in order to ensure a smooth transition with minimal loss of jobs.
The researcher shortlisted his conclusions to three main challenges with recommendations to address those challenges.

5.1. Technological challenges

The conclusion of MuNIN project regarding the lack of maturity in current Big Data, ML and AI technology is still relevant and paired with the shortcomings of SatCom it is very unlikely that we will see the ships be operated solely by those technologies(Burmeister et al., 2014). Eniram project on the other part proves that those technologies are still usable in one way or the other in order to ensure high levels of efficiencies(Eniram Studies, 2012).

The current day ships are also not designed to accommodate such technologies and massive hardware upgrades or ship rebuilds will be needed to integrate the current technology to the older vessels which is a very unattractive process for most shipowners. It's also known that shipyards use pre-approved designs to build many sister ships with minor upgrades which reduces the logistical, managerial and technical costs like patent approval and certification by classification societies therefore trying to bring down the costs involved in building ships and be more competitive in the market and because of the lead lag relationship between the available technology and their integration process industry will need to wait a long time to have such a ship designed, approved and built(Molland, 2011).

There is also a problem of integration between different manufacturers and their equipment. In usual instances a vessel will have pumps, engines, valves, separators, SatCom and communication and many more equipment and machinery from different manufacturers that all those equipment come with their control panel which is not integrated to the central system creating a problem of consolidation of data and information which is a bottleneck in integration of BDA and ML. A standardization of codes between those equipments for the sake of communication among them is necessary in order for the engineer to have a single panel that "rules them all" which is able to consolidate data and find patterns among the equipment and help with the decision making regarding the maintenance.

5.2. Educational challenges

Just as it was with Dynamic Positioning, the new vessels with Big Data analysis tools and AI will require retraining for the personnel in order for the personnel to understand how this technology works and what can go wrong. Great theoretical understanding of sensors and their communication with computers is needed for proper troubleshooting of the system in order to stop the computer from making wrong decisions based on wrong data.

The complicated nature of newer vessels already has already impacted the way engine room and bridge crew work. Engineer nowadays only carry out less complicated maintenance operations and the more complicated fixes that require engine overhaul is made by the specialized team that is being sent on board by the manufacturer. As an example, such fixes on were a normal maintenance done by the engine crew on truly mechanical engines where not many electrical parts exist and such engines have gone out of popularity long time ago. While the universities around the world adapt their education to newer technology, the experienced seamen are having a hard time allocating time and resources to get proper education on newer, modern systems therefore proper programmes are needed to readapt the crew of hire them in managerial positions where their experience can be utilized in other parts of the organization.

Underdeveloped countries are also having a hard time on training such qualified crew for modern ships. As ships get more complicated, the simulators get more complex and expensive making it impossible for the universities of such countries to invest in those highly modernized training sims.

5.3. Regulative challenges

The regulation and standardization of equipment has been carried out pretty well by the IMO and the upcoming technology puts a big chip on their shoulder. In order to achieve high safety standards in autonomous ships and future of shipping as a whole, IMO and member states will need to participate and fund research programmes to create new standards that address cyber security, reliability and redundancy measures of such technology.

Apart from the technical side, a legal framework must be developed to draw clear lines. Such a framework can serve as a guideline for the companies and countries in their development process of technologically advanced vessels and training standards for the crew of such vessels.

6. Recommendations

After the thorough analysis of the findings and research on how such challenges are tackled on other industries, the following recommendations are proposed to the IMO, Shipping companies and seafarers for their consideration.

IMO:

- Develop an extensive study programme and handbooks for the seamen to assist them in adaptation of the new technology in vessels
- Create guidelines for the development and implementation of highly advanced digital technology no modern or future autonomous vessels
- Develop standardized IT infrastructure with enhanced cyber defence for the sake of future of safety in shipping industry
- Conduct surveys among scientists, researchers, companies and especially seamen, the members of shipping community who are affected by the technological developments the most
- Create education programs and infrastructure for underdeveloped countries for seamen from such countries to be competitive in shipping world with modern standards
- Legal framework must be developed for strict regulatory measures in order to prevent companies from compromising their cyber security for financial benefits. In todays connected world, an e-mail sent from an infected server to another company's address can cause disruptiveresults

Shipping companies:

- Companies should have education programmes regarding the new technology used on board of the ships to have a smooth transition for their personnel and ensure uncompromised safety on board
- Need to actively participate on the developments of Autonomous ships, MASS and IT technologies and raise the concerns of the industry

Seafarers:

- Should follow the developments of the upcoming technology and use the e-studying platforms to educate themselves on the modern technology used on board of modern ships.
- Should actively participate and be proactive in the development of such technology deliver their concerns to their National Marine Administration. Getting the perspective of the hard-working seamen is very important in these matters and will serve a great reference point for IMO and all the respective member states.

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