NELSON MANDELA UNIVERSITY

Business School

AN ANALYSIS OF HOW SMART SHIPS ARE GOING TO IMPACT THE MANNING COSTS OF MERCHANT SHIPS BY 2028

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PORT ELIZABETH

DECLARATION

I, Tshepo Ramonyaluoe, declare that;

- This work has not been previously submitted in full or partial fulfilment of the requirements of any other degree at any other university
- This treatise is being submitted in fulfilment of the requirements of the degree of Masters in Business Administration
- This treatise is the result of my independent work and investigation, except where otherwise stated. All the sources used are documented in the attached reference list and duly acknowledged; and
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Tshepo Ramonyaluoe

13 March, 2019

ABSTRACT

The maritime shipping industry is one of the most important industries in global logistics and economics. It facilitates international trade of goods and other commodities, whilst also supporting other sectors like tourism and the oil and gas industry.

Despite technological breakthroughs over the years, the maritime shipping industry has not undergone any huge and fundamental changes in the way it conducts business. This is about to drastically change with the advent of the fourth industrial revolution.

For the past two decades, the industry has been battling escalating operating costs due to challenges pertaining to diminishing skilled labour, increasing fuel costs and growing environmental concerns. These challenges are fast approaching crisis levels and a solution appears to be on the horizon in the form of smart ships; autonomous and remotely controlled ships that fully embrace the benefits of artificial intelligence, robotics and automation.

The main purpose of this research is to determine how smart ships are going to affect the costs of manning a merchant ship by 2028. The study analyses the voyage cost structure of merchant vessels, and looks at how smart ships are going to impact the costs of crewing a ship. This is a qualitative study that employed a futures methodology called Environmental Scanning.

This paper has led to conclusions and recommendations that should enable maritime shipping companies and agents to develop strategies that yield increased competitiveness in the age of smart technologies and big data.

ACKNOWLEDGEMENTS

As I look back and reflect on the MBA journey, I am compelled to quote renowned author and radio speaker, Earl Nightingale, when he said; “Never give up on a dream because of the time it will take to accomplish it. The time will pass anyway”.

This quote is as relevant today, as it was three years ago when I embarked on the MBA journey. It has been a long and challenging journey, however, it has also been inspiring and fulfilling at the same time.

As such, I wish to take this moment to thank and acknowledge all those who have made a positive contribution in my pursuit of the MBA;

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1. INTRODUCTION, PROBLEM STATEMENT AND RESEARCH OBJECTIVES

1.1. INTRODUCTION

The maritime shipping industry is, arguably, one of the most important industries in the world. The history of maritime shipping stretches back thousands of years to the times of the earliest humans, and today, the industry is as important as it has ever been. While the industry has undergone several major changes over the centuries, it has often been regarded as one of the slowest sectors to adopt and embrace change and technology. However, given the upcoming wave of the fourth industrial revolution, the merchant shipping industry is due to undergo the largest change it has ever experienced since the advent of containerization.

Disruption is unavoidable for merchant shipping as multiple technologies converge with unprecedented speed, requiring a complete revision of the strategies currently used to deal with the opportunities and threats currently facing the industry. The maritime shipping industry has been strongly affected by the previous industrial revolutions. The industry moved from sail-powered shipping to steam-powered shipping in the first industrial revolution. The second industrial revolution brought oil-powered shipping, whilst the third industrial revolution resulted in satellite-guided navigation and digital transport systems. The fourth industrial revolution is now expected to bring to the sector a networks of autonomous vehicles (Journal Of Commerce, 2017).

A merchant ship is any ship that is mainly engaged in cargo carrying or passenger ferrying activities. All vessels that are presently involved in active commercial sea transportation fall within this category (Marine Connector, n.d.).

Merchant ships come in distinctive shapes, dimensions and carrying capacities. They can be as small as a six metre long diving boat, or as big as ultra large crude carriers (ULCC) that can measure up to 415 metres in length. They are the main vehicles of ocean transportation in the world today, carrying crude oil and other commodities throughout the world, in varied sizes of tankers, containers and bulk carriers.

CHAPTER 1

Figure 1: Merchant Container Ship (Source: shipspotting.com)

Today, ninety percent of all international trade is carried by merchant ships and they are regarded as the most energy-efficient mode of transportation in terms of distance of freight transported for the same energy input, as compared to land and air transport (Ang, Goh, Saldivar, & Li, 2017).

The majority of merchant ships on our oceans today are loosely termed “traditional ships”. These are ships that are fully manned and rely on significant human skill and effort to undertake normal sea passage.

The enormous increase in computing power, brought about by the fourth industrial revolution, has enabled programmable methods for automating functions in marine applications, giving rise to the concept of a smart ship; a ship in which personnel strength and intelligence are now augmented with programmable automation functions and labour-saving devices that multiply the crew’s ship handling capabilities (Reilly & Jorgensen, 2016).

Currently, there is no clear definition of what a smart ship is, but according to authors Naukowe and Warszawskiej (2016), a smart ship is any ship that falls within the following parameters

1. Unmanned and autonomous, where the "human operator is replaced by software controls taking action themselves, but with remote supervision and emergency control from the shore station",
2. Unmanned but remotely controlled from the shore station,
3. Autonomous, but with a small crew on-board for inspections and emergency control.

For this study, a smart ship is presumed to be a merchant vessel that meets either of the three definitions given by Naukowe & Warszawskiej (2016)

Smart ships are presently not as widespread as autonomous cars and Unmanned Aerial Systems (UAS). YARA Birkeland, the world's first autonomous ship, is only expected to enter service in the latter half of 2018. The vessel will be the world's first fully electric and autonomous container ship, with zero emissions, shipping products from a production plant in Porsgrunn, to sites in Brevik and Larvik in Norway.

According to a Kongsberg Press Release (2017), the YARA Birkeland is going to "initially operate as a manned vessel, moving to remote operation in 2019 and expected to be capable of performing fully autonomous operations from 2020. The new zero-emission vessel will be a game-changer for global maritime transport, contributing to meet the UN sustainability goals".

The vessel is the result of a unique and unlikely partnership between chemicals giant YARA and oil-and-gas technology systems supplier KONGSBERG. The two companies agreed to a partnership to build the world's first autonomous and zero emissions ship. This feat has been hailed as the first and decisive step towards a future of autonomous vessels sailing the seven seas.

Other organisations throughout the world, most notably Japanese shipbuilders and Rolls Royce, are developing similar systems with the intention to offer complementary systems, even competing concepts and systems to support unmanned operations, coupled with infrastructure initiatives, including autonomous ports and high bandwidth communications (Lockwood et al., 2017).

There are, however, still significant hurdles in place that must be overcome before we see widespread adoption of smart ships. International sea passages will not be possible until such a time that the regulatory and legislative framework is in place. With the International Maritime Organisation having only begun work in 2017, even the most optimistic of observers do not envisage this work being completed before 2028 (World Maritime News, 2017).

Figure 2: Development of Smart Ships. (Source: Rolls Royce Ship Intelligence)

It is worth noting that among the obstacles facing the international maritime industry today, skills shortages is one of the biggest. The merchant shipping industry is currently experiencing a severe shortage of skilled crews. The 2016 BIMCO/ISF Manpower Report indicated that there was a scarcity of 16500 qualified ship officers in 2015. Elementary forecasts indicate that the global supply of suitably qualified ship officers will rise steadily, but will continue to be outpaced by escalating demand for officers, resulting in the shortage of 94000 ship officers in the year 2020, reaching a staggering shortage of 147500 in the year 2025.

These shortages are likely going to extend beyond 2025 as seaborne trade is still predicted to double in volume by the year 2030 (World Maritime News, 2017). As a result of this growth, The 2015 BIMCO Report states that; “the forecast growth in the world merchant fleet over the next ten years, and its anticipated demand for seafarers, will likely continue the trend of an overall shortage in the supply of officers”. This will be despite the improved recruitment and training levels and reductions in officer wastage rates over the past five years from China, Philippines, Russia, Ukraine and India (Aron Sørensen et al., 2016).

The reasons behind the high skills turnover in the industry are well understood. Primary push factors include; the mistreatment of maritime personnel through unfair work contracts, abandonment by ship owners, salary arrears, insufficient shore leave, lack of communication infrastructure for seafarers to contact families while at sea, highly pressurised working conditions and the additional workload on-board (Caesar, Cahoon, & Fei, 2015).

While there may be a variety of reasons why the industry is struggling to retain personnel, the overall message is clear; the industry is fast approaching a crisis point should proper actions both in terms of recruitment and retention not be implemented (Thai, Balasubramanyam, Yeoh, & Norsofiana, 2013).

In an attempt to arrest the skills shortages, the provision of attractive remuneration and adequate motivation is used by some ship management companies in a bid to improve retention among crew (Caesar et al., 2015). This strategy has back-fired, leading to soaring labour costs. Today, labour is the second highest operating cost of a merchant vessel, second only to the cost of fuel.

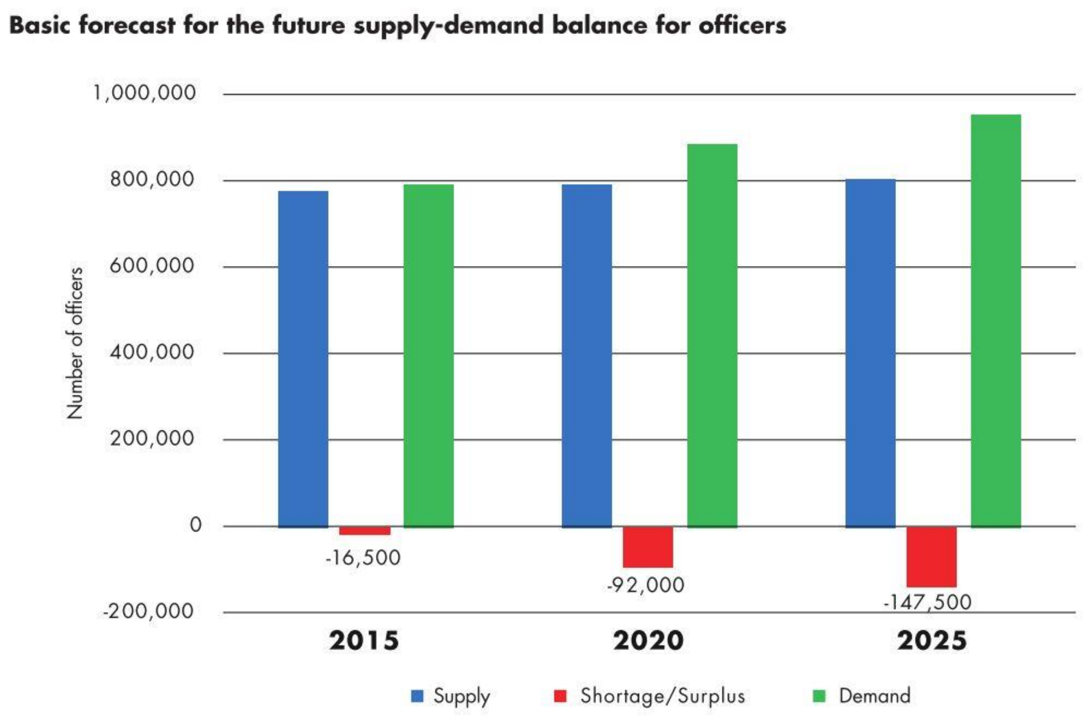

Figure 3: Source: BIMCO 2015 Manpower Report

According to Lockwood et al. (2017), Initiatives currently in progress throughout the industry are driven by pressures around manning overheads, fuel expenses, and environmental requirements. Smart ships have the potential to address all three concerns simultaneously. Firstly, by doing away with crews, or operating with skeleton crew, smart ships are set to dramatically reduce the cost of labour in the shipping industry (Lagersmit, 2018).

Secondly, fuel is the number one expense for each of the over 70 000 ships currently engaged in international trade. According to the Swedish-Swiss company, Asea Brown Boveri (ABB), “it accounts for between 30-40 percent of the cost of running a cruise ship and between 50-60 percent for most merchant vessels. Reducing fuel consumption by just 1 percent can mean an annual saving of $50,000 for a mid-sized bulk carrier and $300,000 a year for a large container ship”. Multiply this by 20, and the potential savings in fuel and carbon dioxide emissions are astronomical. ABB (an electrical equipment manufacturer) is currently developing a comprehensive array of software products tipped to cut ship fuel consumption by an unparalleled twenty percent. (ABB Communications, 2012).

Smart ships will be equipped with a network of sensors that capture a range of voyage information, including: location, weather, ocean currents, status of on-board equipment and status of cargo. Vessel operators will be able to monitor the vessel’s status in real time, applying analytics to current and historical data to make decisions that enable vessels to run more efficiently, saving time and fuel (Liu, Perez, Muñoz, & Regueira, 2016). Advanced monitoring and analysis systems that enable ships to optimize trim, speed and voyage routing among other factors, have produced verified fuel savings and reductions in emissions (Chang-wei, 2015).

The focus of this study will look, specifically, at how smart ships are going to impact the manning costs of a merchant vessel.

Artificial intelligence, robotics and automation are already changing the way most industries function today. Technical feasibility combined with compelling economic advantages such as reduced operating and labour costs, as well as improved efficiency, are driving implementation, especially in manufacturing industries, engineering, aviation, construction and in healthcare services, sectors which are all investing heavily (Lockwood et al., 2017).

In the race to introduce smart ships, technology is not the problem, adoption is. Other industries are arguably farther down the path of integrated and interconnected systems than the marine industry. Therefore, as the marine industry enters the smart era, it is possible and responsible to learn from previous mistakes and to apply the lessons learned, particularly during system architecture design (Reilly & Jorgensen, 2016).

CHAPTER 1

From drones and driverless cars to the smartphones, autonomous technology has become commonplace in the world. It is now the understanding of the technological, economic and legal, as well as the safety characteristics of remote and autonomous operation that is being explored.

A vessel's sea passage is covered by a range of private, national and international legal frameworks. To further complicate matters, maritime law does not anticipate the development of remote or autonomous ships. This presents many uncertainties (Rolls-Royce, 2016).

Smart ships will certainly create a great challenge to the current maritime legislation. It appears that commercial operation of unmanned or remotely controlled ships may/will require amending almost all international conventions related to marine transport. In all legal instruments, a ship is defined as a manned object. Manned ships with some autonomous systems (autopilot, etc.) fall under this definition. However, it is clear that unmanned ships do not fall under this definition. The old principle with regard to shipping was based on the assumption that the full responsibility for the ship at sea lies on the master who is on-board and is "the first after the God" (Naukowe & Warszawskiej, 2016).

1.2. PROBLEM STATEMENT

The main reason for conducting this research study is due to current and future escalation of the maritime skills shortages and the fact that seafarers currently exit the industry even before the completion of a decade at sea. The possibility of replacing staff with smart technologies is a current issue to be investigated.

The retention of qualified ship officers on-board merchant vessels remains a significant matter within the maritime shipping industry, with a reported one in ten officers leaving the industry prematurely (Caesar et al., 2015). Pekcan et al. (2003) (cited in Caesar et al., 2015) also suggest that fewer seafarers are opting to stay in sea-going careers beyond ten years. This high employee turnover jeopardises the entire backbone of global trade since merchant shipping accounts for nine out of every ten units of cargo traded in the world.

Skills shortages also threaten the profitability of shipping companies (International Association of Maritime Universities, 2015). Forecasts from the Manpower Report

(2016) point to an ever deteriorating outlook where officer demand far exceeds supply. This scenario, where there are more ships than people qualified to man them, could only lead to an unsustainable scenario where crew costs eventually exceed fuel costs and ship owners are forced out of business.

Smart ships seem to be the most viable and sustainable solution to this problem.

According to Baraniuk (2017), a recent report by the University of Southampton has suggested that, due to declining technological costs and demands to address labour shortages in certain critical areas of shipping, autonomous ships will arrive faster than expected. The main foreseeable hurdle in the mass introduction of smart ships will be legislation.

In the last 200 years of drawn up international codes and conventions, autonomous ships have not been mentioned because it has been presumed that all ships are always manned. It is exactly this fact that presents a major challenge. It may result in the legal framework lagging behind the technological development, thus inhibiting some of the advanced ways in which autonomous ships are capable of operating internationally. In some way, the initial conclusion is that it is not necessary to wait for United Nations' International Maritime Organization (IMO) because national regulations permit autonomous vessels to operate in domestic waters (Blanke, Henrique, & Bang, 2017).

The introduction of smart ships will bring much needed relief to operators as, not only will crew costs come down, the number of accidents are expected to decline as well. It is widely-known that 75-96% of all maritime incidents are a direct result of some form of human error (International Association of Maritime Universities, 2015). According to statistics of the European Maritime Safety Agency, human error was the main cause in 62% of incidents with EU registered ships from 2011 to 2016, hence advocates for increased autonomy point to the possibility of increasing safety at sea significantly by introducing highly automatized/autonomous ships (Blanke et al., 2017).

Given the statistics, smart ships seem to be a much needed solution to the problems facing a merchant vessel.

CHAPTER 1

1.3. RESEARCH OBJECTIVE

The world is currently experiencing the dawn of the fourth industrial revolution. This wave of big data and exponential computing power is expected to happen around the middle of the twenty first century, resulting in an intelligent world. The amount of data collected, processed, and transmitted during this period will be extremely big. This would be the fourth industrial revolution (Naukowe & Warszawskiej, 2016).

Through the integration of computational intelligence and cyber-physical systems, Ang et al. (2017) envision that the fourth industrial revolution has the potential to transform ship design, manufacturing and ship operations in a smart and efficient way, resulting in the mass production and operation of smart ships. The **objective of this study is to determine how smart ships are going to affect the manning costs of a merchant ship by 2028**.

Ship owners are currently facing multiple cost pressures that the advent of smart ships is going to drastically address. This study aims to focus particularly on the manning costs, a significant portion of running costs in the modern merchant shipping industry. The shortage of critical skills in the maritime industry is fast approaching crisis levels, with high skills turnover and exorbitant wage bills threating the profitability of many of the world's carriers. This study aims to also assess the benefits and drawbacks of smart ships, and also determine if industry stakeholders, particularly the custodians of legislation, are ready for smart ships.

1.4. RESEARCH QUESTIONS

1.4.1. Primary Research Question

This study will assess the international maritime landscape and determine how smart ships are going to affect manning costs of a merchant vessel.

1.4.2. Secondary Research Questions

- WHAT ARE THE CURRENT COSTS OF MANNING A MERCHANT SHIP? (Payroll, training, certification, medicals, travel and accommodation?)
- IN WHICH WAY WILL SMART SHIPS AFFECT MANNING COSTS? (What will smart ships change in the way recruitment, training and manning is handled?)

- WHAT EFFECT CAN WE FORESEE IN REPLACING CREW WITH SMART TECHNOLOGIES ON MERCHANT SHIPS? (Legislation, insurance, risk, environment, safety, future skills development, organised labour, profitability)

1.5. RESEARCH METHODOLOGY

This is a futures study paper and the chosen research methodology for this study will be the Environmental Scanning methodology. Since the study looks at the future of merchant shipping and how smart ships are going to impact the manning costs, scanning the horizon is important for identifying new developments that can challenge past and present assumptions, or provide new perspectives about future threats or opportunities. Environmental scanning systems give early warnings about critical changes and detect "weak signals" that indicate plans should be amended (Gordon & Glenn, 1994).

Environmental scanning is a systemic futures methodology that was developed by Aguilar in 1967. It is a systematic review of literature and other modes of communication to determine emergent concerns (Lang, 2001). Futures methodologies generally seek to gather data and make sense of it so that people can think in different and new ways about the future. In terms of Environmental scanning, the data might be collected from humans (experts in the field), or from analysing documents and artefacts, or even both (Conway, 1997).

Future studies methodologies, or foresight methodologies as some literature prefers to call them, may be viewed as frameworks for making sense of data generated by structured processes to think about the future (Conway, 1997). No system will be able to completely remove all uncertainty; therefore the objective of a scanning system is simply to find early indications of possibly important future developments to gain as much lead-time as possible (Gordon & Glenn, 1994).

Joseph Voros (2003), classified futures studies methodologies into four levels, each with its own guiding questions:

- Input Level: what is going on?
- Analytical Level: what seems to be happening?
- Interpretive Level: what’s really happening?
- Prospective Level: what might happen?

The *input* level is the gathering of information and scanning for strategic intelligence. Many input techniques, methods and frameworks exist, of which the ‘Delphi’ method and environmental scanning are perhaps the best known (Voros, 2003). For this study, it is the environmental scanning method that will be used.

Gordon & Glenn (1994) identify seven scanning techniques for executing environmental scanning; expert panels, database literature reviews, Google alerts, websites, literature reviews, publications by experts, and key person tracking. This study will employ two techniques, database literature reviews and essays by experts.

1.6. OUTLINE OF THE STUDY

The first chapter delivers an introduction and the outline of the study. This chapter gives the research problem, research objectives and the research questions. The research methodology is also outlined in this chapter.

The second chapter clarifies the research methodology employed in this research study. This includes the research approach used for this study. The Environmental Scanning technique is discussed in detail in this chapter.

The third chapter is a literature review of the research problem. This is an effort to comprehend the research problem. The chapter will look at manning costs and maritime skills shortages, as well as current techniques used by ship-owners to mitigate against these challenges. The solutions anticipated from the advent of smart ships are also investigated in this chapter.

In the fourth chapter, the Environmental Scanning process is applied and a STEEP analysis of the international maritime industry is undertaken. The focus of the chapter is on the inputs and foresight stages of the Foresight Framework, detailing what is currently happening in the maritime sector.

In the fifth and final chapter, the strategy development in the age of digital technology is outlined. The purpose of the chapter is to propose ways in which shipping companies can re-asses their strategies and maintain competitiveness in the age of smart technologies and big data. The chapter will give conclusions and recommendations for management, limitations of the study and the highlighting of areas for future research.

CHAPTER 2

2. RESEARCH METHODOLOGY

2.1. INTRODUCTION

Chapter one defined the context of this paper by giving an introduction and the outline of the study. The chapter briefly touched on the impact of maritime shipping on international trade, as well as the latest advances currently under development in the industry. The definition of smart ship was also explored, and the potential advantages the industry stands to benefit in the advent of the fourth industrial revolution were given. The research problem, research objectives and the research questions were also covered in this chapter. The research methodology, which will be covered thoroughly in chapter two, was introduced in chapter one.

In chapter two, the study will go deeper into defining futures thinking and exploring the Environmental Scanning research methodology. This chapter will also go to great lengths to explain how the different futures methodologies compare to one another, and why the environmental scanning methodology was the preferred methodology for this study. The work of Maree Conway and Rafael Popper will form an integral part of this chapter.

What is important to note in this chapter is that, the terms "*futures*" and "*foresight*" will be used interchangeably. When the chapter refers to futures studies or foresight research, the researcher is talking about the same concept/term/definition.

2.2. FUTURES STUDIES/FORESIGHT RESEARCH

In a journal article titled; Ten Principles For Thinking About The Future, author David Bengston talked about the future being fast. The idea that change is occurring at a fast and accelerating pace is common in society and among futurists. The searing pace of change, and the "stress and disorientation that individuals and organizations feel when they experience too much change in too short a time" (Bengston, 2017) necessitates that organisations and individuals dedicate more thought into the future.

Future methodologies may be viewed as frameworks for making sense of data generated by structured processes to think about the future (Conway, 1997). Under the term *future studies,* "scholars build primarily on the logic that the future is and will remain uncertain, thus future-oriented planning should aim to explore possible futures rather than trying to predict the one future” (Rohrbeck & Bade, 2012).

Whatever the term or definition, no system can ever be able to eliminate all uncertainty (Gordon & Glenn, 1994). Perceived reality always departs qualitatively from expectation (Bengston, 2017). The objective of doing future studies is “simply to find early indications of possibly important future developments to gain as much lead-time as possible. Therefore, foresight methodologies seek to gather data and make sense of it so that people can think in different and new ways about the future” (Conway, 1997).

2.3. ALTERNATIVE FUTURES CONCEPT

Futures literature is abound with concepts of possible and probable futures. The whole concept of future studies is about gathering data and making decisions about the future, probable or possible. Joseph Voros goes one step future in his concept of alternative futures. Voros deemed it beneficial to differentiate between the five classes of alternative futures: potential, possible, plausible, probable and preferable. The alternative futures concept was later supported by David Bengston (2017)

Potential futures is the class which “contains all of the futures which lie ahead, including those which we cannot even begin to imagine”. If this premise is rejected, then “the entire futures cone ‘collapses’ into a single future time-line, all potentialities disappear, and all our futures work becomes simply an attempt to find more information about a pre-determined but unknown future. The future thereby becomes merely an information problem, rather than being undetermined” (Voros, 2003).

Possible futures refers to the class of futures which “includes all the kinds of futures we can possibly imagine —futures which ‘might happen’— no matter how far-fetched, unlikely or ‘way out’ they may be”. These futures may comprise usage of knowledge and information we do not yet possess thus far, knowledge which might even transgress the currently-accepted principles and laws of physics (Voros, 2003).

Plausible futures encompass all futures which “most people would consider believable and are consistent with our current understanding of science, technology, and social and economic systems” (Bengston, 2017). These futures are dependent upon what is deemed sensible by our present knowledge of how the world operates.

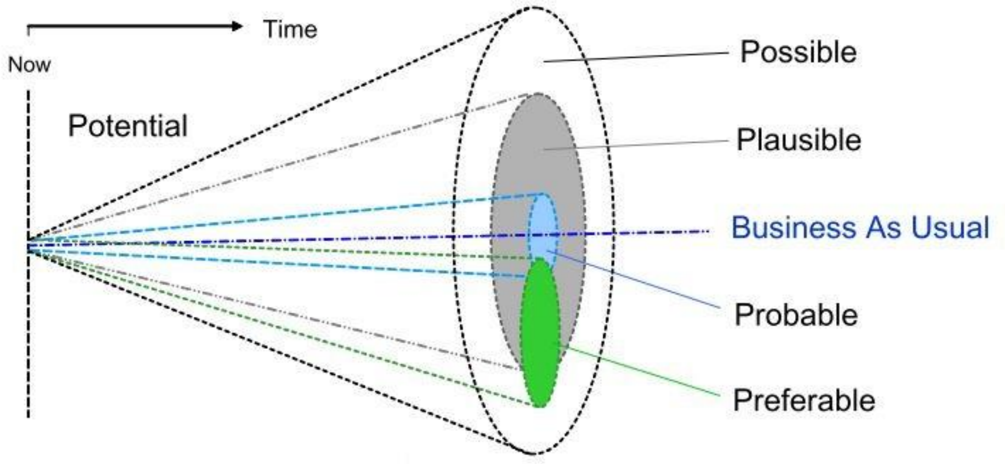

Figure 4: The Futures Cone - Hancock & Bezold (1994)

Probable futures denotes futures which “contains futures which are considered ‘likely to happen’, and stem from the continuation of current trends. Some probable futures are considered more likely than others, and the one considered most likely (*business-as-usual*) is a simple linear extension of the present from the past” (Voros, 2003).

The final class of futures, called *preferable futures,* are “concerned with what we individually or collectively want to happen in the future. They are explicitly subjective and derive from value judgments. They are often developed through a visioning or preferred futuring process” (Bengston, 2017).

Since probable futures are considered those likely to happen, this study will work in the probable futures paradigm. Probable futures class stems from the continuation of current trends. This gives rise to a much smaller class of futures and therefore, a narrower, more realistic range of forward views.

2.4. NATURE OF STUDY

Foresight methods generally have two attributes that influence the methodology of a study. The attributes are; *nature* and *capabilities*. Methods can be characterised as qualitative, quantitative or semi-quantitative (*nature*). Capabilities refer to “the capability to gather or process information based on evidence, expertise, interaction or creativity” (Popper, 2008). These attributes give rise to what is known as *The Foresight Diamond* (Figure 5).

The nature of the study, and the method mix, are the two most influential elements of method selection. Qualitative approaches are mostly favoured when working with futures studies and that is because “qualitative methods generally provide meaning to events and perceptions. Such interpretations tend to be based on subjectivity or creativity that is often difficult to corroborate, i.e. opinions, judgements, beliefs, attitudes, etc.” (Popper, 2008).

Qualitative methods fundamentally use instinct, invention, theory, hypothesis, and judgement, as compared to quantitative methods which favour the use of numerical data, statistical models, mathematical equations and calculations, as well as measuring instruments. They (qualitative methods) may and may not be empirically based, allowing for detailed empirical facts of the past and present situation and the inclusion of the intuitive, the speculative, and the hypothetical when probing about the future (Puglisi, 2001).

Quantitative methods generally measure variables and apply statistical analyses through the use of theory to generate reliable and valid data. Semi-quantitative methods are basically those that apply mathematical principles to quantify subjectivity, rational judgements and viewpoints of experts and commentators, i.e. weighting opinions and probabilities.

This study will employ the qualitative approach, using the environmental scanning methodology to explore how the advent of smart ships is going to affect manning costs of contemporary merchant vessels. Since this study relies on evidence to explain and forecast future technological trends that will affect the manning costs of a contemporary merchant vessel, the Foresight Diamond points to Environmental Scanning and literature review as the preferred qualitative methodology.

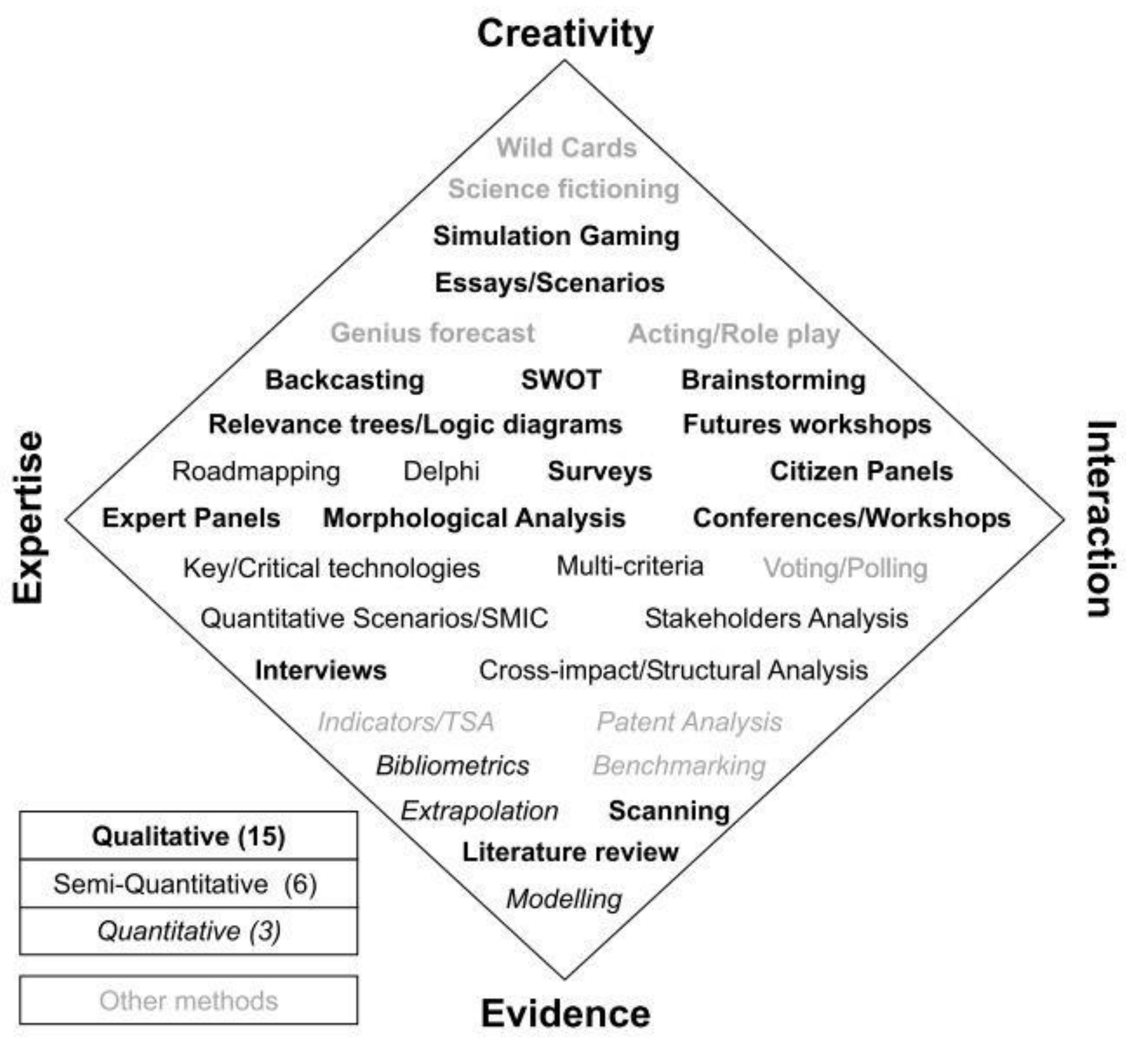

Figure 5: The Foresight Diamond - Rafael Popper (2008)

The *Evidence* attribute acknowledges that it is imperative that an attempt is made to explain and/or forecast a particular phenomenon with the support of reliable documentation and means of analysis, as opposed to *Creativity*, which refers to “the mixture of original and imaginative thinking and is often provided by artists or technology gurus’’ (Popper, 2008). The *Expertise attribute* refers to the skills and knowledge of individuals in a particular area or subject. This is often used to support top-down decisions, provide advice and make recommendations. *Interaction*, recognises that expertise often gains considerably from being brought together and challenged to articulate with other expertise (Popper, 2008).

The above attributes are the building blocks of the Foresight Diamond (Figure 5), which Rafael Popper (2008) has adapted to highlight the 25 methods considered in the mapping.

2.5. APPROACH OF THE STUDY

This paper adopted an exploratory approach and purpose in studying the literature that is relevant to this research topic. Explorative studies look at the future from the present whereas normative studies investigate what needs to happen in order to realise a specific goal. “Normative forecasting establishes objectives and defines desirable futures and then studies the ways to reach them staying in the sphere of the possible. While explorative forecasts look at the ongoing trends and explore where they might lead us, they study plausible futures” (Gordon, 1992 cited in Puglisi, 2001).

In this paper, the aim is to define an accurate, objective and qualitative picture of the future using an explorative approach (looking at possibilities). This also entails using the inductive research approach. Inductive research is “a study in which theory is developed from the learning of factual reality; therefore, general interpretations and extrapolations are induced from particular occurrences” (Collis and Hussey, 2009 cited in Marope, 2014).

2.6. FORESIGHT FRAMEWORK

The foresight framework emerged from the amalgamation and adaptation of various ideas from several futurists. Richard Slaughter (1999) developed the framework further and recommended numerous methodologies which could be employed. Joseph Voros adapted the framework and presented it with the four key elements (*Inputs*, *Foresights*, *Outputs* and *Strategy*) of the process described in detail.

The Foresight Framework (Figure 6) details the four key elements of futures studies, and the preferred methodology in each element. Environmental scanning fits in the Inputs stage, it gathers information about things happening in the external environments to identify future possibilities (Conway, 2013).

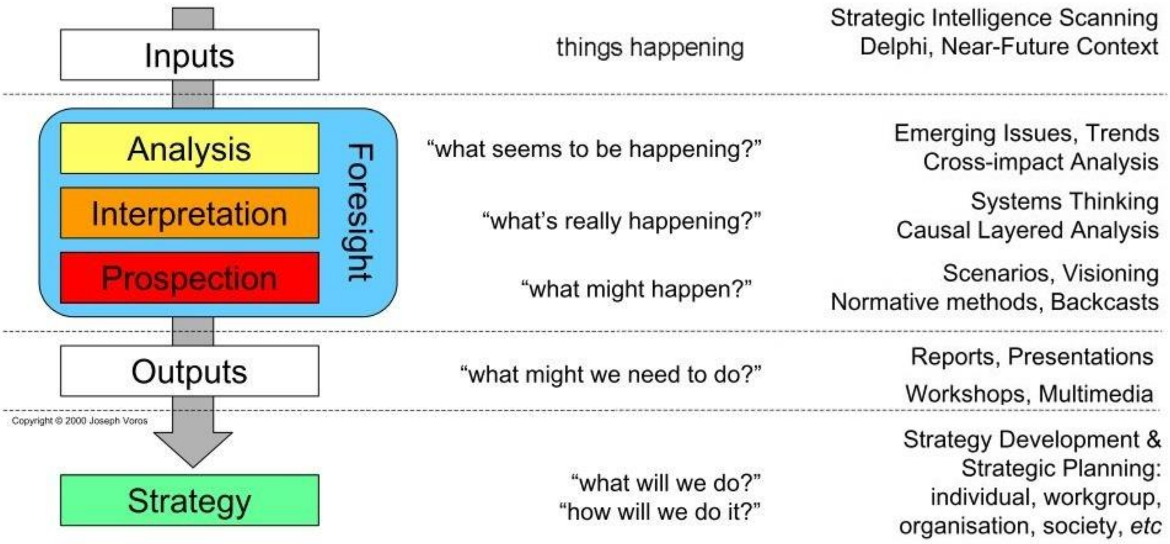

Figure 6: Foresight Framework – Adapted from Voros (2003)

Inputs is the element that is concerned with the gathering of information and scanning for strategic intelligence. This study will be undertaken within this element. It deals with things currently happening in the environment. Many techniques, methods and frameworks exist, of which the 'Delphi' method and environmental scanning are the best known. The other three elements of the foresight framework are beyond the scope of this paper, and as a result, cannot be examined in depth due to time and financial constraints, however, this research study will provide a brief overview based on the inputs sourced from the environmental scan in order to synthesize the themes (trends) and insights that emerge.

2.7. ENVIRONMENTAL SCANNING

Environmental scanning is the process of methodically surveying the external environment to better understand the nature and pace of change in that environment. This allows the industry/organisation to identify potential opportunities, challenges and likely future developments relevant to the industry/organisation. It entails "exploring both present certainty and future uncertainty, and moving beyond what we accept as valid ways of doing things today" (Conway, 2013).

The main purpose of performing an environmental scan is, "to identify relevant information, both trends and weak signals of change appearing on the horizon, in order to broaden and deepen thinking about strategic options. It is about ensuring that there are no surprises in the future operating environment – that is, avoiding organisational myopia" (Conway, 2013). Organisations that cannot afford organisational short-sightedness include merchant shipping companies, freight forwarders, manufacturers and the supply chain networks that they form part of.

At the end of the study, the aim is to have details about relevant trends in the external environment that are likely to have a significant impact on the manning costs of a merchant vessel, and the implications of those trends on your shipping companies around the world.

2.8. MODES OF ENVIRONMENTAL SCANNING

Scanning is not a monolithic activity. Environmental scanning includes both looking at information (viewing) and looking for information (searching). Chun Wei Choo (1999) speaks of the four modes of organisational scanning: undirected viewing, conditioned viewing, informal search, and formal search. These four modes are elaborated further by Naude (2016).

In *undirected viewing*, the researcher gathers information with no specific informational need in mind. The general intention is cast the net wide and scan broadly in order to detect early signs of change. In *conditioned viewing*, the researcher narrows the gathering of information only to selected topics, or to certain types of information. The goal is to assess the quality of the information encountered in order to evaluate the general nature of the impact on the industry/organisation. During *informal search*, the researcher actively seeks information to strengthen the knowledge and understanding of a specific issue. It is deemed informal because it involves a relatively limited and unstructured effort. The goal is to collect information in order to elaborate an issue so as to determine the need for action. During *formal search*, the researcher makes a deliberate effort to obtain information about a specific issue. The search is deemed formal because it is organised according to some pre-established procedure or methodology (Choo, 1999).

Environmental scanning needs to engage all four modes of viewing and searching in order for it to be effective. However, for the purpose of this study, much of the undirected viewing and informal search was conducted whilst evaluating this topic. Therefore, only conditioned viewing and formal search will be employed.

Conditioned viewing tracks trends and gives the organisation early warning about emerging issues, whereas formal search systematically gathers all relevant information about an issue to enable intelligent decision making.

2.9. STEEP ANALYSIS

Environmental scanning as a futures methodology is heavily reliant on a STEEP analysis. Organisations need to scan beyond technological factors and into the political, economic, environmental and social environment (Rohrbeck & Bade, 2012). Choo (1999) has also identified several types of scanning and concluded that, for wider trends in the external environment, a STEEP analysis is preferred. This is particularly true in the context of this study since STEEP factors will mainly be affected by the advent of smart ships.

An effective environmental scanning system is able to “identify important emerging issues that may constitute either obstacles or opportunities. This process helps allocate resources in a way that anticipates or responds to changes in the external environment” (Lang, 2001). Therefore, this study will perform a STEEP analysis to evaluate how the advent of smart ships is going to impact the manning costs of running a merchant vessel.

2.10. ENVIRONMENTAL SCANNING FOCI AND SCANNING ANCHOR

Terry (1977) (cited in Lang, 2001) contends that “environmental scanning has three foci. The first being the immediate environment (of current and immediate concern to the industry/organisation), the second being the probable environment (not of immediate concern to the organisation but likely to be in the future) and the third is the possible environment (weaker signals on the radar screen which might turn out to be game changers)”.

As indicated in the alternative futures theory, this study will focus on probable futures since they stem from the continuation of current trends and are therefore most likely to happen. The scanning anchor of the study (issue within which the scanning revolves) will be the costs of manning merchant vessels, and the scanning scope will be on the global shipping industry since ships operate on the international landscape.

2.11. SCANNING TECHNIQUES

Gordon & Glenn (1994) recommend several different techniques that can be used to execute an environmental scan. For this paper, the two techniques that will be employed are: literature reviews and essays by experts. Literature reviews give access to a comprehensive collection of useful information to planners, policy makers, strategists and futurists. Essays by experts explore critical long-term issues for recommendations on policy and strategy. The two sources of information help in gaining good understanding of the investigated phenomenon from different perspectives. This does not essentially mean cross-referencing the information from the two sources or techniques and endorsing it as correct or not, it is more about increasing the level of knowledge about smart ships, and to deepen the researcher's outlook from numerous aspects.

2.12. EVALUATING QUALITATIVE RESEARCH

Criteria used to evaluate the quality and thoroughness of qualitative studies differ somewhat, based on methods used. Most concerns are regarding the subjectivity and biasness of the researcher. As a result, the quality and rigor of this qualitative study will be based trustworthiness and authenticity of the sources. The triangulation of multiple sources should also help to improve the validity of the study.

2.13. LIMITATIONS OF ENVIRONMENTAL SCANNING

Environmental scanning is a futures study methodology that stands at the juncture of foresight and strategy. It establishes organisationally relevant criteria that allow prepared human minds to discern information, knowledge and insight from the multitude of ‘signals’ that occur daily. One of the meta-skills of good environmental scanning work is knowing when to use the standard ‘rules’ of discrimination, and when to set them aside. This is a matter of human judgement, not of calculation. As such environmental scanning stands firmly in the interpretative domain, not that of the dominant empirical tradition of futures work (Slaughter, 1999).

However, environmental scanning is progressively evolving out of its academic origins, and moving into a more common practice where it has a range of practical implications. The environmental scanning process may appear to be a long and intricate process, but its effectiveness is undisputable (Choo Wei, Slaugther, & Voros, 2003). “The process allows the necessary data collection (and the identification of past and present trends more relevant for the survey) and the estimation of the potential values of indicators related to the occurrence or non-occurrence of specific events" (Puglisi, 2001).

2.14. CONCLUSION

The challenge with environmental scanning is determining the applicable timespan of the scan. For this study, the research will look at year 2028, as this is the year that maritime legislation is expected to have evolved enough to accommodate autonomous maritime systems (Unknown Author, 2017).

The study will be qualitative because futures studies require depth and meaning that is difficult to corroborate with quantitative statistical analyses. The use of academic journals and maritime literature as evidence and means of analysis leads the paper to adopt Environmental Scanning as the appropriate futures methodology for conducting this study. Environmental Scanning represents the *Input* phase of the foresight framework. This choice of using Environmental Scanning is also supported by the Foresight Diamond, which dictates that qualitative studies that rely on literature as evidence and means of analyses must employ the Environmental Scanning methodology.

The research will be exploratory, looking at the future from the present, whilst also using the inductive research approach, developing theory from learning factual reality. Working in the probable futures paradigm, the intention is to ultimately determine how the continuation of current technological trends will eventually impact the manning costs of merchant ships.

CHAPTER 3

3. LITERATURE REVIEW

3.1. INTRODUCTION

The maritime industry, known for its slow pace in adoption of new technologies, is on the verge of undergoing the biggest, and most rapid change it has ever undergone. The fourth industrial revolution, with its wave of big data and exponential computing power, is expected to usher in a new era of unmanned, remote-controlled and autonomous sea vessels, commonly referred to as smart ships.

The world's first autonomous commercial ship, YARA Birkeland, is near completion and expected to launch a later in 2018, initially operating as a manned vessel, moving to remote operation in 2019 and in full autonomous operation by 2020 (Kongsberg, 2017). According to a 2016 Rolls Royce report, autonomous vessels will be the greatest fundamental change in shipping that the maritime industry will experience (Levander & Jokioinen, 2016).

Figure 7: Artist's Impression of Yara Birkeland (Source: Kongsberg Maritime)

The shipping industry has gradually evolved, navigating its way through each industrial revolution that came to pass. The industry adapted to the global trade of between 1490 and 1790, spurred the introduction of the lateen sail, the centreline rudder and the compass. It later navigated its way through the era of imperial trade between 1790 and 1950, adopting the steam engine, iron hulls, propellers and cables. Between 1950 and 2015, the global free trade, known for oil, diesel engines, welded steel hulls and bulk shipping, also brought technologies that the merchant shipping successfully integrated into the industry (Stopford, 2015). Today, the digital revolution stands to transform merchant shipping in the coming decades.

Smart shipping comprises, among other things, autonomous and connected ships with better performance and lower costs via deployment of various sensors and data analytics. And while the maritime shipping industry has been 'behind the curve' with regards to the adoption of digital technologies when compared with other actors in the supply chain, shipping companies caught a wake-up call and are now looking at adopting new technologies instead of putting too much emphasis on ship utilisation (Mangan, 2017).

The initiative towards reduced construction and ownership cost is what has given rise to corresponding increases in the implementation of vessel automation and advisory systems. Automation systems can significantly improve the operational efficiency of the ship, depending upon how well they are developed, configured and tested (Cartledge, 2001).

3.2. COST DRIVERS IN SHIPPING

Determining the operating costs of a ship is a challenging exercise as the information is often treated as a business secret, and such costs on the same type and size of a vessel can be widely different due to the varied crewing costs, different maintenance schedules as a result of the age of the vessel, as well as the quality of historical maintenance. The differences in operating expenses of a merchant ship may also be the result of insurance costs, and also depend on the number of days in a year that the vessel is in commercial operation (Počuča, 2006).

However, fuel prices, lubrication oil, crew wages, finance costs, food, spare parts, maintenance costs and insurance costs are known to be the most significant cost drivers in the day-to-day running of a ship (V.Ships Ltd., 2012). Fuel costs, in particular, make up the biggest percentage within the voyage cost structure (Počuča, 2006), and crewing costs are regularly also a big percentage of ship operating costs (Psaraftis, 2014). As a result, the merchant fleets of many shipping nations worldwide have experienced a significant weakening in competitiveness over the years. The loss of competitiveness is due to the fact that vessels in these fleets are generally more expensive to operate than other vessels, and shippers prefer the latter because of cost considerations.

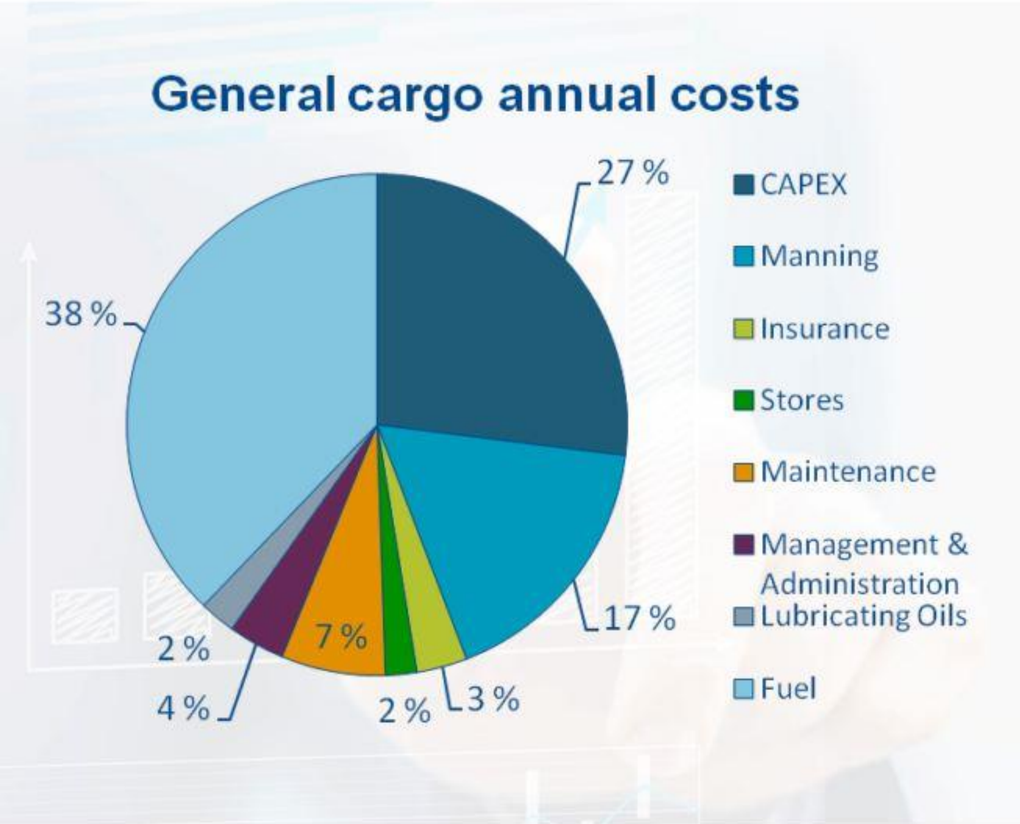

Figure 8: Annual costs of a general cargo ship. (Source: Levander & Jokioinen, 2016)

Cost pressures are forcing shipping companies to find new ways of optimising ship's resources. As such, shipping companies now have to think outside of the box in their efforts to reduce costs. Unfortunately, the only significantly variable component of the voyage-cost equation remains the cost of manning (Jatau, 2002). Manning costs are generally perceived by many operators as the one variable in the running costs of a ship that can be reduced easily, either by changing the crew nationality or reducing the number of personnel on-board. Other running costs cannot be easily managed by the operator; bunker and lube oil costs are determined by oil markets, the costs of spare parts are determined by the manufacturers of spare parts, and insurance costs are determined by insurance markets, hence owners and operators concentrate their energies in reducing manning costs as much as possible in order to increase competitiveness (Bowring, 2006).

From Figure 8, it is necessary to then exclude the costs of CAPEX and fuel in the operational costs structure since these costs are largely beyond the control of the ship owner. This results in a different graph (Figure 9) from which it can be seen that, manning is a big percentage of operating costs.

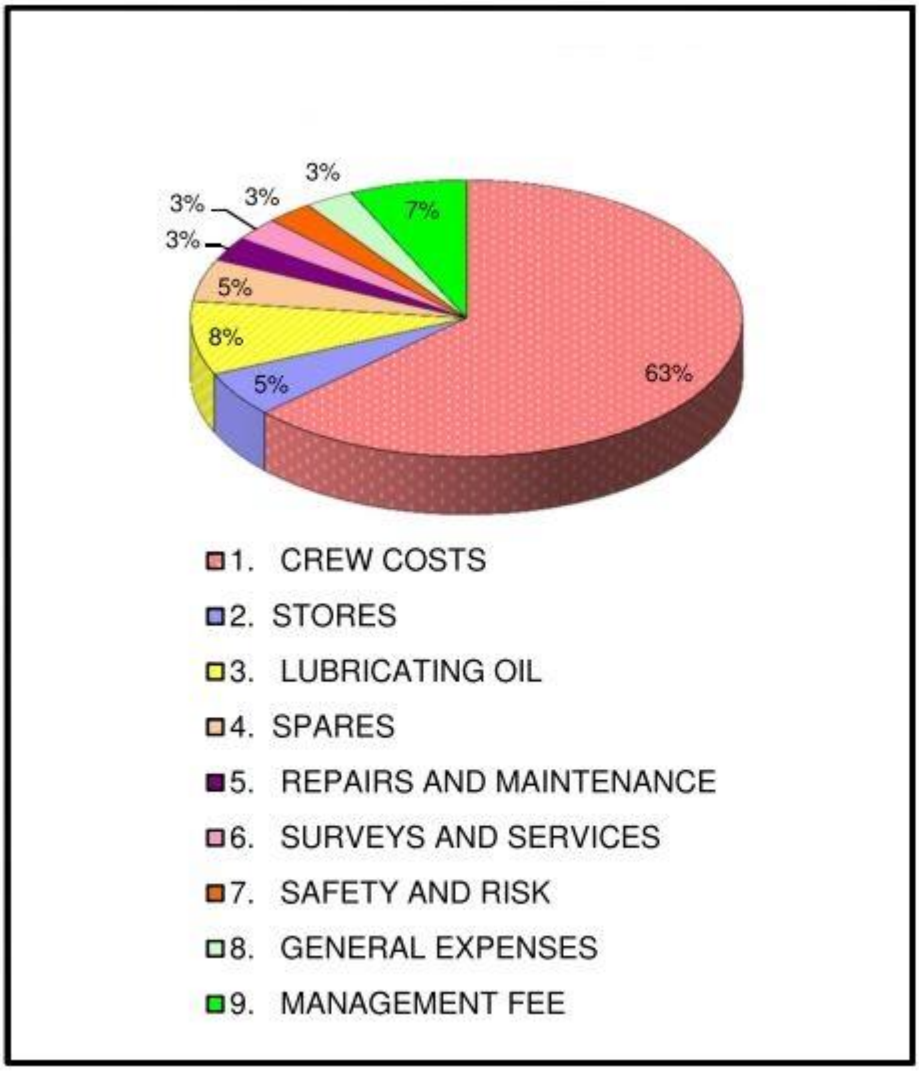

Figure 9: Operating costs of a Panamax Tanker, excluding CAPEX and Fuel Costs (Source: V.Ships Ltd., 2012)

An analysis of the whole life costs of a ship show a clear link between manning levels and total cost of ownership (Cartledge, 2001). The costs of manning a merchant vessel are a major driver of the total costs of ownership. Tyson Scofield (2006) mentioned that, “the cost of the ship’s crew is the largest expense incurred over the ship’s lifetime and this cost is largely determined by decisions made during concept design of a ship”.

Realising that the costs of manning have regularly been a major percentage of ship operating costs, one of the measures being considered to help reverse this trend has been the design, development, and operation of highly automated ships manned by reduced crews.

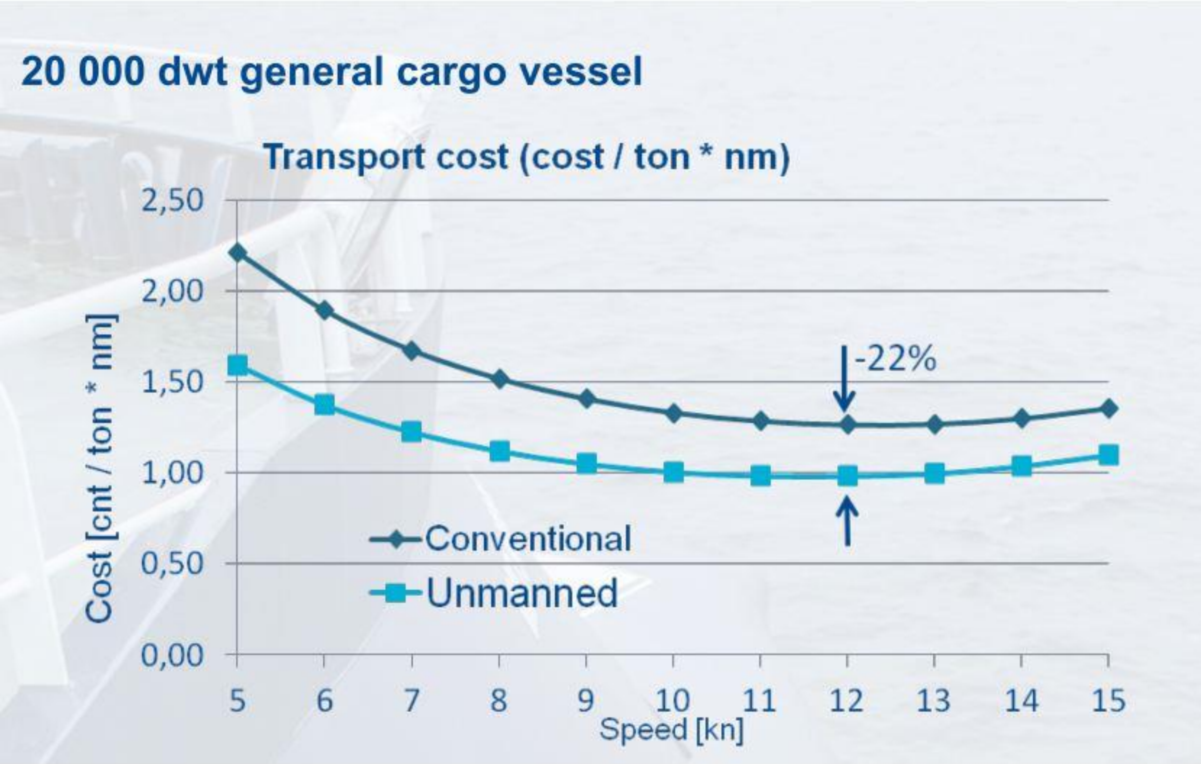

Figure 10: Cost Comparison Manned vs. Unmanned General Cargo Vessel. (Source: Levander & Jokioinen, 2016)

The rationale for such a measure, according to Harilaos Psaraftis (2014), is that; "under appropriate circumstances, the savings realized by a reduced payroll could, over the ship's lifetime, offset the additional capital cost of the automated ship, and hence make that ship more competitive than an equivalent conventional ship, even if the latter is manned by a low-salary crew".

3.3. FLAGGING OUT TO FLAGS OF CONVENIENCE

The attempt to reduce costs began during the 1980s crisis where vessel owners from traditional maritime countries, looking for cost-cutting survival strategies, flagged out their ships to "open registers" of one kind or another which allowed them to make large and immediate labour cost reductions (Jatau, 2002).

CHAPTER 3

Flagging Out is the process of registering a vessel in another foreign country, instead of the home country of the vessel owner. The foreign country is usually one which has lax labour regulations, hence the term *Flags of Convenience*. The countries mainly accountable for most of the flagging out taking place over recent years are countries such as Panama, Malta, Liberia, Cyprus and the Bahamas (Psaraftis, 2014). Such countries do not prioritise the adoption of high safety standards. Their decisions and regulations are mainly governed by vessel operators, owners and other commercial entities who stand to benefit from cutting the minimum manning of ships in order to reduce the cost of operation. Over a period of time, this tends to lead to fatalities which the industry can ill afford.

3.4. FLAGS OF CONVENIENCE

The greatest challenge with flags of convenience is that they have excessively lax regulations. The absence of strong regulation creates an environment where ship owners try to reduce costs by cutting corners, usually to the detriment of the personnel on-board the vessel. This practice leaves crews virtually defenceless and exposed to exploitation (Couper, 2000).

The development of *flags of convenience* has led to the creation of an international market for maritime labour in which the logic is a race to the lowest social denominator, where crew related expenses (salaries, social protection, training and recruitment) were primarily targeted in order to reduce the operating expenses of the ship (Jatau, 2002).

The relative advantages of lower manning costs are impermanent and will not finally save even the most cost-effective operator. The move offshore "not only led to the recruitment of large numbers of seafarers on account of lower costs but also resulted in a massive decline in nautical training and education in the traditional nations and a growing reliance on the under-resourced, inexperienced and poorly regulated training and educational colleges in the new labour-supply countries" (Jatau, 2002).

As a result, the skill shortages have ensured that the maritime sector has moved from an industry where ship officers were technically over-qualified for the ranks they held, to one where they are barely qualified to serve on-board merchant vessels. And since the quality of a ship's crew has a direct bearing on the ship's overall performance, this translates into loss of competitiveness (Hill & Michael, 1996). An incapable crew has the potential to raise operating costs by delaying maintenance, which may be exacerbated by rising labour or material costs (Button, Martin, Sollinger, & Tidwell, 2015).

3.5. DAWN OF THE SMART SHIP

The idea of remote controlled and autonomous vehicles is slowly becoming commonplace in the 21st century. Smart, telemetric technology is already adopted by various industry worldwide. Self-driving cars, remote operated vehicles (ROV's) and unmanned aerial systems (UAS) such as drones have removed the mystery from smart, autonomous vehicles, making them more acceptable in other industries as well.

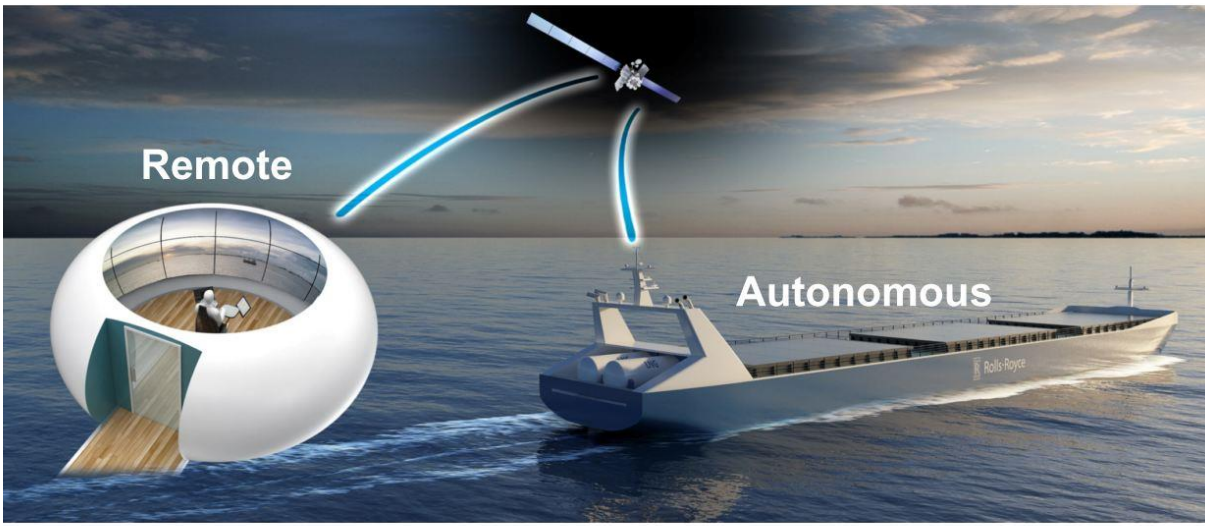

Figure 11: Illustration of Remote Vessel Operation (Source: Levander & Jokioinen, 2016)

The building and operation of such vessels is already possible with the technology we have today, and an unmanned, battery power container feeder vessel named "ReVolt" is already being tested and intended to serve as inspiration for the trajectory of smart shipping (Bertram, 2013).

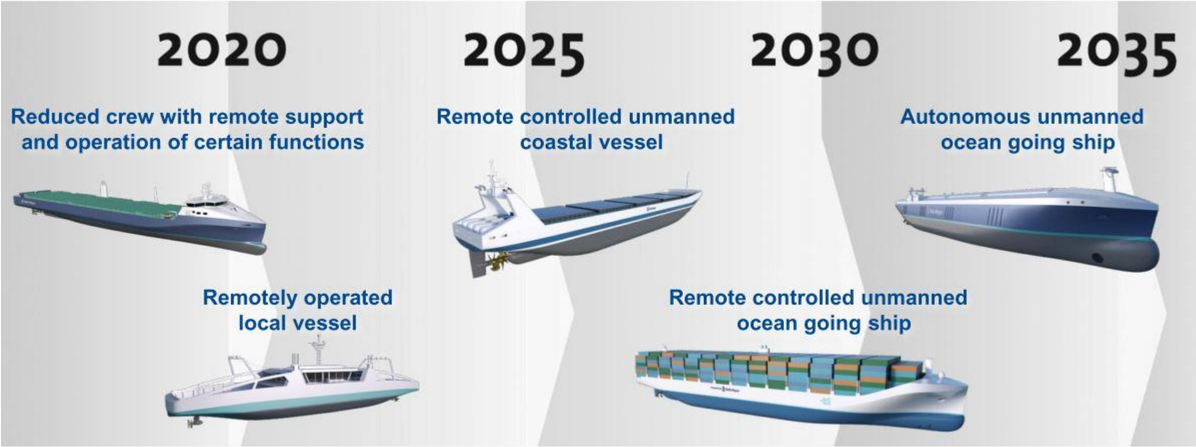

Figure 12: Roadmap for Smart Ships (Source: Levander & Jokioinen, 2016)

3.6. SMART SHIPS AND LOWER COSTS

With the advent of smart ships, labour costs, skills shortages, training, and other crew related costs will be rendered insignificant and negligible. Ship designers now have numerous options available to them to reduce ship manning requirements. These options include automation, changing maintenance philosophies, improving system reliabilities, revising crew training and others (Scofield, 2006). Remote-controlled and autonomous ships provide the best balance. Technologies such as satellite navigation, integrated ship control, voyage management, position fixing devices, automated docking and mooring, automated cargo handling, unmanned machinery room, planned maintenance, fault diagnosis and alarm handling, and others, receive a prominent focus on such ships (Psaraftis, 2014).

These technologies will drastically reduce the number of people on board a vessel, thus eliminating crew related expenses and enabling ships to remain competitive in the maritime shipping industry. A number of “ship of the future” projects have been launched in several countries with the aim of developing shipboard technologies that would ensure an efficient and safe ship operation while drastically reducing manning on board a vessel. A Danish project named “Project Skib” led to the development, design and subsequent operation of a series of four highly automated reefer ships of 21,680 m3 (765,650 ft3) capacity. These ships, owned by Danish ship owner J. Lauritzen A/S operate with a crew of nine, a significant decrease given that a conventional merchant vessel of similar size usually has a crew of 25 personnel (Psaraftis, 2014).

Smart ships are able to bring these changes in the industry because they exploit technology to improve labour productivity (Flemming, 1997). By utilising small operating crews, and being highly automated, smart ships combine the strengths of manned and autonomous crafts (Bertram, 2013), resulting in great efficiency and accuracy. It is essential that this new technology be proven sound and reliable.

Other advantages of smart ships include, reduced fuel consumption, higher cargo capacities per vessel, reduced personnel costs, fewer casualties, better working conditions and the prospect of a whole new branch of industry with thousands of potential jobs (Mauck, 2017). Smart ships, in essence, address multiple crew related problems simultaneously, particularly training and skills shortages.

Reduced number of shipboard personnel, maximum utilisation of crew skills, better working conditions, improved ship efficiency and safety, and reduced CAPEX make smart ships the omnipotent solution to runaway costs in the maritime industry (Levander & Jokioinen, 2016).

Smart ships and their technology have already proved to be able to reduce labour costs. Project ATOMOS (Advanced Technology to Optimize Manpower Onboard Ships) was a European Commission (Directorate General for Transport -DGVII) sponsored project to develop advanced shipboard technologies that would enable increased competitiveness of EU registered vessels, while maintaining sufficient safety levels. Over a broad sample of ships, ship types, and flags (all EU flags included), an ATOMOS-type ship manned by a crew of 10 is likely to realise significant lifetime cost savings over its equivalent conventional parent ship. This means that ATOMOS-type technologies are likely to significantly improve the competitiveness of these ships (Psaraftis, 2014).

This meant that ship owners in expensive EU flags such as Denmark and Germany would have the greatest (among other Community ship owners) economic incentive to invest in such technologies. The Net Present Value (NPV) of the savings they would realise over the lifetime of the ship would be the highest, among other EU ship owners. The same is true for other expensive flags, including other Scandinavian countries, Japan, and the United States. On the other hand, expert analysis has strongly indicated that it is mainly in lower-salary EU flags that ATOMOS-type ships have the greatest chance of beating the competition, that being conventional low-salary non-

EU ships. Since the lower-salary EU flags are the ones that are the closest to the foreign competition (in terms of cost), this brings them in a better position to close the "competitiveness gap" by crew reduction, given the gap is smaller for them than it is for higher-salary EU flags. (Psaraftis, 2014).

3.7. THE HUMAN ELEMENT

One of the subtle, but significant contributors to crew costs is human error. Human error often results in accidents and casualties, which often carry legal penalties, repair costs and, in some cases, civil claims. The 'human element' is well established and the analysis of major claims on Protection & Indemnity (P&I) clubs show that at least 50% of all claims under review are seen to have been a result of human error, although in certain types of incidents (collisions and groundings) the proportion is much higher (Hill & Michael, 1996).

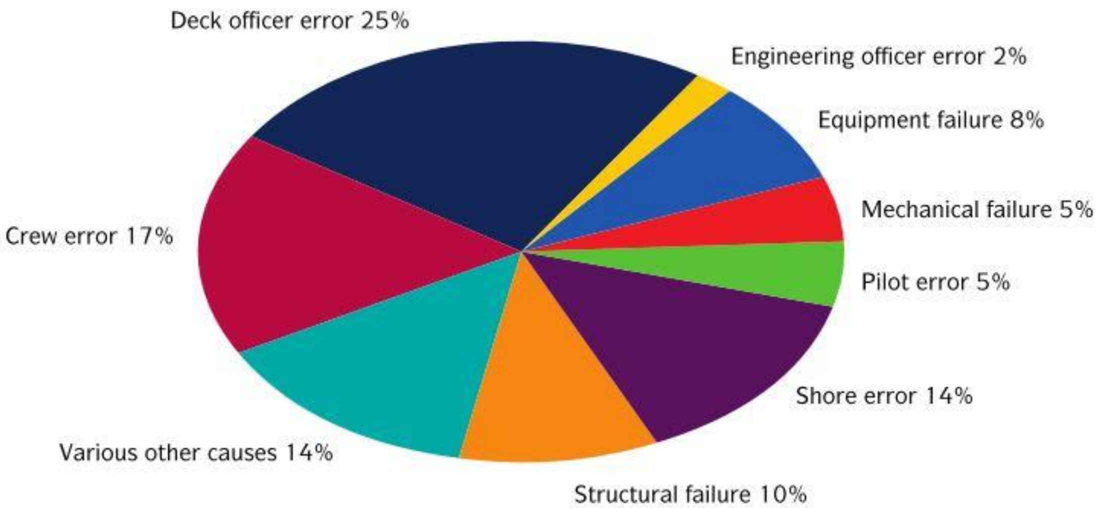

Figure 13: Main causes of major P&I claims (Source: Hill & Michael, 1996)

The term 'human element' is now generally used, but there are numerous constituent factors which are each worthy of separate consideration. Fatigue, for instance, certainly plays a substantial part in many maritime accidents. Ships are required to operate twenty four hours a day and so also are ships' crews (Hill & Michael, 1996). Other human factors such as morale, loyalty, motivation, training, experience, standards of certification, and environment, conditions of service, language and management policies also have implicit costs which cannot be quantified in monetary value.

In this regard, smart ships provide solutions to reduce ship life cycle cost. The elimination, or drastic reduction of on-board personnel mitigates the risks associated with the human element. Automation brings efficiencies that no amount of personnel training can yield, and when fully implemented on all available ships, billions of dollars will be saved over the long run in life cycle cost (Flemming, 1997).

However, operating a highly automated platform with a reduced complement gives rise to a new set of human factor challenges and risks. Operator workloads need to be carefully managed: a workload that is too high increases the rate of human error, especially in high stress situations: whereas too low a workload may lead to reduced situational awareness. Either extreme can have a negative effect. The successful implementation of ship automation systems can only be achieved by understanding the complex interactions between the human operator and the machine (Cartledge, 2001).

3.8. SKILLS SHORTAGES AND TRAINING COSTS

The flagging out of ships to low cost countries has led to a weakening of the maritime shipping industry in some traditional maritime countries like Denmark, Norway and the United Kingdom. Coupled with the associated decline in the numbers of seafarers from these countries, and the continuing pressure on ship owners and operators to contain manning costs, has led to ships that are undermanned, or manned by inadequately qualified ship officers. (Hill & Michael, 1996).

There is now a major international scarcity of qualified ship officers due to the fact that traditional maritime countries have not been recruiting and training sufficient numbers for these posts over the past decades. There are tensions on board many multi-national vessels leading to poor levels of maintenance, accidents and low morale. (Couper, 2000). Poor levels of maintenance and accidents are crew related expenses that increase the cost of shipping.

The continued decrease in the number of seafarers from the traditional maritime countries, and the continuing growth in world fleet translates into persistent undersupply of officers (V.Ships Ltd., 2012). The system cannot supply qualified and quality personnel, and demand for seafarers is so high that quality is now being regularly overlooked in the need to fulfil owners requirements (Jatau, 2002).

This has led to the IMO introducing new Standards of Training, Certification and Watchkeeping (STCW). This compels institutions to upgrade equipment to meet new STCW standards.

This leads to an increase in costs of training (for on-board training (OBT) and shore based facilities) as the industry needs to improve competency levels. (V.Ships Ltd., 2012). The costs are then transferred to shipping companies and this adds on to the overall manning costs of the vessel, adding cost pressures to an already bloated manning budget.

Smart ships, through the elimination or drastic reduction of shipboard personnel, have the potential to render the skills shortage problem irrelevant. A remote controlled or an autonomous ship does not require a full complement of crew, thereby easing the pressure of crew shortages. Another important ramification is that a highly skilled crew required to manage a smart ship will normally command a higher remuneration package than a conventional crew, however, due to the low numbers in which such a crew will be required, the training costs will be reduced.

3.9. CONCLUSION

Smart ships bring a plethora of solutions to the manning challenges currently faced by the marine industry. Labour-related costs constitute a significant percentage of ship's operating costs, and the reduction of shipboard personnel and optimisation of shipboard systems will yield significant cost savings. The salary bill, training costs, crew provisions, and travel and accommodation costs will be reduced as the number of personnel drops.

Smart ships also reduce the human element factor. This should, in theory, translate into 51% fewer accidents and claims against the shipping companies. Maintenance costs will also come down as maintenance will be planned and executed on schedule and within budget.

The implicit costs of the human element, such as fatigue, morale, experience, motivation, etc. will also be eliminated, thus bringing the overall life cycle costs of a merchant vessel down, making the smart ship a viable investment.

Overall, the fourth industrial revolution and the advent of the smart ship is going to improve the competitiveness of merchant shipping companies.

CHAPTER 4

4. APPLYING ENVIRONMENTAL SCANNING

4.1. INTRODUCTION

The previous chapter looked at various cost drivers in the merchant shipping industry, particular focus being paid to manning costs. The chapter also highlighted that manning costs do not only relate to salaries, training, accommodation and other crew related matters, but they also include costs that arise as a result of the human element in shipping, i.e. costs of human errors, etc.

The chapter also raised awareness on various methods companies currently use in attempt to curb and control costs of labour. These methods include flagging out, reducing manning on board, delaying maintenance, extending contracts of sea service for the crew and the recruitment of cheap labour from low cost countries such as China, Russia, India and the Philippines.

In effect, Chapter three answered secondary question number one (WHAT ARE THE CURRENT COSTS OF MANNING A SHIP?) and secondary question number two (IN WHICH WAY WILL SMART SHIPS AFFECT MANNING COSTS?). Consequently, we have thus uncovered that a) manning costs are difficult to accurately determine because they are often treated as a business secret (Počuča, 2006), and b) smart ships are going to lower the cost of manning because they reduce the number of people (in some cases, they completely eliminate the entire crew) on-board the vessel and they optimise vessel operations, helping keep costs down (Levander & Jokioinen, 2016).

This chapter is going to give an environmental scan of the current maritime shipping industry, looking at what is currently happening in the industry regarding technological advancement. A STEEP analysis will be performed to determine how these factors are affecting the industry, and what might happen in the future. From the foresight framework diagram (figure 6), this chapter will touch on Inputs, Analysis and Prospection, scanning the environment, determining trends and the effects of replacing the crew with smart technologies.

This chapter will seek to answer secondary question number three (WHAT EFFECT CAN WE FORESEE IN REPLACING CREW WITH SMART TECHNOLOGIES ON MERCHANT SHIPS?) and in doing so, set the foundation for chapter five to propose ways in which shipping companies can reassess their strategies and maintain competitiveness in the age of smart technologies and big data.

4.2. STEEP ANALYSIS

STEEP analysis is a commonly used tool for evaluating different macro environment factors that affect the operating environment and organisations. This tool enables organisations to evaluate external factors before a decision is made. A STEEP analysis is frequently undertaken by organisations trying to get an in-depth overview on what external factors determine the trends. It helps to predict what might happen in the future (Unknown, 2015). STEEP is an acronym for Social, Technological, Economical, Environmental, and Political.

4.3. APPLYING THE STEEP ANALYSIS

4.3.1. Social Factors:

Research by Livingstone Caesar and Stephen Cahoon (2015) has highlighted that one in ten officers leave the sea prematurely. This is driven by various social factors, primarily coming down to poor working conditions, stress and long contracts. The seafarer of today is very different to the seafarer of yesteryear. Whereas long service contracts were the norm in the 20th century, the seafarer of today is more concerned about their well-being, career progression and work-life balance.

The emergence of landslide career opportunities ashore, coupled with poor work conditions on board, limited opportunities for career progress at sea and the need for young officers to start and build families (Caesar et al., 2015) have led to many young seafarers leaving the sea. As a result, the ageing workforce and difficulties in recruiting seafarers with the right qualifications (Thai et al., 2013) has left the industry with severe shortages of personnel.

The shortage of skills has led to the globalisation of the skills market, creating other social problems along the way. The increasing use of multi-national crew on board has led to the effective disenfranchisement of many seafarers in terms of social and welfare protection. The apparent stereotypical assumptions made by seafarers about other nationalities, and the use of first languages by crews rather than a common language, creates suspicion among multi-national crews. This has resulted in tensions aboard many multi-national ships, leading to poor levels of maintenance, accidents and low morale (Couper, 2000).

This shortage of skills, which is only expected to get worse due to rising shipping volumes and increasing fleet sizes, has left the shipping industry posed with an imminent manning problem. The costs of manning a vessel constitute the second highest proportion, second only to fuel costs, and this is one of the factors that has forced shipping companies and ship builders to explore automation as a solution.

As a result of these social factors, the drive to automate vessels and control them remotely has increased, pushing companies to explore ways of minimising, if not eliminating the entire crew from the vessel.

4.3.2. Technological Factors:

The world is currently undergoing a major technological shift as the fourth industrial revolution is ushered in. The age of big data, increased bandwidth and astronomical computing power has enabled vast leaps in processing technology, thus enabling several industries to explore limits previously not thought of.

The fourth industrial revolution will change the way most industries function. Artificial intelligence, robotics and automation are bringing efficiencies that result in increased competitiveness through reduced operating costs, lower manning expenses, as well as improved efficiency. Adoption of these technologies is gaining traction as manufacturing industries, engineering, aviation, construction and healthcare sectors are all investing heavily (Lockwood et al., 2017).

Technology breakthroughs in the automotive, aviation and rail industries have brought vehicle autonomy to the brink of worldwide acceptance and the maritime is not much further behind. Battery and sensor technologies are developing rapidly, driven by demands across other industries and the advances made there are spilling over into the maritime sector. Whilst these technological developments are still in their infancy, costs and manufacturing processes will improve as processes, costs and accompanying safety concerns are resolved

Smart ships are a natural evolution of current merchant ships and other organisations throughout the world are developing complementary systems (infrastructure initiatives, autonomous ports and high bandwidth communications) to support unmanned operations (Lockwood et al., 2017).

The pace of development in other industries is helping to drive down costs, thus making smart ships a viable and credible solution to the problems currently plaguing the maritime industry. Data analytics and the Internet of Things are two examples of enabling technologies that can move shipping vessels towards being intelligent product.

Sensors are now able to monitor all the significant operating parameters of a vessel, including weather conditions, ship draft, speed and navigation route, to achieve maximum energy efficiency through the selection of optimum settings. These developments are forcing the maritime industry to adapt to these new technologies, thus enabling smart ships to be born.

4.3.3. Economic Factors:

The economics of running a ship business and the changing competitive landscape are putting pressures on shipping companies to find alternative ways to attain a competitive advantage. Fuel prices, LO prices, crew wages and training costs among other things, are pushing industry players to become innovative in how they run their businesses.

Seaborne trade is still predicted to double by year 2030 (World Maritime News, 2017). The demand will largely be driven by emerging markets (Mangan, 2017). The result of this economic boom will be an increased number of ships in service, thus leading to an increase in demand of seafarers. Supply of seafarers, however, is expected to lag demand and this will create problems in that salaries will need to increase as companies poach seafarers from one another. This will only add to the existing costs.

Vessel manning is a major driver of total ownership costs. The total costs associated with the vessel’s crewing requirements are the biggest expenses incurred over the life of a vessel, and these costs are mainly determined by decisions taken during the concept design stage (Scofield, 2006). This, together with fuel costs make the biggest cost drivers of a shipping company, and shipping companies are constantly looking for ways to reduce these costs.

The expected rise in shipping trade, increased vessel fleet, accompanied by increasing labour and fuel costs are all economic factors that make a compelling case for the maritime industry to explore alternative technologies to enable a viable business model.

Smart ships propose a variety of solutions which include reduced number of crew members, increased energy efficiency, reduced fuel consumption, and generally low running costs. This makes for a compelling economic case and it enables industry players to realise huge cost savings, which ultimately result in gaining a competitive advantage in the marketplace.

4.3.4. Environmental Factors:

The maritime shipping industry, like many other polluting industries in the world, is currently endeavouring on initiatives to decrease greenhouse gas emissions. Although the shipping industry is moving more slowly compared to other industries, largely as a result of the slow pace of change that besets worldwide regulation and governance of the sector, emission control areas and other pan-national agreements are slowly coming into force. Many of the green shipping initiatives complement those around smart shipping. Developments include measures to lower emissions, enhance fuel efficiency and develop alternative energy sources, to reduce noise and quantify the carbon footprint of the maritime shipping industry (Mangan, 2017).

With higher cargo volumes being shipped over growing distances, there is an increasing awareness regarding the impact the shipping industry has on the environment. Consequently, numerous international maritime regulations have been made in order to reduce emissions and improve the environmental performance of new and existing ships (Jiang, Kronbak, & Christensen, 2010). This has put pressure on the shipping industry to reduce energy usage and emissions.

Newly built vessels must now meet more stringent environmental standards, have less emissions, higher energy efficiency, with higher standards of equipment, and greater levels of automation (Cahoon, 2008). This puts emphasis on improved energy efficiency and optimised ship design, meaning automated simulations in ship design and manufacturing will continue to be touted as a vital enablers in assisting the maritime industry in meeting new challenges (Ang et al., 2017).

Energy management by information technology has become important future direction of development. Ship systems should be optimised in a design stage for service in order to achieve minimum energy usage and emissions in fleet and individual ships. This entails minimising its own weight and resistance to waves and ice (hull surface and shape, propulsion systems); enhancing energy production systems (diesel engines, fuel cells, nuclear); storage (fuels, batteries etc.) and recovery systems; improving waste material treatment and recycling on and off-board; and by reducing NOX, SOX and CO2. (Ministry of Economic Affairs and Employment of Finland, 2017).

These environmental factors have pushed the industry towards smart ships as the technology enables these vessels to be designed and manufactured with environmental consciousness as one of the top priorities. Smart ships bring reduced emissions and smart energy management.

4.3.5. Political Factors:

The current slowdown in globalisation, caused in part by BREXIT and the new agenda from the United States Administration (Lockwood et al., 2017), and growing protectionism in the developed world is threatening the global labour market the maritime industry relies on. This volatility in global politics is also wreaking havoc in global oil prices, creating uncertainty in fuel costs, one of the most significant cost drivers in shipping.

This, in turn, is forcing companies to look at automation as a means of securing the integrity of their operations. However, automation has its own challenges, particularly for the developing world where jobs are needed to keep economies growing. This poses potential threats from governments and organised labour in the developing world.

There are other complexities in legislation and regulations since a ship's sea passage is covered by a variety of private, national and international legal frameworks. Even more complicating is the fact that, maritime law does not anticipate the development of remote or autonomous ships. This presents many uncertainties. For example, does a ship's master or crew necessarily have to be on board the ship? (Rolls-Royce, 2016).

Another important issue is that present regulations in respect of manning in the international STCW Convention (Standards of Training, Certification and

Watchkeeping) must be entirely changed, which may create important protests from the side of trade unions (Naukowe & Warszawskiej, 2016).

Smart ships have the potential to transcend most of the political and legislative challenges currently in the global maritime space. An example being that a crewless ship will effectively operate under less regulations (SOLAS, COSWOP and STCW will have less impact) thus enabling the ships to operate at a lower cost.

The STEEP analysis reveals that, present macro environmental factors support the advent of smart ships due to the advantages such ships bring into the maritime industry.

4.4. TRENDS IN MARITIME

Autonomous systems, and the adoption thereof, are accelerating so quickly that there is now an increased possibility for the delivery of sound and credible solutions within the next couple of years. Powered by the range of capabilities and adjacent technologies emerging from consumer and commercial markets, artificial intelligence, robotics and automation are already changing a lot of industries. The economic advantages to be gained are driving implementation of autonomous systems (Lockwood et al., 2017).

There is already an increasing number of small-scale, autonomous ships in operation across an extensive range of applications, including naval operations, ocean sciences, surveying and exploration. These autonomous ships, operated in small fleets, are now routinely employed worldwide.

There are, currently, four strong trends that are influencing technological advancements in smart ship technology, and these trends can be categorically classed under; Artificial Intelligence (A.I), Sensors and Situational Awareness, Connectivity and Energy Management and Sustainability.

Artificial intelligence is a term used to define entwined technologies which are expected, in this case, to revolutionise maritime operations and strengthen autonomous systems. *Sensors and situational awareness* refers to technologies that enable, and are critical to the operation of autonomous systems. They create the required levels of situational awareness for the safe operation of autonomous systems. *Connectivity* entails developments in communication and information exchange systems, which will provide a catalyst for the future by enabling the digitization of the maritime environment, and Energy management and sustainability refers to better utilisation of clean energy sources and optimising efficiencies (Lockwood et al., 2017).

Artificial Intelligence:

According to Microsoft's Cortina, Artificial Intelligence (AI) is defined as the simulation of human intelligence processes by machines, especially computer systems. AI is an important enabler for smart technologies and intelligent systems, enabling systems to establish direct communication with people, in a natural, human-like way (Konstantinidis, 2017). It enables machines to assume roles and perform complex tasks that were previously only thought humans can do, and in the course of doing so, is solving problems in novel ways.

The ever-increasing computing power, connectivity, as well as voice and image recognition technologies are key enablers for Artificial Intelligence. It offers the ability to accelerate analysis and fast-track decision making processes in an efficiency that far exceeds that of people. AI is presently undergoing accelerated evolution, driven by investments from almost every major industry vendor, including Apple, Amazon, Microsoft and Alphabet Inc. The trend is set continue, but companies looking to adopt the technology and exploit the potential opportunities should be cautious of the challenges of AI. Artificial Intelligence, still in its infancy, is facing a number of obstacles not certainly related to technology, but more to people-centred issues, such as regulations, trust, ethics and privacy (Lockwood et al., 2017).

Sensors and Situational Awareness:

The rise in computing power has resulted in the development of powerful sensors that generate digital information about equipment and the ship (Stopford, 2015). These sensors enable computers and AI on board the ship to 'sense' what is happening around the ship and adjust the course of action in accordance to what it notices. The information from these sensors is decoded and interpreted by software programmes that recognise elements in the surroundings, which then interpret a situation and can take necessary action (Blanke et al., 2017). Sensors are therefore fundamental to autonomous systems.

Sensors currently available on board are mainly for navigation and collision avoidance. Autonomous systems, however, will also have to monitor location and heading, along with other vital information about the surrounding environment, so that the vessel can manoeuvre to its intended position without colliding or inflicting damage to itself or others. "Unmanned ships will be more efficient, reduce emissions and operate at lower cost, but this will require effective integration of sensors with improved decision-making algorithms. Modern sensing techniques and sensor technology are developing at pace, predominantly in the consumer tech market" (Lockwood et al., 2017).

Terminology related to automatic steering, remote operation, remote monitoring and autonomy	
Manual navigation of merchant ships	The navigating officer gives the command for the wanted course and speed, either to a helmsman or as an autopilot setting and for bridge navigation of the ship's main engine. The navigating officer has electronic charts and own position and course. A radar system shows other ships' course and speed.
Automatic course steering	Course steering takes place between encoded positions; the ship's autopilot ensures that the ship goes from position A to B.
Decision-support	Decision-support consists in planning a route and speed profile in order to reach a port at a given time with a prediction of the sea and wind conditions underway. More extensive decision-support could consist in guidance for the navigating officer about the performance of an evasive action in narrow waters.
Remotely operated navigation	Remote operation is used about the possibility of remotely operating a point for the autopilot and the effect on the propulsion machinery.
Remote monitoring	Measured values from sensors in, for example machinery spaces, on course and speed are shown in real time in an operation centre ashore or on board another vessel. Full monitoring includes transmission of TV monitoring and radar picture so that the operation centre has sufficient information about the ship and its surroundings to be able to perform remotely-operated navigation.
Partial autonomy	The ship has systems for assessing the situation as well as the consequences and advising the navigating officer about how to react. The navigating officer is not necessarily present on the ship's bridge in person.
Full autonomy	The situation is perceived and assessed and a decision on which action to take is made without any intervention by human beings.

Figure 14: Levels of autonomy for Ships (Blanke et al., 2017)

The miniaturisation of electronic components is "being driven by everything from wearable technology and handhelds to the Internet of Things (IoT). Adjacent to this is that smaller components are more energy-efficient than larger ones, and the development of wireless sensors and ubiquitous connectivity enables a continuous flow of data" (Lockwood et al., 2017).

CHAPTER 4

Connectivity:

The evolution of telecommunication networks is heralding a new age of fast connectivity in the maritime space. Maritime surface communications technologies have normally been characterised by: Ship to near ship/shore communication using MF/VHF (Medium Frequency/Very High Frequency) radio, and ship to far ship/shore communication using HF (High Frequency) and SATCOM (satellite communications). These communications channels are usually for voice communications, electronic navigation, identification systems, security alerting and distress and safety systems.

More recently, the maritime industry has started using newer technologies for general maritime communications. Commercial cellular 3G/4G networks and advances in SATCOM technology, together with lower operating costs, have made it possible for high value platforms to deliver high data rates (Lockwood et al., 2017).

It is assessed that smart ships at sea may create as large amount of data as 60 GB per day. In spite of the fact that processing the data on board can considerably reduce the amount of data that need to be transmitted to shore station, this amount still remains big. However it was actually shown that processing and transmitting this amount data could be done as cheaply as 1$ per day (Naukowe & Warszawskiej, 2016).

Maritime communication systems are experiencing a steep increase in technical capabilities. The VHF Data Exchange System (VDES) will increase the throughput and reliability of data services for critical ship systems across all modes of off-ship communications. Unmanned and autonomous vessels will heavily depend on numerous different layers of networks and connectivity in the future; starting with on-board network of sensors and actuators required to monitor and control the ships, these will form an extension of the Internet of Things (Lockwood et al., 2017).

All this has led to the development of the concept; *Internet of Ships* (an integration of IoT in the shipbuilding sector). As a result of high data rates and low data costs, ship owners can monitor the vessel’s status in real time and apply analytics to current and historical data to make decisions that enable them to run more efficiently, saving time and fuel. Sensors and IT technologies are facilitating the introduction of new applications at sea, like energy distribution, water control and treatment, equipment monitoring in real time (Liu et al., 2016).

Smart ships will still need human input from a shore-based station, making connectivity between the vessel and shore-based personnel ever more critical. Such communications will need to be two-way (ship to shore, and shore to ship), be precise, scalable and supported by numerous other systems – creating redundancy and minimising risk. Adequate communications link capacity for ship sensor monitoring and remote control, will have to be guaranteed (Rolls-Royce, 2016).

Energy Management and Sustainability:

Energy management encompasses the entire energy value chain, from exploiting energy sources, through to energy conversion, storage and delivery in a coherent and structured energy architecture and in management systems, maximising the efficient and flexible use of energy. Whilst non-renewable energy sources like fossil fuels still make up a sizeable majority of our current energy requirements, there is a growing shift towards renewable energy sources that are constantly being replenished, such as sunlight, wind, and water. At the same time, sustainability technologies are "attracting more interest as they can improve the efficiency of energy management and enable businesses to be more environmentally friendly" (Lockwood et al., 2017).

In the maritime industry, however, such trends are presenting enormous challenges given that the energy demands of modern ships are ever-increasing. This has sparked great interest in *All Electric Ships* (AES), which are expected to create a paradigm shift in the management of energy whilst also minimising pollution of the atmosphere and creating lower carbon dioxide (CO_2) emissions to improve sustainability (Lockwood et al., 2017). As attention shifts towards artificial intelligence, robotics and autonomous systems, which are anticipated to fully operate with minimal human intervention, the critical area of concern will shift towards energy management and optimisation.

One other key challenge facing the maritime industry is the issue of the environment and sustainability. The current drive towards cleaner and sustainable sources of energy has become a joint crusade across all industries. The maritime shipping industry is a significant contributor of global carbon dioxide emissions (4% CO_2, 10 - 15% NOx and 5 - 9% SOx). Therefore, for autonomous platforms, sustainability technologies and efficient energy management are a vital area of consideration (Lockwood et al., 2017).

The maritime industry is already exploiting new and innovative energy management and sustainability solutions in smaller ships, however, it is more challenging to determine how bigger ships will compare over the next couple of years, especially as autonomous systems begin to permit greater design flexibility for vessels as a result of reductions or elimination of personnel on-board ships.

Smart, innovative energy management systems can systematically monitor energy usage and complement energy usage through a mixture of batteries and renewable energy sources. Through the use of automated simulations, energy consumption can be optimised by altering operation schedules and providing an estimation of energy usage (Ang et al., 2017).

As the industry moves towards all-electric platforms, and all-electric ships in particular, a critical area of concern is battery technology and the storage of energy. Driven by demand across other industries, battery technology is developing very rapidly as numerous electrical solutions gain prominence. Recent developments include aluminium-ion, lithium-air and lithium-sulphur. As these technologies are still in their initial development stages, they are not yet commercially available. However, as costs decline and manufacturing processes improve, these battery types may prove to be revolutionary for the maritime industry.

The supercapacitor, alternatively termed the ‘ultracapacitor’, is another emerging technology that seeks to compete, or even compliment, battery technologies. A supercapacitor is similar an ordinary capacitor, however, it stores a substantially large amount of electrical charge, and unlike batteries, supercapacitors charge almost instantly. It is highly likely that supercapacitors will be used far more frequently in future, especially if there is a need to store and release large amounts of electricity very quickly. Given the opportunities presented by autonomous and unmanned platforms in terms of design and self-sustainment, “it is difficult to predict what strange and revolutionary energy management ideas might appear in the future” (Lockwood et al., 2017).

CHAPTER 4

4.5. PROSPECTION: SHIPS OF TOMORROW

Present estimates indicate that remotely operated short-sea vessels (those operating along the coast) will enter service within the next couple of years, followed closely by unmanned ocean-going vessels thereafter. This will have substantial implications on the nature of work in the maritime industry, as well as on the people who will be doing the work in the future because the Fourth Industrial Revolution is going to be a force that reshapes all industries.

Autonomous systems, along with increased digital connectivity, are poised to completely change the maritime shipping industry. Unmanned ships are currently under development, and some of the autonomous and robotics systems now in operation have already made it possible to explore the most extreme oceanic environments. These changes will have a strong impact, not only in the maritime space, but also across related industries; for instance, environmental challenges are forcing shipping companies to explore alternative logistic models that reduce road haulage in favour of autonomous coastal shipping (Lockwood et al., 2017).

The change of pace in the maritime industry is also driven by availability and cost of labour. The scarcity of skilled people, particularly suitably qualified officers, has resulted in an accelerated shift towards unmanned and autonomous vessels. In addition to environmental concerns, safety is another driving element underpinned by the need to remove the human operator from dangerous work environments, i.e. subsea oil and gas operations, as well as mine clearance operations.

The technology of the future will enhance the vessel's ability to monitor its own health, scan its own surroundings and make effective decisions based on that information and this is critical to the development of autonomous systems. Sensor fusion and control algorithms enable navigation and collision avoidance, which will be substantially significant for remote and autonomous vessels, allowing them to decide which action is suitable in the light of sensory information received. The decision algorithms behind this process still need to be perfected as it requires an interpretation of maritime rules and regulations. This results in interpretation challenges for the programmer (Rolls-Royce, 2016).

New communication technologies will integrate with existing technologies in optimal ways to enable autonomous ship control. Satellite communications will link with land based systems. The operation of remote and autonomous vessels still needs to be as safe as that of existing vessels if they are to secure support and approval from regulators, seafarers, ship owners and operators, as well as the wider public.

As is evident, unmanned and autonomous vessels have the potential to drastically decrease, if not eliminate, human-related errors; but at the same time, they may amend some risks already in existence, or create new types of risks altogether. Cyber security will be critical to the safe and successful operation of remote and autonomous vessels as these vessels will be vulnerable to cyber terrorism. This scenario needs to be explored, together with possible remedies. The maritime industry has experience on systematic and comprehensive risk assessments, however, when new and emerging technologies are concerned, new knowledge, wider and deeper understanding of new and changed risks is needed (Rolls-Royce, 2016).

4.6. CONCLUSION

Cost-saving and business efficiencies have primarily driven emerging autonomous technologies. Technological changes have, instead of enhancing people in the workplace, increasingly focused on substituting the human operator in effort to drive down costs of labour. The social and economic implications of this reality paint a picture of extreme change with a radical alteration of labour markets and new operating models. Shipboard systems and equipment will, in future, be more dynamic, evolving and flexible to meet emerging technologies. Interactions with smart, autonomous systems will be normal. The nature of most shipboard roles will change, most of which will move ashore. It is anticipated that these developments will, ultimately, increase profitability.

This is against a backdrop of a global shifts in both maritime trade and technological development from West to East. Early indications seem to suggest that we are completely unprepared for the social, economic and political disruption that is about to unfold in the era of artificial intelligence and autonomous systems. Opportunities will favour individuals, companies and countries that adapt quickly to skill and industry obsolescence. It will be essential to fundamentally re-examine the role of the contemporary seafarer (Lockwood et al., 2017).

A scarcity of competent and suitably qualified seafarers to operate the increasingly complex and sophisticated merchant ships is a challenge to the maritime industry; first-class marine engineering officers will be in high demand as stringent emission control regulations require vessels to burn lighter fuels in sophisticated new engine designs (International Association of Maritime Universities, 2015). Skills development programmes will need to focus on producing highly skilled officers to operate these smart ships. Deliberations within the maritime shipping industry have identified numerous direct and indirect cost-reduction benefits. Direct benefits at ship level are frequently listed as; effective and efficient use of on-board crew and their skills, more efficient use of space in ship design and increased fuel economy. Indirect benefits occur at company and network levels in the shipping industry (Rolls-Royce, 2016).

Remote and autonomous shipping allows for enhanced optimisation of processes and operations. For instance, optimising processes and operations based on real-time data enables economies of scale at fleet and company level, whilst also decreasing or eliminating the probability of human error, thus contributing both to safety and service quality. Software systems are able to intelligently and effectively manage the electrical/electronic hardware on-board, thus allowing a sophisticated and real-time perception of the situation and a ready management of breakdowns, emergencies, energy peaks, etc.(Agnello, Cossentino, Simone, & Sabatucci, 2017). In the context of the maritime shipping industry, autonomous shipping will recast the roles and reorganise the division of work. All this will reduce (and in some case even eliminate) risks to personnel and the environment, whilst increasing safety of the crew.

Reduced risk and increased safety also leads to changes in insurance cover and insurance premiums, translating to more savings for the operators and increased profitability.

Apart from the impact on shipping, remote controlled and autonomous vessels will also have an impact on maritime resources and management. This transition will not only affect technology-related operations, but it will also lead to extensive changes to the business model of all stakeholders in the maritime shipping industry. New competencies will be mandatory and some stakeholders in the industry will likely find their roles changed. The logistic chains of major global companies are likely to become increasingly integrated and flexible, utilising fleets in more optimal ways. Smart ships are expected to reduce operational costs by 40% and increase vessel productivity by 200% (Sea Machines Robotics Inc, 2017).

Efforts have to be made at all regulatory levels in order to enable the realisation of remote-controlled and autonomous shipping. Whilst the International Maritime Organisation considers appropriate rule changes, the legal challenges of constructing and operating a demonstration vessel at national levels will need to be explored. Questions of accountability for autonomous vessels are subject to different regulations set out by different nations, but it largely seems there is less need for regulatory change in this area. What needs to be explored, however, is to what extent other liability rules, such as product liability, would affect traditional rules of maritime liability and insurance in the field of autonomous shipping (Rolls-Royce, 2016).

CHAPTER 5

5. RECOMMENDATIONS AND CONCLUSIONS

5.1. INTRODUCTION

In chapter four, an environmental scanning process of the maritime industry was undertaken to determine what is currently happening in the industry regarding technological advancement. A STEEP analysis was performed, looking at how Social, Technological, Economic, Environmental and Political factors were shaping the future of the maritime industry.

The chapter also looked at trends that were unfolding in the industry, and how these trends were pushing the industry to adopt smart ships as the answer to prevalent challenges. Artificial Intelligence, Sensors and Situational Awareness, Connectivity and Energy Management were identified as strong trends that were shaping the industry, and were acting as change accelerators for the adoption of smart ships. The chapter looked at ships of tomorrow and effectively answered research question number three; WHAT EFFECT CAN WE FORESEE IN REPLACING CREW WITH SMART TECHNOLOGIES ON MERCHANT SHIPS?

In chapter five, the study is going to conclude and close the research questions and give recommendations on the strategies shipping companies can use to remain competitive in the digital age of digital technologies and smart ships. The chapter will also highlight the limitations of the study, and identify areas for future research on the fourth industrial revolution and the maritime industry.

5.2. INDUSTRY 4.0 AND COSTS

The maritime industry, like any other industry, has benefitted greatly from the introduction of new technologies. The industry was once, “as labour intensive as it was capital intensive and there were millions of workers who provided services in and around the port. The Longshoremen were arranged in gangs and had strong labour union support. With strikes often taking place, even higher shipping costs were incurred and the ability of the industry to provide a reliable service was often called into question” (Gounaris, 2014). The third industrial revolution brought technologies that changed the competitive landscape and enabled the shipping industry to dramatically reduce the labour intensity of the business.

CHAPTER 5

An analysis of the whole life costs of a ship by Cartledge (2001) shows a link between manning levels and total cost of ownership. An analysis of total ownership costs of a ship show the costs of manning as a major driver of the costs. Tyson Scofield (2006) mentioned that “the cost of the ship’s crew is the largest expense incurred over the ship’s lifetime and this cost is largely determined by decisions made during concept design of a ship”, therefore a viable solution would be the design, development, and operation of highly automated merchant vessels operated by reduced crews.

The fourth industrial revolution promises this solution. It is now on the verge of changing the competitive landscape by, among other disruptions, drastically reducing (if not eliminate) humans from the operation. The development of smart, autonomous vessels will enable shipping companies to benefit from lower operational costs compared to conventional vessels, due to reductions in manning expenses, risks associated with human error, and threats to crew safety (Longva, Anand, Balland, & Brandsæte, 2014).

On board maintenance is another crew-related area that piles on the costs of manning a vessel. Poor maintenance, breakdowns and even planned maintenance contribute to downtime and consumption of spare parts.

Smart ships bring smart maintenance systems which enable ship owners and operators to reduce the number and frequency of repairs and maintenance. Predictive maintenance algorithms will enable operators to anticipate and repair damaged and worn parts with minimal resources and interruption. Real-time access to the vessel’s current maintenance status and future maintenance schedules will enable on-board personnel to have a more detailed and accurate picture on system capabilities, allowing for well-timed action to increase reliability, safety and efficiency, whilst reducing costs (Longva et al., 2014).

And given the prevalent issue of skilled labour shortages in the maritime industry, characterised by seafarers leaving the profession, smart ships may be necessary to keep up transport capacity in a time when seafarers are leaving the industry in large numbers (Porathe, 2016). Therefore, cost reductions, safety gains, crew shortages and emission regulations make for a compelling case in favour of smart ships.

5.3. MARKET READINESS

Most of the important ports of the world today were constructed during the industrial revolution in the 19th century. These ports have since been upgraded, expanded and modernised, with the advent of containerisation. Further capacity augmentation took place as a direct result of globalisation and the Information Technology revolution. It also led to deeper penetration of hinterlands, particularly in China, US and Western Europe (Gujar & Yan, 2013).

Presently, ports are having to expand and modernise in order to accommodate the incoming wave of smart ships in the marketplace. Digitalization of port activities where new services either replace or augment traditional port services is already taking place is already taking place, with ports such as Busan, Singapore, Shenzhen, Los Angeles, Felixstowe, Hamburg and Antwerp leading the smart ports initiative (Fiedler, 2017).

The Qingqao New Qianwan Container Terminal became the first port in asia to be fully automated on May 11, 2017 (Port Technology, 2017). This will soon be followed by the Taus mega port in Singapore. The Tuas mega port, slated to open in phases from 2021, and will incorporate smart and green technologies into its operations (Kaur, n.d.).

Given that the most optimistic observers expect the International Maritime Organization to complete legislation governing smart ships by 2028 (World Maritime News, 2017), it appears ports will be ready to receive smart ships long before smart ships gain mass adoption. This bodes well for market readiness, meaning that infrastructure will be in place when smart ships are full adopted.

Vessel operators, in their effort to reduce operating costs, offset the effect of increased fuel prices and regain competitiveness, had no option but to further increase the size of their vessels despite the fact that only a few ports in the world had capabilities to berth them (Gujar & Yan, 2013). This means that not all ports will have to be smart ports, but rather, only the ports that carry the most volumes and traffic, hence the race to full automation is dominated by ports from the largest economic regions i.e. US, Europe and Far East. This race is fuelled by the quest for; operational excellence, migrating activities (challenging external market) and new business opportunities (Berns, Vonck, Dickson, & Dragt, 2017).

Looking into the future one can discern the blurred outlines of the smart ports of tomorrow. They will be highly integrated, multi-role, multi-national entities. It would also be logical to state that "such ports would prefer to interact with similar ports in different regions in order to create synergies for the benefits of their customers, rather than with the old inefficient behemoths" (Gujar & Yan, 2013).

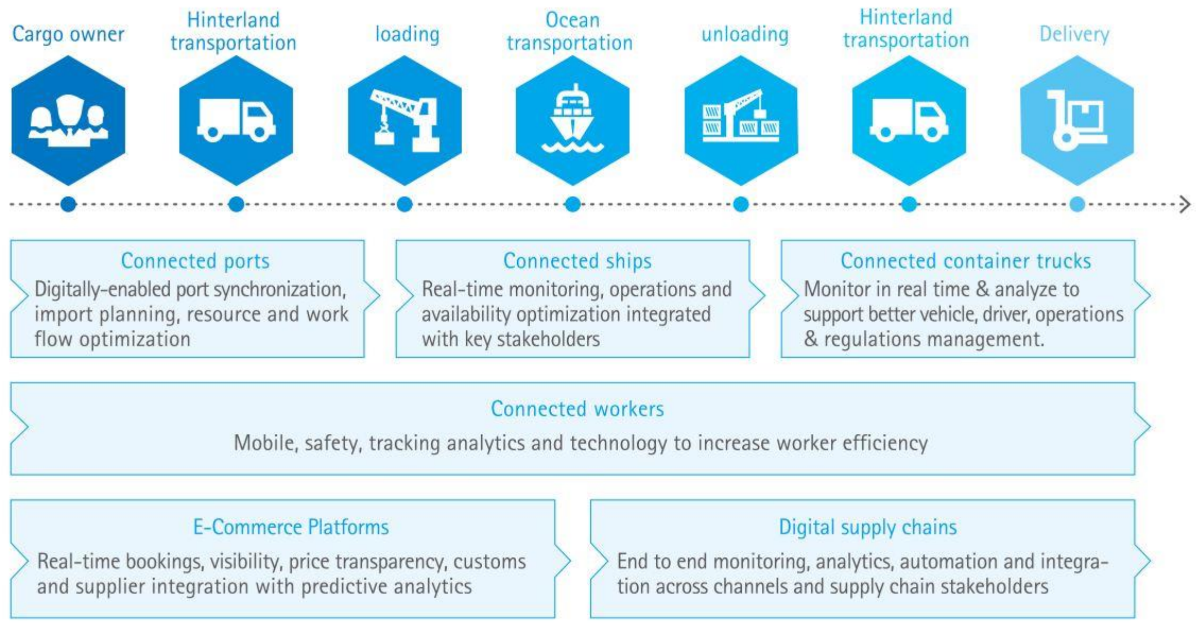

Figure 15 Digitization of the maritime transport chain (Xuyuan & Jun, n.d.)

Consequently, every port will strive to be a smart port in order to realise the same efficiencies enjoyed by smart ports.

5.4. LEVEL OF AUTOMATION AND IMPLEMENTATION

5.4.1. Level of automation

Lloyds Register (the oldest and one of the biggest classification societies in the maritime industry) has established automation levels for the maritime industry. The register applies a range of seven different levels of autonomy for unmanned vessels (Mauck, 2017). These are differentiated as follows:

AL 0: Manual – no autonomous functions. All actions and decisions are taken manually by a human operator who controls all actions at the ship level. Some systems on board may have a level of autonomy, with ‘human in/on the loop’; for example, 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 system can present options or otherwise influence the actions chosen; for example, voyage and route planning.

AL 2: On and off-ship decision support: All actions at the ship level are taken by human operator on board the vessel, but decision support tools and systems can present options or otherwise influence the actions chosen. Data may be provided by systems on or off the ship; for example, Original Equipment Manufacturer (OEM) configuration recommendations, weather routing, etc.

AL 3: ‘Active’ human in the loop: Action and decision-making at ship level is performed autonomously with human supervision. High impact decisions are implemented in a way that gives the human operators an opportunity to intercede and over-ride them. Data may be provided by systems on-board the ship, or from a shore station.

AL 4: Human in the loop - operator/supervisory: Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way that gives human operators the opportunity to intercede and over-ride them.
AL 5: Fully autonomous: Unsupervised or rarely supervised operations where actions and decisions are made 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.

It is unlikely that automation will completely eliminate crew on-board smart ships. Smart ships will mostly fall in the AL 3 and AL 4 category, which means smart ships will be autonomous, but with a small crew on-board for inspections and emergency operations. Therefore, smart ships will likely reduce manning costs and not completely eliminate them as there will exists a need for higher skill levels in the maritime industry.

5.4.2. Implementation

The first, experimental, autonomous ship is expected to enter service sometime in 2019. The YARA Birkeland, initially operating as a manned vessel, will move to remote operation in 2019 and in full autonomous operation by 2020. This new zero-emission vessel will be a game-changer for global maritime transport, contributing to meet the UN sustainability goals. Unmanned coastal vessels are expected to enter service in 2025 and unmanned ocean-going vessels to enter service in 2030 and beyond (Rolls-Royce, 2016).

Therefore, the introduction of smart ships will be phased-in and uptake will be owner-dependent, based on needs and prevailing market conditions.

5.5. CHALLENGES

Challenges facing the introduction of smart ships are mainly labour, legislation and emotional barriers. There is a severe shortage of skills in the industry, however, organised labour is still strong. Therefore, organised labour would likely resist phased-in introduction of smart ships. Legislations is currently lagging behind industry developments and emotional barriers will also pose a challenge.

Smart ships may create great challenge to the current maritime law. It appears that commercial operation of unmanned or remotely controlled ships will require amending almost all international conventions related to marine transport. In all legal instruments "ship" is defined as manned object. Manned ships with some autonomous systems fall under this definition. However it is clear that unmanned ships do not. The old principle with regard to shipping was based on the assumption that the full responsibility for the ship at sea lies on the master who is on board and is "the first after the God" (Naukowe & Warszawskiej, 2016).

Operation of autonomous ships controlled from the shore station put full responsibility for the ship at sea to this station. It is, however, questionable whether the man at control in the shore office could be assessed as "the captain" This would be the most important issue, acceptance of this change by the conservative shipping world would need to overcome legal, and emotional barriers. Emotional barriers against introduction of autonomous ships should not to be dismissed lightly. The shipping world is rather conservative and seafarers' profession has high self-esteem.

Abandoning the position of ship master and replacing it by anonymous controller in the shore control station may be considered as devaluation of the profession. This may induce negative feelings against introduction of unmanned ships. Replacing active ship crew in ships with minimal crew staff for inspections and emergency working on boring shifts will also devaluate attractiveness of profession (Naukowe & Warszawskiej, 2016).

Also important issue is that present regulation in respect of manning in the international STCW Convention (Standards of Training, Certification and Watchkeeping) must be entirely changed, which may create important protests from the side of trade unions. Another problem not easy to be solved is how to implement to smart ships the present regulations on search and rescue operations at sea. According to present regulations all ships are obliged to participate in search operations at sea and rescue people at distress. This certainly could not be applicable to smart ships (Naukowe & Warszawskiej, 2016).

5.6. COMPETITIVE STRATEGIES IN LOGISTICS 4.0

5.6.1. Shipping in the age of big data

The advent of digital technologies and big data in the shipping industry (referred to as Logistics 4.0) brings enormous benefits to the industry. Digitization and logistics 4.0 provide a great of potential for maritime shipping companies. Traffic, port logistics, and just-in-time shipping will change as an electronic revolution takes shape with big data and the increasing networking of technologies. More accurate ship arrival times, weather data in real-time feeds, and smart container technology will enable shipping companies to exploit efficiencies in unprecedented ways in the industry. (Fruth & Teuteberg, 2017).

With massive growth in computational capacity and data storage capabilities, globally accessible networks and cloud infrastructure with increasing bandwidth, availability of smart devises (Internet of Things) and smart and cheap sensors, a significant increase of digitalisation in all maritime sectors is expected. Connection with other modes of transport, or inland-waterway transport, will be seamless. Smart ships will communicate with smart ports to reduce congestion, waiting time and thus costs.

Smart ships will be able adjust their sailing speeds to match harbour slots automatically (Maritime Europe Strategy Action, 2016). Greater alignment of ship and shore operations (enabled through Logistics 4.0) will help the industry capitalise on this potential. The size, operations and functionality of ships must be aligned with land-based infrastructure and solutions, logistics systems and supply chain management in order to unlock synergies and efficiencies (Longva et al., 2014).

Therefore, shipping companies should develop competitive strategies that focus around investment in technologies that will enable the operator to embrace Logistics 4.0 and attain a competitive advantage in the maritime industry.

5.6.2. Personnel training and skill development

Through the digitization and automation of many areas, maritime logistics will change. Crews will get smaller on board vessels, but it is the creation of more attractive and responsible jobs ashore for the monitoring and remote maintenance of ships that makes smart shipping attractive. The use of new technologies will require appropriate expertise and increase the need for advanced skills (Fruth & Teuteberg, 2017). As such, the designing and construction of state-of-the-art ships should go hand-in-hand with training seafarers properly (Mitropoulos, 2013).

An increasing need for training and development in the field of new technologies will be necessary in the future. The major challenge for shipping companies will be the creating and development of new competencies to optimize project organizations, and to gain new talents. Experience, willingness to integrate and technical knowledge will be among the most important attributes that should be considered (Fruth & Teuteberg, 2017).

Higher degree of automation, automation of systems, autonomous operation, as well as, the integration and transformation of sea-based and shore-based operation (Maritime Europe Strategy Action, 2016) will require significant increases in the development of human capital.

Automation and technical robustness has led to a decline in ship accidents. However, de-skilling is a problem that follows with automated systems in all occupations. “An important task for developers will be to ensure that modern technology is used for safety improvement while still keeping the navigator in the loop, practicing skills that allow him or her to step in and perform professionally for the rare situation that automation fails" (Porathe, 2016).

The operation of smart ships will be a blend of manned and unmanned operations. Porathe (2016) postulates that; "The ships will be manned while departing and entering port and unmanned during ocean-passage. When unmanned, the ships will be controlled by an automatic system informed by on board sensors allowing the ship to make standard collision avoidance manoeuvres according to international regulation. The ship will be continuously monitored by a remote shore centre able to take remote control should the automatic systems falter.

Technical and legal problems are envisioned to be solvable. Human error remains, but is shifted to the programmer and maintenance level as well as the remote control centres. For the humans in the shore centres the usual problems of automations remains as well as a pronounced problem of keeping up adequate situation awareness through remote sensing. The big challenge for a future autonomous technology will be to show that an unmanned system is at least as safe as a manned ship system, and to provide the shore control operators with adequate situation awareness". This postulation puts strong emphasis on training and upskill of marine personnel. Even though smart ships will minimise and, eventually, eliminate people on board, there will still be a need for marine personnel in some capacity and ship owners will need to ensure a constant supply of skills into the industry.

It follows that, the elimination of the crew on board will not necessarily translate to the total elimination of manning costs. There will still be a need for shore-based personnel on standby to take control when automatic systems fail. As such, high technical skill levels will be a competitive advantage and companies need to embark on strategies that enhance training programmes. Highly skilled labour will command a premium and shipping companies will have to ensure that the designing and construction of state-of-the-art ships goes hand-in-hand with the training of seafarers.

5.6.3. Value chain optimisation and coopetition

Smart ships also bring a plethora of competitive advantages into the industry. Logistics 4.0 will enable voyage plans optimized by port conditions, shortest routes, hydrodynamic values and weather information will result in reduced costs for ship and cargo owners. Cargo will move faster through the maritime logistics chain (Monalisa Project Team, n.d.). Smart ships may also transform supply chain logistics, which would have far-reaching impacts on the industry. As there would be no human restrictions on how much time a vessel can spend at sea, “ships that do not carry time-sensitive cargoes could, in theory, drift with sea currents when possible to move as energy-efficiently as possible” (Longva et al., 2014). Traditional competitive advantages will be enhanced with the use of new technologies. Economies of scale, value chain efficiency and harmonising the value chain will be better executed through the use of Logistics 4.0

Shipping companies will need to look at alternative business models such as short-sea shipping as this is the space autonomous ships are expected to dominate first. In order to succeed, the competitiveness of sea transport must be strengthened, bringing it in line with other forms of transportation. This involves establishing a far more comprehensive, strategic and systematic approach to marine transport infrastructure than today. Development of major intermodal harbours will be a critical success factor in connecting national logistics in a more environmentally friendly, seamless infrastructure that includes sea, road and rail. The role of sea transport will be considerably larger in this type of system than it is today ((Norwegian Shipowners Association), 2017).

Today, individual players in the industry are more likely to adopt minimum standards due to regulation and competitive pressures in the absence of industry-level requirements and incentives to improve efficiency. As such, triggering the overall efficiency potentials, a process that will require concerted efforts by multiple stakeholders, will be difficult, as the value-capture mechanisms for each player are complex and uncertain. In many cases “the greater good” will also require that certain stakeholders sacrifice some of their profits or benefits (or bargaining power/control), which will of course not happen without some kind of pressure or regulation (Longva et al., 2014).

Therefore, shipping companies need to focus on partnerships and cooperation with one another, as well as with technology companies in order for logistics 4.0 synergies to be exploited. Ship manufacturers, technology companies and programmers will become a bigger stakeholder in the industry, therefore shipping companies need to develop strategies that prioritise strategic partnerships.

5.7. LIMITATIONS OF THE STUDY

Limitations are influences that the researcher cannot control. They are the shortcomings, conditions or influences that cannot be controlled by the researcher that place restrictions on your methodology and conclusions (BCPS.org, n.d.). This study employed a futures methodology called environmental scanning.

Environmental scanning is a futures study methodology that stands at the juncture of foresight and strategy. It establishes organisationally relevant criteria that allow prepared human minds to discern information, knowledge and insight from the multitude of 'signals' that occur daily. One of the meta-skills of good environmental scanning work is to know when to apply the standard 'rules' of discrimination and when to set them aside. This is a matter of human judgement, not of calculation.

As such environmental scanning stands firmly in the interpretative domain, not that of the dominant empirical tradition of futures work (Slaughter, 1999).

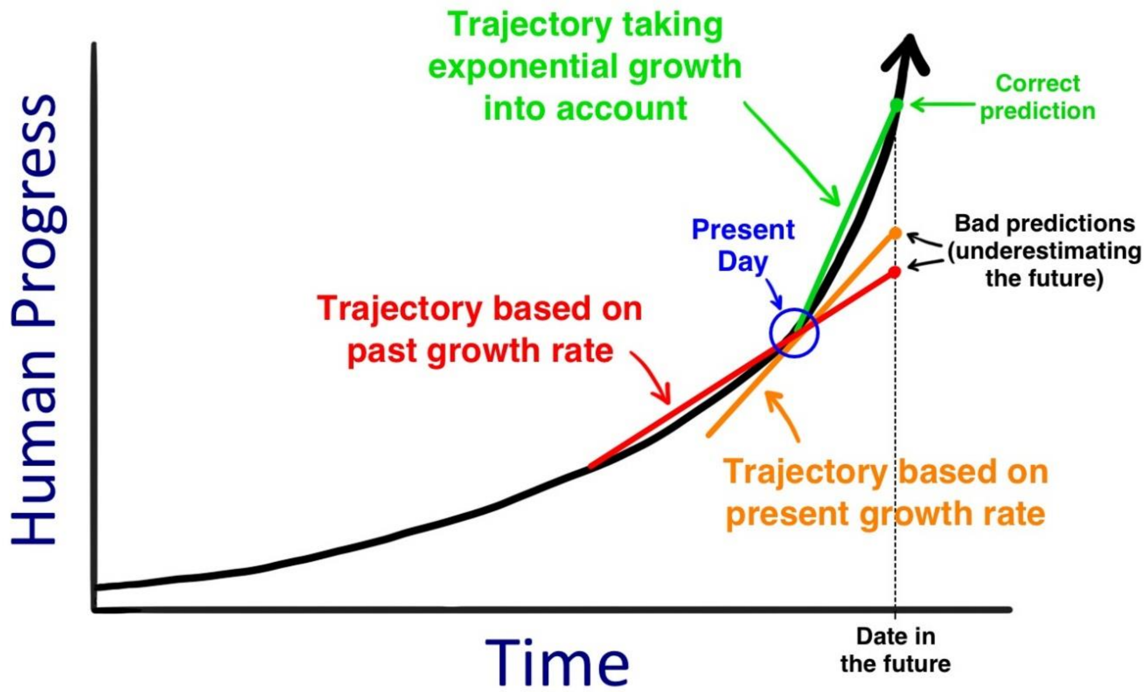

Figure 16: Revolution of Artificial Intelligence (Urban, 2015)

Secondly, working with futures comes with a lot of uncertainty as there is no one certain future. The study is also focused on technology, which is a rapidly evolving environment. Advances in Artificial Intelligence hold much more possibilities beyond which this study can cover. Therefore, as per Figure 15, what's true and valid during the study, may prove outdated in a year or two. Therefore the study is limited by the advancements made in technology and in the maritime industry regarding the fourth industrial revolution.

5.8. AREAS OF FUTURE RESEARCH

Given the changing competitive landscape in the maritime industry, and the ever evolving technology sector, the world in 2028 will be different to what it is today. Ships, regulations, training and expertise will also be different, with different demands on the industry.

Research into the training needs of the future is very minimal at present and this area will prove critical as the fourth industrial revolution wave hits the industry. Smart ships will demand different expertise and a different level of commitment from personnel. Therefore this is a significant area of future research.

5.9. CONCLUSIONS AND CONSIDERATIONS FOR THE FUTURE

This study has shown that, smart ships are going to lower the manning costs of merchant ships. Depending on the type of ship, manning costs can make up the highest or second highest percentage of operating costs. They have consistently been found to be the second highest cost of running a shipping company, second only to fuel costs.

Manning costs do not only relate to salaries, training, accommodation and other crew related matters, but they also include costs of crew safety and costs that arise as a result of the human element in shipping, i.e. costs of human errors, etc. Therefore, smart ships will enable shipping companies to benefit from lower operational costs compared to conventional vessels, due to the elimination of on-board crew costs, risks associated with human error, and threats to crew safety.

Therefore, shipping companies need to develop strategies that prepare them for the future competitive landscape. That means dedicating resources to investment in technologies that will enable them to exploit the advantages of Logistics 4.0 and the future of the maritime industry. The investment should be beyond just technologies. It should include investing in partnerships with competitors and suppliers, as well as training and retention as expertise will be a critical competitive advantage in the fourth industrial revolution.

6. REFERENCES

(Norwegian Shipowners Association). (2017). *Maritime Outlook Report 2017*. *Maritime Outlook Report 2017*. Retrieved from http://www.rederi.no/nrweb/mm.nsf/lupgraphics/Final_6242-Konjunkturrapport-eng-5k.pdf/$file/Final_6242-Konjunkturrapport-eng-5k.pdf%5Cnpapers2://publication/uuid/3678F7E1-B619-4B1A-AFFE-76D30A05CD26

ABB Communications. (2012). Smart ships can reduce fuel consumption by 20 percent. Retrieved May 18, 2018, from http://www.abb.co.uk/cawp/seitp202/14e177677aa71662c12579ff003fad9d.aspx

Agnello, L., Cossentino, M., Simone, G., & Sabatucci, L. (2017). SHIPBOARD POWER SYSTEMS RECONFIGURATION : A COMPARED ANALYSIS OF STATE-OF-THE-ART APPROACHES. *Smart Ship Technology*, (January), 24–25.

Ang, J. H., Goh, C., Saldivar, A. A. F., & Li, Y. (2017). Energy-efficient through-life smart design, manufacturing and operation of ships in an industry 4.0 environment. *Energies*, *10*(5), 1–14. https://doi.org/10.3390/en10050610

Aron Sørensen, Sand, P., Inglis, S., Shaw, N., Dewar, M., & Dearsley, D. (2016). *Manpower Report 2015*.

Baraniuk, C. (2017). The ships that could change the seas forever. Retrieved March 20, 2018, from http://www.bbc.com/future/story/20170918-the-ships-that-could-change-the-seas-forever

BCPS.org. (n.d.). Online Research Framework: Step 4. Retrieved August 16, 2018, from https://www.bcps.org/offices/lis/researchcourse/develop_writing_methodology_limitations.html

Bengston, D. N. (2017). Ten principles for thinking about the future : a primer for environmental professionals of the future, (December), 34.

Berns, S., Vonck, I., Dickson, R., & Dragt, J. (2017). Smart Ports Point of View.

Retrieved from https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/energy-resources/deloitte-nl-er-port-services-smart-ports.pdf

Bertram, V. (2013). Towards Unmanned Ships, 1–52.

Blanke, M., Henrique, M., & Bang, J. (2017). A pre-analysis on autonomous ships, 1–27. Retrieved from https://www.dma.dk/Documents/Publikationer/Autonomeskibe_DTU_rapport_UK.pdf

Bowring, A. (2006, March). Minimum manning levels. *Seaways*.

Button, R. W., Martin, B., Sollinger, J. M., & Tidwell, A. (2015). *Assessment of Surface Ship Maintenance Requirements*.

Caesar, L. D., Cahoon, S., & Fei, J. (2015). Exploring the range of retention issues for seafarers in global shipping: opportunities for further research. *WMU Journal of Maritime Affairs*, *14*(1), 141–157. https://doi.org/10.1007/s13437-015-0078-0

Cahoon, S. (2008). Shipping , Shortages and Generation Y. *Marketing and Human Resource Management Subjects*, (1), 1–9.

Cartledge, K. J. (2001). In Pursuit of Lean Manning: Ship Automation and the Value of Simulation. *IFAC Proceedings Volumes*, *34*(7), 221–225. https://doi.org/https://doi.org/10.1016/S1474-6670(17)35086-3

Chang-wei, K. (2015). GREEN AND SMART SHIPPING MODELING AND SIMULATION Enabling Green and Smart Shipping, (February).

Choo, C. W. (1999). The Art of Scanning the Environment. *Bulletin of the American Society for Information Science and Technology*. https://doi.org/10.1002/bult.117

Choo Wei, C., Slaugther, R. a., & Voros, J. (2003). Reframing Environmental Scanning, 76. https://doi.org/10.1108/14636680110697200

Conway, M. (1997). An Overview of Foresight Methodologies. *Thinking Futures*, 1–10.

Conway, M. (2013). Environmental Scanning, (April), 37 pages. Retrieved from file:///C:/Users/Dad/Desktop/ES-Guide-April-09.pdf

Couper, A. (2000). Implications of maritime globalization for the crews of merchant ships. *Journal for Maritime Research*, *2*(1), 1–8. https://doi.org/10.1080/21533369.2000.9668303

Fiedler, R. (2017). Energy Solutions – Made in Germany. In *Energie Waechter*. Houston.

Flemming, M. G. (1997). The Cost and Benefits of Reduced Manning for U.S. Naval Combatants.

Fruth, M., & Teuteberg, F. (2017). Digitization in maritime logistics—What is there and what is missing? *Cogent Business and Management*, *4*(1), 1–40. https://doi.org/10.1080/23311975.2017.1411066

Gordon, T. J., & Glenn, J. C. (1994). Environmental Scanning.

Gounaris, P. (2014). International Trade and the Maritime Shipping Revolution. *Economic History*, 513–526.

Gujar, G., & Yan, H. (2013). Special Report : Smart Port in a Smart Era. *Marine Insight*, (2), 21–24.

Hancock, T., & Bezold, C. (1994). Possible futures, preferable futures. *Healthcare Forum Journal*, *37*(2), 23–29. Retrieved from http://europepmc.org/abstract/med/10132155

Hill, B., & Michael, S. (1996). The human factor. *Journal of Psychiatric and Mental Health Nursing*, *3*(4), 245–248. https://doi.org/10.1111/j.1365-2850.1996.tb00118.x

International Association of Maritime Universities. (2015). Sustainable and Quality Manpower Supply for Shipping Industry : System Approach, (April 2012), 1–7.

Jatau, S. U. N. (2002). SHIP MANNING AND SAFETY: PROBLEMS IN THE RECRUITMENT, SELECTION AND RETENTION OF SEAFARERS A Global View. Retrieved from http://commons.wmu.se/cgi/viewcontent.cgi?article=1284&context=all_dissertations

Jiang, L., Kronbak, J., & Christensen, L. P. (2010). External costs of maritime shipping : A voyage-based methodology, 1–18.

REFERENCES

Journal-Of-Commerce. (2017). Changing Seas. *The Journal of Commerce*, 44–45.

Kaur, K. (n.d.). Future port, 6.

Kongsberg. (2017). YARA and KONGSBERG enter into partnership to build world's first autonomous and zero emissions ship. Retrieved March 21, 2018, from https://www.km.kongsberg.com/ks/web/nokbg0238.nsf/AllWeb/98A8C576AEFC85AFC125811A0037F6C4?OpenDocument

Konstantinidis, B. M. (2017). *Artificial Intelligence helps Shipping become even SMARTER & more EFFICIENT*.

Lagersmit. (2018). Smart Shipping, the Future of Maritime Shipping? Retrieved March 20, 2018, from https://www.lagersmit.com/smart-shipping-future-maritime-shipping/

Lang, T. (2001). An Overview of Four Futures Methodologies, (Woudenberg 1991), 1–28. Retrieved from http://www.soc.hawaii.edu/~future/j7/LANG.html

Levander, O., & Jokioinen, E. (2016). Smart Ships of the Future.

Liu, G., Perez, R., Muñoz, J. A., & Regueira, F. (2016). Internet of Ships: The Future Ahead. *World Journal of Engineering and Technology*, *4*, 220–227. https://doi.org/10.4236/wjet.2016.43D027

Lockwood, F., Kent, T., Paul, J., Shenoi, A., Westgarth, R., O'Dell, M., … Teagle, D. (2017). *Global Marine Technology Trends 2030 - Autonomous Systems*.

Longva, T., Anand, N., Balland, O., & Brandsæte, A. (2014). A broader view: The future of shipping, (January), 106.

Mangan, J. (2017). Future of the Sea : Trends in the Transport of Goods by Sea Evidence Review Trends in the Transport of Goods by Sea, 21.

Marine Connector. (n.d.). Merchant Vessels. Retrieved May 21, 2018, from http://maritime-connector.com/wiki/merchant-vessels/

Maritime Europe Strategy Action. (2016). *Global Trends Driving Maritime Innovation*.

Marope, T. (2014). Future Technological Factors Affecting Unmanned Aircraft Systems (UAS): A South African Perspective Towards 2025, (December), 1–145.

REFERENCES

Mauck, B. A. (2017). *The unmanned ship sets sail - Is South Africa prepared to open the ship register*.

Ministry of Economic Affairs and Employment of Finland. (2017). Smart Maritime Technology Solutions.

Mitropoulos, E. (2013). Current and future trends affecting shipping. *IMO News*, (1), 21–27.

Monalisa Project Team. (n.d.). *Monalisa 2.0: Securing the chain by intelligence at sea*. Retrieved from http://monalisaproject.eu/wp-content/uploads/MONALISA-2_0-web.pdf

Naude, J. (2016). Constructive Environmental Scanning: A method in creating positive world Paradigms for more Sustainable Alternative Futures, (March). Retrieved from http://scholar.sun.ac.za/handle/10019.1/98653

Naukowe, P., & Warszawskiej, P. (2016). MARINE TRANSPORT AND THE FOURTH.

Počuča, M. (2006). Methodology of day-to-day ship costs assessment. *Promet - Traffic - Traffico*, *18*(5), 337–345.

Popper, R. (2008). *How are foresight methods selected? Foresight* (Vol. 10). https://doi.org/10.1108/14636680810918586

Porathe, T. (2016). A Navigating Navigator Onboard or a Monitoring Operator Ashore? Towards Safe, Effective, and Sustainable Maritime Transportation: Findings from Five Recent EU Projects. *Transportation Research Procedia*, *14*(2352), 233–242. https://doi.org/10.1016/j.trpro.2016.05.060

Port Technology. (2017, May 15). Asia Enters Fully Automated Terminal Era. *Port Technology*. Retrieved from https://www.porttechnology.org/news/asia_enters_fully_automated_terminal_era

Psaraftis, H. N. (2014). *REDUCED MANNING TO INCREASE FLEET COMPETITIVENESS*.

Puglisi, M. (2001). The study of the futures: an overview of futures studies methodologies. *Ciheam*, *463*(44), 439–463. Retrieved from http://om.ciheam.org/article.php?IDPDF=2001611http://www.ciheam.org/

Reilly, G., & Jorgensen, J. (2016). Classification Considerations for Cyber Safety and Security in the Smart Ship Era. *Smart Ships Technology*, (January), 26–27.

Rohrbeck, R., & Bade, M. (2012). Environmental scanning, futures research, strategic foresight and organizational future orientation: a review, integration, and future research directions. *ISPIM Annual Conference*, (June 2012), 1–14. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2080448

Rolls-Royce. (2016). Autonomous ships: The next step. *AAWA: Advanced Autonomous Waterborne Applications*, 7. Retrieved from http://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf

Scofield, T. (2006). Manning and Automation Model for Naval Ship Analysis and Optimization, 97.

Sea Machines Robotics Inc. (2017). Retooling the marine & maritime industries for the 21st century. *Sea Machines*.

Slaughter, R. (1999). A new framework for environmental scanning, *1*(5).

Stopford, M. (2015). Maritime Strategy - The Fourth Wave. In *Onassis Prize Lecture* (pp. 1–8).

Thai, V. V., Balasubramanyam, L., Yeoh, K. K. L., & Norsofiana, S. (2013). Revisiting the seafarer shortage problem: The case of Singapore. *Maritime Policy and Management*, *40*(1), 80–94. https://doi.org/10.1080/03088839.2012.744480

Unknown. (2015). What is a STEEP analysis. Retrieved July 6, 2018, from http://pestleanalysis.com/what-is-steep-analysis/

Unknown. (2017). In Depth: How Will Seafarers Be Impacted by Smart Ships? Retrieved May 1, 2018, from https://worldmaritimenews.com/archives/234353/interview-how-will-seafarers-be-impacted-by-smart-ships/

Urban, T. (2015). The AI Revolution: The Road to Superintelligence. Retrieved August 16, 2018, from https://waitbutwhy.com/2015/01/artificial-intelligence-revolution-1.html

V.Ships Ltd. (2012). Opex the ship management view.

Voros, J. (2003). A generic foresight process framework. *Foresight*, *5*(3), 10–21. https://doi.org/10.1108/14636680310698379

World Maritime News. (2017). In Depth: How Will Seafarers Be Impacted by Smart Ships? Retrieved May 1, 2018, from https://worldmaritimenews.com/archives/234353/interview-how-will-seafarers-be-impacted-by-smart-ships/

Xuyuan, C., & Jun, Y. (n.d.). Connected Ports - Driving Future Trade.

7. ANNEXURES

ANNEXURE A: Ethics Clearance

NELSON MANDELA
UNIVERSITY

FORM E

ETHICS CLEARANCE FOR TREATISES/DISSERTATIONS/THESES

Please type or complete in black ink

FACULTY: BUSINESS AND ECONOMIC SCIENCES

SCHOOL/DEPARTMENT: NMU BUSINESS SCHOOL

I, (surname and initials of supervisor) MR. CELESTIN NDHLOVU

the supervisor for (surname and initials of candidate) RAMONYALUOE, T.

(student number) 216-248-876

a candidate for the degree of MASTER OF BUSINESS ADMINISTRATION

with a treatise/dissertation/thesis entitled (full title of treatise/dissertation/thesis):

AN ANALYSIS OF HOW SMART SHIPS ARE GOING TO IMPACT THE MANNING COSTS OF MERCHANT SHIPS BY 2028

considered the following ethics criteria *(please tick the appropriate block)*:

	YES	NO
1. Is there any risk of harm, embarrassment of offence, however slight or temporary, to the participant, third parties or to the communities at large?		✓
2. Is the study based on a research population defined as 'vulnerable' in terms of age, physical characteristics and/or disease status?		✓
2.1 Are subjects/participants/respondents of your study:		
(a) Children under the age of 18?		✓
(b) NMMU staff?		✓
(c) NMMU students?		✓
(d) The elderly/persons over the age of 60?		✓
(e) A sample from an institution (e.g. hospital/school)?		✓
(f) Handicapped (e.g. mentally or physically)?		✓
3. Does the data that will be collected require consent of an institutional authority for this study? (An institutional authority refers to an organisation that is established by government to protect vulnerable people)		✓
3.1 Are you intending to access participant data from an existing, stored repository (e.g. school, institutional or university records)?		✓
4. Will the participant's privacy, anonymity or confidentiality be compromised?		✓

4.1 Are you administering a questionnaire/survey that:		
(a) Collects sensitive/identifiable data from participants?		✓
(b) Does not guarantee the anonymity of the participant?		✓
(c) Does not guarantee the confidentiality of the participant and the data?		✓
(d) Will offer an incentive to respondents to participate, i.e. a lucky draw or any other prize?		✓
(e) Will create doubt whether sample control measures are in place?		✓
(f) Will be distributed electronically via email (and requesting an email response)?		✓
Note: • If your questionnaire **DOES NOT** request respondents' identification, is distributed electronically and you request respondents to return it *manually* (print out and deliver/mail); **AND** respondent anonymity can be guaranteed, your answer will be NO. • If your questionnaire **DOES NOT** request respondents' identification, is *distributed via an email link and works through a web response system (e.g. the university survey system); **AND*** respondent anonymity can be guaranteed, your answer will be NO.		

Please note that if ANY of the questions above have been answered in the affirmative (YES) the student will need to complete the full ethics clearance form (REC-H application) and submit it with the relevant documentation to the Faculty RECH (Ethics) representative.

and hereby certify that the student has given his/her research ethical consideration and full ethics approval is not required.

SUPERVISOR(S) — DATE: 24/10/2018

p.p HEAD OF DEPARTMENT — DATE: 31 October 2018

STUDENT(S) — DATE: 23 OCTOBER 2018

Student(s) contact details (e.g. telephone number and email address):

Cell No. 078-865-2733. Email address: Ramonvaluoe@gmail.com

Please ensure that the research methodology section from the proposal is attached to this form.

ANNEXURE B: Turnitin Report

AN ANALYSIS OF HOW SMART SHIPS ARE GOING TO IMPACT THE MANNING COSTS OF MERCHANT SHIPS IN 2028

ORIGINALITY REPORT

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