DIRECTORATE GENERAL OF SHIPPING

Mumbai, India

DEVELOPMENTS IN AUTONOMOUS SHIPPING AND ITS POTENTIAL TO IMPACT JOB PROSPECTS OF SEAFARERS

By

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A dissertation submitted to the DG Shipping in partial fulfilment of the requirements for the award of the

Certificate of Competency

of

Extra Master

2024

DECLARATION

I hereby declare that all the material in this dissertation that is not my own work has been identified and highlighted, and that no material is included for which Extra Master Certificate of Competency or a degree has previously been conferred on me.

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

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Acknowledgements

I remain indebted to Dr. (Capt.) Margareta Holtensdotter Lützhöft, Professor, Department of Maritime Studies Western Norway University of Applied Sciences for being my guide and helping me frame the topic correctly, form the chapter scheme, and write the dissertation I place on record my gratitude for her support and patience despite her extremely busy schedule in elevating my work with her deeply nuanced observations.

My sincere gratitude to Capt. Ajay Achuthan, my guru from the very beginning of my sea career days till now, whose dedicated support and enthusiasm and confidence in me, significantly contributed to my authorship.

My sincere thanks and gratitude to Dr Samyuktha Ajay, a teacher, family friend and a great support, who has guided me in the basics of research methodology and who all through my dissertation has been a great source of help, motivation, and guidance.

This work wouldn't have been possible without the unstinting support of my mentor Capt. M S Anantharaman, Master Mariner, and a great family friend, who has been instrumental in keeping me motivated and providing all possible support.

I wish to sincerely thank all the expert resource persons in this dissertation who in spite of their very busy schedule have been kind enough to find time and reason to help me.

My heartfelt thanks to my organisation, seniors, colleagues, fraternity well-wishers and everyone else who contributed by understanding my endeavour and supporting in whichever way I needed it.

I am beholden to my wife Preeti and my kids Rishabh & Rhea for supporting my academic pursuits by enduring long hours of separation and putting up with me all throughout.

Abstract

The development of autonomous shipping is one of the most promising technological advancements in the maritime industry. The concept of autonomous shipping has been around for many years, but only in recent years have we seen significant advancements in the technology that would allow for the widespread use of autonomous ships.

The idea of the topic for my dissertation took root in my mind while pursuing my Extra Master Part B preparations for the module EM 201 – Advanced Navigation and Maritime Cyber Security & EM 203 – Commercial Engineering, Robotics and Alternate Energy.

The study of advanced navigational and position finding systems, increasingly refined and reliable over the existing systems that were on the anvil of finding their way into mainstream acceptance.

The possibilities of automation and use of artificial intelligence and robotics in shipboard applications seemed enormous.

The challenges within the scope of Cyber Security at every step of advancement in technology to deal with unscrupulous elements forever present to derail the smooth adoption of advanced systems.

And

The very palpable uncertainty among fellow seafarers including myself on the possibility of ending up jobless in the near future due to advent of autonomous ships.

India has been a prominent provider of trained seafarers to the merchant fleet around the world. Many Maritime Training Institutes and related vocations thrive on the basis of this seafarer training and employment ecosystem.

Increased automation has always been accepted as a natural course of advancement in all walks of life including shipborne activities, but the thrust has however been to see technology as an aid to the seafarer in decision making and not disruptive uprooting and replacement of the on-board seafarer.

This study has tried to answer this concern by a three-pronged approach.

1. Independent study by using material available in the public domain.

2. Survey questions and responses from 210 respondents from the seafarer community.

3. Expert opinion from resource persons across multiple maritime specialised domains.

Based on the above an attempt has been made to answer the original research question pertaining to the development of autonomous ships and their impact on seafarer jobs.

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List of Abbreviations

1. AAWA - Advanced Autonomous Waterborne Applications Initiative
2. AI – Artificial Intelligence
3. AIS - Automatic Identification Systems
4. ARPA - Automatic RADAR Plotting Aid
5. BHP - Broken Hill Propriety Company Ltd
6. BIMCO - Baltic and International Maritime Council
7. BPO – Business Process Outsourcing
8. CEO – Chief Executive Officer
9. CMI - Comite Maritime International
10. CO2 – Carbon Dioxide
11. COC – Certificate of Competency
12. COF – Certificate of Fitness
13. COLREG - Convention on the International Regulations for Preventing Collisions at Sea, 1972
14. CSC - International Convention for Safe Containers
15. DCE – Dangerous Cargo Endorsement
16. DGS – Directorate General of Shipping
17. DNV -Det Norske Veritas
18. DOD – Department Of Defense (USA)
19. DP - Dynamic Positioning
20. DPA – Designated Person Ashore
21. EAC – Examination Assessment and Certification
22. ETO – Electro Technical Officer
23. FFA – Fire Fighting Appliances
24. FAL - Convention on Facilitation of International Maritime Traffic, 1965
25. GMDSS - Global Maritime Distress and

Safety System

26. GNSS - Global Navigation Satellite System
27. GT – Gross Tonnage
28. HCL – Hindustan Computers Limited
29. HSBA - Hamburg School of Business Administration
30. IACS - International Association of Classification Societies
31. ICS -International Chamber of Shipping
32. ICTT – International Container Transhipment Terminal
33. IoT- Internet of Things
34. IEC - International Electrotechnical Commission
35. IFSMA - International Federation of Shipmasters' Associations
36. ILO - The International Labour Organization
37. IMO – International Maritime Organisation
38. IMODOCS- IMO Documents
39. IRS -Indian Register of Shipping
40. ISM - The International Safety Management (ISM) Code
41. ISO - International Organization for Standardization
42. IT -Information Technology
43. ITF - International Transport Workers' Federation
44. LEG – The Legal Committee
45. LiDAR - Light Detection and Ranging

46. LLP – Limited Liability Partnership
47. LMS -Learning Management System
48. LOA – Length Over All
49. LSA -Life Saving Appliances
50. MARPOL - International Convention for the Prevention of Pollution from Ships
51. MASS - Maritime Autonomous Surface Ships
52. MASSA - Maritime Association of Shipowners Ship managers and Agents
53. MET - Maritime Education and Training
54. ML – Machine Learning
55. MLC - The Maritime Labour Convention, 2006
56. MOL – Mitsui OSK Lines
57. MSC – Maritime Safety Committee
58. MSC – Mediterranean Shipping Company
59. MV – Motor Vessel
60. NASSCOM - National Association of Software and Service Companies
61. NGO – Non-Governmental Organisation
62. NIST - National Institute of Standards and Technology
63. NMA - Norwegian Maritime Authority
64. NOx – Nitrogen Oxides
65. NYK - Nippon Yusen Kaisha
66. OPEX -Operational Expenditure
67. OT -Operational Technology
68. PCTC - Pure Car/Truck Carrier

69. PSA - Port of Singapore Authority
70. PSC – Port State Control
71. RADAR - Radio Detection and Ranging
72. ROC – Remote Operations Centre
73. RPA -Robot process Automation
74. RSE – Regulatory Scoping Exercise
75. SAR – Search and Rescue
76. SCADA - Supervisory Control and Data Acquisition
77. SOLAS - The International Convention for the Safety of Life at Sea
78. SOP – Standard Operating Procedure
79. SSR - Sherpa System for Real ship
80. STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
81. STEM - Science, Technology, Engineering, and Mathematics
82. STP – Special Trade Passenger
83. TCS – Tata Consultancy Services
84. TEU – Twenty Foot Equivalent Units
85. UMS – Unmanned Machinery Space
86. UN -United Nations
87. UNCTAD - United Nations Conference on Trade and Development
88. UNCLOS - United Nations Convention on the Law of the Sea
89. UR/UI – Unified Requirement / Unified Interpretation (IACS)
90. US -United States
91. VTIS - Vessel Traffic Information System
92. VTMS - Vessel Traffic Management

Services	
93.	WEF - World Economic Forum
94.	WMU - World Maritime University (Malmö, Sweden)

1 Introduction

1.1 Technology and the Maritime Industry

1. The maritime industry is a vital component of the global economy, and its growth is essential for sustainable development. Shipping has been an essential mode of transportation since ancient times, but with the advancement of technology, the industry has undergone significant changes. The introduction of autonomous shipping has revolutionized the industry, making it safer, more efficient, and cost-effective.

2. Continuous changes in the economic structure of automation and globalization can affect employment and mortality, but these relationships are not well established. People in very routine and intense occupations are less likely to stay in the long-term workforce and have higher disability and mortality. (Bernt Bratsberg, Ole Rogeberg & Vegard Skirbekk - Technology-induced job loss risk, disability, and all-cause mortality in Norway). Technological unemployment is unemployment due to developments in technology. It is an important form of structural unemployment.

3. The World Economic Forum (WEF) concluded in a recent report[1] that “a new generation of smart machines, fuelled by rapid advances in artificial intelligence (AI) and robotics, could potentially replace a large proportion of existing human jobs.” Robotics and AI cause serious confusion with the use of new technologies to reduce costs, increase productivity, and reduce reliance on real people. According to the WEF, the effects of the Covid-19 pandemic have left millions of people out of work, and machines will now rob workers of more jobs. According to the organization, automation will replace the work of about 85 million people by 2025.

1.2 Technology's Impact on Everyday Work and Life

4. From the time you wake up to the alarm clock to answering a message on the phone, we rely on electronic devices. Whether you're operating your computer at your desk or worried about cyberattacks and phishing

while surfing the web, technology has become an integral part of our work and personal life. Technology is built into every process and function in the workplace, regardless of work area. Virtually every company in every industry is adopting technology. They strive to consistently improve the technical outlook of the organization. [2]

5. According to an Accenture report[3], more than half of the world's population fears losing jobs due to automation. Experts predict that by 2020, 5 to 10 million jobs could be lost by automation. People in industries such as the automotive, financial and manufacturing industries are worried about their future.

6. Covid-19 presented the employer with an easy choice. Either find some way for workers to work safely or shut everything down. At least some people chose the third option to do it completely, if possible, without humans as much as possible. Lots of desperate headlines[4] triggered by the pandemic pander to a new cascade of job-destroying automation.

1.3 Global Concerns About Automation-Related Job Losses

7. As of 2021, about 3 million robots are crowded in our factories [5], doing heavy jobs. From an efficiency standpoint, that's definitely a good thing. But the never-ending and always accurate image of a machine, which runs everything much faster, casts doubt on our minds:

   Will I lose my job?

8. As automation progresses much faster in all industries, especially in technology, domestic software companies that employ more than 16 million people are expected to reduce 3 million employees by 2022. As per NASSCOM, the domestic IT industry employs about 16 million employees, from which about 9 million are working in low-skilled services and BPO capacities. Of these 9 million low-skilled services and BPO roles, 30% or about 3 million will be lost by 2022, primarily due to the impact of Robot Process Automation or RPA. Approximately 700,000 roles are expected to be replaced by RPA only, with the rest being replaced by other technology upgrades and skill upgrades by domestic IT players.

9. According to the NASSCOM report[6], if the average total load employee cost of India-based resources is $ 25,000 per year and US resources are $ 50,000, the company's annual salary and related costs will be reduced by about $ 100 billion. TCS, Infosys, Wipro, HCL, Tech Mahindra, Cognizant and others seem to be planning to reduce low-skilled jobs by $ 3 million by 2022 due to RPA skill-up costs. With the potential to benefit $ 10 billion-for IT companies that have successfully implemented RPA they will have another $ 5 billion opportunity from a dynamic new software niche by 2022. Robots can work 24/7/365 which leads to saving of up to 10: 1 in manpower.

10. Artificial intelligence (AI) exists around us all over the world and is the basis of recent innovations that automate simple tasks and dramatically improve our lives. But given the growing power of AI and automation, how will this alternative source of work affect the future workforce? In the past, there have been great industrial innovations that have rocked the world of work. Technology-driven social changes, such as those seen in AI and automation, always raise concerns and fears, for good reason. A two-year study[7] by the McKinsey Global Institute suggests that sophisticated technology and robots could render jobless up to 30 per cent of the world's existing human workforce by 2030. McKinsey predicts that automation developments could rival the move away from agricultural labour in the United States of America and Europe in the 1900s, and more prominently and recently the explosion of China's labour economy.

1.4 Automation Challenges for the Shipping Industry

11. McKinsey predicts that automation will cause loss of 400 to 800 million jobs and up to 375 million will have to be fully migrated by 2030, depending on various hypothetical scenarios. These changes create fear and concern, especially in the economically vulnerable countries of the world, where the majority of the population struggles to upgrade from low to medium levels. When they reach their goals, do they find that they don't have a taker for what they just upgraded? The Brookings Institution says that even if automation reaches only 38% of the median of most predictions, some western democracies, as they did during the

Great Depression, are authoritarian to stop civil turmoil. We believe that we are likely to resort to authoritarian measures. "The United States will look like Syria and Iraq, and there will be armed groups of young men with little prospect of employment other than war, violence and theft," Brookings wrote.

12. Shipping companies cut costs by simply lowering their crew levels to ridiculously low levels and complying with mandatory safe manning requirements that have been streamlined as much as possible by regulators. Logistical congestion due to crew changes during a pandemic and the new MLC's commitment to onboard crew with additional insurance and liability have increased the cost for ship operators.
13. Temporarily unmanned bridge is one of the issues being considered, and another one being remote control operation for ships with sufficient levels of practical autonomy and machine intelligence to manage most possibilities autonomously.

1.5 Maritime Autonomous Surface Ships (MASS): Definition and Technology

14. Recent technological advances have conducted pilot experiments with varying degrees of autonomy, demonstrating the ability to steer and move ships from the quay of one port and berth at another. (Rolls-Royce, 2016), (Kongsberg-Maritime, 2020). More tests were conducted with remote control of offshore vessels and tugboats from a land control station. (Wartsila, 2017). These tests were performed in assigned test areas under the current set of rules and regulations, (IMO, 2019), (DNV, 2018), which require minimum safe manning during testing. Achieving a fully autonomous vessel without compromising safety requires a fundamental paradigm shift in the onboard systems, land support systems, approval processes, and the onboard and land crew design. (Kjeld Dittmann, Peter Nicholas Hansen, Dimitrios Papageorgiou, Signe Jensen, Marie L¨utzen &Mogens Blanke - Autonomous Surface Vessel with Remote Human on the Loop: System Design for STCW Compliance)

15. The International Maritime Organization （IMO） defines Maritime

Autonomous Surface Ships (MASS)[8] as a ship that, to a varying degree, can operate independently of human interaction. It identified four degrees of autonomy in ships, which are defined as follows:

Degree one: A ship that is operated by seafarers with some of the processes automated.

Degree two: Remotely controlled ship controlled and operated from a different location,

with seafarers on board.

Degree three: Remotely controlled ship controlled and operated from a different

location without seafarers on board.

Degree four: Fully autonomous ship, with an operating system that will make decisions,

and determine actions by itself.

16. The IMO integrates new and advancing technologies into its regulatory framework, with security concerns, environmental impacts, promotion of international trade, potential industry balancing costs, and cost impacts on staff. The aim is to balance the benefits that come from new technologies both on board and on land. The IMO aims to enable the regulatory framework for Maritime Autonomous Surface Ships (MASS) to accommodate rapidly evolving technological advancements.

1.6 IMO Regulatory Framework for Autonomous Shipping

17. The IMO has completed a MASS Regulatory Scoping Exercise (RSE) designed to evaluate existing IMO tools and see how they can be applied to vessels with varying levels of automation. The (RSE) was completed at the 103rd MSC Conference in May 2021 and for agreements under the jurisdiction of the Legal Committee in July 2021. This exercise included the evaluation of a number of IMO Convention documents under the authority of the MSC and the identification of provisions that applied to MASS and impeded the operation of MASS, or applied to MASS, does not interfere with MASS operation and requires no action, or applied to

MASS and does not interfere with MASS operations, but may need to include changes, clarifications, and / or gaps, or it does not apply to MASS operations at all.

18. The results highlight several high-priority issues that span multiple means that need to be addressed at the policy level to guide future work. These include the creation of MASS terminology and definitions, including the worldwide agreed definitions of MASS and clarity on the terms relating to “master”, “crew” or “responsible person”, especially in MASS 3 (remotely controlled ship) and MASS 4 (fully autonomous ship). Other important points are pertaining to operational & functional needs of the remote-control station and the possibility of designating a remote operator as a seafarer.

19. Other common potential gaps and issues were identified in multiple security contracts related to regulations, including manual bridge operation and alarms. Regulatory gaps we identified related to personnel measures (firefighting, cargo loading, fixing and maintenance, etc.), security guards; impact on search and rescue; information needed on board for safe operation.

20. The MSC recommended that the best way going ahead to deal with issues pertaining to MASS in the IMO’s regulatory framework could, possibly, be with a holistic approach through the development of a goal-based instrument[9]. It could be called the “MASS Code”, with goal(s), functional requirements and appropriate regulations, suitable for all four degrees of MASS, and addressing the concerns identified by the RSE. It was finalised by MSC 104 to develop a goal-based instrument for MASS, with a target for completion in the year 2025. This has been included in MSC biennial agenda for 2022-2023 and the provisional agenda for the MSC 105.

2 Background

2.1 Technology Overview

2.1.1 The History of Technology and Its Impact

1. The history of technology is the history of the invention of tools and means and belongs to the category of world history. Technology refers to methods ranging from basic stone tools to higher forms like genetic engineering and information technology that have emerged since the 1980s. The term technology is derived from the Greek word “techne”, which means art and craft, and the word “logos”, which means word and speech. First used to describe the applied arts, it is now used to describe the progress and changes that affect the environment around us. (Buchanan, R. Angus (2020, November 18).
2. New knowledge has enabled humans to create new things. Conversely, many scientific attempts are made possible by techniques that help humans move to previously unreachable places and scientific tools that allow us to explore nature in more detail than humans can. Since much of the technology is applied science, the history of technology is intertwined with the history of science. Because technology consumes resources, the history of technology is closely linked to the history of the economy. From these resources, technology creates other resources, including technical deliverables used in everyday life.

2.1.2 Technology, Invention, and the Wheel

3. Technological changes affect and are influenced by the cultural traditions of society. It is the power of economic growth and the means to develop and predict economic, political and military power. The ancestors used stones and other tools about 300,000 years ago, long before the advent of Homo Sapiens.[10]
4. Technology simply uses knowledge for practical purposes. Technology means using knowledge to simplify tasks. Invention is an important technical tool. Invention can be categorised as a new device or process

created for a particular reason. A nearly unanimous assumption about one of the greatest inventions and uses of technology in history is the invention of the wheel. Most experts believe that the wheel first appeared in the ancient Sumerian civilization in 5th millennium BC. This would have been in the Neolithic period, somewhere around 5,000 BC. The Sumerian civilization was in the Middle East in what is now Iraq, between the Tigris and Euphrates rivers.[11]

2.2 Automation and the Changing Workplace

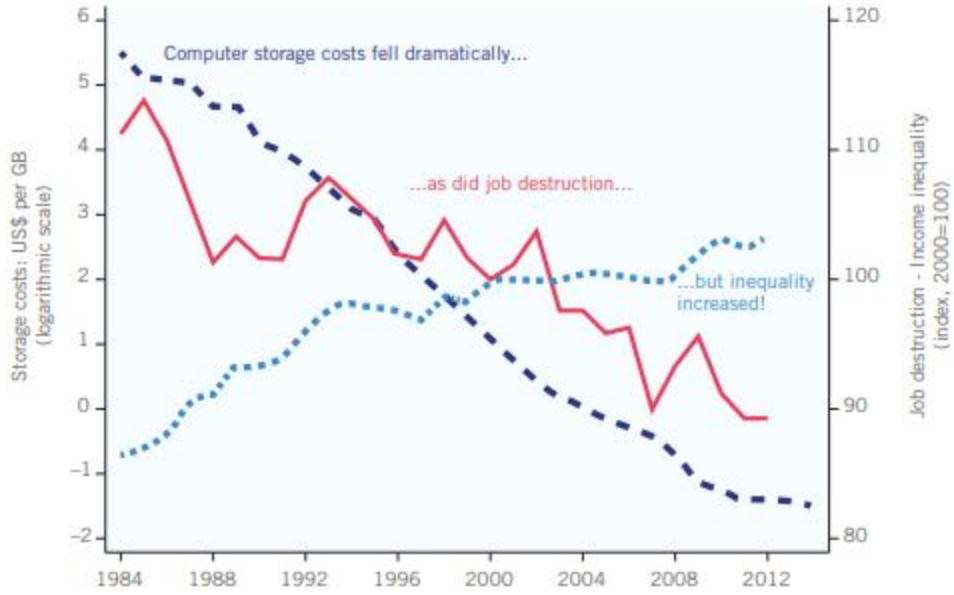
2.2.1 Technology's Influence on the Labour Market

5. Increased digitization and automation are expected to have a significant impact on both quality and quantity of work. New types of work and employment are changing the nature and conditions of work, changing skill requirements and replacing traditional work patterns and income sources. They open up opportunities for developing countries to enter new and fast-growing sectors and catch up with more developed countries. The unequal impact of digitization and automation on industry and location carries the risk of exacerbating existing gender imbalances. In certain automation-prone industries, such as automobiles, men can face greater unemployment than women.

2.2.2 Disruption, Inequality, and Job Transformation

6. At the same time, new technologies disrupt the functioning of the labour market, challenge the effectiveness of existing labour market systems and produce widespread results.

7. Present research[12] illustrate the revolutionary nature of technological change and highlight the potentially widespread impact of job destruction (ILO, 2017).



Note: Job destruction rate is a weighted average of Australia, Belgium, Canada, Denmark, France, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Sweden, United Kingdom and United States.

Sources: ILO, Labour Flows database, 2013; OECD, Labour Force Statistics; Muehlhauser, 2014.

Figure 1 – Inequality as a result of job destruction

Assessments of the degree of labour market turmoil vary widely from less than 10% of all jobs to over 60%. Jobs usually consist of both tasks that can be easily automated and tasks that cannot be easily automated. This raises the question of whether automation of the work process leads to downsizing or can the remaining tasks be shared among existing employees. The answer to this relies on how the work is organized in the workplace and how well the personnel can bundle tasks that are not easily automated into the new workplace. (Kucera, 2017).

2.3 The Maritime Landscape

2.3.1 The Vital Role of Maritime Trade

8. Almost 71% of the earth's surface is covered with water, and the ocean

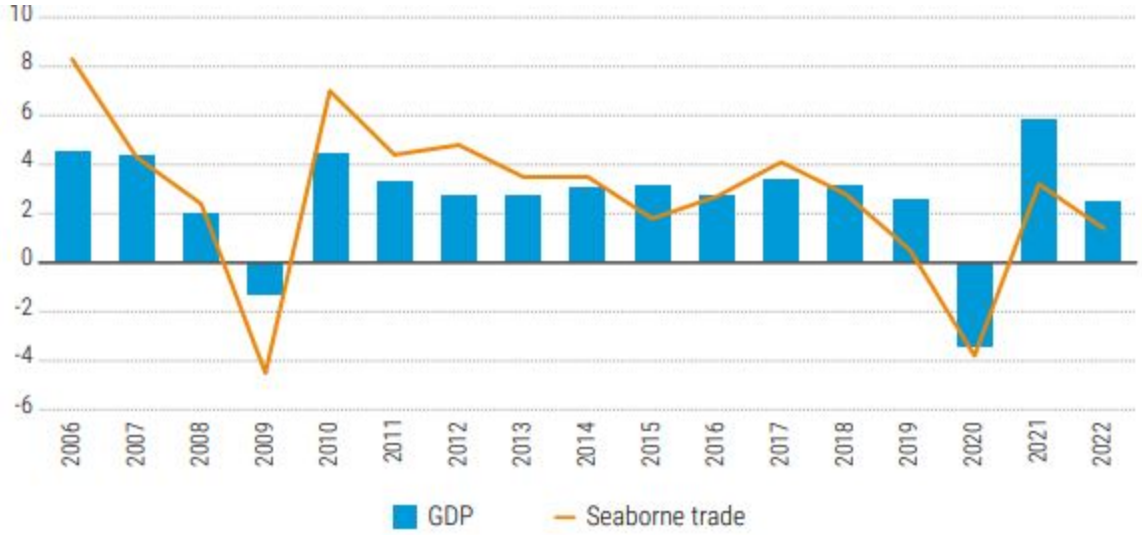
contains about 96.5% of all the water on earth.[13] Life has evolved over the years near water sources such as Mesopotamia, Harappa, and the ancient Egypt, emerging from riverbanks and slowly moving towards the high seas. The sea is the lifeline of humankind and will continue to be so.

Water source	Water volume, in cubic miles	Water volume, in cubic kilometers	Percent of freshwater	Percent of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.54
Ice caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	*2,526,000*	*10,530,000*	*30.1*	*0.76*
Saline	*3,088,000*	*12,870,000*	--	*0.93*
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	*21,830*	*91,000*	*0.26*	*0.007*
Saline	*20,490*	*85,400*	--	*0.006*
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

Table 1 – Estimate of Global Water Distribution

From simple products to high-end technology shipments, trade continues across the ocean. By volume approximately 80% of world trade and more than 70% of world trade in value are carried out at sea and handled in ports around the world.[14]



Source: UNCTAD secretariat, based on UNCTADstat data and *Review of Maritime Transport*, various issues. GDP figure for 2022 based on table 1.1, World Output Growth, 1991–2023, UNCTAD Trade and Development Report 2022.

Figure 2 – International Maritime Trade and World GDP(percentage and annual change)

2.3.2 Transportation, Innovation, and the Need for Adaptability

9. Transportation provides an important service to the national economy and to the global community.

Year	Tanker[a]	Main bulk[b]	Other dry cargo[c]	Total cargo
1970	1 440	448	717	2 605
1980	1 871	608	1 225	3 704
1990	1 755	988	1 265	4 008
2000	2 163	1 186	2 635	5 984
2005	2 422	1 579	3 108	7 109
2006	2 698	1 676	3 328	7 702
2007	2 747	1 811	3 478	8 036
2008	2 742	1 911	3 578	8 231
2009	2 641	1 998	3 218	7 857
2010	2 752	2 232	3 423	8 408
2011	2 785	2 364	3 626	8 775
2012	2 840	2 564	3 791	9 195
2013	2 828	2 734	3 951	9 513
2014	2 825	2 964	4 054	9 842
2015	2 932	2 930	4 161	10 023
2016	3 058	3 009	4 228	10 295
2017	3 146	3 151	4 419	10 716
2018	3 201	3 215	4 603	11 019
2019	3 163	3 218	4 690	11 071
2020	2 918	3 196	4 531	10 645
2021	2 952	3 272	4 761	10 985

Source: Compiled by the UNCTAD secretariat based on data supplied by reporting countries and as published on the relevant government and port industry websites, and by specialist sources. Dry cargo data for 2006 onwards has been revised and updated to reflect improved reporting, including more recent figures and a better breakdown by cargo type. Since 2006, the breakdown of dry cargo into "Main bulk" and "Dry cargo other than main bulk" is based on various issues of the Shipping Review & Outlook and Seaborne Trade Monitor, produced by Clarksons Research. Total maritime trade figures for 2021 are estimated based on preliminary data or on the last year for which data were available.

[a] Tanker includes crude oil, refined petroleum products, gas, and chemicals.

[b] Main bulk includes iron ore, grain, coal, bauxite/alumina and phosphate. Starting in 2006, "Main bulk" includes iron ore, grain, and coal only. Data relating to bauxite/alumina and phosphate are included under "Dry cargo other than main bulk".

[c] Other dry cargo includes minor bulk commodities, containerized trade, and residual general cargo.

Table 2 – Report on International Maritime Trade (Millions of tons loaded)

Innovation and technological advancements have always been a part of its development and have made transportation the engine of industrialization, globalization, and development. New technologies and increasing levels of automation are often introduced into transportation for reasons of safety or efficiency and, more recently, for the sake of the environment. However, each invention changes the nature of work. This may require new skills or a change in work habits. This can lead to a decrease in demand for workers with certain qualifications and can create new demand for workers with varied qualifications. This is not unheard of, and similar situations have been observed in the industrial development of our global community. What is always concerned in today's rapidly evolving technology age is the impact of changes in the nature of work on society and on employment.

10. The challenges of automation, emerging technology and the future of work are among the most important challenges facing workers today. As for unions, they need to be strong enough to be able to shape change. It is essential to understand the potential impacts and opportunities for workers and to prepare appropriate responses. This includes increasing engagement with industry partners and identifying the appropriate education, training and capacity building needs of the workers. The transport workers of today and tomorrow must be equipped with the knowledge, skills and expertise needed for the jobs of tomorrow.

2.4 Automation's Challenge to Traditional Employment

2.4.1 Automation's Potential to Reduce Demand for Workers

11. Research shows that the transport workers face a similarly corresponding risk of automation like their contemporaries in other sectors. The visualised advancement in automation technologies, such as artificial intelligence & mobile robotics, together with a declining price in computing power, is likely to have a similar impact on the tasks of workers across most industries. On an average, the transport sector has a similar potential for automation as other industries, especially for the

low and median-skilled groups of workers. The technology and related applications to be introduced in various industries will also affect job profiles in transportation.

12. The potential for reducing the demand for transport workers as a result of the introduction of technology varies among different transportation modes. Visionary simulations undertaken for aviation, road and rail, show a potential decline in employment due to increasing technology use. Similarly, futuristic simulations conducted for maritime transportation show that the introduction of advanced automated ships will lead to an overall decrease in the global demand for seafarers by 2040 vis-à-vis the baseline projection based on current technology. The introduction of highly automated ships can cut down the global demand for seafarers by 22 %. Simulations show that such results are not compensated by an increase in the volume of sea trade projected till 2040, and they reduce the effect of automation on demand by 8 percentage points.

2.4.2 Strategies for the Evolving Maritime Industry

13. Although there is much ongoing debate about automation and other innovations related to the maritime industry, the maritime sector is still in the early stages of change. Many countries do not have automation strategies in place. While some countries that strive to be leaders in many areas, including relevant regulatory, infrastructure and capacity development, have strived to develop policies and strategies in response to expected developments in the industry. These are also in the early stages of adoption.

14. The maritime industry is a vital component of the global economy, and its growth is essential for sustainable development. Shipping has been an essential mode of transportation since ancient times, but with the advancement of technology, the industry has undergone significant changes. The introduction of autonomous shipping has revolutionized the industry, making it safer, more efficient, and cost-effective.

15. In this regard, the international shipping fraternity has just begun discussions on the regulation of autonomous vessels, including the

scope of regulation by the IMO mentioned earlier. Many countries are active in this regard, including Australia, China, Denmark, France, Japan, Norway, the Republic of Korea, Sweden and the United States. So far, no country has announced a comprehensive strategy for shipping in 2040 that combines regulation and innovation, skills and capabilities, infrastructure, and future business models.[15]

2.5 Real-World Implications: Automation Isn't Science Fiction

2.5.1 Automation Trends and their Impact in Various Industries

16. Humanity has a strange relation with automation technology. As a whole, we love it. It has made our lives simpler & easier. Free time for leisure & free time to think ... about more possibilities of automation. Little by little, we've made automation smarter. First armed it with simple decision-making capability, then progressively with monitored thoughts until a self-learning mathematical model was reached. In the process, automation with artificial intelligence has allowed us to eliminate human effort everywhere. To get the big picture, elevator operators were replaced with buttons and auto-locking doors. We have reached self-driving cars that make better driving decisions than humans themselves. It has also reduced the population of factory buildings, bank branches, authorities and airport service areas.

Sources: Frey and Osborne. Tech. Forecast. Soc. Change. 114 (2017), Occupational Information Network (O*Net), WMU analysis

Figure 3 – Automation potential for job profiles in transport (percentage and annual change)

Today AI programs can check lab test results, patient medical records, and even handwritten medical notes to consistently match or exceed the performance of primary care paediatricians. Industrial manufacturing pioneered the use of robotics and artificial intelligence on the factory floor to automate labour-intensive, repetitive and task processes. After that the back offices such as purchasing, billing, collection and customer service joined the list. Predictive analytics have been used to improve demand forecasting, increase asset utilization, and keep various equipment more economical. In all cases, AI-based technologies have been shown to learn and improve in ways similar to humans, but with virtually unlimited ability to process and store data.

"Technological advances may disrupt labour markets as traditional jobs change or disappear, even as the number of young job-seekers continues to grow. Re-training will be needed at previously unimaginable scales. Education must adapt, from the earliest grades. And the very nature of work will change. Governments may have to consider stronger social safety nets and eventually universal basic income."

UN Secretary General's Address to the General Assembly, 25 September 2018[16]

17. Transport is not immune to the tendency of automation and the displacement of humans due to some automation that is often complemented by artificial intelligence.

18. The transportation company's back office came first. Contract optimization eliminated contract managers, price optimization reduced the number of price analysts, attribution optimization reduced the need for trade analysts, conversation bots become customer service centre mainstays. The recent news about OpenAI, which writes compelling

news and novels, is just a step away from digitizing them into speech, paving the way to displace humans in already scaled-down sales offices.

19. The causes here are different, but the front lines of traffic were also affected by these changes. The truck sector was hit hardest as the number of drivers leaving far outnumbered the number of new candidates to replace them. The additional weight of regulation affecting driver employment, as seen in European Union countries, has pushed many drivers back to their home countries, causing a driver supply crisis sooner than expected.

20. Next inline are locomotive drivers and operators. Railroad operators are looking at fully automated trains led by Australian mining company Rio Tinto. Equipped with unmanned trains, robot operators, cameras, lasers and position sensors, the company can remotely manage the mine-to-port supply chain while improving the overall security of its rail business. Competitor BHP Billiton is developing and enabling a fully automated mine. Removing a person from the equation eliminates human safety measures and improves mine efficiency by allowing dangerous operations such as blasting to continue without waiting for the person to leave the danger zone.

21. However, looking at automation, its adoption has always reduced the need for human labour. Companies in the tide of full automation claim to be able to retrain their dismissed employees for more attractive jobs overseeing new technologies. So far, none of these firms have been able to prove this. In the end, there are fewer and fewer employees.

22. Shipping is not unaffected by all these automation trends. At the terminal wharf, a group of 25 workers has been reduced to 8-10. In terminals where gangs are still around 15, half of the gang workers are roaming around. On ships, this technique reduces human activity from the engine room to the bridge. Yes, things are still collapsing, and we need a solid pair of human hands and human intelligence, but the general need for the numbers of the erstwhile crew is diminishing. Larger ships do not require larger crews, and modern ships that replace older and larger ships allow for smaller crews. The reality of manned vessels

today tells a story that is worrisome enough for the future of human employment.[17]

2.6 The Human Element in a Changing Industry

2.6.1 India as a Key Source of Global Seafarers

23. Shipping was the world's first globalized industry. A labour-intensive country, India has always provided excellent seafarers for domestic and international shipping. India is globally recognized as a reliable and important source of seafarers. Indian seafarers, both officers and deck & engine hands, are in high demand by the world's maritime nations. Over the past four years (2013-2017), Indian seafarers' onboard jobs increased by an unprecedented 42.3%. The number of seafarers employed by vessels around the world increased from 108,446 in 2013 to 154,349 in 2017. India currently accounts for 9.35% of the world's seafarers and is ranked third on the list of major seafarers supplying the country to the world's maritime industry.[18].

24. In 2019, more than 234,000 Indian seafarers were hired on domestic and international vessels. Year-on-year, the number of seafarers employed increased by more than 12% in 2019. Some of the reasons[19] were improved maritime training standards, increased training opportunities on board, and improved testing and certification systems.

2.6.2 Automation, Job Prospects, and the Need for Skills Evolution

25. AI and automation are altering the world in one industry at a time. Whatever humans can do, machines learn to do it effectively, reducing costs and errors. There is no difference in the marine industry. Ships are now becoming more and more automated (so-called maritime autonomous surface ships or MASS), reducing the need for human input. This is good news to the ship owners when it comes to labour and fuel costs, but if MASS takes over, the question naturally arises is that of the future of seafarers, the main labour force in the shipping industry. To understand this, South Korean researchers used complex mathematical models and simulations to determine the impact of MASS technology on lost and acquired work in relation to time.[20]

26. Autonomous shipping refers to the use of advanced technologies, such as artificial intelligence, machine learning, and the internet of things (IoT), to operate ships without human intervention. Autonomous ships are equipped with a range of sensors and navigation systems that allow them to navigate and avoid obstacles. The development of autonomous shipping is a significant advancement in the maritime industry, with the potential to revolutionize the way shipping operates.

27. Autonomous ships are equipped with a range of technologies that enable them to navigate and operate without human intervention. These technologies include sensors, cameras, radar, and advanced navigation systems. The ships use algorithms to analyse data from these technologies to make decisions about their course and speed. Autonomous ships are also equipped with collision avoidance systems, which help them avoid obstacles and other vessels.

28. The development of autonomous shipping has the potential to impact the job prospects of seafarers. With the introduction of autonomous ships, the need for crew members may decrease, leading to job losses in the industry. Seafarers who are currently employed on ships may need to acquire new skills to remain relevant in the industry.

29. A recent two-year study carried out by The World Maritime University and funded by International Transport Workers' Federation (ITF) concludes that the new technology would reduce global demand for seafarers by about 22% by 2040. According to this study, the impact of automation varies from region to region, and workers are affected in many ways due to their different skill and readiness levels in different countries. However, it encourages unions, shipowners, and shipping authorities to work together to do more to develop new training programs and new skills.

30. In the words of ITF general secretary Stephen Cotton:

    'Transport workers of today and tomorrow must be equipped with the required knowledge, skills and expertise for the jobs of tomorrow".

    The study[21] gives the information needed to support these goals. The ITF

stays committed to working in partnership to ensure that the unions and affiliates are at the centre of development in building the future of work.

2.7 Autonomous Shipping: The Technology

2.7.1 Automation and Seafarer Concerns

31. In a survey[22] prepared by the HSBA (Hamburg School of Business Administration) for the International Chamber of Shipping, more than 80% of seafarers expressed concern about the potential for unemployment due to automation.

32. The above shows that automation is very likely to face opposition from seafarers and their unions. Seafarers and their unions believe that livelihoods and safety will be compromised if introduced in a way that focuses primarily on initial enthusiasm and cost savings. This view sparks a new challenge for automation of gaining public acceptance to help influence legislators and regulators' decisions regarding the creation and modification of regulations that affect the implementation of autonomy in worldwide deep-sea transport.

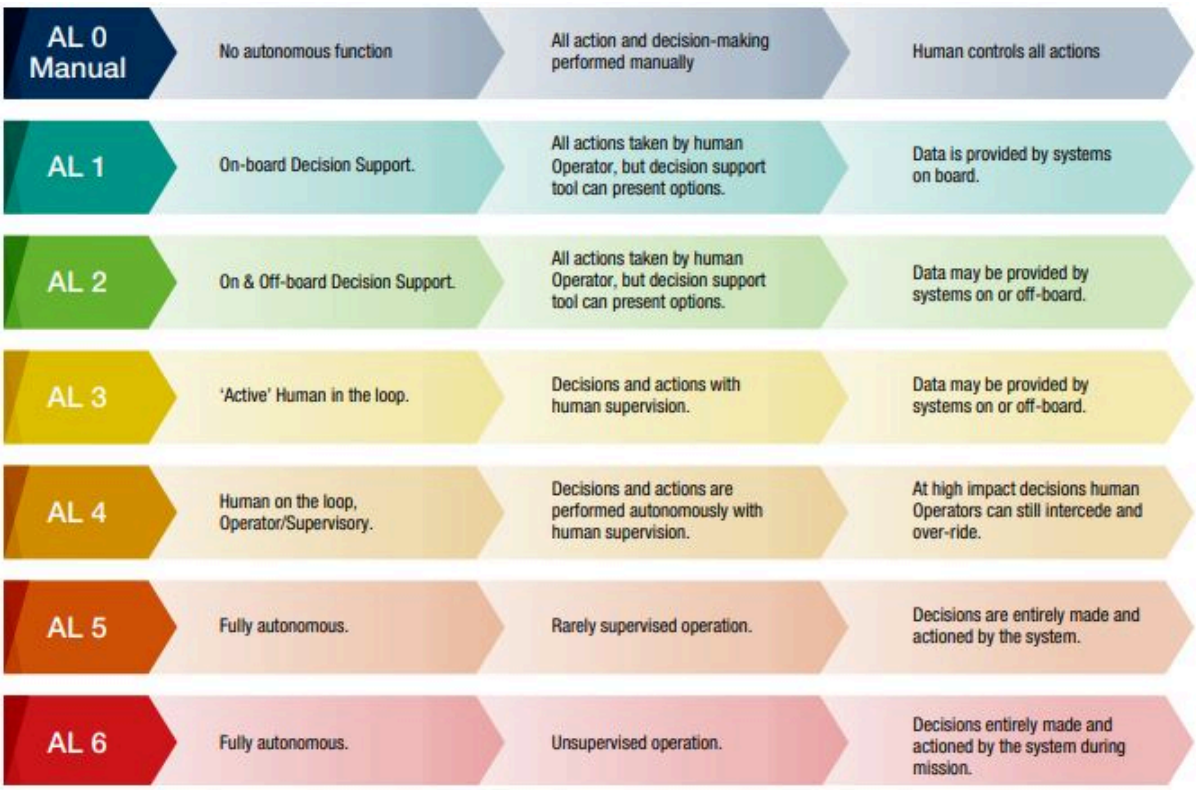


Figure 4 – Six levels of Autonomy defined by Lloyds Register for Merchant Ships

2.7.2 Leaders in Autonomous Ship Innovation

33. Rolls-Royce – A world leader in ship design, ship propulsion, engineering, fluid dynamics and system integration, is deeply involved in autonomous ship research.

"Autonomous shipping is the future of the maritime industry. As disruptive as the smartphone, the smart ship will revolutionise the landscape of ship design and operations".

Mikael Mäkinen, President, Marine, Rolls Royce[23]

34. The ability to self-monitor the condition of a ship, determine and communicate about its surroundings, and make informed decisions is essential to the development of autonomous operations. What is needed is to develop a set of electronic sensations that inform the electronic brain and allow ships to navigate safely and avoid collisions. The AAWA (Advanced Autonomous Waterborne Applications Initiative) project[24] is exploring three areas:

(A) Sensor fusion

(B) Control algorithms.

(C) Communication and connectivity

35. Remote and autonomous vessels have the potential to reduce human error, but at the same time modify some existing risks and create new types of risks. Corrective actions that may be considered for these situations should be investigated. The shipping industry has experience in systematic and comprehensive risk assessment. However, it requires a broader and deeper understanding of new technologies, new knowledge, and new and changing risks, including many known and unknown hazards. Cyber security is important for remote control and the safe and

successful operation of autonomous vessels. This project identifies current best practices in various industries and adapts them for application to the marine environment. The results will be used to make recommendations to regulators, classification societies and other AAWA partners to support development efforts to develop the first set of standards for remote and unmanned vessel operations. In the shipping industry, autonomous transportation by remote control is increasingly being considered. Discussions with the industry have identified direct cost savings and other indirect benefits.

Direct benefits get mentioned at a ship level:

(A) Better use of space in ship design

(B) Better use of crew and their skills

(C) Better use of fuel.

2.7.3 Advantages and Indirect Benefits of Autonomy

36. Indirect benefits occur in the enterprise and network level in the shipping industry. Remotely controlled autonomous dispatch improves procedural and process optimization. For example, optimizing processes and operations based on real-time data not only enables economies of scale at the fleet and enterprise level, but also reduces the likelihood of human error, and ensures safety and quality of service. In transport, autonomous transport reorganizes roles and reorganizes the division of labour.

37. The AAWA team believes that these indirect benefits are the key to achieving a long-term competitive advantage through autonomous delivery. The industry now needs to look for tasks where autonomous vessels are particularly profitable.

38. The technology for Autonomous ships is no more in the realm of theory. Below a few extracts from successful prototype trials and reports.

2.8 Autonomous Shipping: Success in Trials

2.8.1 Japan's MOL Lines: Autonomous Ship Trials

39. MOL Lines Co., Ltd. (MOL; President and CEO: Takeshi Hashimoto), together with two group companies and the following consortium partners, is the world's first maritime unmanned ship operator (from: Tsuruga Port - Fukui Prefecture, to: Sakai Port - Tottori Prefecture) on 24th and 25th January 2022, as part of the MEGURI 2040 unmanned ship project led by the Nippon Foundation. [25]

40. The following two points are important features of the consortium's role in the MEGURI 2040 project:

    (A) Sea trials were carried out with two different types of ships: a coastal container vessel and a coastal car ferry. Intention was to develop state-of-the-art technology by identifying similarities and differences between the two types of ships.

    (B) Drones were used to develop automated mooring operation processes.

41. Since the establishment of MEGURI 2040 in 2020, the consortium has conducted various basic experiments to realize autonomous ship operations. Prior to this sea trial, in October 2021, MOL Marine & Engineering Co., Ltd. Carried out a safety clearance test using their own 3D simulator. In the case of autonomous navigation, the vessel used the autonomous vessel operation control system to follow the previously formulated route, considering the following factors:

    (A) Accurately capture the location information of the ship

    (B) various external factors such as wind and currents

    (C) Ship handling performance (manoeuvrability, condition, equipment configuration) unique to each ship.

    (D) Safety of navigation rules that are applied to ships.

42. Furuno Electric's autonomous environmental information integrated system collects information on other vessels, obstacles, and debris existing on the set route (measures position, speed, type of surrounding vessels, and position of obstacles and rubble by providing integrated information from various on-board navaids). This further helps in creating secure routes created by an autonomous collision avoidance

routing system based on integrated information.

43. Great care should be taken with autonomous docking and undocking. When docking and undocking, the ship uses information from the docking/undocking assist sensor (a device that obtains the exact relative distance and angle between the pier and the hull from the collected information) developed by Furuno Electric. Calculated and displayed visually using aids like LiDAR/camera/satellite compass.

44. "Automated mooring" using an automatic flight drone to carry the line to the pier was demonstrated. This is being touted as the future of mooring, especially in the realm of autonomous ships.

2.8.2 NYK Line: Advances in Autonomous Ship Navigation

45. A recent trial undertaken by NYK Line[26] has taken a major step towards achieving the company's goal of operating a manned autonomous vessel. This should ultimately lead to safer operation and reduced crew workload. This technology is especially needed in the coastal shipping industry, where shipping companies are suffering from severe labour shortages.

46. The first NYK maritime autonomous surface vessel (mass) test was conducted in accordance with IMO's interim mass test guidelines and included a 70,826 tonnes vessel, Iris leader, a pure car and truck carrier (PCTC) operated by NYK. The ship was navigated 24 hours a day using the Sherpa System for Real Ship (SSR) navigation system. This two-part trip includes the first transit from Xinsha (China) to Nagoya (Japan) from September 14th to 17th, and then to Yokohama (Japan) between September 19th to 20th. During this time, the crew performed typical missions during the voyage. The main objective of this study was to use existing navigation equipment to gather information about the environmental conditions around the ship and see how the SSR works under real sea conditions. Collision risk was calculated with continuous monitoring of automatically determined optimal routes at a safe and economical speed.

2.8.3 American Steamship Company & Wärtsilä: SmartMove Suite for Autonomous Navigation

47. American Steamship Company with Wärtsilä are on the anvil of a breakthrough with a hands-off, self-driving and self-docking navigation system which has been set up on a conventional lake freighter. According to Wärtsilä[27], the 24,000 GT American Courage is the biggest ship ever to carry out automatic dock-to-dock navigation. Wärtsilä's Voyage division set up its pioneering business-oriented SmartMove Suite operation system aboard the 42-year-old laker ship the MV American Courage as early as March 2020. The self-unloading vessel is 630 ft in length and operates on the winding Cuyahoga River waters of Ohio. This waterway tends to get very congested off and on, and Wärtsilä confirms that it is one of the most difficult routes for any vessel using autonomous sailing and docking technology presently.

48. Sophisticated decision-help systems, such as Wärtsilä SmartMove, bring tremendous value as per Wärtsilä's John J. Marshall because they can automate seemingly repetitive tasks, such as docking on the same stations. Stated intentions are enhancing the capabilities of the onboard crew as they navigate liner-like routes and congested or restricted areas.

49. The Wärtsilä SmartMove suite comes with backed up controllers and displays, along with a collection of advanced sensors (gyro, motion reference unit, anemometer and advanced position fixing systems). These are then unified with a single digital platform. The basic blocks of software that make it work are taken from Wärtsilä Voyage's DP products, that have been in use for a long time in the offshore sector. The version of the complete arrangement installed aboard the MV American Courage uses the nearby environment for vessel position fixing, further making it ship-centred rather than on shore, according to Mr. Pierre Pelletreau of Rand-ASC Holdings, the parent company of American Steamship. It is created to meet the company's requirement for a position error margin of less than two meters.

    "We are effectively making each component 'smart' so that the ship itself becomes the sum of the parts and is capable of working as

efficiently and smartly as possible," said Thomas Pedersen, director of automation and DP for Wärtsilä Voyage.[28]

2.8.4 Other Notable Autonomous Ship Projects

50. In December 2018, Rolls-Royce and Finferries demonstrated a vessel classified as an autonomous vessel as described earlier, with car ferry Falco (LOA: 53.8m) by carrying out fully autonomous navigation between Parainen and Nauvo in Finland. The ship is equipped with an obstacle detection system that integrates sensors and AI and avoids obstacles based on information from this obstacle detection system, providing fully autonomous navigation control without the intervention of seafarers. It also carried out automatic docking.[29]

51. In February 2020, in a joint project with Bastø Fosen, Kongsberg and the Norwegian Maritime Authority (NMA), Kongsberg Maritime installed an automated operating system on the Bastø Fosen-operated car ferry Bastø Fosen VI (total length: approximately 140 m). They then succeeded in experimenting with MASS, demonstrating autonomous operation from departure to arrival under normal operating conditions between Horten and Moss, Norway.[30]

52. In 2021 January, the United States. Department of Defense (DOD) announced[31] that their craft named MASS, had demonstrated successful navigation on a route of approx. 4,700 miles from the Gulf Coast to the US west coast of California via the Panama Canal. Approximately 97% of the voyage was self-sustaining (autonomous), and one of the few situations in which a small crew on board operated the ship was when passing through the Panama Canal. Although the US Department of Defense press release uses the term "unmanned," the vessel was categorized as an autonomous vessel / MASS by definition because it was tested with on board crew.

2.8.5 The Yara Birkeland: World's First Zero-Emission Autonomous Containership

53. The Norwegian vessel YARA Birkeland is the world's first fully electric and autonomous container ship, with zero emissions[32]. KONGSBERG is

the entity responsible for the development and delivery of all key technologies, including electric propulsion, batteries and propulsion control systems, as well as sensors and integration required for remote and autonomous ship operations. The 120 TEU (20-foot equivalent unit) open container vessel is a fully battery-powered solution, ready for autonomous and unattended operation. The vessel reduces NOx and CO2 emissions by eliminating approximately 40,000 diesel-powered truck trips per year. This eco-initiative will help achieve the UN Sustainable Development Goals and improve road safety and congestion.

54. The first segment of the project will implement a removable bridge with manoeuvring and navigation equipment. This module is lifted when the ship is ready for autonomous operation. Loading and unloading is done automatically with an electric crane and related equipment. The ship does not have a ballast tank but uses the battery pack as a permanent ballast. The ship will be fitted with an automatic mooring system. Docking and undocking is done without human intervention and does not require any special implementation on the dock.

2.9 Deduction

55. There is a strong contemporary relevance to investigate the research for developments in autonomous shipping and its potential to impact job prospects of seafarers.

3 Aims and Objectives

1. Study and understand the latest developments in autonomous shipping.
2. Examine operational feasibility in worldwide launching of autonomous ships especially MASS Degree 3 & MASS Degree 4.
3. Find out the effect of automation on shipboard job prospects of seafarers from a chronological perspective and combine those findings with the present-day scenario with autonomous ships and extrapolate as a forecast for the future with increased implementation of autonomous ships.
4. Understand the general course of job prospects worldwide across sectors with increasing dependence on technology and prognose the scenario in shipping.
5. Look at the possibility of improvement in existing skill sets and imbibing contemporary and futuristic skill sets to help seafarers survive in an environment of autonomous ships.
6. Work out possible training modules and formal programs that will help a primarily seafarer supply country like India to better prepare to tap into the possible job opportunities that may be created in the future.

4 Research Question and Hypothesis

Developments in autonomous shipping and its potential to impact job prospects of seafarers. - Is there a definite cause of worry for the seafarers and a primarily seafarer providing country like India on loss of employment?

5 Research Methodology

5.1 PLAN

The approach to the dissertation was planned on the below lines:

(A) Reading and collating from research papers and freely available study material related to the research question from authentic and reputed sources online.

(B) Preparing and circulating a simple to read and respond validated mass survey questionnaire to seafarers in general across ranks and competency.

(C) Identifying specialised fields related to the research questions →zeroing in on willing subject matter experts in the identified fields →preparing targeted sets of questions to the willing experts based on A and responses to B.

(D) Collating the responses received under C and combining with A to arrive at a conclusion to the original research question.

5.2 PROCEDURE

A) As part of the initial process of collecting and studying relevant material, the internet was widely used.

Research papers were primarily sourced from Google Scholar and inputs were also collected from IMODOCS.

Reputed and authentic material freely available online was read and collated to prepare for the Abstract, Introduction and Background sections of this dissertation with applicable citations.

B) A set of online survey questions basis the preparatory study & personal experience was created on the platform of SURVEYMONKEY.COM. For content and construct validity, this was

then piloted through the guide. Then the finalised set of 9 questions were widely circulated among the marine officers predominantly on the management and operational level via social networking platforms like WhatsApp and Facebook on the principle of relay forwarding.

Confidentiality of responses was maintained through the survey portal with names and identities being withheld from public domain.

The seafarers – Nautical and Engine officers primarily at the management level were chosen across the board among all ranks and competency and among the various organisations involved with seafarers namely.

- The Company of Master Mariners of India,
- Various branches of the Nautical Institute,
- The Mariners Society,
- The Institute of Mariner Engineers India,
- The Indian Maritime University,
- The Kerala Merchant Navy Officers Association,
- Mariners Club, Thrissur,
- Kannur Mariners Club,
- Employees of the Marine Departments of the Major Ports of India,
- The All-India Maritime Pilots Association,

and various colleagues and fellow senior marine professionals in my acquaintance.

5.2.1 *Qualitative Analysis - 1*

The survey responses from 210 respondents were subject to analysis as per

below:

a) Reading through the entire set of responses.

b) Organizing chunks of responses conveying the same idea into meaningful parts.

c) Collating each chunk of responses data.

d) Allocating structured themes emanating out of the analysis.

The responses were then compiled and grouped as per questions.

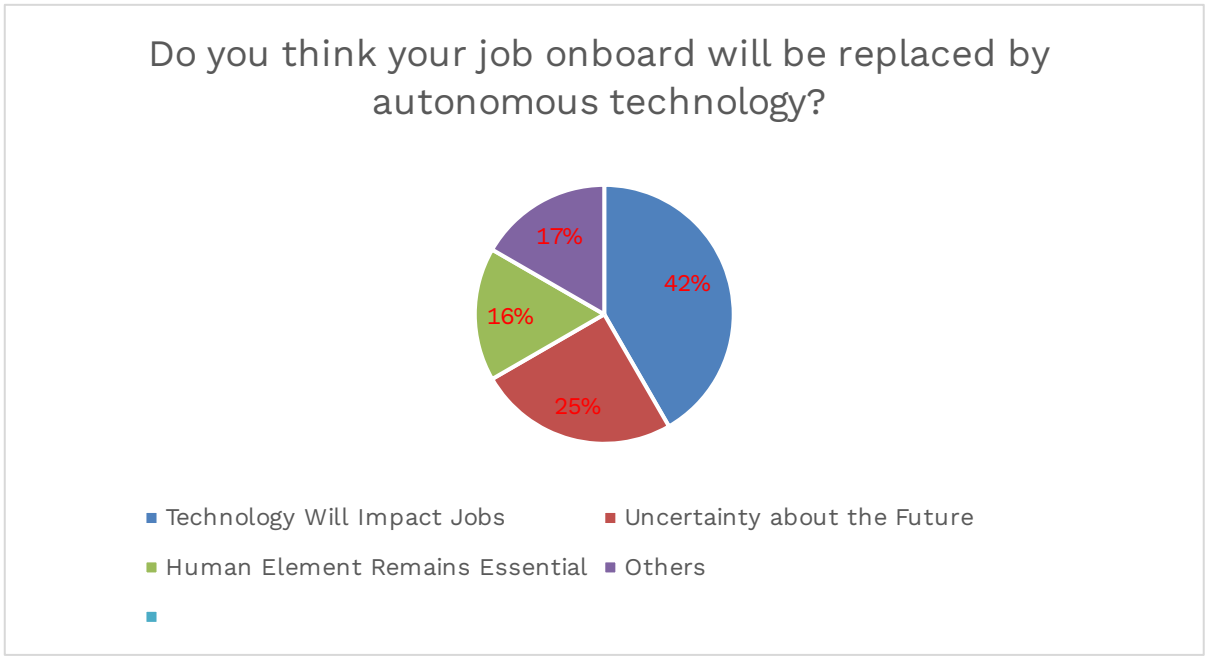


Figure 5 – Survey Question number 1

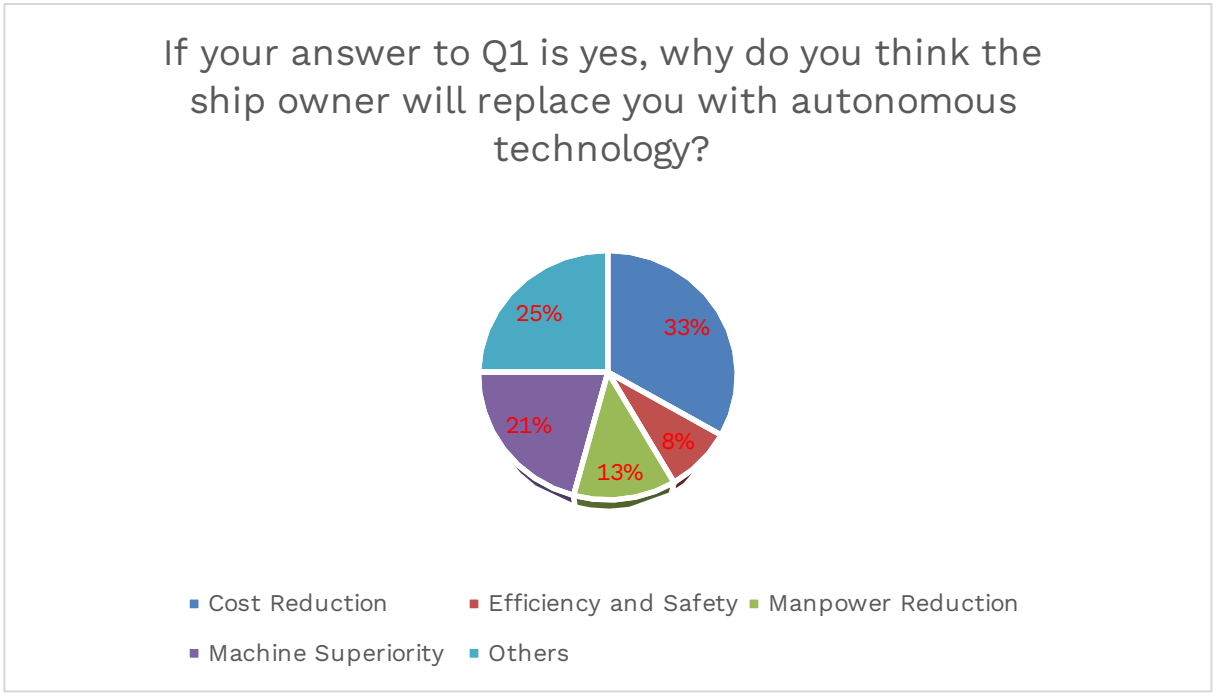


Figure 6 – Survey Question number 2

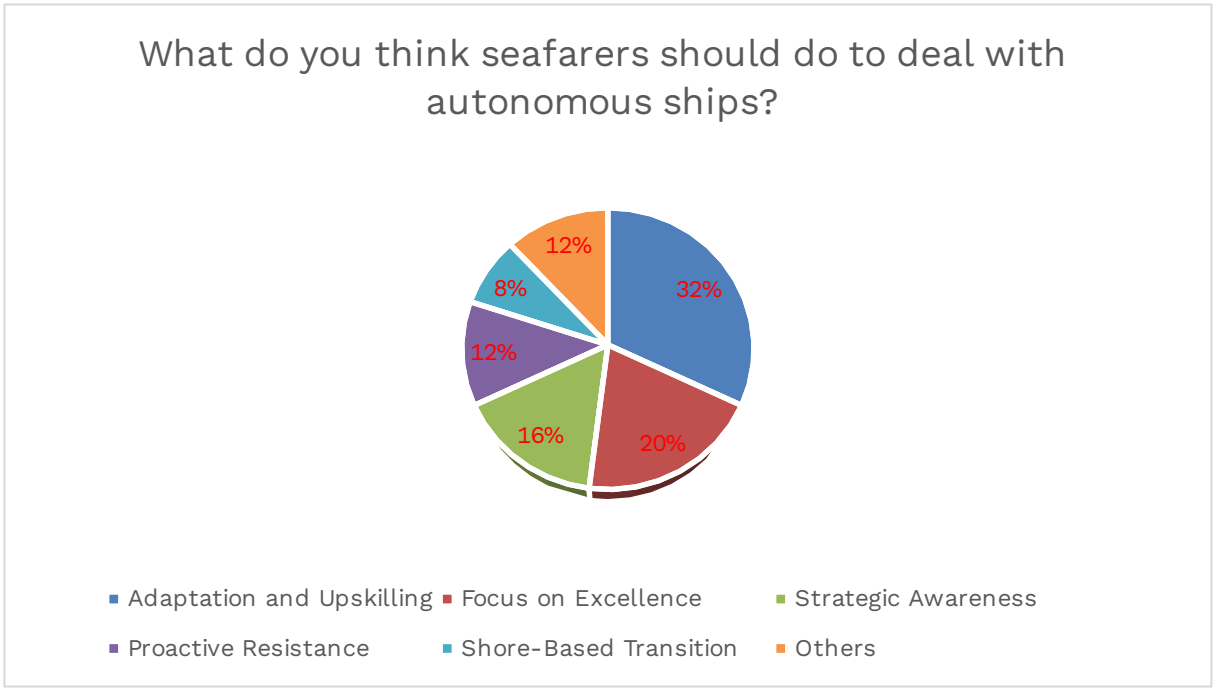


Figure 7 – Survey Question number 3

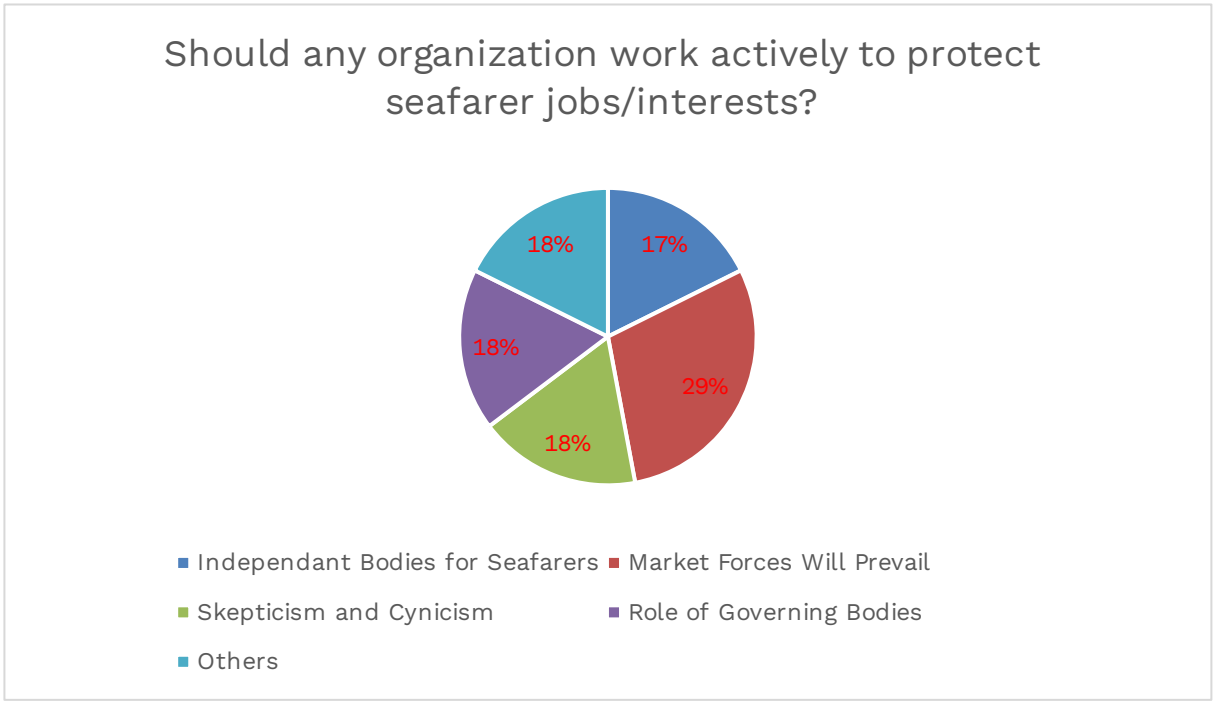


Figure 8 – Survey Question number 4

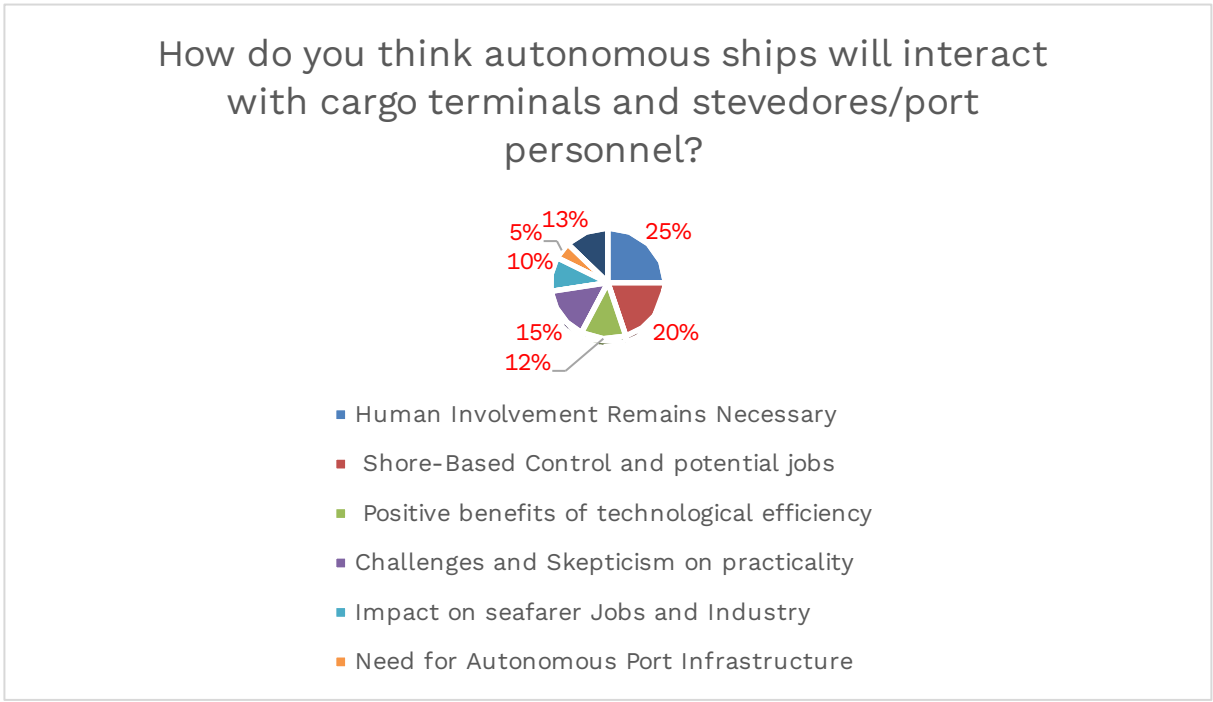


Figure 9 – Survey Question number 5

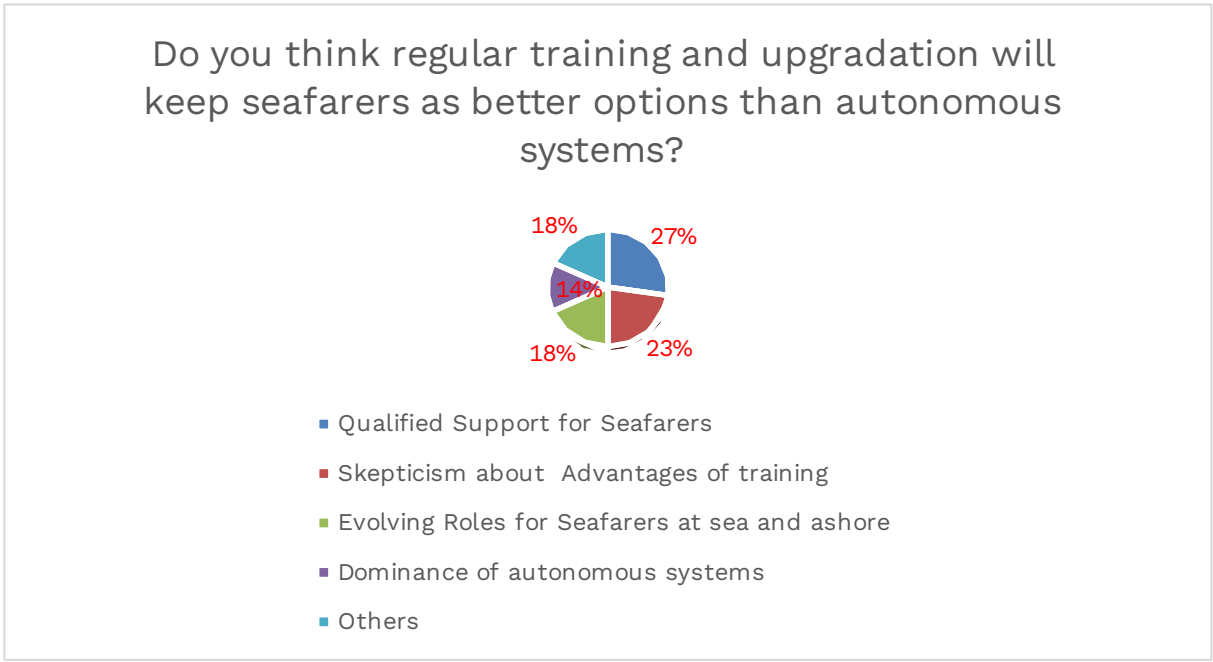


Figure 10 – Survey Question number 6

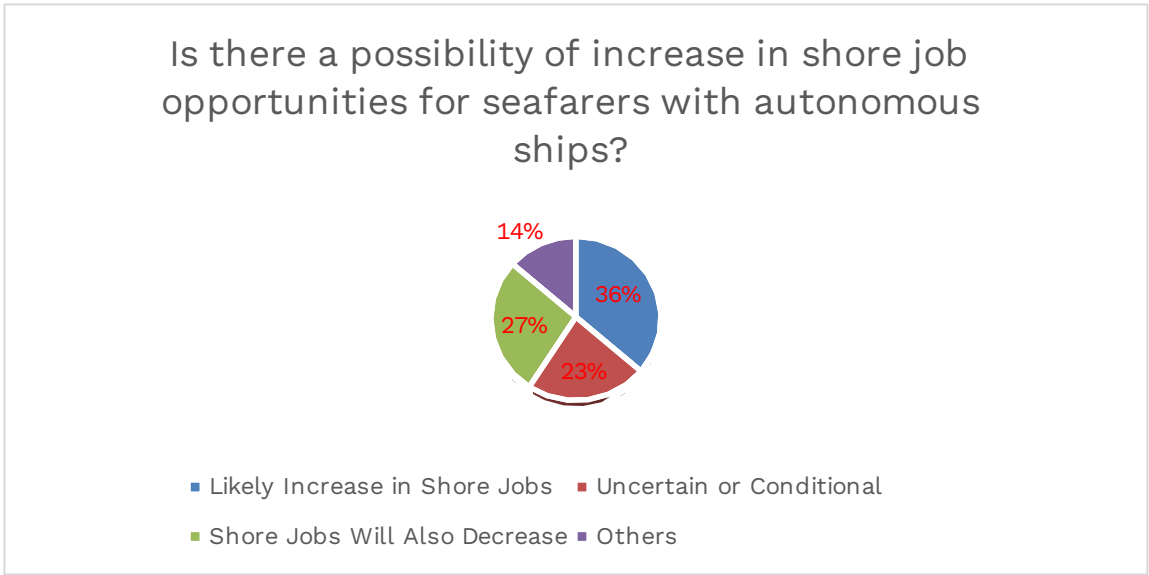


Figure 11 – Survey Question number 7

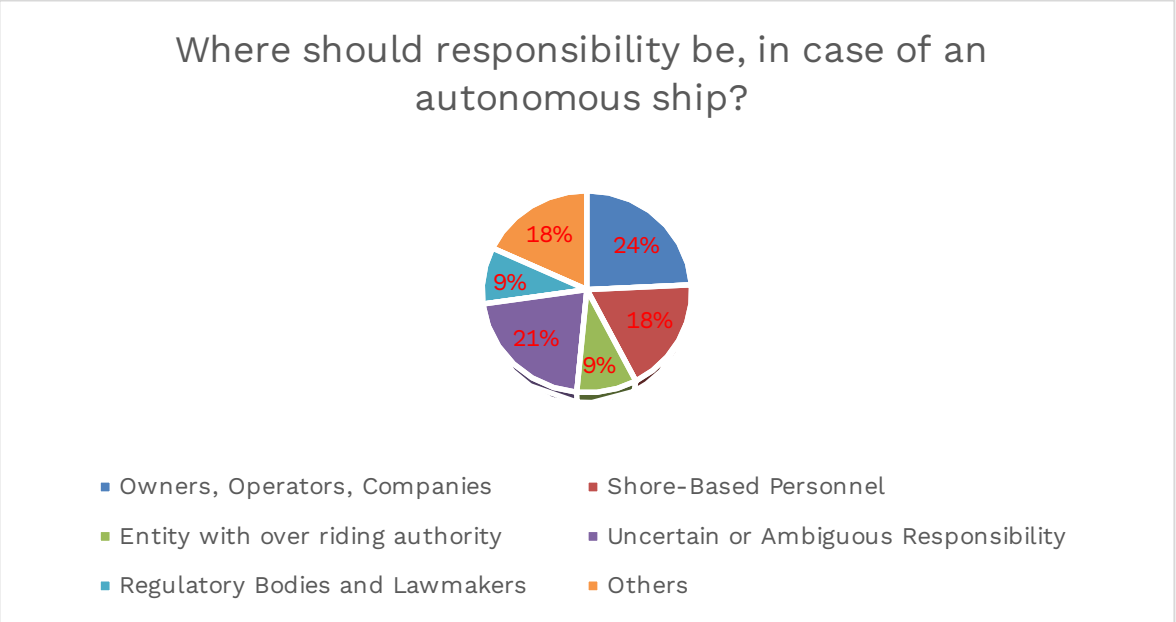


Figure 12 – Survey Question number 8

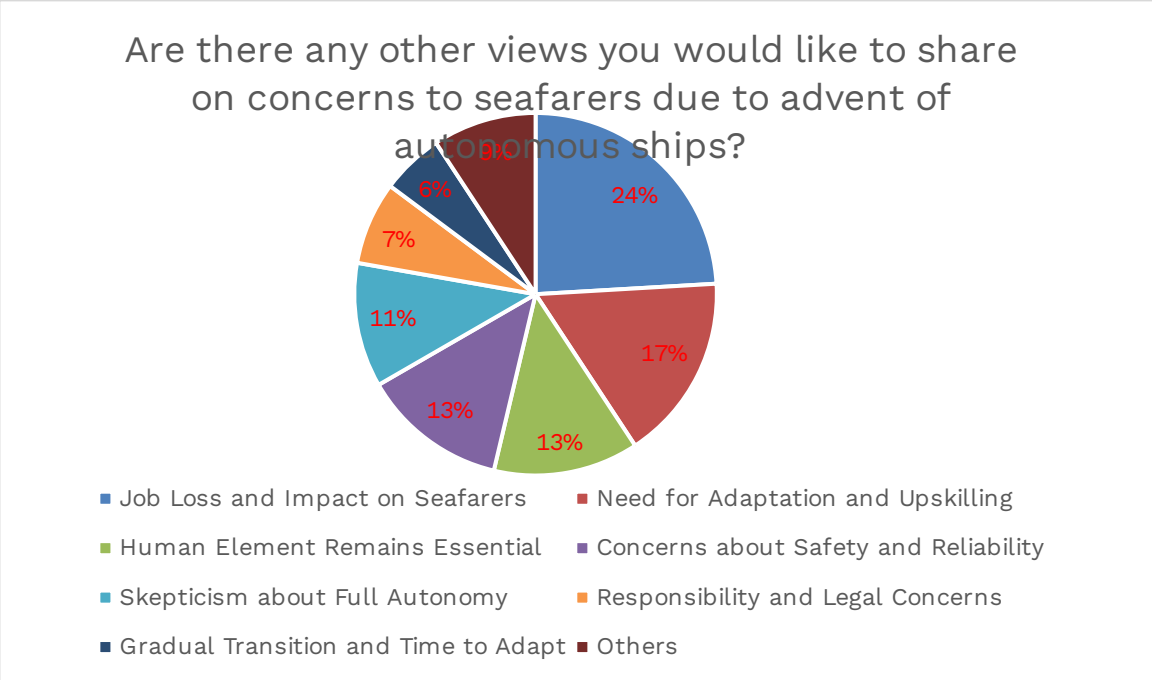


Figure 13 – Survey Question number 9

Key findings after the analysis as per below:

1. Job Security Concerns are Prevalent:
    a) A significant majority of seafarers believe autonomous ships pose a threat to their jobs.
    b) They primarily cite reduced labour costs and efficiency as ship owners' motivations for replacing them with technology.
2. Seafarers See a Need for Adaptation:
    a) Most respondents agree that continuous training, technology upskilling, and embracing change are crucial for seafarers to remain relevant in the evolving industry.
    b) They express a desire to learn about AI, autonomous systems, and their potential roles in the future of shipping.
3. Support for Seafarer Interests is Desired:
    a) An overwhelming majority of respondents believe dedicated organizations should proactively work to protect seafarer jobs and interests in the autonomous shipping era.
        - Suggested stakeholders include unions, the IMO, and educational institutions.
4. Shore Opportunities May Increase, but Uncertainty Prevails:
    a) While most seafarers see the potential for increased shore-based jobs with autonomous shipping, there's uncertainty about:
        - Whether seafaring experience will be valued in these roles.
        - If enough shore jobs will exist to offset seagoing job losses.
5. Complex Interactions with Ports are Foreseen:
    a) Respondents anticipate challenges and the need for new protocols in how autonomous ships interact with port personnel,

cargo terminals, and stevedores.

b) Concerns include potential communication difficulties and the need for human supervision during loading/unloading.

6. Responsibility Allocation Remains a Key Question:

a) There's no clear consensus on who should bear ultimate responsibility in the event of an incident involving an autonomous ship and manned ship.

b) Potential liable parties include:

- Ship owners/managers/operators.
- Remote control operators
- Technology manufacturers
- Flag states.
- Classification societies

C) A total of 10 specialised domains were subsequently identified basis outcome of the initial survey questions, background study and guide recommendations, suitable for correlation with the intended study.

RESOURCE	DOMAIN	ORGANISATION	EXPERT PROFILE	METHOD
1	*Regulatory*	*DG shipping*	*Chief Surveyor*	*Questionnaire*
2	*Port*	*Cochin Port*	*Deputy Conservator*	*Questionnaire*
3	*Ship owner*	*Massterly AS*	*Vice President*	*Questionnaire*

3	*Ship owner*	*Alpha Ori*	*Chief Business Officer*	*Questionnaire*
4	*Class*	*IRS*	*Senior Principal Surveyor*	*Questionnaire*
5	*Ship design*	*Cochin Shipyard*	*Assistant General Manager*	*Questionnaire*
6	*Terminal*	*DP World*	*CEO*	*Questionnaire*
7	*Cyber security*	*Principle Business Consultants*	*CEO*	*Questionnaire*
8	*Maritime training*	*Synergistic Solutions MASSA Maritime Academy*	*Senior Faculty, Extra Master*	*Questionnaire*
9	*Fleet personnel*	*MSC Crewing Services*	*Director*	*Questionnaire*
10	*Insurance*	*None*	*None*	*NA*

Table 3 – Expert Resource Details

5.2.2 The Panel of Experts

1. Experts of long-standing repute were short listed basis guidance from professional peers, guide, online resumes, and personal experience.
2. Elaborate sifting was done of the mass survey responses numbering 210 in total for removing blank and non-committal responses for the creation of the customised survey questions for each specialised domain. This was then vetted with the guide for final compilation.
3. Detailed requests elucidating the intention of this study and objectives under the ambit of DG Shipping were prepared and sent to each

identified expert as part of the request email to join in the dissertation process. A separate consent form suitably worded to assure confidentiality and non-disclosure of identity if so desired by the respondent was also sent along with the emails to the experts.

4. This was then combined with data gathered from study online leading to the creation of separate itemised questionnaires for each of the identified specialist domains.
5. These itemised questionnaires were then sent out by email to the experts willing to be part of the dissertation process for their appropriate response.

6 Findings

6.1 Benefits & Challenges of Autonomous Shipping

1. There are several potential benefits of autonomous shipping, including:
    - Reduced labour costs: Autonomous ships do not require a crew, which could significantly reduce labour costs.
    - Improved safety: Autonomous ships could reduce the risk of human error, which is one of the leading causes of maritime accidents.
    - Increased efficiency: Autonomous ships could operate beyond the ambit of rest periods, which could improve efficiency and reduce transit times.
    - Reduced environmental impact: Autonomous ships could reduce emissions by optimizing their routes and speeds without the human comfort and safety considerations.

2. While there are many potential benefits of autonomous shipping, there are also significant challenges, including:
    - Technological limitations: The technology required for autonomous shipping is still in its infancy, and there are several technical challenges that need to be overcome.
    - Regulatory challenges: The regulatory environment for autonomous shipping is still developing, and there are many legal and regulatory challenges that need to be addressed. Regulatory structures surrounding autonomous shipping are significantly lagging behind technological progress. This gap creates uncertainty for all maritime stakeholders.
    - Cybersecurity risks: Autonomous ships are vulnerable to cyberattacks, which could have significant safety and security implications.
    - Social and ethical concerns: There are concerns about the impact of autonomous shipping on the job market and the potential loss of jobs for seafarers.

6.2 Autonomous Ships and the Future of Seafaring

3. As per Baum-Talmor, Polina & Kitada, Momoko, (Industry 4.0 in shipping: Implications to seafarers' skills and training), Since the late 18th century, individuals have undergone several industrial revolutions. At this time, a mechanism powered by water and steam accelerated the production of products. The shipping industry has benefited directly from these technological advances in the form of increased cross-sea trade and improved shipbuilding technology, following mass production in Industry 2.0 in the 19th century. In the 20th century, the first computers and automation were introduced as part of Industry 3.0. Correspondingly, the shipping industry has significantly increased not only the volume of cargo, but also the opportunities for maritime careers, including sea and land work. Looking at the development of the 21st century, individual elements of human activities and work began to be digitized. Innovative solutions and opportunities arise in the industry connect various digital systems seamlessly between cyber-physical systems. As part of this trend, the shipping industry has also begun to find new horizons for technological development. One of them is Industry 4.0, which is autonomous ships.

4. The maritime industry has just started to witness the effects of Industry 4.0 The maritime industry has just witnessed the impact of Industry 4.0. Radical advocacy of digitization in shipping is often discussed in terms of autonomous or unmanned vessels entering the marine vocabulary. There are several projects that have been examining the practicability of autonomous ships (Porathe, 2016). For example, in November 2021, the first autonomous container ship, Yara Birkeland, successfully navigated to Oslo. In Japan, many unmanned ship projects are in the pipeline, which are foreseen to culminate by 2025, for testing purposes. Even though, these projects are noteworthy, their limitation to land or inland navigation means that most ocean-going vessels are still far from fully autonomous operations. In the near future, seafarer qualifications and skills will evolve. Seafarers still play an important role in the operation of the world's fleet. Changes in skills and roles required on board the Industry 4.0 era can impact seafarers' career paths. After working on

ships for several years, seafarers often quit the sea for shore-based employment (Baum-Talmor, 2021) in different areas and sectors, ranging from training, port operations, maritime administration to ship broking and finance being some of the common ones (Baum-Talmor, 2018; Cicek et al, 2019).

5. Digitization is expected to improve ship-shore connectivity and increase shore-based ship operations. (Baldauf et al., 2018).

6.3 Seafarers: Profile, Challenges, and concerns

6. Seafarers usually obtain many work-related certificates along with the main CoC (Certificate of Competence). These include, for example, Advanced Fire Fighting Training Certificates, Dangerous Cargo Endorsement related (DCE) Certificates, Fitness Certificates (COF), and Global Maritime Distress and Safety System (GMDSS) Certificates. If they are sailing on certain types of vessels (oil, gas, chemical tankers, etc.), they will need to renew the relevant certificates from time to time to keep their employment. The data showed that renewal of such an important certificate demonstrating the ability of the seafarer is highly dependent on the seafarer's personal initiative, including the cost of the renewal. Almost all mandatory training costs are borne by the seafarers and their family.

7. Increase in administrative burden on board and the busy schedule combined with the reduction in the number of crew members make it difficult for seafarers to acquire new skills and knowledge on board. In the age of digitalization, this can lead to a crisis in maritime upskilling. Further training opportunities for seafarers on land are either too expensive or simply not available on board even as distance learning programmes. The problem of lack of training and upskilling raises another problem of unemployment of young seafarers. In fact, many seafarers are still unemployed after completion of training because training institutions cannot guarantee the employment of seafarers after completion of training.

8. The literature on digitization and automation within and outside the shipping industry largely points to the need for new skills to prepare for Industry 4.0 and its impact on jobs. This paper argues that a technology-centric approach overlooks the human perspective of developing skills and advancing an individual's career as a maritime professional. The data confirms that maritime stakeholders need to consider a human-centred approach, including looking at the careers of seafarers, when shaping the workforce of the future for the shipping industry.

9. It has been found that many seafarers generally tend to plan a temporary career at sea until they reach their desired rank within the ship's hierarchy, and then seek another career ashore. The hierarchical yet flexible nature of a seafarer's career provides a degree of mobility from company to company, sea to land and sea to even non-sea jobs. This portability of sailor careers serves as a good foundation for increased adaptability to Industry 4.0.

10. The study also identified a lack of institutional support for seafarers' skills development. The majority of seafarers will need to invest in training and recertifying in order to access the maritime labour market as we move ahead. Skilling up is highly dependent on the sailor himself. Therefore, if digitally equipped seafarers are to work on modern ships, shipping companies will need to take greater responsibility for investing in seafarer training.

11. The most recent reports, from Kennedy and Marsh law firm to those by the International Chamber of Shipping, say the biggest concern is whether seafarers could lose their jobs. However, according to IMO, most projections believe that autonomous or semi-autonomous operations will be limited to short trips, such as from one port to another.

12. According to ICS research on the potential impact of autonomous vessels on the role of seafarers and the global shipping industry, there are currently over 1.6 million seafarers on board international merchant

vessels. The study shows that there will be no shortage of jobs for seafarers, especially officers, in the next 20 years.

13. Crew size is subject to change due to technological changes on board. However, there may also be important additional work on land that requires sailor experience. There are numerous changes that will be seen in the future, but some things like sea water and rough weather and their debilitating abilities on shipboard equipment remain the same. Techniques require the development of both hard and soft skills, suggesting that training is at the core of improving the seafarer evolution.[33]

14. For those who want to foster and encourage the use of automation in their industry, they must address the fears and longstanding attitudes of stakeholders who question the claims of those who defend technological change and its interests.

15. A classic example of this can be found in The Nautilus Telegraph. It reported in its February 2018 issue on the feedback it received when it launched a survey of more than 1,000 members from 21 unions within the Nautilus Federation. Much of the feedback indicates that automation is seen as a threat to the work of maritime professionals and that unmanned/remotely piloted vessels pose a safety threat at sea. The study shows that the rush by manufacturers and maritime nations to invest capital and time in autonomous systems research and the digitization of ships, and the ability to do so, has led to the neglect of critical social and human issues to date. The article ended by requesting work to be done to investigate how new technologies can protect and enhance maritime capabilities.

16. The position of the transport union was further reflected in MSC99 with the International Transport 'Federation (ITF) in cooperation with International Federation of Shipmasters' Associations (IFSMA), issued Paper 99/5/1. This treatise took a very dark view of autonomy, as most clearly shown by Proposal 8 from the document. It espoused explicit

statements by circulation or other means to protect the safety of the vessel and marine environment from risk of unregulated activities and the risk of collisions between conventional vessels and remote-controlled or unmanned vessels. Remote-controlled or unmanned vessels are not compliant with existing international regulations and shall not be used for international voyages until the international regulatory framework governing their operation has been adopted and enforced. This proposal was strongly opposed by most of the representatives present. However, it has shown the combative approach taken by the unions in this regard when it comes to autonomous ships.

6.4 Legal Hurdles for Autonomous Shipping

17. As per an ICS/BIMCO report (2016)[34], projected growth in the world's merchant fleet over the next decade and projected demand for seafarers may continue the trend of overall shortages in officer supplies. This is despite improvements in hiring and training levels over the past five years and a decrease in overall attrition levels.

Figure 14 – ICS & BIMCO report on supply and demand for Officers

18. The report projects a shortage of 147,500 officers by 2025, accounting for more than 18% of the global officers required for ships. The report's figures clearly show that more highly skilled seafarers will enter a very comfortable labour market situation, with demand significantly outstripping supply.

19. Very optimistically, if around 1000 ships are fully autonomous and another 2000 semi-autonomous by 2025, this could reduce the demand for seafarers by 30,000-50,000. But at the same time, it takes skilled remote operators, new variety of pilots, and gangs of highly skilled riding teams to keep the ship running. Before any development leaves the protected test grounds, the maritime community must define a trustworthy regulatory environment (Craig Allen, 2018). This is especially important so that the assets can be insured. The Government of Canada has requested the IMO Legal Committee to conduct a similar exercise (IMO 2018). This exercise is supported by submission from ICS (ICS 2018) to MSC.

20. Despite advancements in technology and automation within the maritime industry, the legal framework governing maritime transport has not kept up with these changes. Seafarers have traditionally played a critical role in ship operations, and proper manning is considered essential to ensure the seaworthiness of a vessel and its authorization to operate in both national and international waters.

21. However, the outsourcing of some ship activities to mechanical counterparts and the increasing use of automation has prompted a re-evaluation of legal obligations undertaken by flag states. For instance, questions have arisen regarding whether automated ships without a crew onboard should be considered seagoing vessels under UNCLOS and international and national law, and how minimum manning requirements for various tasks would need to evolve to accommodate extensive

automation.

22. There remain additional regulations that depend upon the crew on board and become an obstacle for mass adoption of autonomous shipping. Objectively:
    A) The ISM Code requiring shipowners to “ensure that each ship is manned with qualified, certificated and medically fit seafarers”.
    B) SOLAS Chapter V Regulation 5, stating that all ships must be “sufficiently and efficiently manned”.
    C) The United Nations Convention on the Law of the Sea (UNCLOS), Article 94, requiring that each ship must be in the charge of a master ‘who possess appropriate qualifications, particularly in seamanship, navigation, communications and marine engineering’.

    Many other conventions like COLREGS, MLC, STCW have also been identified so also a myriad of maritime rules and associated procedures that depend on the presence of a Master and crew on board.

23. Apart from the obvious technical implications, the regulatory environment should also consider conventions such as STCW & MLC 2006. Elaborate thought needs to be provided to specific notions like that of the implicit meaning of the term “seafarer” if borders between shore-driven and onboard-driven vessels vanish (Veal and Tsimplis, The integration of unmanned ships into the lex maritima 2017).

24. Regulators need to define the equivalence between human control and mechanical control. There are clear similarities to the legal debate on road transport, except that the marine world needs to be regulated globally through IMO. Only domestic pilot projects on a national level require additional flexibility.

25. The Comité Maritime International (CMI) along with its national member organisations have reviewed the current regulatory environment for autonomous ships and submitted an information document to the 99th

session of the IMO's Maritime Safety Committee (CMI 2018)[35]. The legal study investigates questions of what becomes a ship, the concept of the Master who is not present on the ship, and the composition of the crew. Can a person who is heavily involved in the operation of a remotely controlled vessel be classified as a permanent or temporary member of the crew?

26. At the heart of some of the questions is the idea of "ship manning" that is incorporated into various maritime conventions and modern applications. In addition, personnel levels, master's responsibilities and the presence of passengers on board will affect the application of existing insurance systems and regulatory frameworks such as the Hague Visby rules. (Carey 2017).

27. Many law associations have pointed to the potential for openness in the regulatory environment, warning that "unmanned ships must be at least as safe as ships operated by qualified ship crews." (CMI 2018, p. 8).

28. Other questions include how training for existing crews will adapt to incorporate new digital tools, and whether manufacturers of automated systems can be held liable for damages caused by malfunctions. Additionally, there are concerns about whether all national jurisdictions will permit the operation of MASS (Maritime Autonomous Surface Ships) in their waters, and how the safety of navigation can be ensured in the absence of a crew.

29. These questions are of great importance, particularly for developing states, which account for over 80% of flag states and are among the major suppliers of seafarers. A harmonization of the legal framework surrounding the use of MASS could increase navigation safety, facilitate trade, and ensure that seafarers from developing states are equipped with the necessary skills for an automated reality onboard MASS. The UNCTAD's Review of Maritime Transport 2019 has emphasized the need for such harmonization, as well as re-skilling seafarers to meet the

demands of an increasingly automated industry[36].

30. In response to the many questions surrounding the use of Maritime Autonomous Surface Ships (MASS), the International Maritime Organization (IMO) initiated a regulatory scoping exercise in 2017. The exercise was conducted by the Maritime Safety Committee (MSC), as well as the Legal (LEG) and Facilitation (FAL) Committees and concluded in 2021. Its goal was to assess how existing IMO instruments could be applied to ships with varying levels of automation.

6.5 The IMO's Response

31. The MSC concluded that several high-priority issues would need to be addressed in existing maritime conventions relating to navigation safety, such as SOLAS, STWC, MARPOL, and COLREGs. These issues included the development of MASS terminology and definitions for the terms “MASS”, “master”, “crew”, or “responsible person”, as well as the functional and operational requirements of remote-control stations/centres and the possible designation of remote operators as seafarers. Other issues included the revision of provisions relating to manual operations, alarms on the bridge, watch keeping, search and rescue, and information required on board for safe operation.

32. Meanwhile, the LEG concluded that existing provisions in the international conventions under its purview could accommodate the concept of MASS, although interpretations or amendments might be required. The LEG highlighted issues such as the role and responsibility of the master/remote operator, questions of liability, and certification requirements under the conventions, particularly in Degrees Three and Four where there is no seafarer on board. The LEG also noted that conventions not under the auspices of the IMO, such as UNCLOS and MLC 2006, might need to consider any future work of the IMO on MASS.

33. The FAL Committee agreed with most of the MSC and LEG’s conclusions, emphasizing the need for definitions and clarifications of certain terms in the context of the FAL Convention. The FAL Committee also

highlighted the need to consider situations such as the discovery of stowaways and the accommodation of people rescued at sea and refugees, and the importance of effective information exchange with the introduction of MASS. It was noted that machine-readable and decentralized formats based on open and interoperable interfaces would be required to enable automated processes.

34. After completing the regulatory scoping exercise, the IMO's Maritime Safety Committee (MSC), Legal (LEG) and Facilitation (FAL) Committees agreed in November 2022 to develop a non-mandatory goal-based Maritime Autonomous Surface Ships (MASS) Code for adoption and take effect in 2025. Based on the experience gained in its application, a mandatory MASS Code will follow, entering into force on January 1, 2028[37].

35. To facilitate the development of a regulatory framework for MASS, the IMO held an online seminar in September 2022 with broad participation from researchers, academia, the private sector, and member states. Additionally, a Joint MSC-LEG-FAL Working Group was established to address common high-priority issues identified by the regulatory scoping exercises conducted by the three committees.

36. The first session of the Joint Working Group took place in September 2022, focusing on issues such as the definition of "master", crew roles and responsibilities, requirements for remote control stations/centers and remote operators, and the potential designation of MASS crew as seafarers. While no decisions were made, a template was created to collect information on interpretation options for the next meeting, which was scheduled for 2023, according to the approved roadmap. The Joint Working Group also agreed to organize a seminar on legal issues, including UNCLOS, to be held back-to-back with the next MASS-JWG meeting. The second session was subsequently conducted between 17-21 April 2023 at IMO Headquarters.

Key Decisions by the Joint Working Group second session

- **Master Responsibility:** A human master must be assigned responsibility for a MASS (Maritime Autonomous Surface Ship) regardless of its operational mode or level of autonomy. The master's physical location may be flexible based on technology and onboard human presence.
- **Intervention:** The assigned master must possess the means to intervene in MASS operations when deemed necessary.
- **Multiple MASS Responsibility:** Under specific conditions (to be determined), a single master may be responsible for multiple MASS simultaneously.
- **Multiple Masters per Voyage:** The possibility of multiple masters sharing responsibility for a single MASS voyage under certain conditions (to be determined) was acknowledged.
- **Crew Roles:** Further discussion is required to define crew roles on MASS, as these roles will be influenced by the finalized definition of the master's role.
- **Remote Operations Centre (ROC):** Definition adopted: "A location remote from the MASS that can operate some or all aspects of the functions of the MASS."
- **ROC Responsibility:** The possibility of multiple ROCs being responsible for a MASS on a single voyage under specific conditions (to be determined) was not excluded.
- **Single ROC at a Time:** Only one ROC may be actively responsible for a MASS at any given time.
- **ROC Master and Multiple MASS:** Under certain conditions (to be determined), a single person (master) located at a ROC may oversee multiple MASS.
- **ROC Requirements:** The Maritime Safety Committee (MSC) will further define requirements for ROCs during the development of the MASS Code.
- **Remote Operator:** Definition adopted: "A qualified person who is employed or engaged to operate some or all aspects of the functions of a MASS from a remote operations centre."
- **Remote Operator Requirements:** MSC will establish requirements for remote operators as part of the MASS Code development.

Additional Actions

- **Work Plan Update:** The Working Group approved an updated Work Plan for submission and approval by the three Committees.
- **Terms of Reference Revision:** The Working Group revised its terms of reference in accordance with the Work Plan and regulatory scoping exercises. This revision awaits approval by the three Committees.

The joint working group will convene for its next (third) meeting in London, with the meeting scheduled for May 8th through 10th.

37. Ongoing work on the legal framework to accommodate MASS is taking place at the IMO, with the goal of providing legal certainty for the safe and secure operation of automated vessels. This could spur more legislative change in other international fora and at national levels. Developing countries and seafarers' associations are encouraged to participate actively in this important ongoing work.[38]

However, the below questions will be at the core of any future research:

1. What are the works needed to be done on board the vessel?
2. What sort of work can be attempted in a remote manner?
3. Where should the large amounts of data be stored, ashore or on board the vessel?
4. What sort of work requires presence of permanent staff on ship?
5. What sort of work can be done by the riding teams?
6. What differences will be there between ship types and trades (i.e., Shortsea,
Deepsea, Harbour Operations, Ferry, Cruise).
7. Is today's ship staff suitable for evolutionary electronic and data-driven challenges on board ships?
8. How can existing staff be nurtured and trained to acquire new sets of competencies?
9. Is change essential for the existing mindset & culture within the industry?

10. Can existing skills be carried over to newer generations to avoid skill loss?

11. Will the compulsory sea time still be a relevant factor for the operations personnel?

12.How cyber-conscious do crews need to be?

13. What are repercussions for CBAs and labour relations overall?

14. Will there be a need to redefine pay scales and pay criteria?

15. What are the safeguards to be considered for the seafarers' wellbeing?

16. What impact is foreseen on seafarers' mental health condition if manning numbers drop?

17. Will the Safe Manning Levels set by SOLAS and the MLC be altered?

18. What level of autonomy does the end-user want/need?

(Shipping companies)?[39]

Autonomous shipping, often referred to as the "next frontier" in the maritime industry, is driven by several cutting-edge technologies that enable these vessels to operate with minimal or no human intervention.

6.6 Qualitative Analysis - 2

Constant Comparative technique was used for the Qualitative analysis of the Expert Resource Data in the below mentioned process:

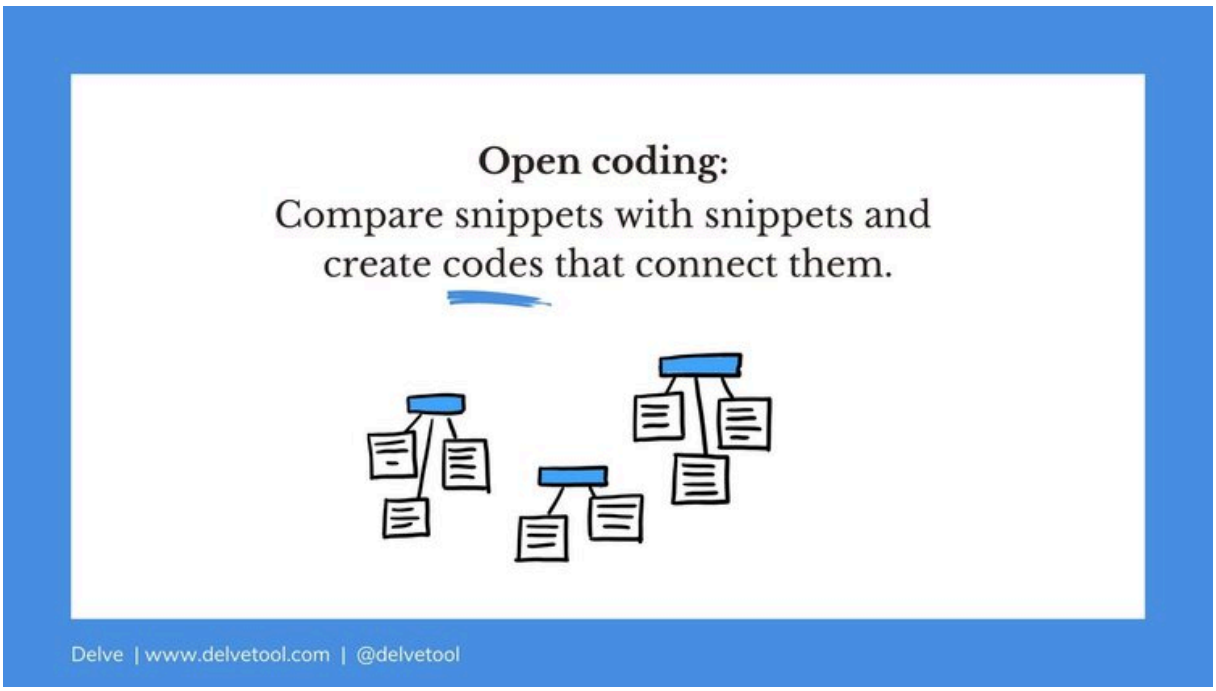


Figure 15 – Open Coding

Raw data taken and broken down to individual snippets.

Constant Comparative method practiced by comparing snippets with snippets and creating codes to connect snippets together.

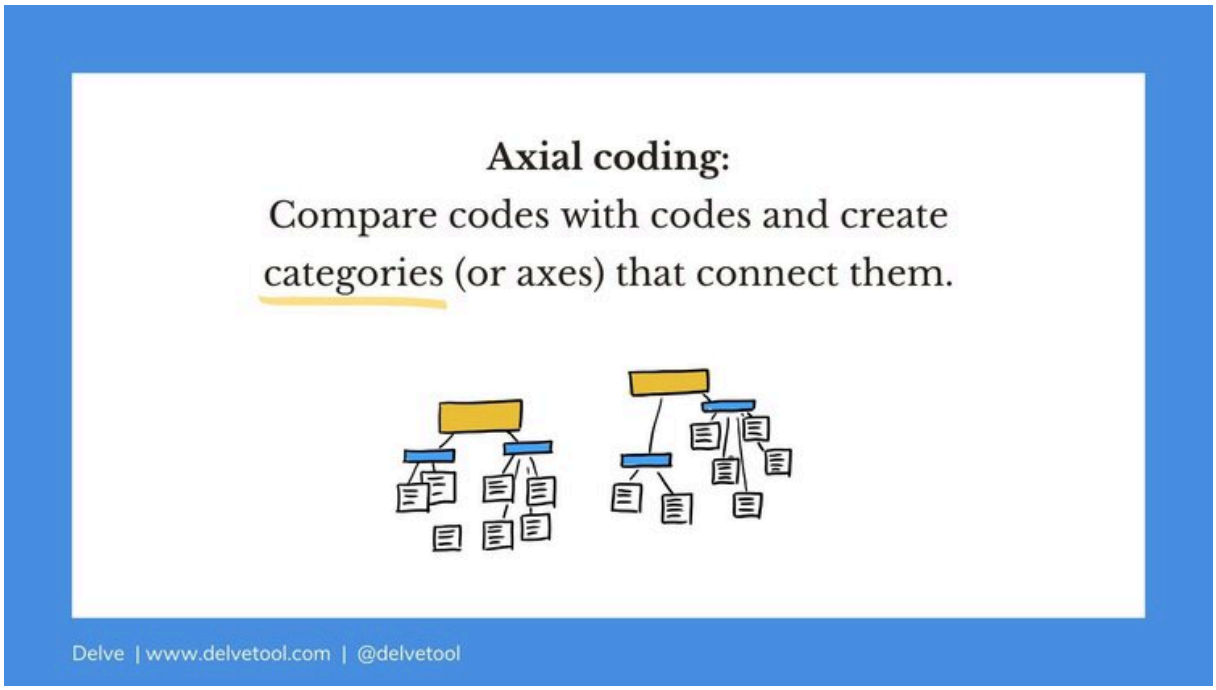


Figure 16 – Axial Coding

Connections between codes explored.

Codes further compared with each other, and categories created that connect the codes together.

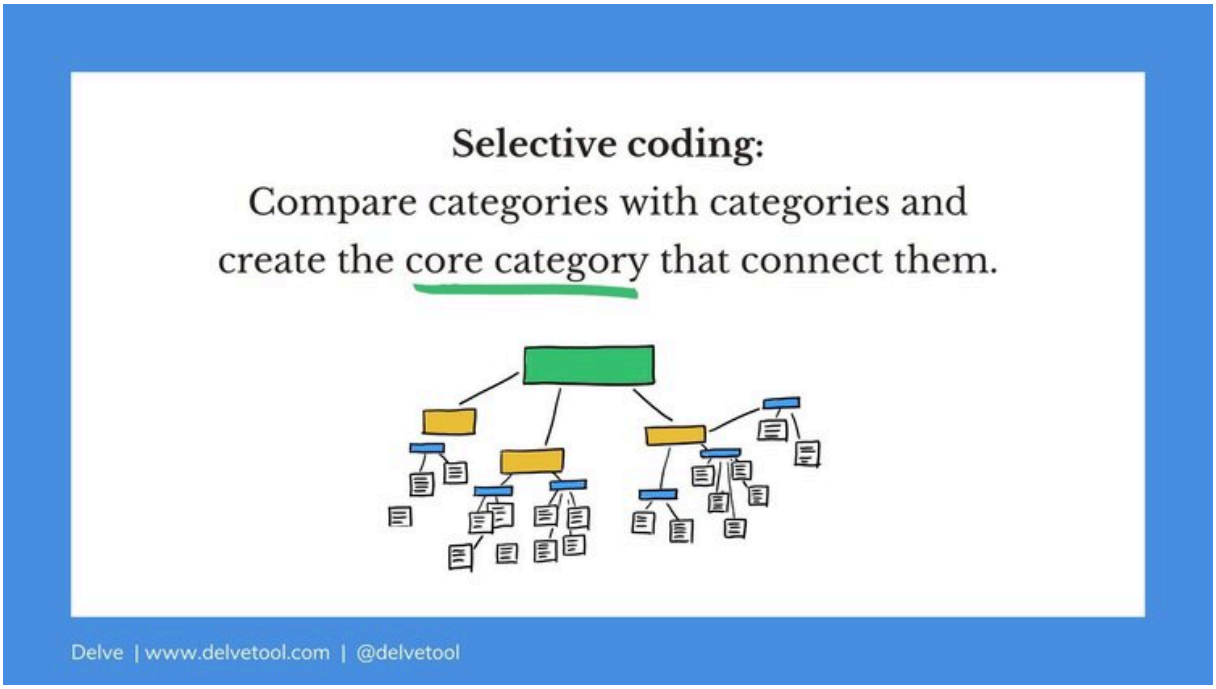


Figure 17 – Axial Coding

Explored connections between categories.

Compared categories with each other and created a core category to connect them.

The findings of the qualitative analysis across the spectrum can be summarised as below.

(A) Timeline

Most experts think MASS stage 3 & stage 4 implementation where Seafarers are physically replaced on ships with technology will be within a time span of 10 and 20 years. This, however, will be a highly limited introduction, dependent on the business case. Most respondents mention the likelihood of it only being in coastal waters on very controlled and limited voyages. There are exceptions like those from Regulatory, Terminals & Ports, where they don't see it coming in the foreseeable future, or responses indicating such a stance.

(B) Development

As the maritime industry moves towards the adoption of autonomous shipping, the establishment of a comprehensive regulatory framework

becomes essential to ensure safety, efficiency, and environmental protection.

It is believed that technology will drive the development and changes will follow. Examples are port regulations, skill training, pilots and VTIS services. Many refer to the IMO scoping exercise and await its further development.

(C) Operation and manning

Guidelines may someday be developed separately by IMO and state whereas others believe that existing regulations should be followed, possibly with amendments. Most trust that humans will still be involved in the operations process, but from other locations than onboard. Only a few mentions the loss of seafarer jobs but also point to new skilled jobs being made available. New skills are envisaged but not detailed.

Successful personnel in the autonomous era will possess a mix of traditional maritime knowledge and expertise in advanced technologies (AI, automation, data-driven systems).

The impact of autonomy on the seafaring job market is complex. Some roles will be lost, others created. The net change, both in terms of job numbers and the nature of these jobs, is difficult to forecast.

(D) Technology

The shipbuilding itself seems relatively well covered by Class notations or similar. Some mention that it needs to be failsafe to allow for complete unmanned operations. As autonomous ships rely heavily on digital systems and connectivity, ensuring adequate cybersecurity measures are in place becomes a critical regulatory concern.

Developing means that address the unique cybersecurity challenges presented by autonomous shipping is essential to protect sensitive data and systems from potential cyber threats. Cyberthreats are clearly present and still unsolved. The solution is clearly to train operators and address the technical loopholes.

(E) Regulatory

Rapid advancements in technology can make it difficult for regulators to keep up with the latest innovations and ensure that regulations remain relevant and effective. Furthermore, the lack of standardized definitions and classifications for varying levels of autonomy can complicate the regulatory process.

The shift towards autonomous shipping raises questions about liability and insurance in the event of accidents or incidents. Clarifying the allocation of responsibility between ship owners, operators, manufacturers, and other stakeholders is critical to the development of a robust regulatory framework.

(F) There is no existing insurance coverage yet for MASS 3 and MASS 4 ships. However, the insurance industry itself is undergoing a revolutionary change with AI models being increasingly used in fundamental processes like underwriting. This calls for a comprehensive risk assessment and risk management initiative whenever the models are extrapolated to shipping insurance.

In addition to the IMO's efforts at the international level, individual countries are also working on developing their own regulatory frameworks to address the specific needs and concerns of their respective maritime sectors. For instance, countries like Norway, Finland, and the United States have taken steps to establish guidelines and rules for the testing and operation of autonomous vessels in their waters. However, the lack of uniformity among national regulations can present challenges for the seamless integration of autonomous shipping on a global scale.

(G) Training

The introduction of autonomous shipping will necessitate changes to the current training and certification requirements for seafarers. Regulators will need to update the STCW and other relevant conventions to reflect the new skills and competencies required to operate and maintain autonomous vessels.

Maritime education must undergo significant transformation to meet the demands of the autonomous era. Immediate needs include increased IT

focus and the creation of remote operations specific programs.

Seafarers who wish to remain relevant in the industry may need to acquire new skills and undergo training. The skills required for autonomous shipping may be different from those required for traditional shipping. Seafarers may need to learn new technologies, such as artificial intelligence and machine learning, to remain competitive in the industry.

With the autonomous shipping industry in its nascent stage, the training programs designed to equip seafarers and non-seafarers who will be working with autonomous ships are presently few and far between. A standardised training program with modules broadly covering management, operations, cyber security, and support is the need of the future.

The training for seafarers on autonomous ships has evolved to address the complex interplay between human operators and advanced technologies. Here are some of the latest developments:

1. MASSPeople Initiative: Launched in early 2021, the Maritime Autonomous Surface Ships (MASS) International Training Standards working group, known as MASSPeople, focuses on developing world-class training and competency standards for maritime personnel. This group includes multiple national maritime authorities from various countries like the Netherlands, United Kingdom, Norway, Belgium, Denmark, France, New Zealand, Italy, and Poland. MASSPeople explores the human dimension of remote and autonomously enabled ships, working on developing new job profiles for those involved in the safe operation of MASS.

2. Research on Training Requirements: A research project is underway to understand the evolving role of seafarers in the context of autonomous shipping. This exploratory qualitative study aims to investigate the characteristics of future workplaces for seafarers, their roles, the required skills and competencies, and the pathway towards future training standards during the transition to autonomous shipping. The research includes diverse methods like semi-structured interviews, focus group discussions, and thematic analysis of data from various stakeholders like technology

providers, shipping companies, training institutions, seafarers, and regulatory bodies.

3. Partnership Between Robosys Automation and AMC Search (AMCS): In 2023, Robosys Automation and AMCS launched a partnership to provide AI-based training for maritime operations involving autonomous ships. This training includes using the VOYAGER AI software in simulations to understand how humans and AI collaborate. The training session at Ocean Business 2023, titled 'Understanding Human and AI Collaboration for future shipping,' highlighted the use of simulations for developing skills to operate MASS systems. The training focused on how AI reacts in different navigational situations, including a comparison of human and AI responses in the same scenarios. This partnership aims to enhance MASS-certified training and present at international conferences on maritime autonomy.

These developments reflect a concerted effort to equip maritime personnel with the necessary skills and knowledge to operate in an increasingly automated and technologically advanced maritime industry safely and effectively.

6.7 Summation

1. Job Shift, Not Elimination:

- Seafaring Roles Will Evolve: While the traditional onboard seafarer role may diminish over time, new opportunities will arise in areas like remote control centers, MASS design, and cybersecurity.
- Demand for Increased Skill Levels: Success in the new maritime landscape will require strong IT, data analysis, AI, and cybersecurity skills, along with a foundational understanding of maritime operations.
- Hybrid Models Likely: Experts suggest scenarios where remote control handles routine operations, while onboard crews or "riding teams" address specific situations, maintenance, and cargo care.

2. Gradual, Segmented Adoption of MASS:

- Short Sea Shipping as Proving Ground: Initial focus will be on less complex, short-sea voyages (ferry operations, coastal shipping) with limited cargo types.
- Varied Timelines: Experts provide timelines ranging from 10-20 years for broader adoption, suggesting uncertainty but a general acceptance of the eventual shift.
- Container Sector Skepticism: Major container ship operators express doubt about the near-term cost-benefit analysis for their specific segment, emphasizing the potential for niche applications of MASS alongside traditional vessels.

3. Regulatory Uncertainty Creates Challenges & Opportunities:

- IMO's Central Role: The International Maritime Organization is conducting a regulatory scoping exercise, with significant revisions to international conventions expected to accommodate MASS.
- Stalled Progress: Ship owners and technology providers await regulatory clarity from IMO before making major investments in autonomous systems.
- National vs. International Adaptation: Countries may take varied approaches to MASS, creating potential legal complexity and influencing job opportunities for their seafarers.

4. Training as a Transformation Catalyst:

- Educational Overhaul: Maritime academies must adapt curricula to focus on IT, AI, and cybersecurity alongside traditional maritime knowledge.
- Re-Skilling Initiatives: There's a need to develop programs to help existing seafarers acquire the skills needed for shore-based MASS positions.
- Simulator Training's Importance: Realistic simulation will play a vital role in preparing seafarers for both onboard roles in a transitioning industry and remote-control center positions.

5. Additional Considerations:

- Cybersecurity Risks: MASS introduces unique cybersecurity threats that must be mitigated for both safety and to protect shore-based jobs. Training programs need to emphasize cybersecurity awareness and resilience.
- Liability Distribution: Who is ultimately responsible for incidents when complex autonomous systems are involved? This remains unresolved, impacting classification rules, insurance, and job roles.
- Economic Impact on Coastal Communities: Reduced onboard crewing may affect local economies that have traditionally relied on the seafaring profession.

The development of autonomous shipping has the potential to significantly reshape the maritime industry and the job prospects of seafarers. While some traditional roles may be lost, the analysis suggests a transition towards a more complex, technology-driven industry with a demand for new skill sets. Successful navigation of this transformation will require:

- Proactive Regulatory Action: Clear international guidance for MASS is needed.
- Educational Innovation: Maritime academies must revamp to meet evolving needs.
- Seafarer Support: Seafarers will need targeted programs to help them adapt.

Limitations & Future Research Directions

- Small Sample Size: Larger-scale studies would provide more generalizable results.
- Specific Job Forecasts: Quantifying the number of jobs gained vs. traditional jobs lost would be valuable for policymakers.

7 Recommendations and Conclusion

7.1 The Inevitability and Impact of Autonomous Shipping

7.1.1 Historical Precedents

There is sometimes a generic tendency to underestimate technology. History is replete with big names perishing because of lack of vision especially with regards to their competition. Big names like KODAK & NOKIA bear testimony to this lack of vision to embrace change.

"How, sir, would you make a ship sail against the wind and currents by lighting a bonfire under her deck? I pray you, excuse me, I have not the time to listen to such nonsense."- Napoleon Bonaparte, when told of Robert Fulton's steamboat, 1800s

7.1.2 Current State

Autonomous ships are a reality and will progressively be a part of shipping lexicon in the figurative and operative way in the future. However adequate risk assessment and risk management seem to be lacking at present due to several unknown variables in the scene.

7.1.3 Regulatory Progress

Recent months have seen a significant progress in autonomous shipping, with breakthroughs in technology and regulatory frameworks. During MSC 105, the International Maritime Organization (IMO) provided a roadmap for developing the MASS Code, anticipating a global regulatory framework for the operation of maritime autonomous surface ships (MASS).

7.1.4 Technological Advancements

Advances in autonomous technology are progressing at a fast pace, including successful real-life trials such as Avikus completing the first -ever transoceanic voyage of a merchant ship using autonomous navigation technologies, and Mitsubishi Shipbuilding and Shin Nihonkai Ferry demonstrating fully autonomous ship navigation systems on a RoPax ferry in Japan. The success of these trials demonstrates a growing trend towards trials taking place in international waters and involving representatives of multiple flag states.

7.2 The Impact on Seafarers

7.2.1 Shifting Skillsets

Ship staff on board are likely to shrink and few ships will be fully

autonomous in the next 10 or 20 years. With the overall increase in global fleets, at least the number of officers on board will remain stable. At the same time, the number of land-based "crews" in supporting roles could increase significantly. This frees up valuable time to adjust training patterns and retrain experienced seafarers in digital skills.

7.2.2 Potential for Increased Safety

Automation has the potential to increase safety for crews and passengers further and safeguard the environment. Shipboard tasks have inbuilt risks due to the specialised and hazardous nature of tasks on the ship. Even though these occupational hazards have been minutely observed and successfully addressed with in order to mitigate accidents, it can be assumed that less crew on board will put fewer lives at risk.

7.2.3 Need for Social Safety Nets

Seafarers provide their skills to a global transportation market. They are familiar with international competition as there is a globally acceptable competency level. The regulatory apparatus is given by international conventions such as STCW and MLC, 2006. Seafarers may be more inclined to compete in open markets if they can fall back into some safety net. This can consist of a national safety net with unemployment benefits, or a relatively advanced skill set which generates job opportunities even outside the parent domain.

7.3 Challenges to Overcome

7.3.1 Regulatory Gaps

Regardless of the advancements in technology, the regulatory framework (IMO is still at the regulatory scoping stage) and the associated arms of the industry viz. Ports/Terminals, Insurance, Cargo/Commercial operations etc are not yet in sync with adapting to these advancements.

The development of a comprehensive regulatory framework for autonomous shipping is a complex and ongoing process that must address various challenges and considerations. International and national regulatory bodies, such as the IMO and individual countries, play a critical role in shaping the rules and guidelines that will govern the safe and efficient integration of autonomous ships into the global maritime sector. As the technology continues to evolve, regulatory frameworks will need to adapt and respond to the changing landscape

of the industry to ensure the successful implementation of autonomous shipping.

7.3.2 Commercial Viability

There seems to be no coherence among the different players on the commercial viability with respect to returns on investment by jumping onto the autonomous ships' bandwagon yet.

7.3.3 Cybersecurity Concerns

Industry experience with cybersecurity risks of almost anything connected to the internet acts as a further deterrent to the smooth adoption of autonomous ships, especially where the commercial stakes are so high. There seems to be no immediate concern for loss of jobs on the horizon for the seafarers. Like every other sector including shipping has demonstrated historically, routine, low risk and mundane jobs with lesser skills requirement that do not require higher analytic, troubleshooting, or creative skills slowly get taken over by technology. This undermines the evolutionary nature of the adoption of technology eventually paving way for autonomous ships.

7.4 Opportunities and Focus Areas

7.4.1 Environmental Potential

The adoption of autonomous ships presents both opportunities and challenges in terms of environmental protection. While advanced propulsion systems and optimized operations have the potential to reduce emissions and improve fuel efficiency, regulators must also address concerns about the potential environmental impact of increased maritime traffic and the disposal of end-of-life autonomous vessels.

7.4.2 Psychological Impacts

There are potential social and psychological impacts of autonomous shipping, particularly around mental health, that warrant closer research attention.

7.4.3 The Human Factor

The technical implementation and integration of today's digital technology and its legal framework manifests itself in various and complex dimensions of technical problems that will sooner or later be

resolved. Commercial implementations rely on the feasibility of business models based on more technology and reduced human involvement. When dealing with “human factors", some common ones include:

(A) Autonomous ships adoption will be a seamless process rather than a disruptive one.
(B) There will be no shortage of jobs for seafarers in the foreseeable future.
(C) There will be considerable additional jobs ashore.
(D) There will be significant training needs.

7.5 India's Role in Shaping the Future

7.5.1 Training Initiatives

1. Presently there is no tailormade course for autonomous ship operations with worldwide acceptance. DGS Circular NT/01/2019 is the first circular that has introduced concepts like autonomous ships, cybersecurity, Artificial Intelligence, Block Chain, Machine Learning followed by DGS Circular No.09 of 2022 [EAC Branch (Engineering)] pertaining to - Recommendatory guidelines for inclusion of multi-disciplinary courses in Marine Engineering stream from academic year 2022/2023 is a welcome measure in recognising the need for a futuristic approach to maritime training vis-à-vis the emergence of autonomous ships.

   However, this is just a proverbial tip of the iceberg and much more needs to be done to tap into the potential within.

2. There needs to be training programs exclusively to improve the cybersecurity element so essential to adoption of autonomous ships. These should definitely include but not be limited to:
   (A) Basic awareness on the information security management system like ISO/IEC 27001, ISO 31000 (Risk management), NIST etc.
   (B) Improve the cyber security competence of the crew.

(C) Implementation of robust risk management process for the IT and OT systems.

(D) Periodic review of the controls implemented.

(E) Implementation of effective backup and restoration methods for the critical applications and systems.

7.5.2 Cross-Industry Collaboration

With the advent of digital data driven technology, it is imperative that our training modules accept and embrace Data Analytics as a prominent subject for the future vessel staff both on board and ashore to enable greater flexibility in adapting to workspace conditions and upskilling. Suitable courses will have to be designed in collaboration with the various industry players for seamless transition.

Another promising avenue for seafarer learning, contribution and employment are areas of insurance and law where comprehensive guidelines are yet to be issued with respect to autonomous ship operations.

7.5.3 Holistic Leadership in Training

A 2 year post graduate program like a Masters in engineering may be considered for Autonomous Maritime Operations with focus on management and business administration in maritime operations. These should include but not be limited to:

A. Studying in the Masters programme and introduction to research and research methods
B. Autonomous vessels-automation
C. Artificial Intelligence, Machine Learning, Human-Machine Interaction
D. Remote Operations
E. Cyber Security and Connectivity
F. Classification, Qualification and Safety Perspectives

B. A significant amount of contemporary learning on autonomous ships and future technologies exists in the present Extra Master curriculum. There must be significant initiatives from the part of our administration

to get such industry leading courses like the Extra Masters and Extra First Class Engineers to be accepted and integrated into the mainstream university lexicon. This is important so that the industry does not lose out on the contribution in future skilling of seafarers by trained and experiences professionals simply on technical grounds of recognition and certification.

C. What the world needs to understand is that no matter what the advancements in neural networks and Artificial Intelligence along with cutting edge technology, they can only assimilate the Body, Mind and Intellect parts of the human intelligence. The concept of Spiritual Intelligence is not something that can be “programmed”. India with its rich heritage of spirituality and cultural leanings must be a world leader in contributing this aspect of seafarer skills to the essential training elements of future seafarers.

7.6 Additional Recommendations

7.6.1 Bridging the Gap

It is evident that there is considerable concern on interaction between autonomous and conventional ships in the future sea lanes. Suitable bridging courses will be the need of the hour.

7.6.2 Dedicated Traffic Lanes

It is further proposed that separate Traffic Separation Schemes exclusively for the use of autonomous ships be demarcated as a definitive safety measure.

7.6.3 Proactive Policy

It is strongly recommended that further research be carried out on future skills that will be needed by the maritime industry professionals and means to seamlessly integrate those requirements into our maritime training regimen.

India should also take the lead in researching on and contributing to the world maritime community - the necessary regulatory framework that will be enabling in nature and facilitate smooth transition to a world of autonomous ships.

A national policy level initiative must be proactively created to seize the

time horizon advantage and carry out the necessary research to invest and create infrastructure and resources that are ready for the future.

7.7 Personal conclusion

This study has illuminated the significant disparity between the upskilling needs of industry professionals and the impending requirements of Maritime Autonomous Surface Ships (MASS). It presents a remarkable opportunity for India to assume a leadership role, establishing itself as a global repository for maritime knowledge and securing a dominant position in the international maritime landscape. By capitalizing on this prospect, India can not only bridge the existing skills gap but also position itself at the forefront of maritime innovation and expertise, fostering sustainable growth and influence in the global maritime sector.

Appendix 1- The Initial Mass Survey Questionnaire

The responses summarised as below by omitting overlapping responses and blank/nil responses.

Q1. Do you think your job onboard will be replaced by autonomous technology?

Yes (80)

No (93)

Others (37)

***** qualifiers*

1.No, I don't think that all the fields of work can be done by A.I but a lot of people’s job may be replaced by robots.

2.Yes, there may be a chance that we may lose our job. But we can’t predict our job.

3.Maybe or may not because at times we cannot fully depend on automatic movement of ships.

4.No. If anything, it will evolve.

5.Yes, but not just yet. I give it a 15-year window.

6.Yes, but new job opportunities will arise.

7.Workplace may be relocated.

8.Yes, with the latest technology, this can be possible. Vessel can be controlled from shore.

9.No .it might lead to lesser people onboard

10.Not, it’s hard to replace us by technology.

11.Advance technology May come and go but manual supervisor necessary

12.Yes, in a matter of time.

Q2. If your answer to Q1 is yes, why do you think the ship owner will replace you with autonomous technology?

***** qualifiers*

1.They don't need give salary for seafarers

2.Safety, Efficiency.

3.Because they can reduce the labour charge, be more efficient in work field.

4.company always thinks about profit

5.Because man can't compete with machine

6.Autonomous technology is more accurate and also maybe cheap in future

7.I have answered no. because I still believe in our profession.

8.I don't think navigating officers are replaceable.

9.autonomous technology offer ship owners' advantages in terms of safety and cost.

10.It is evident that number of workers onboard is constantly decreasing with time. They think that less officers means more profit but forget that it also means more danger.

11.The cost for maintaining an autonomous system will be much lesser than hiring us

12.because the technology is advancing day by day

13.Machines will do the recurring jobs

14.It will save them money and space onboard which is acquired by LSA and FFA equipment

15.For more cargo carrying capacity and more profit

16.Lot of new technology come up with the different ideas that's having a onetime investment, that's why the shipowners will prefer that

17.This kind of ship requires less manpower. So, I'm afraid that most of the navigation can be done by the ship itself or controlled from shore stations

18.May be same reason as we are going for autonomous cars.

19.Owners will not have to deal with variance is competency standard of seafarers.

20.24hrs output without rest hours, without food and crew change.

21.Less human error, no forgetfulness

22.Crewing budget is the only variable in vessel management expenses and should there be a saving as such they may adopt technology over manpower.

23.Manning is important then automation as automation can fail anytime

24.They can place several machines parameters under monitoring from shore with camera and with electric boards showing all parameter and with standby units available several ranks can be replaced in future

25.Look at the Starship Enterprise.

Q3. What do you think seafarers should do to deal with autonomous ships?

***** qualifiers***

1.Embrace the future & adapt.

2.Work efficiently

3.Protesting is not the right way; I think we should accept the change.

4.They should make the company realize the unity and power of them of their manual work

5.They should encourage technology....and only an experienced seafarer can navigate a vessel

6.Get the people who could change the situation aware about this

7.To do the job better than the AI use the natural human brain to do so and aware the ship owners about the risk of using AI and breakdowns

8.Increase our productivity and potential. Do things that automation cannot.

9.Do more courses based on these autonomous ships so that they can stick on to the industry.

10.learn new skills

11.The question is unclear. What is the deal? Evolution of a field of work is inevitable. To be cautious of it is reasonable, but to oppose it is naive.

12.Whatever technology it may be, it is all been created by humans. This should be realized by all.

13.We must adjust with the fact that technology will play a very major role

in shipping industry, we have to learn to live with this type of technology and learn new skill

14.Machine learning and AI and other short courses to be included to enhance the knowledge of seafarers, but one day we have to face the truth

15.Try to maintain a balance between manual work and work which can be done by technology

16.As the shipping is the mostly depends on the critical ideas at critical time that can be fulfilled by the humans only, human intelligence can never be replaced by the AI, so we don't have to worry more about it, yes but we have to do our work very effectively, efficiently and mostly using of common sense that is most important on-board ship

17.become good video game players to drive ships from home remotely

18.Be more diligent in the work culture and counter the myth of having AI being better than human mind

19.The technology may be OK for very short sea routes, but not long voyages where ship maintenance works will be required. Steel is steel and the sea is the sea.

20.change is inevitable, but owners must understand the job scope onboard and decide if they want to go fully autonomous or semi-autonomous. In that case Ships will then be like aeroplanes where maintenance takes place once in port.

21.Get trained for shore jobs. After all, for every person serving on board there are 10 serving ashore.

22.Question is not valid

23.Provide good input. Realize that cost effectiveness of these vessels will be key to whether or not they are implemented. Redundancies and costs associated will likely eliminate many vessels from autonomous operations. Realizing that the human onboard provides adaptability and resilience that machines cannot provide.

24.Upskill, demonstrate adaptability, critical thinking & problem-solving skills that can’t be reciprocated by technology

25.it will be slow process, process and procedures will come into place. seafarers will be accommodated with newer roles; Proactive ones will be able to get to work on new technology first.

Q4. Should any organization work actively to protect seafarer jobs/interests?

Yes (96)

No (41)

******* qualifiers***

1.Yes, there should be an organization to protect seafarer jobs.

2.Education bodies should try to build the core of pre sea cadets, so that they may not face an ultimate danger of unemployment and IMO should also ensure some courses in-between to safeguard the employment

3.Are you joking. Since when has any organization really worried about seafarers' interests?

4.Not per se, it should be left to free market, then only will shipping & seafaring remain a cost effective & sustainable option. Guidelines could be put in place by IMO but basically, it's a natural evolution process, did someone protect the jobs of Radio Officers?

5.Absolutely this is not only seafarers issue it may seem now our but gradually this will become a concern for all sectors

6.Look in the possibility of becoming an owner of Autonomous Ships

7.Union

8.IMO

9.ITF

10.Yes, sure they should. And it should not be an organisation which has interest in only protection of owners' views. The ship owners have all these

years been given full commitment by the seafarers. They should not be neglected with the introduction of autonomous ships.

11.Shipping is pure business, no budget for protecting jobs. Business is business.

12.Not necessarily

13.No organisation can. The market will decide the best course. No one runs ships to protect seafarers. They run to make money. They make money by transporting goods. Seafarers are incidental.

14.No need, changes happened as time move

15.No... I can compare it with how communist party protested against computers. We have to accept the change and adapt with it.

16.No. Technology cannot be resisted for long.

17.Shipping industry is not interested in protecting seafarers who demand high salary and get most of the work done by shore people.

Q5. How do you think autonomous ships will interact with cargo terminals and stevedores/port personnel?

******* qualifiers***

1.Cargo supervisor will visit load / disc port to protect owner's interest. Seafarers can perform the role of Cargo Supervisor.

2.I think cargo movement will be fast and in more efficient way. port official may be get replaced by robots.

3.It will not be effective as human interference. Effective communication is maintained everywhere in ship at present. The whole system will turn upside down with this system.

4.It will be like a programmed robot who will just do the programmed work only nothing else

5.It will be technically efficient

6.Without manual Operation nothing goes in proper way

7.Autonomous alone can’t be able to do this. There it needs a human touch.

8.That's why some works can done by autonomous and other can done by seafarers.

9.By personnel who are controlling them from shore.

10.At first it will have some trouble but eventually it will be working more effectively

11.It would make lot mess and confusions leading hazards

12.Should have personnel when entering port

13.Paperwork could be done from offshore

14.As they are programmed to function and interact.

15.Autonomous ports are already in existence now i.e., Port of Rotterdam

16.It is still undetermined, how did Tesla cars interacted with humans, ours Radios, telephones, television got replaced by a single small gadget through the past years, were we threatened to use it

17.Faster of a human but it won't work in critical situation s

18.I don't know that since I haven't work in one!

19.Autonomous ships are practicable in open seas not in port or shallow waters

20.I autonomous ships machineries are controlled by the ship owners exactly as remote-control vehicles as modern vehicles like Tesla in this type there is a huge rush I maintenance.

21.for the next century there will be need for reduced human interaction for all operations. as solutions present themselves human will be left out

22.I think during port operations shipowners will engage some manpower.

23.They can be easily operated by combination of Automation and human controls. This will expedite cargo operations with minimum delays.

24.possible but an uphill task. Imagine AI trying to deal with cargo figure discrepancy with shipper.

25.It will put a lot of people ashore out of business. Difficult for PSC, Vetting, Flag State, Insurance and myriad other members of the parallel parasitic industry will find themselves out of business. Since I would have retired by then it puts a smile on my face!

26.Pilot & port safety personnel system will remain alive

27.This is where more manpower will be recruited ashore

28.Port Captains and port will be placed on board as Japanese tanker owners have been doing for many years in Japanese ports

29.most probably expert teams will board the ship before she interacts with cargo terminals and stevedores/port personnel.

30.Of Autonomous ships can successfully traverse from Point A to Point B then interaction with Cargo Terminals is not so challenging task

31.Every port will have a separate office. Where cargo expert (mariner) will sit and handle cargo. They will be free to choose ships, owners etc. They will work like flight dispatcher in airport. Ship dispatcher for ports.

32.semiautonomous. Plans sent in advance by shore personnel, agreed by company. safety officer checks systems onboard.

33.There would be ship shore interface to cater to this requirement by way of arranging for trained shore personnel who would board the vessel at the pilot station

34.Depends on the cargo terminal. Large container terminals are already automated, so it'll look much the same with autonomous ships. Smaller ports, dry bulk, etc. will probably need to keep or put people on board for cargo work.

35.Ports and terminal should also capable and autonomous in this case.

36.Easy to cause disaster

37.It will be very hard for shore staff to deal with, and chances of accidents may increase

38.All computerized

39.With humongous glitches and impractical solutions.

40.It will be an interaction between shore personnel and the personnel handling the autonomous ships.

41.Not well. The needs of autonomous vessels to conduct maintenance and repairs while alongside will likely conflict with “efficient” cargo operations.

42.Full autonomous vessels are too far in the horizon, but semi-autonomous vessels could be a possibility. However, for coastal passages, port calls etc, human interaction would still be required at some level with the current framework and systems.

43.All controls will be shote based, shipboard personal will only be for following orders. There is possibility that BOTS will eventually replace humans with 2-4 humans on ships.

44.God knows

45.Lots of issues need to be addressed. Such as customs clearances, prevention of stowaways, drug trafficking etc. Documentations framework between vessel and port would require a complete change. Safety of shore personnel and security issues in port would need to be addressed.

46.If ever it comes to this, then it will be in the most efficient way. If it isn't efficient, everyone will go back to seafarers. It is after all about making money. transporting goods. loading and unloading goods. If that can't be efficient, then the interested parties will find the best way to make it efficient -even if that be going back to the seafarers.

47.Ship specific loadicator if available ashore and external draft and trim. Monitored load & discharge on containers and bulk carriers can be monitored by shore itself.

Q6. Do you think regular training and upgradation will keep seafarers as better options than autonomous systems?

Yes (117)

No (37)

***** qualifiers*

1.Yes, shipping industry has been evolved through times. With the help of technology and better and efficient labour we can be as competent as autonomous systems.

2.yes, correct" practice make a man perfect”. But at some time, automation is also needed.

3.Yes, because their hard work and experience all give them the idea to challenge with any situation

4.No, autonomous system will surpass human

5.Cent percentage. It is the best way to deal the issue.

6.The question is vastly generalized. There are probably fields in the job where seafarers prove to be better than autonomous systems and vice versa.

7.It won't be enough unless there's upgradation in our current syllabus and introduction to AI and IT

8.Nope, someday or the other we will be replaced by machines, and that is the truth, but maybe we see still can get hold in the industry if we have radio-controlled operations from land, such like UAVs

9.I surely agree with this statement. Because a computer system is not as safe as we think. It can be hacked and hijacked. So, in all circumstances we can’t trust on computers.

10.no, not unless they’re hiring teenagers, or third world works that are cheaper once the technology is affordable

11.Depends on quality of personnel and quality of work carried out. Also make seafaring an attractive profession where brilliant mind comes to work.

12.Yes. And more application of the skill and knowledge. More positive attitude towards the profession.

13.No, our training is not for alternative employment. You only hone existing skills and upgrade knowledge.

14.It had been proven that technology can replace humans in some cases effectively and in many other disastrously, so success of autonomous operation of ships is something to be seen.

15.Autonomous ship will be a reality within next 10 to 20yrs. Seafarers has to evolve according to the available job scope in shipping industry.

16.Yes, sure will be a better option. The seafarers also need to step up to this new role. I am totally against criminalization of seafarers. Wonder who would be held responsible of any accident or pollution in case of autonomous ships. Will the owner take the responsibility? Just like how seafarers are held responsible.

17.No. It's not about improving standards of seafarer. It is about how autonomous ships is going to bring change commercially.

18.SMEs will be in demand & that too digital techy

19.No. Autonomous ships replacing seafarers would still take a lot of time. There is no need to create panic among seafarers.

20.No training can prepare one for jobs that don't exist.

21.Unlikely as change is dictated by circumstances and advances in science and technology

22.Training and upgradation have nothing to do with sincerity in working. Autonomous ships will be the future.

Q7. Is there a possibility of increase in shore job opportunities for seafarers with autonomous ships?

Yes (114)

No (34)

******* qualifiers***

1.Yes, we should look forward to autonomous ships if they are a better option for sustainable future.

2.I don't think so. With increase in autonomous there will also be a replacement with artificial intelligence in the shore jobs.

3.It depends on upcoming technology.

4.Yes, there is a huge chance of increase in shore jobs

5.Yes, for autonomous ships alone there should be section for shore labour

6.Yes, to manage those autonomous ships

7.It is a topic to studied

8.Yes, may be but the seafarers should be competent enough to get that job

9.Well, if autonomous ships show a success, then ultimately, shore jobs will face the same situations, we have autonomous container ports

10.I'm not sure but may be, because somebody will be there to guide the autonomous ship, that will be done by trained seafarers only

11.possibly, if owners want qualified mariners operating the controls otherwise, they'll just hire the cheapest labour that can operate a mouse

12.Yes, back up teams at all levels with seafarers in control with enhance. Specially for senior officers and engineers. But crew / ratings will have limited options in shipping.

13.No. There will be an oversupply ashore

14.No. They are likely to be replaced earlier than seafarers at sea.

15.Yes - they're already being advertised, particularly in Belgium and Norway

16.shore jobs will decrease, mostly things will be outsourcing to OEMs

17.Not jobs as we know it now.... a different set of skills will be required.

18.There is very less opportunity for seafarers at shore in case of autonomous ships take over the Market as there are plenty people in shore job (shipping) and others are waiting with proper degree and all

19.Not automatically. Did GMDSS bring in lot of shore-based opportunities to Radio Officers?

20.Of course. But in autonomous environment jobs will open more to techies and IT sector.

21.Yes, increase in shore job but relatively loss of job combined.

22.Only a Possibility. Seafarers are the people who work at sea. Not ashore

23.Of course. However, only for the skilled. Numbers will be down.

Q8. Where should responsibility be, in case of an autonomous ship?

******* qualifiers***

1.Owners/ Managers/Operators

2.Seafarers' duty

3.Even if autonomous, human should be given the responsibility. No machine is perfect, and a machine can never be perfect.

4.No one will be responsible

5.No idea

6.The controller

7.To the seafarer onboard ships, because if something happened wrong our lives is going to affected not a machine.

8.Every where

9.Surely with greedy owners and in case of accident strict action to be taken

10.Ship Shore interface segment

11.Repairing side

12.On various ship operations that an AI may face difficult to perform Eg mooring arrangements, anchoring, cleaning etc

13.Where is the responsibility if the ship sinks, or any Maritime peril humans face onboard vessel, there will be rules for that also?

14.There will be no responsibility because we cannot fully depend on machine, there will be many technical errors, faults and all....

15.unsure of the question. as far as navigation goes- with the remote operator.

16.Company shall be solely responsible for Autonomous ships. They can control the vessel and should develop safe and secure SOPs to handle any untoward incident with help of classification societies and flag states.

17.Responsibility will always rest with owners

18.That is the big, big question!

19.At the shore station controlling the system along with flag registry

20.Semi-Autonomous because everybody needs somebody to be responsible (Read- Blame) So ultimate responsibility will be on that overall, in charge person onboard who can override any command.

21.Very difficult question, especially with some recent Judgements of the Courts

22.It is all going to be artificial intelligence. Laws have to made or reframed in assigning responsibility to the Company as defined in ISM code. Catch the DPA if he chooses to operate an AI ship and that ship meets with an accident.

23.With whoever has the power to override the autonomous system in an emergency. That could be the master or watchkeeper on board (remember, autonomous and unmanned are not the same thing), the remote-control operator/manager, or (in the case of a completely unmanned, autonomous, non-remote-controlled ship) the owner or manufacturer.

24.IMO have to figure it out.

25.Good question- who goes to jail?

26.Rules and regulations as per Conventions should still apply

27.Responsibility will have to rest with an individual whether fully manned,

remotely operated or fully autonomous. Society will not allow a corporation to be held solely responsible as there is a general human need to hold one liable when there is an incident.

28.New Management should be created

29.Let IMO decide. Its highly debatable.

30.I believe, the person in charge of the watch ashore or their team leader shall assume the responsibility.

31.Responsibility for? If this is about master's authority or something similar (making a scapegoat), I think it wouldn't matter. So long as it enables business with least disruptions, the system will figure out where this would lie. But if I assume right, your question is asking if it should be with the master or with someone ashore. I think this is irrelevant and incidental to the business. the market will figure this out.

32.God only knows

33.Engine Watchkeeping will most likely be carried out from shore?

Q9. Are there any other views you would like to share on concerns to seafarers due to advent of autonomous ships?

Yes (00)

No (55)

******* qualifiers***

1.A lot of seafarers and their family is affected in this situation. I don't think artificial intelligence can make instant decision as an experienced captain or seafarer.

2.If such systems are introduced, millions of seafarers will lose their job opportunities. The years they studied for their career, the dreams they have about their future, will all become wasted. Many will become unemployed.

3.It will be somewhat good for the company, but it will decrease the jobs of seafarers and will affect the company in later terms as the autonomous ships can't do the small things on their own so in short seafarers are needed on ship as

4.Autonomous ships are good. But not only technology can work easily but there is also the need of human resource.

5.Don’t be afraid…. we won’t be out fashioned.

6.Autonomous ships should be there without affecting the job of seafarer

7.The jobs are reduced as well as the risk

8.The involvement of Autonomous can be helpful for seafarers onboard to reduce their workload and thereby more effective in time management. So instead of replacing seafarers, autonomous also can be also added along with the seafarers.

9.Yes, my concern is there should be both in onboard ship, and can't believe with just shut our eyes with machines

10.Combining AI intelligence in shipping sector is good. But we can't completely relay on AI

11.Anyways autonomous system will surpass human labour, so provide a better job opportunity for shore section to deal with autonomous ships

12.Enhance the work skill seafarers with modern technology rather than this

13.If you have to become a seafarer you have to spend lakhs and work hard, after training not getting a job now a days, then what will happen if autonomous ships come

14.Training syllabus is already being upgraded but what about the seafarers who are already out there onboard? There should be some courses for the seafarers to prepare themselves for the autonomous future.

15.The next ten years will be revolutionary for Maritime industry and so will be for seafarers, it is now in the hands of international organisations and government of countries, where this revolution leads

16.In case of emergencies (common at sea), skilled and experienced

seafarers are the best options

17.Autonomous ships can reduce the job opportunities of seafarers. But technology has to be tested for long time before implementing in ships, because older the ships more will be the risk.

18.Standard of training of seafarers should increase, quality of knowledge to the seafarers should also increase that should relay with the current demands of shipping industry and to give preference to practical knowledge and practice of the things....

19.Many seafarers are flooding up each year and still not all of them are getting job. So, we can easily predict what will be seafarer's future by the entry of autonomous ships.

20.Seafarers might lose jobs at sea. Only limited and highly qualified will get the shore jobs to handle Autonomous ships.

21.This will be a gradual, phase-out from human to artificial intelligence. Enough time to adapt.

22.No two human beings will react the same way to the same situation. More important is that the same individual will not respond to the same problem differently. Whereas robots are more predictable and hence a lower risk.

23.Rights of seafarers to be protected

24.It's a good thesis subject. But in my opinion, a long time away to replace manpower completely from ships.

25.Ship owners’ quest for profits by reduction of manpower will ultimately backfire.

26.Accountability, safety of navigation, safety of property, safety of environment and safe and efficient conduct of cargo operations

27.Yes - The transition stage, navigation will be a challenge when both autonomous and manned ship will co-exist. 2 - Pilotage in less developed ports of the world.

28.Ships are not like spacecrafts, ships operate in conditions which are contiguous with other elements both which are natural and human, both can

be unpredictable in their responses and actions. Hence, it is not possible to cater to every possible situation by memory chips. Hence, the human element on the spot is required for making good and proper decisions.

29.It is not an immediate concern. Various viruses are more likely to take over humans than AI

30.The concerns are overblown. Ships being built today will be around for at least 20 years (they're not going to scrap them before end-of-life). Automation has already made our lives easier (think about autopilots, ARPA, etc.), and unmanned ships aren't viable on anything other than near coastal/inland routes. People keep on conflating "autonomous" with "unmanned", but all ships will still need maintenance, repair, etc., and it's not economical for companies to keep ships in port for maintenance and repair - makes more sense to put people on board and do it underway.

31.In my view future accidents by the pioneers' Autonomous ships will change this initiative and will change the perceptions of over relaying on autonomous.

32.In my view the chance of autonomous ships is very far, as it's very difficult when it comes with a manned and in manned Vessels comes together. In that case, who is responsible and if anything happens, the manned vessel will have more damage, so like that lots of questions will come. So, I don't think, it's possible, maybe it will come after 50-60 years.

33.Autonomous ships will have more trouble and problems than manned vessels. And expert hacker can stop the ship in mid-Atlantic and even sink them.

34.Going to be a competitive for seafarer and so we must be mentally and physically stronger to face challenges endangered by autonomous ships

35.Ultimately, it's all machinery and human being is required to handle it. Autonomous ships are idea is really bad and making seafarers life really difficult.

36.Autonomous ships concept is good for short inland voyages. I don't this it is practicable for ocean going trade is feasible in near future.

37.Regular technological disruption happens in lot of industries

38.I feel that even though automation might still the future of shipping, it will take a long time for complete automation in the industry. Till that happen human intervention is unavoidable

39.Continual education and training will be key to the survival of seafarers - whether aboard or ashore.

40.Seafarers are highly adaptive by nature, so we shouldn't be afraid of the autonomous vessels threat looming at the horizon, instead we should work on creating collaborative solutions, that will take out some of the negative factors (e.g., Fatigue). Eg: autopilot system onboard - it is a great relief but in case of emergency or during coasting or evasive manoeuvres, heavy weather etc., we still need a helmsman.

41.Ratings who are taking up the profession now will be more affected than any other group. They might not be able to seek other job avenue at that stage of their life. An alternate plan for absorbing this pool of seafarers to the shore industry must be done.

42.Maybe effective in coastal and shorter voyages. Ocean crossings would be a challenge if vessel runs into problems far away from land. Naval vessels and specialised operations like offshore, surveying, cable laying etc will still require manned operations.

43.Technology should be used to ease a seafarers' burden, not to replace them. Ship owners should invest in seafarers rather than technology which cripples/confuses seafarers. Long term savings should be envisaged and planned by balancing seafarer skills with technological advances.

44.The seafarers like catering staff, crew who are not tech savvy, junior staff who find difficulty to get shore staff. The owners should not forget them for all the work they did in running ships all these years. They need to be taken care of

45.The entire change is not going to happen overnight. So, like IMO is going to introduce 4 phases to achieve the target of autonomous ships, each phase will slowly affect seafarer in some way or the other. They will be required to update themselves with new technology, so new courses will be included, may be new COC will be introduced, seems seafarers are going to be as restless on shore as on ship.

46.multi-tasking in operations in shipping optimised to other arenas apart from shipping especially where there is inter-phase in the whole chain of cargo end to end, i.e., ex-factory to end user

47.It is more than a generation away. Seafarers need not be alarmed. As society and technology evolves, new jobs will come. And old ones may go. We need to adapt. We will adapt. There will be an equilibrium which will be determined by how empty the pockets of those who matter are.

48.Conduct trials first. Responsibility, documentation, safety, etc would have to be handled by responsible and adequate number of suitably qualified personnel.

49.Let's get updated. Let's enjoy the change.100%autonomous may not be economical as a small failure for example in a pipeline, gasket etc will require human interference. Entire money saved due to autonomous ship may be lost if the ship is required to be towed from mid ocean. Insurance, P&I acceptance may be another issue.

50.If it is "semi-autonomous " with min Manning, it is going to be more tough for those minimum people onboard, with no social life, may be with" ready to eat foods "and so on.

51.Only don't panic. Flow with the change. Resistance will not lead you anywhere. Upskill to the needs of the emerging technology. Nothing to worry. Opportunities will be sufficient in other fields.

Appendix 2- Expert Survey

The Expert Survey results listed as below basis the responses given as per the convenience and choice of the respondents.

(1). Regulatory – Expert Resource → Shri Ajithkumar Sukumaran, Chief Surveyor, DG Shipping, Mumbai.

1. Does the present international regulatory framework allow seamless operations of autonomous ships?

Ans: No. Current regulatory framework for international shipping only

permits vessels complying with safe manning requirements stipulated by respective flag states.

2. If answer to 1 is no, then which conventions (on international level) and ACTs (on the Indian Level) will need overhaul/amendment to facilitate autonomous operations?

Ans: The Maritime Safety Committee (MSC) of the International Maritime Organization (IMO), at its 103rd session in May 2021, has just completed a Regulatory Scoping Exercise (RSE) to analyze relevant ship safety treaties, to assess how Maritime Autonomous Surface Ships (MASS) could be regulated. Detailed discussions on it expected to continue in the coming sessions of the MSC.

The outcome of the MSC's regulatory scoping exercise, as approved by the Committee, including the full analysis of treaties, can be found as an annex to the report of MSC 103 (MSC 103/21/Add.1, annex 8) and can also be found in circular MSC.1/Circ.1638 (Outcome of the Regulatory Scoping Exercise for the use of Maritime Autonomous Surface Ships (MASS).

3. Without the MASTER on board, who will be taking over the corresponding responsibilities in matters of safety & pollution prevention?

Ans: The issues are only at preliminary discussion levels at the IMO. These involve the development of MASS terminology and definitions, including clarifying the meaning of the term "master", "crew" or "responsible person", particularly in Degrees Three (remotely controlled ship) and Four (fully autonomous ship).

4. Will the STCW convention need to be reshuffled for including shore controllers in MASS Degree 3 vessels? What scope do you think STCW will

have in such a scenario?

Ans: Several requirements of STCW now applicable only to seafarers may need to be extensive amendments to (1) introduce new technologies and/or automated processes; and (2) to address the relationship between the "remote operator" and other seafarers serving on board.

These changes can be made through the existing Convention processes and other flexibilities – through authorized equivalencies or amendments to the codes or regulations.

5. Is there a possibility of two separate versions of the international regulations to be prepared to facilitate existence of conventional & autonomous ships?

Ans. Certainly, yes. The general feeling of the MSC was that the best way forward to address MASS in the IMO regulatory framework could, preferably, be in a holistic manner through the development of a goal-based MASS instrument. Such an instrument could take the form of a “MASS Code”, with goal(s), functional requirements and corresponding regulations, suitable for all four degrees of autonomy, and addressing the various gaps and themes identified by the RSE.

(2). Ports – Expert Resource → Capt. Joseph J Alapat, Deputy Conservator, Cochin Port.

1. Is there any plan in place for the ports to deal with autonomous ships?

Cochin Port has not started thinking about autonomous ships as yet. They will be led by ships, so the ports are waiting to see how the move to autonomous ships move in order to incorporate the same into the ports. Singapore's TUAS port would be a good guide to how ports would adapt as PSA are incorporating a lot of futuristic thinking into the development of the port.

2. Does the present legal framework permit autonomous ships to operate in port waters?

At present ships are required to have adequate crew and be under the command of the Master to enter the port. These regulations would have to change as autonomous ships develop. Here again ports will follow the leads by ships.

3. What training do you envisage for the Pilots, Tugs & VTIS when autonomous ships start coming to port?

Not much change is seen in the operations of tugs at most increased use of sunken bollards for securing of the tugs will be seen. However, VTMS and Pilots who have direct contact with the ship, would see changes. VTIS would have to incorporate how communications with ships will be on autonomous ships. The operators will have to incorporate these changes in their operations. The VTIS will also likely have a direct link with the ship with exchange of information so the systems will have to incorporate these interfaces.

The Pilots will have to change to do the Pilotage with ship systems as designed by the ships. The basis skill of Pilotage will not change but how

this service is provided to the ship would. When this is in place on ships, Pilots would have to be adapted to change accordingly.

4. Which pertinent provisions of the regulations in the relevant ACTs at the macro level and harbour rules at the micro level will have to be modified to allow autonomous ships to operate in port waters?

The Acts do not get into the level of the operations but enable ports to make regulations that do. So, most of the changes will be in port regulations. In Cochin Port we do see at least 4 to 5 regulations which will need amending.

5. Do you see a possibility of autonomous vessels being allowed full pilotage exemption in the future? If not, what impediments on a legal, safety and commercial level do you foresee?

Autonomous ships and exemption are not co related as ships would still pose a grave risk to ports given their size irrespective of how they operated. Unless risk of maritime accidents can be fully eliminated by automation, exemption will not come into the picture. The cost of automation is also a major factor in its acceptance. The high technology which would have to be put into the ships as well as higher number of equipment and propulsion systems would be in the end the deciding factor in autonomous ships getting widespread acceptance. As always money has the last word. Another factor in the regard is whether insurance premium for autonomous ships end up higher than for manned ships. So autonomous ships would only eliminate the 25 odd seafarers on board. To achieve this, it will require more equipment, machinery, communications among other things. Unless this additional investment is costing the shipowner less, it will not work. Even with all the automation on airplanes including automated take off and landings, two Pilots continue.

6. What time horizon do you envisage for seamless autonomous ship operations worldwide?

While change is increasingly fast paced these days, this is a huge change of something that is thousands of years old. while all forms of transportation have seen great inputs of technology and research, apart from the road vehicle, no other form of transportation has seen successfully automated till date. Given the number of ships across the globe and the fact that shipping

reaches every part of the world, it is hard to imagine a fast-paced movement to autonomous ships worldwide.

7. Are there any other valuable inputs you would like to share in line with the objectives of this study?

Autonomous ships are the first thing to be developed. Only when that is done can the rest of the eco system develop the means to work with ships.

(3). Ship Owner – Expert Resource → Ms Pia Meling, Vice President, Sales & Marketing Massterly AS - A Kongsberg Wilhelmsen joint venture.

1. Are you in favour of autonomous ships? If yes, why?

Yes, I believe autonomous ships can increase safety, efficiency, and the share of maritime transport for shorter distances (where we compete with trucking) due to lower OPEX and higher operational flexibility (no crew change limitations)

2. What level of autonomy exists on board your ships?

Degree 2 now and degree 3 from 2024

3. Do you think you will be able to achieve successful autonomous ship operations?

Yes

4. Are regular Hull & Machinery / Protection & Indemnity, insurance covers forthcoming for your autonomous ships? If not, are you looking at Self Insurance?

Gard and Skuld have signed insurance cover for the ships we operate (Massterly is the Vessel Manager and Operator, not Ship Owner – that is Yara and ASKO)

5.Will you encourage any of your existing seafarer employees to work on transition to shore-based roles with advent of autonomous ships in your fleet?

Yes, some of the existing seafarer employees in Wilhelmsen Ship Management will transition to shore-based roles for Massterly.

6.What time horizon do you envisage for seamless autonomous ship operations worldwide?

We need much better connectivity (latency, coverage, cost) for deep sea adoption of level 2 and 3 autonomies, so perhaps 5-10 years ahead? Level 4 autonomy without any human interaction I am not sure we will see for commercial shipping at all (this may be suited for small research vessels, navy applications etc.)

(4). Ship Owner – Expert Resource → Mr. Sanjeev Namath, Chief Business Officer, Alpha Ori Technologies Pte. Ltd; 3 Fusionopolis Way, #13-20 Symbiosis | Singapore 138633

1. **Are you in favour of autonomous ships? If yes, why?**

Whether we are in favour of autonomous ships or not, it is bound to happen. It's only a question of when?

Our view is to prepare the seafarer's as well as the ships for that eventuality by approaching the issue in a staged manner. First go for digitalization and leverage on the real time data analytics to improve the efficiency & reduce losses.

There is good potential for 'Decision Support System' to the crew and Shore

management basis real time data analytics – which falls between degree 1 and degree 2 of autonomy.

For transition to Autonomous Shipping, the transfer of decision making from Ship to the Shore is critical and we are focusing in that area with few Cargo solutions that we have built for the Oil Tanker segment.

2. **What level of autonomy exists on board your ships?**

Currently we have achieved degree one with progressively automating certain functions that are currently performed on-board, such as: Cargo stowage planning on Oil Tankers etc.

3. **Do you think you will be able to achieve successful autonomous ship operations?**

We believe the industry will be able to achieve successful autonomous ship operations.

4. **Are regular Hull & Machinery / Protection & Indemnity, insurance covers forthcoming for your autonomous ships? If not, are you looking at Self Insurance?**

We have not yet engaged the insurers for autonomous ships. However, most of the insurer's (both P&I and Hull & Machinery) are engaged with us for our SMARTShip solutions & other Cargo Solutions on the loss prevention and mitigation angle.

5. **Will you encourage any of your existing seafarer employees to work on transition to shore-based roles with advent of autonomous ships in your fleet?**

We have at any given point of time around 20+ crew working during their leave period on our SMART products. We also have mandated that crew joining ships installed with SMARTShips go through the Training & Familiarisation on digital solutions. We also have LMS system that the crew go through to test their competency levels.

6. **What time horizon do you envisage for seamless autonomous ship operations worldwide?**

Nobody can predict this timeline as there are lot of pieces that needs to

come together and align – industry business need, regulatory & legal landscape, insurance sector etc.

7. **Is there any other valuable inputs you would like to share in line with the objectives of this study?**

As the saying goes – 'Change is the only constant'. We need to change with times. We need SMART systems that will gel well with the current generation of crew who are not adapt to convention systems onboard ships. They are mostly adapted to SMART systems in their daily life ashore. We need SMART systems to support them in decision making – that takes away repetitive tasks and mundane reporting needs.

I suggest the focus of this study be on Digitalisation in general and how crew needs to adapt to 'real time automated data analytics' that can be the first step towards autonomous shipping. This will enable the crew to be confident of the forthcoming changes and will equip them better for the transition to shore jobs that will be generated when remote control stations come up with increasing degrees of autonomy takes shape in the future.

(5). Classification Society – Expert Resource → Mr. Renganathan S, Senior Principal Surveyor, Indian Register of Shipping

1.**Presently what standards of construction, equipment & operation govern autonomous ships?**

IRS has published guidelines 2021, the primary aim of this document is to provide a broad framework (based on best practices), for the stakeholders involved in design, construction and testing of such vessels. The guidelines do not cover manning and operational aspects, which are to comply with the regulatory requirements, as applicable.

2.**Is IACS in general & IRS in particular looking at overhaul of present class rules to facilitate autonomous ships?**

IMO has completed its REGULATORY SCOPING EXERCISE FOR THE USE OF MARITIME AUTONOMOUS SURFACE SHIPS (MASS) last year. The Committee noted that the best way forward to address MASS in the IMO regulatory framework could, preferably, be in a holistic manner through the development of a goal-based MASS instrument. Relevant Class rules will be updated subsequent to issue of above "code".

3.**What will Class rules be like for autonomous ships?**

As stated above guidelines have been developed and further work is expected to commence after issue of regulatory requirements for MASS. However, IRS will keep itself and its guidelines updated with technological developments, without considering the manning aspect. Any technical requirements including IACS UR/UI on upcoming technologies, would be suitably incorporated in our rules/guidelines.

4.**What additional training are you planning for your class surveyors for initial, periodic and emergency inspections on autonomous ships?**

Training needs will be drawn out from updated rules / regulations. The present focus would be on technology such as decision support systems, data communication, cyber security etc.

5.**Is IACS planning to include shore-based control centres within the Class ambit considering that there will be increased shift of critical decision making to shore offices especially in MASS Degree 3?**

No such agenda yet at IACS. However, our guidelines address high level requirements for autonomous vessels which can be remotely monitored /supported, with normal crew on board.

6. **What time horizon do you envisage for seamless autonomous ship operations worldwide?**

MSC 104 agreed to develop of a goal-based instrument for MASS, with a target completion year of 2025. However commercial viability of such vessels would be the deciding factor.

7. **Is there any other valuable inputs you would like to share in line with the objectives of this study?**

At present instance we do not have any further inputs

(6). Ship Design – Expert Resource → Mr Charles Thomas, Assistant General Manager, Project Management, Cochin Shipyard Ltd.

1. **Are you designing autonomous ships?**

• We are doing detailed design and production of autonomous ships (MASS Degree Three). Basic design is done by an external party.

2. **Do existing autonomous ship designs comply with the present Class and regulatory requirements?**

• Complies with the requirements stipulated by Class notations finalized in the shipbuilding contract.

3. **Any new design criteria being followed as per new class/regulatory criteria?**

• Complies with applicable Class and flag state requirements.

More details are available only with basic design firm.

4. **Are the present autonomous designs capable of prolonged deep-sea operations?**

• No. They are intended for short trips – ferry operations between predefined ports.

5. **Do you see increased job opportunities for seafarers in ship design when dealing with autonomous ships? What time horizon do you envisage for seamless autonomous ship operations worldwide?**

• With increased number of autonomous ships, job opportunities for highly skilled persons for remote control of the ships, various systems design and control etc. will increase. On the other hand, opportunities for unskilled persons can come down as most of the manual operations will be replaced with automatic operations.

• I expect seamless autonomous operations will be in place within 15 years.

6. **Is there any other valuable inputs you would like to share in line with the objectives of this study?**

• Autonomous vessels with high efficiency and zero emission propulsion system are required to overcome most of the challenges and negative sides of present marine transportation systems. Skill development and training programs shall be developed after identifying the opportunities and skill requirement in line with future technology to avoid unemployment related issues of seafarers.

(7). Terminal – Expert Resource → Mr. Praveen Thomas Joseph, CEO, DP World ICTT- Port Terminal, Vallarpadam, Cochin

Autonomous ships do not seem to be on our radar for the near or medium term. Our current view is that, due to the nature of container operation and the comparatively few seafarers already deployed on very big vessels, one can't see that the benefit of going autonomous even remotely would outweigh the risks/complications such an operation will carry with it. The cost savings could be limited, and we do not see that automation would enhance safety nor improve vessel performances compared to the downsides. We are currently not aware of any ocean-going shipping lines considering this in earnest despite the reports of the trial in Japan. We feel it could be more relevant to coastal, protected waters, maybe barging. Here too, whether the value would outweigh the risk even remotely, needs to be seen. For non-container vessels, the situation might be slightly different in so that the transport/cargo is simpler and often from point to point. Some vessels in fact ONLY sail between given ports and one could therefore construct a system matching exactly that. It would take away all the flexibility of a vessel, but we could say that the possibilities are larger here than for container vessels.

(8). Cyber Security – Expert Resource → Mr. Shinaj Karuwath, CEO, Principle Business Consultants LLP

1. In your experience is there a completely hack proof software platform? If yes, is it available in the mainstream?

There is no hack proof software available. Every software comes with its own vulnerabilities. These vulnerabilities may be exploited based on the know-how of the technology being used in developing the software.

2. What type of Cyber Security risks do you foresee for autonomous ships?

The risk will arise for both IT and OT systems. IT (Information Technology) is basically for the data and business information, while OT (Operational Technology) is the combination of hardware and software which controls the devices on the ship. There are many controls available for the IT systems, however it is not the same with OT. Few common vulnerabilities are.

- ineffective patching of the application,
- obsolete technology or legacy operating system,
- maintaining the secure connection with the shore systems etc.

Few critical risks may be.

- breakdown the SCADA system which helps in controlling the ship,
- misuse of the access control for the on-board applications

3. Considering that the merchant marine is primarily a commercial

endeavour and not a military one, what is your experience of commercial entities investing in the latest cyber security systems?

Investing in cyber security is similar to investing in insurance. Due to the surge in the technology domain and increase in privacy laws, it is always good to invest in cyber security.

4. **What measures do you suggest that the industry incorporate technically and legally to mitigate the threat of cybercrime in autonomous ships?**

Few of the suggested controls would be.

- Improve the cyber security competence of the crew.
- Implementation of robust risk management process for the IT and OT systems.
- Periodic review of the controls implemented.
- Implementation of effective backup and restoration methods for the critical applications and systems.

5. **What kind of Cyber Security training do you propose for the seafarers?**

Basic awareness on the information security management system like ISO/IEC 27001, ISO 31000 (Risk management), NIST etc.

6. **What time horizon do you envisage for seamless autonomous ship operations worldwide?**

Autonomous ship operations shall be there in the next 10 years.

7. **Is there any other valuable inputs you would like to share in line with the objectives of this study?**

Research can also focus on how the sea farers can be equipped with the competence on managing the autonomous ships as AI/ML will not be standalone with zero percentage of human interactions.

(9). Maritime Training – Expert Resource → Capt. Ajay P Singh, Extra Master, Extra Master Faculty, Synergistic Solutions & Visiting Faculty, MASSA Maritime Academy

1. **Are there any regulatory directives or internal value-added courses on offer to seafarers to deal with autonomous ships?**

People working within the Maritime sector know the key stakeholders very well.

IMO
United Nation
European Commission
Classification societies
Governments
Industry and commercial actors
National authorities
Ship owners.
Universities and educational institutions.
The studies optimized for flexible learning and studying, parallel with

fulltime employment ashore or at sea.

Master of Engineering, Autonomous Maritime Operations
Degree: Master of Engineering
Field of study: Technology and Seafaring
Extent: 2 years

Structure of Studies

The programme has a special focus concerning the management and business administration in maritime operations. The studies include 6 courses of relevant subjects each of an extent of 5 credits. Following subjects are covered:
• Studying in the Masters programme and introduction to Research and research methods
• Autonomous vessels-automation
• Artificial Intelligence, Machine Learning, Human-Machine Interaction
• Remote Operations
• Cyber Security and Connectivity
• Classification, Qualification and Safety Perspectives

The studies are optimized for flexible learning and studying, parallel with fulltime employment ashore or at sea. The studies to be arranged at site and online with lecture materials, as well as the assignments to be completed online.

2. **Do you think specific competitive and associated training will be needed for the seafarers to operate in the realm of autonomous ships?**

A common statement from the interlocutors is that education and training is important, and it has to change to support the new technology and the autonomous shipping.

Needs to develop the education in two lanes in the transition phase, one supporting the autonomous ships and one supporting the conventional ships.

- The content of the training will change.
- Remote operator does not need to be a master mariner.
- Pilots do not work in flight control.
- Additional education needed for understand automation systems.
- IT will play an important role in the future.
- Separate qualification and certificates needed for remote operators.
- More simulation-based training needed.
- Important that we don't get stuck with old roles.
- More understanding of complex systems.
- Maybe learning how to use the sextant is not needed in future courses.

Recommending additional competences related to steering an autonomous ship and the equipment in use, should be added into the education and qualifications required.

3. **How will young people be attracted to education in the future?**

- New technology attracts youngsters.
- Would rather go to a control centre or simulator than spending long times at sea.
- Spend more time at home with family and friends.
- Doing office work 9 to 5
- Rather work at a remote operation centre, than spending 3-5 months at sea
- No risk for seasickness working at a remote operating centre.

Maybe marketing of the education needs to be targeting some other group than today.
In the future we may need to hire 'PlayStation' players.

4. **How will future affect the education development – what kind of knowledge will be needed**?

1) More IT education will be needed.

- Basic understanding of AI and Cyber Security.
- Ability to understand processes, conditions, and combinations.
- Automation knowledge.
- Combined education (deck officer, engine, electrician), e.g., Electro Technician Officer (ETO).
- Simulator training is a good concept for teaching things.

One will still need to understand the ship's movements and how it behaves. A lot of data will be available, and the ability will be needed to choose relevant data in a specific situation.

5. **Do remote operators need sea experience?**

This question divides opinions, those having an active maritime background from ships feel that sea (practical) experience is a must.

- It depends on the operations.
- One will need practical experience during the transition period.
- We will still educate master mariners for the conventional fleet and additional training for operators.
- Without the touch and feel and the knowledge of the ships characteristics one might drive the ship to its limits from on operating centre.

Ramboll et al (2017) is recommending that additional competences related are needed and that the operators have minimum complete training for supporting COLREG rule 2, with virtual simulator experience replacing practical seagoing experience.

6. **What will happen with the certification and qualification in the future?**

This is very much a political and economic question.

1) Qualifications and certificates will be needed in the future as well.
2) The existing renewal for certain certificates every five year is ok.

1. It is generally agreed that qualifications and certificates will be needed in the future as well. The existing renewal for certain certificates every five year seems ok for the majority of requirements. Combined education should be promoted (deck officer, engine, and electrician).
2. The technology develops so fast that maybe yearly updates, from the companies would be in place. Training will be needed, but in a different way, on systems and hardware. In general, we need to work more with life-long learning in all working situations. Certification is one way to verify the education and knowledge. Maybe in the future practical experience can be received from other industries, e.g., forest or paper industry. Operator education will be needed. IMO and STCW is controlling this on a detailed level.

3. SOLAS requires that certificates exist and are maintained. Clear need for education, training and certification. The Danish model with “dual officer” will be more common. “To cope with increasing industrial demand and accelerated technological development, the global standard of maritime training and certification will also require revision and adaption”.

    - Autonomous Ship’s effect on the maritime business?
    - Cost saving will be achieved.
    - Changes in ships design, materials.
    - Uberisation or consolidation of maritime transports.
    - More space for cargo less for crew.
    - Increased safety.
    - Removing of brokers, intermediates as a lot of surveys will disappear.
    - More risk bade approach and on-line audits and inspections.
    - Changes in firefighting and emergency equipment and procedures.
    - Crew will spend much more times in simulators.
    - Jobs will be lost, but new ones will be created, and roles adjusted.

Many of the manual routines will be automated in the future, and job descriptions will be changed as a result.

7. **How will the technology change the behaviour in the future?**

There will be shift of control from ship to shore.
The interaction and communication with small vessels will be a big challenge.
The technology becomes faster and faster, and we need to adapt.
We need tools for faster adaptation to the changes.
A big advantage being ashore compared to on board from a stress point of view.
Connecting to experts easier when working from shore.
Mooring operations will be automatically.
The big picture needs to be approved and accepted by the society.

8. **Are there any regulatory directives or internal value-added courses on offer to seafarers to deal with autonomous ships?**

1. IMO aims to integrate new and advancing technologies in its regulatory framework - balancing the benefits derived from new and advancing technologies against safety and security concerns, the impact on the environment and on international trade facilitation, the potential costs to the industry, and their impact on personnel, both on board and ashore. IMO wants to ensure that the regulatory framework for Maritime Autonomous Surface Ships (MASS) keeps pace with technological developments that are rapidly evolving.

2. IMO has recently completed a regulatory scoping exercise on Maritime Autonomous Surface Ships (MASS) that was designed to assess existing IMO instruments to see how they might apply to ships with varying degrees of automation. The regulatory scoping exercise (RSE) for safety treaties was finalized at the 103rd Session of the MSC in May 2021, and for treaties under the purview of the Legal Committee, in July 2021.

Maritime Safety Committee (MSC)
The list of instruments to be covered in the MSC's scoping exercise for MASS includes those covering:

• safety and maritime security (SOLAS).
• collision regulations (COLREG).
• loading and stability (Load Lines).
• training of seafarers and fishers (STCW, STCW-F).
• search and rescue (SAR).
• tonnage measurement (Tonnage Convention); Safe Containers (CSC); and
• special trade passenger ship instruments (SPACE STP, STP).

9. **Which disruptive technology or equipment is available that can lead to seafarers losing jobs in the present scenario?**

1. Automation, Digitalization and Artificial intelligence can and will bring about major changes in which seafarers will be affected in a gradual manner over a period in which we will see a shift from routine task towards higher level of problem solving and mastering of unusually complex situations.

2. Seafarers will be a directly affected by automation. Their natural focus may not be on the human involvement in routine operations of technical assets. When focusing on the impact of automated ships on seafarers it is important to consider a paradigm shift triggered by new asset holders. They may bring an entirely new perspective into the equation between technical assets and human operation, away from routine tasks and towards high level problem solving and mastering of unusually complex situations.

3. Embracing change means redefining the “seafarer”- Disregarding the traditional role of seafarers with a disruptive approach is easy for start-ups and newcomers. If companies with a legacy of seafarers in well-established roles consider a disruptive approach, they will have to redefine roles, communicate, train and re-train their employees. They will also have to carefully compare the commercial viability of technically disruptive projects.

4. For those wishing to foster and encourage the use of automation in the industry, an area to address is the fears of stakeholders and long held attitudes which mistrust technological change and the claims of those who espouse its benefits. Report on the feedback received from over 1,000 members from 21 unions within the Nautilus Federation. Most of the feedback suggested that automation was seen a threat to maritime professional's jobs and that unmanned/ remotely controlled vessels presented a safety threat at sea. The study argued that the rush by manufacturers and maritime nations into investing capital and time into researching autonomous systems and digitalization for ships has meant that so far important social and human issues such as skills are being neglected. The article ended by calling for work to be carried out to examine ways in which maritime skills can be protected and enhanced by new technology.

5. The long-term effects that automated and unmanned ships will have on the employment prospects of seafarers are unknown. Studies visualize that if 1,000 ships are fully automated by 2025, the demand for seafarers may be reduced by 30,000 to 50,000 seafarers. It is difficult, however, to predict the exact impact of technological developments and automation on job losses or creation in the maritime sector.

10. **Where do you think that the regulatory changes will be essential in present maritime training to prepare for autonomous ships?**

(A) Legislation needs to change.
(B) Education and training need to be restructured and changed.
(C) Medical requirements need to be adjusted.
(D) More IT knowledge will be needed.
(E) Everything will gradually change training, classification societies, pilots, manufacturers, regulators, port operators, search and rescue, law enforcement etc.

Broadly
(A) Uberisation of shipping.

(B) Port must be adapted to handle Autonomous ships.
(C) Ship building, no one-offs are built, should go for mass production.
(D) Certification will be renewed.
(E) The way technology is developed and tested need to change.
(F) The whole infrastructure needs to be developed; it is one entity.
(G) Society's approval.
(H) VTIS need to access navigational information.
(I) Simulations need to play a key role.
(J) Search and Rescue procedures need to be updated.
(K) Firefighting procedures need to be updated.
(L) Acceptance from the society
(M) Identify the importance of IT skills in the future education.

There is a need for improved IT skills due to new systems and increased automation.

11. **Is there a need for changes regarding Health/Medical requirements?**

(A) Health and medical requirements need to be revised.
(B) Remotely operating a ship from a wheelchair should not be a hinder.
(C) Mental health is still important.

(D) The requirements could be broadened to offer more diversity.
(E) People are healthier if they are less fatigue and stressed.
(F) On Autonomous ships the medical equipment on board needs to be revised compared to today's situation.
(G) 70+ seafarers the health of whom does not allow to work onboard, climbing stairs, but their mental health is good, and they could easily work in a remote-control centre, passing on their knowledge to the younger people.

(H) Health and safety issue could be subject to the legislation ashore in remote operating centres. Technostress characteristics fatigue, headache and restlessness was brought up by Brod (1984). Studies has also been done by Arnetz and Wiholm (1997) and Burmeister (2014) identifying similar characteristics.

(I) Perspectives on changing education Bringing in new technologies is one important part in the shipping and might impact how we need to develop maritime education and training (MET)

12. **What time horizon do you envisage for seamless autonomous ship operations worldwide?**

1. About 20 to 30 years mainly dependent on advancing technology in artificial intelligence and robotics.

2. Over the next 30 years the skills profile across the sector will alter as new technology takes effect. Old skills will not disappear but new skills, particularly in IT, digital and new technology more generally, will be required to complement existing skills. There will be a need for highly qualified personnel with the ability to create, operate, and maintain autonomous and technological systems. This will call for increasing numbers who have studied STEM subjects.

3. By 2050 jobs will become more highly skilled and roles will be diverse in their requirements, meaning multi-skilled people will be highly desired, as will those with relevant specialisms. Skills will likely be increasingly data-focussed and digitally based, yet these will remain supported by knowledge of mechanical systems, as individuals create, manage, interpret, maintain and repair technology. This will call for increasing numbers of the maritime workforce to have STEM based skills, setting the maritime sector in direct competition for those skills with other transport sectors.

4. Recognisable skills, such as navigation, will still be necessary even with autonomous ships in case of technological malfunctions.

13. **What are the advantages/disadvantages of unmanned cargo ships?**

Pros

(A) **Minimization of high maintenance parts such as rotational components.** Data shows repair and maintenance expenditures are expected to rise by 2.5 to 3 % annually for container ships.
(B) **Elimination of harmful emissions.** For example, the Emma Maersk, the biggest container ship in service back in 2007, generates 40 tons of CO2 when transporting a full load – more than what a 5-member household in Germany generates in 1 year.
(C) **Decrease of human error risk and the resulting associated accidents.** Currently, there are about 900 fatalities per year occurring in shipping.
(D) **Reduction of fuel costs.** At 11,000 TEU, for example, the Emma Maersk burns 14,000 litres (~3,700 gallons) of heavy oil per hour.
(E) **Offsetting the expected shortage of seafarers in the future.** There is an expected shortfall of approximately 21,700 officers by 2018.
(F) **Reduction of total operating expenses.** Crew costs today run about 3,299 USD (~2,600 Euro) a day, accounting for 44% of total operating cost for a large container ship.

Cons

(A) **Reduction of seafarer jobs.** Job cuts would directly affect the 610,000 officers in the currently estimated supply work force.
(B) **Unknown safety risks.** Current machines are unable to replicate the human element (i.e., experience and reaction) of professional seafarers.
(C) Vulnerability to computer hackers hijacking control.

Final Observations

(A) Digital transformation will be a seamless process rather than a disruptive one.
(B) There will be no shortage of jobs for seafarers in the foreseeable future.
(C) There will be considerable additional jobs ashore.

(D) There will be significant training needs.

However, the following questions will be at the core of future discussions:

1. What work needs to be done on board?
2. What work can be done remotely?
3. Where should larger amounts of data be assembled, ashore or onboard?
4. Which work requires permanent staff on board?
5. Which work can be achieved by riding gangs?
6. What will be the differences between ship types and trades (i.e., Shortsea, Deepsea, Harbour Operations, Ferry, Cruise).
7. Is today's staff suitable for new electronic and data-driven tasks on board?
8. How can staff be trained to obtain new skills?
9. Will the existing mindset/culture within the industry have to be confronted and changed?
10. Will existing skills be able to be passed on to a new generation to avoid skill erosion?
11. Will compulsory sea time still be relevant for operators?
12. How much increased awareness will crew have to have in regard to cyber security?
13. What are repercussions for CBAs and labour relations in general?
14. Will pay scales and pay logic have to be redefined?
15. What safeguards should be considered for seafarer welfare?
16. What will be the impact on seafarers' mental health if crew numbers fall?
17. Will Safe Manning Levels as set out by SOLAS and the MLC be affected?
18. To what level of autonomy is required/ needed by the end users (shipping companies)?

1. The long-term effects that automated and unmanned ships will have on the employment prospects of seafarers are unknown. Studies visualize that if 1,000 ships are fully automated by 2025, the demand for seafarers may be reduced by 30,000 to 50,000 seafarers. It is difficult, however, to predict the exact impact of technological developments and automation on job losses or creation in the maritime sector.

2. The automation of certain tasks may improve the working lives of

seafarers, with 83 per cent of surveyed seafarers in a study on autonomous shipping believing that technological developments could potentially improve working conditions at sea. Automation could reduce the number of physically burdensome activities and dangerous, monotonous, or tedious tasks; this would reduce excessive working hours and fatigue in addition to work-related injuries and other occupational health and safety concerns. Yet, the use of unmanned ships, robotics, and artificial intelligence have been perceived by the surveyed seafarers as the main threats to their careers in the future.

(10). Fleet Personnel – Expert Resource → Capt. M P Bhasin, Director, MSC Crewing Services, India.

1. **Do you think the intake of seafarers will reduce with advent of autonomous ships?**

   In my opinion the intake of seafarers may reduce with advent of autonomous ships, but there would be increase of qualified seafarer requirement for shore employment to handle such ships.

2. **Are you working on any special training for your employees to prepare them for autonomous ships?**

   No, currently no such training is planned yet.

3. **Is there any pattern that you have been observing relating to reduction in seafarer recruitment over the years? If yes, then in which roles?**

   As per the past 30 years trend, shipping has changed drastically, where the manning on board earlier vessels was about 30 to 40 persons in average in 1990 to 1997, whereas after the UMS introduction same has been reduced to 18 to 24 persons on board each vessel. The trend reflects reduction in rating numbers in machinery space and to some extent in Deck/ Galley department too.

4. **Do you think, the manning companies will also diversify into recruitment for seafarers in roles ashore for managing autonomous ships?**

   Yes, very much, As the autonomous ships demand rises the supply of qualified seafarers will increase ashore.

5. **Are you working with any union/government body/NGO to protect seafarer jobs with the advent of autonomous ships?**

   No, currently no project is being handled.

6. **What time horizon do you envisage for seamless autonomous ship operations worldwide?**

   10 years towards coastal trade and about 20 years for ocean going long voyages trade.

7. **Is there any other valuable input you would like to share in line with the objectives of this study?**

   In my opinion the autonomous ship concept will work in line with airline industry, where all the decisions pertaining to regulate the air traffic are in hands of air traffic controller. However, the on-board cargo care on a vessel and continuous monitoring of key parameters will be essential to make it happen. There may be need for riding teams to be present on board for short durations depending on the exigencies of the route and the specific demands of the cargo.

(10). Insurance – Expert Resource → Unfortunately, no competent and willing expert in insurance of autonomous ships could be involved.

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