Future of Shipping

Eur. Ing. Jacque Powell BEng, LLB, LLM, CEng, CMarEng, FIMarEST
Seaspec Marine Consultancy Services FZE

Dubai, United Arab Emirates
Japow@Emirates.net.ae

Synopsis

Technology is changing and rapidly evolving many industries including shipping. Advances in information, telecommunication, computer, robotic, Artificial Intelligence, machine/deep learning technologies together with cutting edge automation are proliferating every facet of maritime industry and changes are expected to accelerate. However, challenges of new technologies, pace of change and wide spread automation have taken many by surprise. In maritime, the regulatory framework which has often been the cornerstone and by and large the driving force for change, albeit in response to an event or market forces or political pressure, is conspicuously missing and currently engaged in a race against time to catch up and rework the applicable Conventions. Despite early success, there are indeed numerous challenges for the new technologies to bed in and gain wider acceptance and recognition before being considered as a worthy and viable replacement for tried and tested designs on a global scale. Various projects developed thus far or undergoing development, are exclusively intended for coastal waters and therefore, subject to class and Flag national requirements and in the circumstance, rules and regulatory requirements are devised and enforced at national level, as deemed fit. Successful and historical Rolls Royce-Finferries autonomous operation of car ferry Falcon, underlined the arrival of new technologies and demonstrated that it is no longer a question of if but when, wide spread use of automation and autonomous systems are implemented on board. There are of course many hurdles to overcome but with the buzz, energy and willingness of stakeholders in maritime nations and scales of investment in research and development, it is only a matter of time before unmanned, semi-autonomous, autonomous vessels join the world fleet in numbers and set the trend for a new era in shipping.
With steady and continuous growth in world trade and world fleet, indications are that current shortfall for officers will be multiplied by 2025. Although, there are no reliable records for total number of qualified seafarers worldwide and perhaps seafarers available for work, there will reportedly be a substantial shortfall in the number of officers by 2025, as per (BIMCO-ICS 2015) Manpower Report. This paper attempts to examine underlying reasons for introduction of new and viable technologies for potentially unmanned, semi and fully autonomous operations and its socioeconomic impact on seafarers and affiliated workforce.

Keywords— Automation, autonomous, technology, unmanned, seafarers

1. Introduction

Shipping shifts over 90% of the goods and moves over $9 trillion worth of cargo around the globe every year. There are over 90000 vessels in service, out of which approximately 64000[1] are carrying cargoes around the globe and employ over 1.6 million seafarers worldwide.[2] With such colossal contribution to the global economy and its central role in socioeconomic development and globalization, it's logical

 http://doi.org/10.24868/icmet.oman.2019.029

to expect the industry to undergo continuous scrutiny for, inter alia, social, economic and political impact as well as modification to regulatory framework and other facets vis-à-vis design and construction optimization, operation and environmental footprint.
Whilst in the past six decades, there have been plethora of conventions, protocols, codes and resolutions to regulate and enhance safety and security, often as a result of public outcry and reactionary measures to shipping disasters, introduction and incorporation of the new technologies in shipping have been slow and arguably at a trickledown pace. it is remarkable that in an era filled with innovations and technological marvels, shipping managed to steadfastly continue with the status quo, retaining old and introducing new technologies with varying degree depending on ship types, building yards, purchasers' specifications, charter party requirements, competition and to an extent regulators input. The outcome is a fleet comprising vessels with varying degree of complexity ranging from basic and arguably outdated design with limited monitoring and automation to highly complex, sophisticated and state of the art vessels.
In contrast, civil aviation has been relentless in its pursuit of new technologies, continuously pushing the frontiers and invest, explore, test and incorporate new technologies at a frantic pace. Added to this, the main impetus has seemingly been towards standardization of equipment, centralized traffic control and continuously streamlining operational and administration procedures for improving performance and safety standards. There is seemingly a safety culture that is embedded in the industry at large that goes beyond mere compliance, and routine checks, inspections and trainings are sufficiently detailed rigorous and strictly adhered to. However, that doesn't mean the industry is without problems, Civil Aviation has its own shortcomings, case in point Boeing 737 MAX recent fatal crashes and grounding of 737 fleet worldwide since mid-March 2019.[3] Maritime transport's periodical inspections, checks, surveys and training requirements pale in comparison with aviation industry's inspection regime and therefore, it is not a surprise that maritime is purportedly 25 times riskier than air transport, based on death per 100 Km.[4]
Arguably, maritime lags aviation industry in many respects and nowhere this is more pronounced than the broad field of technology, automation, safety culture, transparency, application, research, setting and maintaining standards, pioneering work and incorporation of new technologies.
Going back almost half a century, microprocessors were introduced to aviation industry in early 1970s[5] and it wasn't a decade or so later that microprocessors found their way into ships, in limited context, and with that the leap for monitoring, automation, unmanned machinery spaces and reduced manning.
There are certainly similarities but in terms of using new technologies, in particular automation, the two industries are as far apart and out of sync they have ever been.
Early automations were introduced on aircrafts in 1920-1930, in the form of mechanical systems such as autopilot that maintained aircrafts flying straight, followed by introduction of servo-mechanisms aiding the pilots in skill-based activities. Second generation of automation included electric devices replacing the old mechanisms such as electric gyroscope replacing pneumatic gyroscopes. At this stage in 1960s, pilots' inputs were accessible, controllable and monitored almost instantly and if there was a deviation from intended outcome, inputs were invariably adjusted accordingly.[6] The third generation of automation manifested during the electronic revolution and helped shape new generation of aircrafts and pilots. Unlike previous mechanical and electrical systems, pilots are no longer acquainted with the inner logic of the system and at times, out of the loop. For example, every time an input is made, a sequence is started which includes many interactions amongst various systems completely unknow to the pilots, this is indicative of the complexity of current

airplanes and flight management systems. During the first and second phase of automation, pilots had a thorough knowledge and understanding of the entire airplane and could conceivably operate creatively and improvise as the circumstances required, but now increasing reliance on automation and new approach that is both procedural and sequential.[7] Automation is so extensive that on a A-320 airplane there are approximately 190 computers fitted in fuselage which are continuously interacting with each other without pilot being aware of ongoing interactions.[8] In short, technological advances have been the drivers for shaping up the aviation industry and improving operating efficiencies so much so that during 4 decades spanning 1960-2000s, the industry achieved 90% reduction in noise and 70% improvement on fuel and CO2 emission.[9] Maritime industry is, as usual, following in the aviation industries footsteps for the same reasons, namely, elimination of costly human errors, operating cost and reducing carbon footprint. Earnest drive for increased automation in shipping has been gathering pace for some time and accelerated by following factors;

i) escalating operating cost,
ii) depressed market,
iii) advances in technology,
iv) shrinking pool of experienced seafarers,
v) costly accidents and maritime disasters,[10]
vi) economic gain,
vii) labor shortage/ageing population[11]
viii) market forces.

With spread of computers in 80s and introduction of worldwide web in 90s plus concurrent development in mobile wireless communication; computer and communication technology are integral parts of social fabric[12] and arguably increasingly a necessity. With digital age already here, perhaps it is not surprising that the industry is breaking with tradition, and introducing rapid changes for integration of new technologies in particular AI and with that higher degree of automation into the industry with the ultimate goal of autonomous ships. With many unmanned or autonomous projects completed or underway, this paper attempts to examine the industry landscape in short, medium and long term and its social, economic and political impacts as well as the future for resources divested from shipping plus regulatory landscape and implications for education and training of transitional and future seafarers for ships dominated by AI/machine learning. With wide spread automation on the horizon, in shipping and other industries, and expected increase in unemployment, would that prompt a rethink for fundamental changes in education, employment and welfare systems?

1.1 Background

Despite decades of improvement to regulatory requirements, implementation and verification processes, majority of maritime accidents are reportedly due to human error with some estimate as high as 96%.[13] In general, main reasons for maritime accidents are purportedly;

- Fatigue,
- Communication shortcomings,
- Lack of general technical knowledge,
- Inadequate knowledge of and/or unfamiliarity with the ships' systems,
- Automation error/problems,
- Decision based on incomplete information,
- Faulty standards and/or procedures followed,
- Poor inspection/maintenance,
- Hazardous Working Environment.[14]

However, there are 3 types of errors and these are related to *Skill based* performance, *Rule based* performance and *Knowledge based* performance.[15] The riskiest of them all is rule based performance as rule breaking is seen as contributory factor to most incidents/accidents.[16] In many instances, rule following is seen as counterproductive or in other occasions, risks are conceded to meet the demand for productivity and efficiency.[17] There is seemingly a universal tendency that cuts across cultures and competencies and that is the tendency to deviate from the shipboard operating procedures to suit the operators' needs or priorities or circumstances, for instance, filling checklists/forms after completion of the work or personal protective equipment or rest hours or work permits or reporting related to incidents/accidents, sickness, risk assessments, etc. Increasing number of regulatory requirements, inspections, surveys and integrated management systems requirements on one hand and reduction in crew and tighter schedules and turnaround on the other, have substantially increased the volume of the paperwork and with that demands on operators' time which invariably feed into the narrative of those adopting and defending the workaround approach.

Skills and Rule based performances are substituted by computers/AI but at knowledge-based level, considering the complexity of shipping, it will arguably prove a harder task to replace experienced seafarers with the machines. However, It is worth mentioning that over 20 years ago, IBM supercomputer *Deep Blue* made history by defeating the reigning world chess champion Garry Kasparov under tournament conditions[18] and the experiment was repeated again in 2016 but this time round, it was Google supercomputer, *Deep Mind*, which beat the Go world champion, Lee Sedol, at a 3000 years old Chinese game which is purportedly far more complex than chess. In following year, *Deep Mind* astounded the world yet again by learning and surpassing thousands years of human knowledge in 40 days.[19] IBM supercomputer underlined the arrival of AI[20] and Google supercomputer proved beyond doubt that a machine can think logically, strategically, anticipate, mitigate, emulate and surpass human thought process with an unmatched speed, make necessary calculations and arrive at the best possible solution in micro seconds and act on it promptly and efficiently.[21] In other words, computers equipped with sophisticated algorithm are getting smarter and can meet the challenge of knowledge-based activities, activities that many argue and consider untouchable and irreplaceable. It is therefore no longer a question of if but when, wide spread proliferation of artificial intelligence with machine or deep learning capabilities replacing the need for human interface for monitoring/intervention. As expected, some industries embrace the technology quicker than others and maritime industry with its cautious approach to change has already taken those tentative but crucial steps for incorporation and use of technologies for a new era of autonomous systems.

2. Automation

Automation may be defined as "the technology by which a process or procedure is performed with minimal human assistance".[22] The aim is to boost quality, safety, reliability, efficiency and reduce operating cost.

Automation has permeated every facet of daily life as well as industries great and small, for instance food and drink, video surveillance, mining, robotics, manufacturing, etc., and indications are that this trend, in line with what is termed as 4th industrial revolution,[23] will not only continue but accelerate at a faster pace.

"…the fourth industrial revolution is unlike anything humankind has experienced before. We have yet to grasp fully the speed and breadth of this new revolution. Consider the unlimited possibilities of having billions of people connected by mobile devices, giving rise to unprecedented processing power, storage capabilities and knowledge access. Or think about the staggering confluence of emerging technology breakthroughs, covering wide-ranging fields such as artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing, to name a few. Many of these innovations are in their infancy, but they are already reaching an inflection point in their development as they build on and amplify each other in a fusion of technologies across the physical, digital and biological worlds."[24] Following events underline the arrival of digital age and transformation of industries and adoption of new norms;

In 2011, The State of Nevada passed a law authorizing Department of Transportation to develop rules and regulations for operation of autonomous vehicles on roads within the State of Nevada.[25] In 2014, Deep Knowledge venture, a Hong Kong based venture capital company, appointed a computer algorithm called Vital to its board of directors.[26] "We are witnessing profound shifts across all industries, marked by the emergence of new business models, the disruption of incumbents and the reshaping of production, consumption, transportation and delivery systems."[27]

Despite the usual cautious approach, maritime industry is not immune to these changes and transformation and reshaping of the industry are inevitable; owing primarily to the technological advances and in no small measures to the vision, concerted efforts, drive, determination and investment by European Commission, Governments, owners, yards, manufacturers and equipment makers with a singular goal, to harness and incorporate new technologies and remain competitive in an everchanging technological landscape. Afterall, unmanned and autonomous vessels, spacecrafts, drones including underwater vehicles have already been in use in military and commercially for some time.[28] Case in point, US Navy autonomous anti-submarine warfare vessel known as the Medium Displacement Unmanned Surface Vehicle (MDUSV),[29] remotely operated vehicles (ROV), Autonomous Underwater Vehicle, MUNIN[30] and Automated Guide Vehicles (AGV) in use in store houses, ports and mines.[31]

There have thus far been many related projects such as Rolls Royce-Finferries Advanced Autonomous Waterborne Applications Initiative (AAWA), launched in 2015 and sea trial conducted in 2018,[32] Autonomous Marine Operation and Systems (AMOS) developed by Norwegian University of Science and Technology (NTNU) in partnership with others and Yara Birkland developed jointly by Yara and Kongsberg, launched in 2017, due for delivery in 2020 and intended for remote operation and subsequently operation in autonomous mode.[33, 34] Rolls Royce-Finferries made maritime history with the trial of the first fully autonomous ferry (Falco) on 3rd December 2018.[35] This demonstrates the core technology for autonomous operation exist but there remain many areas including ship-ship/ship-port communication, security, regulatory requirements, etc., which are to be addressed. Regulatory challenge is best encapsulated by Kongsberg Maritime Director of Technology stating that developing systems as regulations emerge has been "*like aiming for a moving target*".[36]

2.1 Recent Development

i) In May 2019, European Commission revealed *new* funding for an autonomous shipping initiative *for* European waters. Project is titled *Autoship* and for a duration of three and half years. It includes two vessels plus shore control and operating infrastructure for coastal and inland operation.[37] According to European Commission *"The high ambition is to deliver the technology on the market in 5 years boosting ocean and intercontinental unmanned shipping. It is an ambition with a solid base in the involved value-chain and in the financial and commercial commitment."*[38]

ii) In July 2019, Autonomous technology alliance, One Sea and European Space

Agency (ESA) signed a memorandum of intent to collaborate on maritime digitization and autonomous shipping initiative and support development of space-based applications to analyze, enable and implement maritime digitization and autonomous systems using latest generation connectivity.[39]
iii) In June 2019, IMO (MSC 101st meeting) approved autonomous ship trial guidelines. IMO also stated that it has made progress with the scoping exercise.[40]
iv) In April 2019, Keppel O&M secured a grant from Maritime and Port Authority of Singapore (MPA) to develop the first autonomous tug for delivery in 4th quarter of 2020 to be operated by Keppel Smit Towage. Project involves retrofitting an existing 65MT Tug with the advanced systems such as position maneuvering, digital pilot vision as well as collision detection and avoidance plus an onshore control center for control and remote operation.[41]
v) In November 2018, Wartsila successfully concluded testing of its automated dock-to-dock solutions on the Norwegian coastal ferry "Folgefonn".[42]
vi) In July 2019, Zhuhai Yunzhou Intelligence Technology (ZYIT) and Zhuhai Port Shipping form partnership to develop automation technology for ships serving domestic trade. Also, in December 2018, ZYIT launched a 771 sq km testbed in Zhuhai for autonomous ships in collaboration with others, which is set to become the main base for developing China autonomous ship technologies.[43]
vii) In 2019, DNVGL, Norwegian Maritime Authority, Fjord1 and Hoglund successfully concluded the trial voyages of a remotely controlled ferry.[44]
viii) In April 2019, Nippon Foundation report estimates that by 2040, unmanned vessels will impact $9bn of Japan economy. In 2040 all newbuild domestic vessels will be unmanned. By 2025 specification of newbuild would begin having unmanned features, etc.[45]

ix) In April 2019, Maritime and Port Authority of Singapore co-funding following projects, amongst others, for autonomous navigations; [46]

- Retrofit a Mitsui Singapore Flagged car carrier for autonomous navigation, ST Engineering in collaboration with Lloyds Register.
- Conversion of an existing manned tugboat to an autonomous vessel, ST engineering in collaboration with American Bureau of Shipping and PACC Offshore Services Holdings.
- Autonomous Tug Boat Project, IntelliTug, Wartsila in collaboration with PSA Marine and Technology Centre for Offshore and Marine Singapore.

x) In March 2019, 1st drone shore to ship delivery by Wilhelmsen and Airbus Skyways drone, at Singapore anchorage.[47]
xi) In March 2019, a consortium of 17 partners led by Netherland Maritime Technology (NMT) satisfactorily concluded trials on board SeaZip 3, an offshore supply vessel. Vessel was retrofitted with for collision avoidance technology and trial included different scenarios to demonstrate autonomous safe navigation.[48]
xii) In February 2019, a joint venture comprising Finish Geospatial Research Institute, Aalto University, Fleetrange and Tallink Grupp will develop sensors for autonomous shipping. The goal is to develop techniques for autonomous safe navigation using different sensors in combination with machine learning and AI. Sensors will be installed on Megastar cruise vessel for trial.[49]

Mikael Makinen et al., Rolls-Royce President is on record stating "….*the autonomous ship is not just a concept, but something that will transform shipping as we know it."* Of course, there are questions in abundance and despite a promising new era in shipping, transition is fraught with challenges and not seamless. However, it is clearly and unequivocally demonstrated that the technology exists but there are regulatory challenges to overcome. With reduction and/or removal of the seafarers from the vessels would there be a proportional reduction in maritime accidents?

2.2 Social and economic impact

How would the introduction of new technologies ashore and onboard impact seafarers' employment? What are the social and economic impacts? It is a fact that every job in every industry is under threat by the arrival of artificial intelligence/robotics/automation and marine industry is no exception. The industry has already witnessed a gradual reduction in manning over the past decades and indications are that with the introduction of new technologies on board, this trend will continue, though the pace of change may vary in different countries.

BIMCO and ICS report 2015, estimated that global supply and demand for seafarers for both officers and ratings, were 1,647,500 and 1,545,000 respectively. However, breakdown of supply and demand identified a shortage of 16,500 officers and a surplus of 119,000 ratings. The report also forecast growth in the world merchant fleet and with that the demand for seafarers for the period 2015-2025. Estimated demands indicate a shortfall of 92,000 officers in 2020 followed by a substantially higher shortfall (147,500) in 2025,[50] an increase of approximately 60% from 2020 figure and an increase of almost nine folds comparing to 2015 figures. Increase in demand is evidently due to continuous growth in world fleet and seaborne trade. It appears that irrespective of market condition, world fleet has continued to grow, both in terms of total number as well as gross tonnage, reference Equasis world fleet reports 2005-2017. Report for 2017 shows total number of vessel and gross tonnage at 90715 and 1304.3 million respectively, an increase of approximately 50% in number of vessels and well over 110% in gross tonnage from 2005. As indicated in BIMCO-ICS report, growth in world fleet is expected to continue and therefore an uptick in demand for seafarers, namely officers. Question is whether or not industry's drive for autonomous systems, would lead to reduction in overall manning and offset the demand? Although, it has already been demonstrated, technology for unmanned and autonomous operation exist, however, due to radical technical and operational changes, there are still fundamental issues such as regulatory requirements, infrastructure, connectivity, cybersecurity, etc., which are currently unresolved but in hand and sooner or later, will be addressed. Therefore, given the global nature of issues and industry's track record in dealing with challenges as well as varying desire to embrace new technology amongst developed and developing countries, it would be some time, probably mid to long term, before new developments gain sufficient traction and adopted on a scale that can influence supply and demand for seafarers.

However, new technology is certainly making head wave in many areas with direct impact on employment elsewhere. As always, automation will continue to impact jobs across the industries and the political fallout from other industries may influence the path and the direction that maritime may be forced to adopt. As per Office for National Statistics (ONS) study in 2017, 1.5 million workforce in UK may be made redundant due to automation.[51] Also, it is estimated that Amazon workforce may already be made up of 20% robots.[52] What is alarming is the sheer scale of job losses to robots/automation. In a study by consultancy firm Oxford Economics, rapid introduction of automation/robots would result in loss of 20 million jobs worldwide by 2030[53] and the new study which was compiled by McKinsey Global Institute put that figure at a much higher figure, approximately 400 to 800 million jobs, that could be lost to automation worldwide. Results of the study stipulate a two tiers labor market, one tier

with highly paid cognitive jobs and another showing decline for low-medium skill occupations.[54] However, new technologies will create new jobs requiring new skill sets and net losses are generally expected, though difficult to quantify.
Although, the focus is currently on the supply and demand for seafarers but automation will impact other jobs such as dockers, ports employees, pilots, crane operators, drivers, stevedores, customs, immigration, etc. In general, automation of any task would have an impact on labour demand and history shows that whilst some jobs will be rendered obsolete other jobs will be created. Indeed, as recent World Economic Forum (2018) report highlighted, further use of technology may create even more jobs.[55] However, in light of economic drive for change, it is doubtful if the full automation of maritime industry would lead to more jobs. Indeed, low and medium skill jobs, which are at higher risk of automation, may disappear for good, especially as automation technologies become cheaper than labor. As crew wages form a large part of the operating cost of a vessel plus savings from fuel, provisions, stores, increased cargo capacity, etc., provide sufficient incentives to proceed with the full automation barring political consideration in some countries. For sea transport, employment-weight probability of automation of low, medium and high skill jobs are 68%, 77% and 27% respectively, therefore, low and medium skilled workers have a higher potential to be replaced than those categorized as high-skilled.[56] Figure 1 shows the sharp contrast in potential for automation between low and high skilled jobs. Jobs such as dockers and crane operators could be rendered obsolete by 2040.[57]

According to PwC report titled “Will robots really steal our jobs”, based on tasks involved in 200,000 jobs across 29 countries (27 countries from OECD + Singapore & Russia), compiled by OECD, identified 3 waves of automation between 2018 and mid 2030;

1. Algorithm wave – this is already underway and could come to maturity by early 2020,
2. Augmentation wave – this is also underway and could come to maturity late 2020s,
3. Autonomy wave – this could come to maturity by mid 2030s.

Research shows low skilled workers at higher risk of exposure to automation. Conversely highly educated workers have greater potential for adaptability and change and therefore attract a lesser degree of exposure to automation.[58]

With wide spread redundancy looming, labours and labour unions have already started to fight back and sample cases given below, may spread to other maritime sectors;

1. Threat of strike action in Port of Vancouver, dispute between Columbia Maritime Employer’s Association (CMEA) and International Longshore Warehouse Union (ILWU), the main impasse in contract talk is employer’s intention to increase automation which will result in loss of jobs for union members.[59]
2. Dispute between APM Terminal and Labor Union over introduction of autonomous battery-operated machinery at Los Angeles Port, which will potentially result in loss of 400 jobs.[60]

Nonetheless, with accelerating rate of automation, and expected job losses, multiplication of labour disputes look increasingly more likely. With societies evolving with advances in technologies, and dependency on consumer comforts and reliance on full time employment to meet expected financial demands, wider social impacts and steady rise in employment disputes well beyond the current norms, will

inevitably prove a natural discourse. Substitution of man by machine, is certainly not without drawbacks and perhaps the argument in shipping appears more logical for the very simple reason, that a ship laden with sought after cargo will certainly be an easy prize target.
However, and in a wider sense, convergence of technologies and exponential infiltration of automation into our daily lives and beyond, is in fact the continuation of what has driven humanity throughout the ages, inherent laziness as a species, and often disguised under the banner of ingenuity, efficiency and progression where our wants and needs are much simpler! All manners of inventions both simple and complex, are to sate our innate desire to do as little as possible. Seemingly, with exponential increase in our technological capabilities, this has become a double edge sword. With booming population and high employment rate amongst the low and medium skilled workforce, automation despite its apparent commercial benefits, will further shrink the job market for low-medium skill workers with consequential social and political fall outs, unless safeguards are put in place by public and private sectors for the surge in unemployment.

Whilst unmanned and autonomous operations may be the goal for some operators, others may only employ elements of autonomous operation to suit, for example, autodocking or remotely operated engine room or safety systems, etc., and manned the remaining operations.

3. Conclusion

Due to rapid diffusion of automation in maritime and affiliated industries, disputes such as those between port authorities at Vancouver and Los Angeles and labour unions will not remain isolated events and given the profound impact of automation on employment, further disputes on a wider scale become a common occurrence. These are mere test cases, which will certainly interest Port operators and Unions in Canada, USA and elsewhere and more importantly provide an opportune time for policy makers to debate and scrutinize benefits of automation in the wider context of its socioeconomic impact.
Although, lower risks are attached to high skilled jobs and with the ultimate goal of unmanned and autonomous ships within reach in a not too distant future, supply should substantially outstrip the demand. However, in short term, there is potentially little or no risk of automation for high skilled jobs but in medium term the risk for automation of some of the high skilled jobs, will be on the rise. For low-medium skilled jobs, the risk of automation is presently high and it will further increase with the passage of time.
Given the current push for disruption and accelerated introduction of new technologies across the whole spectrum, inadequacy of current STCW training becomes more apparent and should be altered to cater for ships with increased automation and indeed

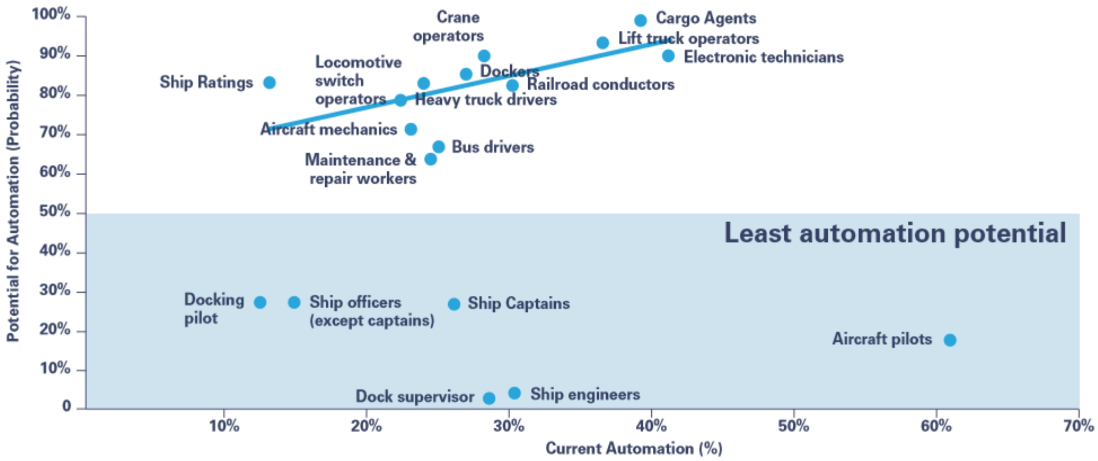

Figure 1: Automation potential for jobs in transport industry
Source: World Maritime University, Transport 2040 Report

for ships of tomorrow, ships with skalaton crew, remote and autonomous operation. Although, it is difficult to estimate a timeframe for influx of reduced manned, unmanned and autonomous ships into the mainstream for transportation, it remains to be seen the extent to which it will impact the the demand for seaferers, primarily due to uncertainties about industry's preference for either automated ships with reduced manning or unmanned ships or autonomous ships. It is envisaged that vessel size, trading pattern an cargo would dictate the design and mode of operation. In any event, increased automation will have a substantial impact on shipping as a whole and in particular the demand for seafarers and low-middium skilled workers involved in port operation. Considering the lead time to train, prepare and equip seafarers for new technologies, and considering the pace at which automation is shaping the future ships and shipping, it may not be too early to introduce modular courses for different modes of operation.

Acknowledgments

NA

References

1.Equasis: World Merchant Fleet. 2017. [accessed 2019 July 8]. http://www.equasis.org/Fichiers/Statistique/MOA/Documents%20availables%20on%20statistics%20of%20Equasis/Equasis%20Statistics%20-%20The%20world%20fleet%202017.pdf

2. United Nation Conference on Trade and Development : Seafarers Supply, quinquennial, stat. 2015. [accessed 2019 July 8]. https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=157422

3. Fox Business: Boeing 737 Jet had anomalies. 2019. [accessed 2019 July 18]. https://www.foxbusiness.com/politics/faa-boeing-737-max-jet-irregularities

4. Berg H.P. 2013. Human Factors and Safety Culture in Maritime Safety. The International Journal of Marine Navigation and Safety of Sea Transportation. 7(3).

5. Wikipedia: Microprocessor. (Unknown). [accessed 2019 July 21]. https://en.wikipedia.org/wiki/Microprocessor

6. Chialastri A. (Unknown). Automation in Aviation. [accessed 2019 July 24]. https://pdfs.semanticscholar.org/8232/21400579c2d309f84b33667cf3a7b4772d04.pdf

7. Ibid 6

8. Ibid 6

9. Market List. (2014). Must Know: The role of technology in airline industry. [accessed 2019 July 10]. https://marketrealist.com/2014/09/must-know-the-role-of-technology-in-the-airline-industry/

10. Lloyd's List: Human error remains key factor in global shipping claim. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1123789/Human-error-remains-key-factor-in-global-shipping-claims?vid=Maritime

11. Lloyd's List. (2018). Japan looks to unmanned ships to offset shortage. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1127790/Japan-looks-to-unmanned-ships-to-offset-labour-shortage

12. Furber S. (2017). Microprocessors: the engines of the digital age. Proc. R. Soc. A473: 201608 93

13. Ibid 10

14. Marine Insight (2019). The Relation between Human error and Marine Industry. [accessed 2019 July 27]. https://www.marineinsight.com/marine-safety/the-relation-between-human-error-and-marine-industry/

15. Reason J. 1990. Human Errors: Performance levels and error types. Cambridge: Cambridge University Press. p.53-96.

16. Skalle. P, Aomodt A, Laumann, K. 2014. Integrating human related errors with technical errors to determine causes behind offshore accidents, Safety Science 63: 179-190.

17. El-Ladan S.B,Turan, O. 2012. Human reliability analysis Taxonomy and praxes of human entropy boundary conditions for marine and offshore applications, J Reliab Eng Syst Safe. 98: p.43-54.

18. Wikipedia: Deep Blue (Chess Computer). (Unknown). [accessed 2019 July 25] https://en.wikipedia.org/wiki/Deep_Blue_(chess_computer)

19. AlphaGo Zero: Deep Mind Supercomputer. [accessed 2019 July 25]. https://www.telegraph.co.uk/science/2017/10/18/alphago-zero-google-deepmind-supercomputer-learns-3000-years/

20. Ibid 18

21. Ibid 19

22. Wikipedia: Automation. [accessed 2019 July 25]. https://en.wikipedia.org/wiki/Automation

23. Foreign Affairs: The fourth Industrial Revolution. [accessed 2019 July 27]. https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution

24. Schwab C. 2016. The Fourth Industrial Revolution. World Economic Forum. p.7
25. Forbes: Nevada Passes Law Authorising Driverless. [accessed 2019 July 27]. https://www.forbes.com/sites/alexknapp/2011/06/22/nevada-passes-law-authorizing-driverless-cars/#2c8b61d21332
26. BBC News: Algorithm appointed board director. [accessed 2019 July 27]. https://www.bbc.com/news/technology-27426942
27. Ibid 24
28. Komianos A.2018. The Autonomous Shipping Era. Operational, Regulatory, and Quality Challenges, TransNav the International Journal on Marine Navigation and Safety of Sea Transportation. 12. p.335-347.
29. Digital Trends: Sea Hunter, a drone ship with no crew. [accessed 2019 July 29]. https://www.digitaltrends.com/cool-tech/darpa-sea-hunter-joins-navy-fleet/
30. Kongsberg: Autonomous Underwater Vehicle, MUNIN. [accessed 2019 July 28]. https://www.kongsberg.com/maritime/products/marine-robotics/autonomous-underwater-vehicles/AUV-munin/
31. European Commission: Maritime Unmanned Navigation through Intelligence in Networks (MUNIN). [accessed 2019 July 28]. https://cordis.europa.eu/project/rcn/104631/reporting/en
32. World Maritime News: Rolls Royce Finferries presents world's 1st fully autonomous ferry. [accessed 2019 July 28]. https://worldmaritimenews.com/archives/265905/rolls-royce-finferries-present-worlds-1st-fully-autonomous-ferry/
33. Ibid 19
34. Riviera: Breathing life into Yara Birkeland. [accessed 2019 July 29]. https://www.rivieramm.com/opinion/breathing-life-into-iyara-birkelandi-54833
35. Ibid 22
36. Ibid 24
37. World Maritime News: EU funds Autonomous Shipping Initiative for European Waters. [accessed 2019 July 29] https://worldmaritimenews.com/archives/277757/eu-funds-autonomous-shipping-initiative-for-european-waters/
38. Ibid 27
39. World Maritime News: One Sea Partners Up with European Space Agency on Digitalization, Autonomous Ships [accessed 2019 July 28]. https://worldmaritimenews.com/archives/279462/one-sea-partners-up-with-european-space-agency-on-digitalization-autonomous-ships/
40. World Maritime News: IMO Approves Autonomous Ship Trial Guidelines. [accessed 2019 July 28]. https://worldmaritimenews.com/archives/279047/imo-approves-autonomous-ship-trial-guidelines/
41.World Maritime News: Keppel to develop its 1st Autonomous Unit for Singapore. [accessed 2019 July 28]. Mathttps://worldmaritimenews.com/archives/274732/keppel-to-develop-its-1st-autonomous-unit-for-singapore/
42. Wartsila: Auto-docking a giant leap for merchant shipping. [accessed 2019 July 29]. https://www.wartsila.com/twentyfour7/innovation/auto-docking-a-giant-leap-for-merchant-shipping
43. Maritime Intelligence: Autonomous Shipping boost for Zhuhai. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1128508/Autonomous-shipping-boost-for-Zhuhai
44. Maritime Intelligence: Norway successfully tests remotely controlled vessel. [accessed 2019 July 29]. https://lloydslist.maritimeintelligence.informa.com/LL1127800/Norway-successfully-tests-remotely-controlled-vessel
45. Maritime Intelligence: Japan looks to unmanned ships to offest labour shortage. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1127790/Japan-looks-to-unmanned-ships-to-offset-labour-shortage
46. Lloyd's List: Singapore lines up quintet of autonomous projects. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1126976/Singapore-lines-up-quintet-of-autonomous-ship-projects
47. Lloyd's List: Wilhelmsen drone project makes first shore to ship delivery. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1126625/Wilhelmsen-drone-project-makes-first-shoretoship-delivery
48. Insurance Market Source: Autonomous Ships shaping new Coverage Considerations. [accessed 2019 July 30]. http://insurancemarketsource.com/trending/autonomous-ships-shaping-new-coverage-considerations/
49.Port Technology: Autonomous Shipping Project to trial sensor. [accessed 2019 August 4]. https://www.porttechnology.org/news/autonomous_shipping_project_to_trial_sensor_technology/?cn-reloaded=1
50. BIMCO and ICS. 2015. Manpower Report, The global supply and demand for seafarers in 2015.
51. BBC News: Automation could replace 1.5 million jobs. [accessed 2019 July 28]. https://www.bbc.com/news/business-47691078
52. Ibid 49
53. Vision Systems Design: Oxford Economics study on robotics and industrial automation suggests loss of 20 M jobs by 2030. [accessed 2019 July 28]. https://www.vision-systems.com/factory/article/14035437/oxford-economics-report-robots-job-losses-by-2030

54. The Verge: Automation threatens 800 million jobs, but technology could still save us. [accessed 2019 July 28]. https://www.theverge.com/2017/11/30/16719092/automation-robots-jobs-global-800-million-forecast
55. World Maritime University. 2019. Transport 2040: Automation, Technology, Employment - The Future of Work
56. Ibid 53
57. Ibid 53
58. PwC report. 2018. Will robots really steal our jobs? An international analysis of the potential long term impact of automation. [accessed 2019 July 28]. https://www.pwc.co.uk/economic-services/assets/international-impact-of-automation-feb-2018.pdf
59. Lloyd's List: Canadian Federal mediator enters negotiation to avoid stike action in the port of Vancouver. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1127692/Canadian-federal-mediator-enters-negotiations-to-avoid-strike-action-in-the-Port-of-Vancouver
60. Lloyd's List: Los Angeles confrontation signals smart ports battle. [accessed 2019 July 27]. https://lloydslist.maritimeintelligence.informa.com/LL1126798/Los-Angeles-confrontation-signals-smart-ports-battle