A Review of Technology, Infrastructure and Human Competence of Maritime Stakeholders on the Path Towards Autonomous Short Sea Shipping

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ABSTRACT

Shipping is fast moving towards digitalisation and minimising human intervention in its processes. This article intends to explore the implications of such changes in human element competencies across core-stakeholders such as Ports, Vessel Traffic Services (VTS) and Information and Communication Technology (ICT) providers. It is apparent from the findings of this article that digitalisation is assisting stakeholders to be efficient and competitive. This trend is complementing the implementation of autonomous ships that depends on stakeholders for safe and efficient operations. However, as stakeholders continue to automate the processes previously performed by humans, the required physical and manual skills of employees would decline. Alternatively, future employees would require multitasking and cross-functional competence at all levels. It is also evident that future employees of these stakeholders would require to have a degree of technological competence to be to perform their jobs.

1. Introduction

Autonomous ships without seafarers' on-board is the inevitable future. Thus, it is important to understand how the stakeholders involved in shipbuilding to ship operation would complement the transition [1] [2]. Automation is not a new concept in shipping [3]. More than a decade ago, a Radio officer was mandatory on-board all trading ships. However, Global Maritime Distress and Safety System (GMDSS) made the Radio officer's job redundant as deck officers were allocated the task of operating the GMDSS equipment [4]. As the result the radio officers needed to upskill to be able to work in other capacities such as electrical engineers with different functional competence [4]. The GMDSS system made it easy for Search and Rescue (SAR) teams ashore to quickly assess the ships situation with regard to casualty and exact position with a click of a button.

Currently, on board ships human is the final decision maker. In future, as the automation of systems progresses, autonomous ships would operate by Artificial Intelligence without human assistance. Thus, it is important to comprehend how the transformation from conventional to smart ships (Automated Functions with Crew on-board) and from Smart ships to Remote Controlled ships (Without crew on-board. Crew embark in port area to carry out critical functions such as mooring) to finally autonomous ships with human operator (at a remote Shore Control Centre (SCC)) to only convene in case of an emergency would take place.

In this process it is important to understand that shipping is multi-faceted and involves multiple stakeholders [2]. Thus, to operate an autonomous MASS safely and efficiently, cooperation and partnership with stakeholders are critical.

2. Methodology

In this study, Integrative Literature Review method was utilized (Torraco, 2016). In this method, relevant bodies of literature were synthesized to propose a competence framework for the human element required for the autonomous operation of a MASS. In addition, stakeholders career webpages were analysed. This helped to find the competence of the employees who were being recruited.

3. Findings

This paper studied the type of services that would require to be provided by stakeholders to successfully complete a MASS voyage both safely and efficiently. The findings of this study show that the stakeholders' involvement with shipping can be categorized into Operational, Technical, Commercial, Regulatory, Legal and Financial aspects. The following sections present findings of this study regarding possible future technology, infrastructure and competence of the stakeholders that would complement autonomous shipping.

3.1 OPERATIONAL

3.1.1 Terminals and Ports (Technology, Infrastructure & Competence)

Future ports are expected to be interconnected with ships, other ports and other modes of transport such as trains and trucks. Thus, most of the port logistics functions would be automated and almost all stakeholder data would be on the cloud [5]. This would also complement Just in Time arrival that is part of port call optimisation [6]. Also, technology such as automated mooring solutions without human involvement and fast charging for battery powered MASS would be available for autonomous ships [5].

It is expected that the demand for employees with competence in cloud computing and networking would increase, as most logistics functions would be carried out autonomously using AI [7]. Port employees who are delegated the maintenance of equipment in port and managing repairs of MASS would have to undergo further training to be competent in handling 3D printing or maintenance of MASS equipment. Port employees responsible for the maintenance function are presently being trained using advanced Augmented Reality (AR) to swiftly troubleshoot autonomous machinery failures. They would require cross-functional competence in electro technological, mechanical and IT functions to complete most port jobs successfully as further digitisation and interconnectivity between port and other stakeholders takes place [5].

3.1.2 VTS (Technology, Infrastructure & Competence)

The future VTS operation would be affected be autonomous shipping. As a matter of fact, the changes are already started to happen. For example, MONALISA 2.0 is a project that carried out to enhance Sea Traffic Management (STM). In this project ships entering the VTS area would upload their passage plan into the VTS server where a VTS operator would advice

on the limitations and precautions. Further, a comparison of all ships in the operational area would be analysed for assessing safety of transit [8]. Porathe et al (2014) suggests a different perspective where the VTS operator should only warn the Shore Control Centre (SCC) operator as in the case of conventional ships. The ship should decide how to utilize the resources on-board especially in case of emergency. Further, the current communication medium requires improvement. Instead of communication over VHF, it is suggested to use messages that would prompt on the SCC operator's screen [9]. Thus, VTS would complement autonomous shipping by providing their core-competence that is reliable navigational assistance for MASS.

As VTS transforms to being a STM, the responsibility of managing the ships safely and efficiently would be vested more on the STM operators. Further responsibility would be vested if VTS operator were given the task of MASS navigation. In that scenario, VTS operators would require complete understanding of MASS navigation including the technology and its limitations [10]. As in the present VTS, STM could employ a navigator who has experience navigating a MASS, as the competence would be almost similar. However, the STM operator would require higher cognitive skills such as critical thinking and decision-making more than the present day VTS operators have [8].

3.1.3 Equipment Suppliers (Technology, Infrastructure & Competence)

The MUNIN has proposed IEC 61162-460 standard, which assures persistent communication with cyber security capability even in case of worst weather conditions [11]. Hoyhtya et al (2017) suggest a resilient communication architecture, which comprised of terrestrial and satellite components as well as High Altitude Platforms (HAP) system. Also for ships on intercontinental voyages the European Space Agency (ESA) is developing a 5G-satellite network that would help the implementation of autonomous shipping [12]. Thus, communication technology providers would complement autonomous shipping by providing their core-competence that is reliable with cyber security enabled data communication.

Future workforce would require competence in machine learning or artificial intelligence as the 5G satellites would not only be communicating between earth stations but also among themselves [12]. Therefore knowledge of tidal patterns, current and seismographic data analysis would be required for HAP or similar marine communication systems in place [13].

Big Data storage and analytics companies would be commonplace in maritime transport domain as stakeholders become more connected and share information [14]. Technology companies such as StormGeo have commenced to provide shipping companies with services such as real time updating of route planning [15]. Thus a SCC operator would have to only follow the route provided by the route planning company to safely and efficiently navigate between destinations.

3.1.4 Search and Rescue Coordination Centre (Technology, Infrastructure & Competence)

UK Maritime & Coastguard Agency (MCA) recently commenced testing the use of drones for SAR missions. Thus Unmanned Aerial Vehicles (UAV) would initially be sent to assess the situation before sending human rescue teams [16]. Also, international maritime consultancy and software company Qinetiq is constructing an autonomous fire fighting crafts

that would continuously be deployed in ports and offshore area. Thus, human SAR teams would not have to risk their lives [17]. As the result, SAR would complement autonomous shipping by providing their core-competence that is salvage and assistance in safe operation of MASS.

The SAR team would require licenced UAV pilots as well as licensed USV operators for navigating and operating the autonomous or remote controlled fire fighting crafts [18]. Also SAR teams would require upgrading their competence to salvage a MASS as design and on-board features are peculiar to a conventional ship.

3.2 Technical

3.2.1 Classification Society (Technology, Infrastructure & Competence)

Future Classification Societies would assume a central role in relation to verification and certification of MASS [19]. It is expected that the MASS would continuously be remotely monitored from Shore unlike present day where Classification Society surveyors board the ship for inspection [20]. Further Classification Societies would be liable to third party claims levied directly against them [19]. Thus, classification societies would be legally responsible for maintaining safety of MASS. Classification Society surveyors would require advanced IT skills, as system verification on a MASS would be mostly on software such as Artificial Intelligence systems [21].

3.2.2 Insurance (Technology, Infrastructure & Competence)

The Original Equipment Manufacturers (OEM) of critical equipment of MASS such as Navigation would be held liable in case of a collision or grounding instead of the ship owner [1]. The Insurance company staff would need to be proficient on the maritime law for MASS [22].

3.3 Legal—*Arbitrators (Technology, Infrastructure & Competence)*

Maritime lawyers would require having knowledge of amendments to law such as Hague Visby rules [22].

3.4 Regulatory—*Flag State (Technology, Infrastructure & Competence)*

Many of the present regulations would require to be amended upon introduction of MASS [22]. Regulations pertaining to IMO regulations such as SOLAS, COLREG, STCW and Load Lines would be affected [23]. Thus ,staff of flag states such as Australian Maritime Safety Authority would require having knowledge of amendments to National Law Act 2012 [22].

3.5 Financial—*Ship construction (Technology, Infrastructure & Competence)*

Ship manufacturers' are looking for innovative business models as present ship construction business market has saturated [14]. Thus innovative business models such, as MASS renting similar to the UBER Autonomous Vehicle (AV) fleet business model would be common among the ship builders [14]. Staff of ship Construction Companies would require having technological skills as the business would be operating on a software platform [14].

3.6 Commercial—*Freight Forwarders and agents (Technology, Infrastructure & Competence)*

Recently Container shipping companies such as Maersk has digitalised maritime transactions amalgamating with IBM block-chain technology [24]. Thus the middlemen such as Freight Forwarders or agents would become obsolete as more companies adapt the technology and become connected [24].

4. Discussion

It is evident from the findings that present day ports, VTS, shipyards and other stakeholders are fast embracing digitization to improve productivity and competitiveness. Inadvertently, this transition is aiding conventional ship to smoothly transform towards autonomous shipping. Presently, most of the responsibility in assuring seaworthiness of a ship including maintenance and repair function is all done by ship staff. However, as the transition from shipboard to SCC takes place most functions carried out by shipboard staff is expected to be delegated. For instance, maintenance staff of MASS would be designated at Ports. It is also apparent that few stakeholders would become obsolete as digitalisation and connectivity between stakeholders improve. It is also expected that new regulations would make all stakeholders responsible for the part they play in ship operation. As per Australian Consumer Law (ACL), the product manufacturer is liable for any casualty arising by using a product [25]. Such a regulation would enhance relationship and coordination among the stakeholders. This would further assist in making all stakeholders interconnected through technology such as cloud computing [26]. It was also identified that new companies and new jobs would be created as the transition of seafarers takes place from shipboard to SCC. Many new start-up companies with competence in specialization of digital service solutions such as vessel performance monitoring or vessel tracking that are presently being performed manually by many ship operators are on the rise. Thus, employees with technological competence in big data analytics, software development, robotics and AI would be in demand.

5. Conclusion

This digitization trend is paving the path towards autonomous shipping. Even presently many of ship operational functions are delegated to stakeholders. In the near future the stakeholders need to possess core-competence that would complement autonomous shipping functions without seafarers onboard. The industry would evidence more employees with competence in AI and advanced technological skill is joining the workforce. The current physical and manual activities for instance in places such, as ports will be replaced with robotics and automation. It is evident that the future workforce in shipping apart from their core competence e.g. mechanical engineering would need to be digitally savvy. We are in a transition period so, as in the past, the current employees would have to upskill their competence to suit the future job profiles.

Bibliography

[1] Cefor, "Maritime Autonomous Surface Ships- Zooming in on civil liability and insurance," The Central Union of Marine Underwriters, Oslo, Systematic Review 2018.

[2] Margareta Lutzhoft, Michelle R Grech, and Thomas Porathe, "Information Environment, Fatigue, and Culture in the Maritime Domain," *Reviews of Human Factors and Ergonomics*, vol. 7, no. 1, pp. 280-322, 2011.

[3] Oskar Levander, "Autonomous ships on the high seas," *IEEE spectrum*, February 2017.

[4] International Maritime Organization, "Shipping Emergencies- SAR and the GMDSS," IMO, London, Regulatory 1999.

[5] Fox Chu, Sven Gailus, Lisa Liu, and Liumin Ni, "The Future og Automated Ports," McKinsey & Company, Systematic review 2018.

[6] Port of Rotterdam, ""Just in Time" sailing saves hundreds of thousands of tonnes of CO2," Port Of Rotterdam, Systematic Review 2018.

[7] Manuel Bauml and Ludwig Hausmann, "Air Freight Forwarders move forward into a digital future," McKinsey & Company, Munich, Systematic Review 2019.

[8] Gesa Praetorius, "Vessel Traffic Service (VTS): a maritime information service or traffic control system? Understanding everyday performance and resilience in a socio-technical system under change," Department of Shipping and Marine Technology, CHALMERS UNIVERSITY OF TECHNOLOGY, Gothenburg, Thesis 2015.

[9] Jillian Caron Jackson, "Maritime Radio in the Digital Age- Introduction to the VHF Data Exchange System," The Nautical Institute, Systematic Review 2018.

[10] Lloyd's Register, "Cyber-enabled ships : ShipRight procedure assignment for cyber descriptive notes for autonomous & remote access ships ," Lloyd's Register, Guidance document 2017.

[11] Trudi Hogg and Samrat Ghosh, "Autonomous merchant vessels: examination of factors that impact the effective implementation of unmanned ships," *Australian Journal of Maritime & Ocean Affairs*, vol. 8, no. 3, pp. 206-222, September 2016.

[12] Jesse Phaler and Emmet Fletcher, "Space Technology to Drive Autonomous Ships," European Space Agency, Systematic Review 2017.

[13] Marko Höyhtyä, Jyrki Huusko, Markku Kiviranta, Kenneth Solberg, and Juha Rokka, "Connectivity for Autonomous Ships: Architecture, Use Cases, and Research Challenges," *IEEE*, pp. 345-350, 2017, Rolls-Royce Marine, Ship Intelligence.

[14] Adar Granot, "Autonomous Cargo Vessels: Analysis for a Future Operations Model ," Erasmus University Rotterdam , Dissertation 2016.

[15] StormGeo. (2019, April) Ports and Terminals: Reduced downtime and increased throughput. [Online]. https://www.stormgeo.com/solutions/marine-operations/ports-and-terminals/

[16] International Institute of Marine Surveying. (2018, May) UK MCA and RNLI test drones for Search and Rescue. [Online]. https://www.iims.org.uk-mca-mli-test-drones-search-rescue/

[17] QINETIQ. (2018) Autonomous Fire Fighting Vessel Concept Design. [Online].

https://imcs.qinetiq.com/projects/autonmous-firefighting-vessel-concept-design.aspx

[18] Maritime & Coastguard Agency. (2019, April) Working for MCA. [Online]. https://www.gov.uk/government/organisations/maritime-and-coastguard-agency/about/recruitment

[19] Cefor and CORE Advokatfirma, "Maritime Autonomous Surface Ships- Zooming in on Civil liability and Insurance," Cefor and CORE Advokatfirma, OSLO, 2018.

[20] BUREAU VERITAS, "Smart Ships- Addressing cyber risk, improving performance," Classification Society, Paris, 2018.

[21] Rogelio Estrada Villanueva, "The Emerging Role of the Classificaton Society as an extension of the Flag state Administration," World Maritime University, 2004.

[22] Grant Judson, "Regulating Unmanned and Autonomous Vessels ," Navigation systems and safety , Australian Maritime Safety Authority, Melbourne, 2018.

[23] Nic Van Der Reyden, "Cyber risk and Maritime Autonomous Surface Ships," HFW Australia, 2018.

[24] Mikkel Elbek Linnet and Katherine Mosquera. (2019, May) MAERSK. [Online]. https://www.maersk.com/news/articles/2019/05/28/cma-cgm-and-msc-to-join-tradelens-digital-shipping-platform

[25] Australian Consumer Law. (2019, April) Consumers and ACL. [Online]. https://www.consumerlaw.gov.au/consumers-and-the-act/

[26] Keh Sik Min, "Automation and Control Systems Technology in Korean Shipbuilding Industry: The state of the art and the future perspectives," in *17th World Congress, The international Federation of Automatic Control* , Seoul, 2008, pp. 7185-7590.

[27] T Porathe, J Prison, and Y Man, "SITUATION AWARENESS IN REMOTE CONTROL CENTRES FOR UNMANNED SHIPS," *The Royal Institution of Naval Architects*, p. 9, 2014.

[28] Mykoo A Wayne, "The Role and Responsibility of Minor Stakeholders in the Elimination of Substandard Shipping: A Critical Analysis," World Maritime University, Malmo, Dissertation 2003.

[29] Inmarsat. (2019, April) Shipside Software Solutions Engineer. [Online]. https://www.smartrecruiters.com/inmarsat/743999685050625-shipside-software-solutions-engineer?trid=dae99e02-3615-47e8-9de7-078b22e271cd

[30] Vinh V Thai, "Competencies required by port personnel in the new era: Conceptual framework and case study," *International Journal of Shipping and Transport Logistics*, p. 38, January 2012.

[31] Päivi Antikainen, "Digitalization and Autonomous Ships ," in *Conference on Maritime Autonomous Surface Ships* , Copenhagen, 2017.

[32] Remi Eriksen, "What does the future hold for shipping," in *Danish Maritime Technology Conference*, Copenhagen, 2018.

[33] Peter Barthelsson and Jacob Sagefjord, "Autonomous ships and the operator's role in a Shore Control Centre ," Department of Shipping and marine technology , CHALMERS

UNIVERSITY OF TECHNOLOGY , Gothenburg, Thesis 2017.

[34] Andrew Rawson, "An Analysis of Vessel Traffic Flow Before and After the Grounding of the MV Rena," in *12Th International conference on Marine Navigation and Safety of Sea Transportation*, 2017.