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Autonomous Shipping and the Future Workplace of Marine Engineers

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Abstract

Although ship design has not changed substantially for a very long time the engine room machinery and their operation have evolved dramatically. For example, in the 1970s engine rooms tended to be very spacious but by the 1980s engine rooms needed to be much shorter in length. This triggered engineers to set up engine room design and machinery to be more vertical than horizontal. The same is true for the current development toward autonomous shipping. Dual-fuel engines and electric motors with batteries free up a lot of space in the engine rooms. As the engine room and its technologies are evolving, so are the engineers' role and their jobs onboard ship. This paper reports on the initial finding of our latest ongoing research project "Investigating the future of maritime workplace and the role of marine engineers in autonomous ships" (ROME). The ROME project studies the workplace of marine engineers in future autonomous shipping and investigates the possible effect on engineers' roles and the type of skill and competency required to perform the role.

Keywords: Marine Engineer, Safe Return to Port, Unattended engine room, Mooring, MASS, Autonomous Ship

1 Introduction

Ships have evolved to a large degree over the last decades. Although the structure and body of ships stayed almost the same, however, the technology in marine engine design and operation has evolved dramatically. This is partly due to the digitalisation and the implementation of advanced technologies. Looking at the other industries that are more advanced in implementing technologies assures that the maritime industry is at the dawn of an industrial revolution called Industry 4.0. Industry 4.0 promises to disrupt all industries including maritime. The evolution has already started in some maritime industry sectors such as automated container terminals, remotely controlled surface

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ships, and autonomous underwater vehicles. The evolved workplaces have a profound effect on the type of jobs the mariners are expected to perform, and the skill and competency required to be developed (Emad & Ghosh 2023). In the process, some jobs will be eliminated, and new ones will emerge. This will also result in a new composition and level of manning on ships (Emad, Enshaei, and Ghosh, 2021).

In response, IMO sets new standards through the SOALS convention for manning and safe operation of the newly developed ships. Based on the requirement of SOLAS, the Maritime administrations and the flag states will develop the level of safe manning for the ships under their flags. This complex process requires the maritime administration (such as Finland's TRAFICOM) to receive feedback from seafarers through their unions and the ship owners and then set the minimum safe manning level considering the type, size, and trading area of the ship in question. Maritime administrations will meet new challenges when autonomous shipping develops further. For example, who will be the negotiating parties for the ships that have not been developed yet?

Recently many shipping companies have started to order new ships and set the supervising team without prior experience of the required novel ship-building process. Additionally, shipbuilders must conform to their national regulations and standards. For example, in Europe, ships "shall be designed and furnished by contemporary North European shipbuilding standards". There, classification societies are to guide shipbuilders in regulatory conformity and close supervision of the shipbuilding process.

2 Method

To have a better understanding of the future of work and the role of marine engineers, we designed a qualitative research project (ROME). The project will provide a comprehensive understanding of the role of marine engineers in the operation and maintenance of autonomous ships. ROME project is funded by the International Association of Maritime Universities (IAMU)-Nippon Foundation. This project is a collaboration between Satakunta University of Applied Sciences (SAMK), Finland and Australian Maritime College, Australia. We are collecting data from different stakeholders including shipowners, seafarers, and shipbuilders. To provide contextual data, we study the status of remote operations onboard two newly built ships. M/S AURORA BOTNIA (Wärtsilä main engines, delivered to Wasa Line on 8/2021) and M/S MySTAR, (Mann main engines, delivered in fall 2022). We utilise the Safe Return to Port (SRtP) classification notation, M/S AURORA BOTNIA as a case study for future shipping. Also, we will collect data during the sea trials and on the maiden voyage of the first TT-line new ship that is currently under construction.

3 New Built Ships at Rauma Shipyard

Shipbuilding started in Rauma during the Second World War and got the boost when Finland and the Soviet Union signed a peace agreement where Finland committed to building hundreds of ships for free to compensate for the scars of war. This work ended in 1952 when the last ship was delivered to the Soviet Union. This "training session" made possible today's shipbuilding industry in Finland, an industry with 50,000 employees and a 15-billion-euro turnover.

During the last decades, major technological advancements in shipbuilding happened in the design and operation of marine engines. Recent climate change mitigation action exacerbated the move toward more efficiency with the goal of zero emissions. This resulted in engine manufacturers developing automated low-fuel-consumption engines. The ship engine operation also has the capability of being monitored from Remote Operation Centres. This resulted in not only a reduction in fuel consumption but also an increase in maritime safety.

Today, shipping companies such as Tallink Finland is monitoring all their vessels' engine remotely. Crew onboard are also trained to modify their fuel consumable actions such as sailing with optimal speed at sea and when manoeuvre at the port with the goal of reduction in fuel consumption. Their Ro-Ro passenger ferries like M/S MyStar (Technical Specification NB 6003, 2020) were delivered to Tallink in 2022 sailing three daily round trips from Helsinki to Tallinn. During the nighttime, the ship is moored at the port of Tallinn where maintenance and bunkering take place. Tight-controlled scheduling with advanced speed control resulted in considerable cost and fuel savings compared to a ship of the same class. Also, the new vacuum mooring system in both Helsinki and Tallinn ports ensures smooth speedy arrivals and departures, saving time and fuel. The main particulars of M/S MyStar are shown in Table 1 below.

Characteristic	Indicator
LOA, m	212,1
Beam, m	30,6
Depth, m	12
Draught (full), m	7
Eco speed, knots	21
Max speed, knots	28
Main engines	5 × MAN 5L51/60DF (5 × 9,334 kW)

Table 1: M/S MyStar's main particulars

Figure 1: M/S MyStar arriving in the port of Helsinki, six mooring pads activated via AIS

The second ship included in our investigation is the Passenger ferry M/S AURORA BOTNIA (Technical Specification NB 6002, 2019) delivered 2021 to Wasa Line and operating route Vaasa, Finland – Umeå, Sweden with 2-3 daily departures. She is a dual-fuel ship but also has batteries. Its Engine room is bigger than M/S MyStar with more monitoring and maintenance tasks for engineers. Currently, they have started to use biodiesel every Friday.

Characteristic	Indicator
LOA, m	150
Beam, m	26
Depth, m	12
Draught (full), m	7
Eco speed, knots	15
Max speed, knots	20
Capacity: **Cargo capacity, lane meters Deadweight, tons**	120 5936
Propulsion **2 azipulls, kW** **Tunnel thrusters, bow**	2 x 2900 2 x 700
Year built	2021

Table 2: M/S AURORA BOTNIA's main particulars

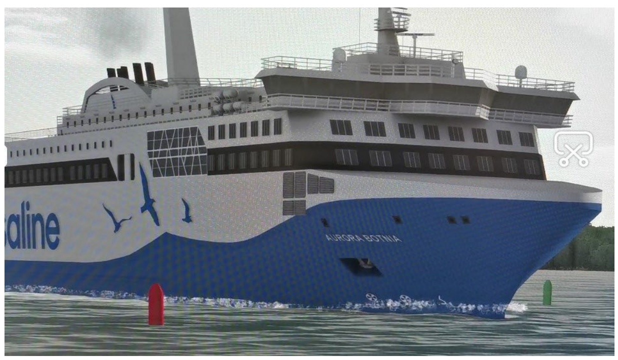

Figure 2: M/S AURORA BOTNIA, specially tailored model in SAMK simulator

The introduction of alternative fuels such as Methanol, ammonium, and hydrogen although fulfill the requirement of green shipping brought new challenges to engineers for safe and efficient operation. Newly introduced marine engines became lighter and more efficient but complex and required a new set of competencies and skills for the maintenance and operation of the engines. At the same time, newly introduced cargo such as fully electric cars are setting new requirements for safe cargo operation. A recent fire on board M/S FREMANTLE HIGHWAY raised concerns and demanded the introduction of new regulations. Fighting the fire of a car with fully charged batteries requires an immense amount of water with potentially devastating consequences for the ship's stability. The recent suggestion of reducing the charges of batteries to a maximum of 20% is beneficial but still fighting any electric fire is more than a challenging task for the ship's crew. This will be exacerbated in the remotely operated ship with the reduced crew onboard when the captain is commanding from a Remote Operation Centre (ROC) onshore. In these ships, marine engineers' job is extremely challenging engineers apart from their jobs will be responsible for occasionally performing safe navigation and all other activities on board including fighting battery fire.

Although SOLAS (Safety of Life at Sea) chapter II-2 introduced Safe Return to Port (SRtP), which requires ships to be able to remain operational after a fire onboard, however, this applies only to passenger ships with a length of 120 meters or more, constructed on or after 1st of July 2010 (SOLAS 1974, as amended, 2014 edition). P&O Ferries' new building ship M/S SPIRIT OF BRITAIN was the first passenger ship to be built and delivered according to this rule in January 2011 from the shipyard in Rauma, Finland. The purpose of this regulation is to establish design criteria for a ship's safe return to port under its propulsion after a fire incident, as well as to provide design criteria for systems that are required to remain operational to support the orderly evacuation and abandonment of the ship.

The SRtP tests for example require a simulated loss of starboard engine room in a fire leading to failure of power generating, propulsion, and steering capabilities on the starboard side of the ship. During the simulation, the availability of essential systems for SRtP is being monitored to see if any failures occur in the part of the ship intended to be used during the incident (the main and auxiliaries' systems on the port side). The goal of the exercise is to examine whether the ship can maintain the required essential systems in operation with only one power plant. This is quite challenging, especially on the TT-Line route as the return voyage is quite long compared to many ferries built earlier. This challenges the fulfilment of all requirements set by the SRtP rule.

The limited scope of the assessment procedure and the fact that the test is being performed while the ship is new and in perfect working condition plus no passengers onboard is a drawback in assuring the effectiveness of the proposed SRtP system. Additionally, we foresee that during the working life of the ship, it will progress to degree two of MASS with a reduced crew and remote operation from ROC. We suggested that in that scenario with engineers as the only crew onboard, the SRtP system is not capable of delivering the required safety features. We recommend that while designing such a system, the administrators and regulatory bodies need to consider the natural progression of ships into the MASS operation systems with a limited number of engineers onboard to operate such a system.

Following are the particulars of the new TT-Line 2500LM fast RoPax ferries. M/S SPIRIT OF TASMANIA IV & V (Technical Specification NB 6009, 6010, 2022) are built to LR 100 A 1, including SRtP.

Characteristic	Indicator
LOA, m	212,1
Beam, m	31
Depth, m	12
Draught (full), m	7
Eco speed, knots	21
Max speed, knots	28
Capacity: **Cargo capacity, lane meters**	2500
Deadweight tons	5936

Table 3: M/S SPIRIT OF TASMANIA IV & V main particulars

Figure 3: Figure 3. M/S SPIRIT OF TASMANIA IV, under construction in Rauma, Finland

4 Rome Project

The introduction of Industry 4.0 technologies in the maritime domain resulted in the Shipping 4.0 revolution. IMO envisioned with the gradual implementation of Shipping 4.0 ships will go through 4 degrees of autonomy under MASS (Maritime Autonomous Surface Ship). We are currently in the transition from first degree to second degree where ships will be remotely navigated from remote control centres (ROC) while engineers onboard not only operate and maintain engines but help navigate the ship when required. All this happens when the smart ship is connected and being monitored from ashore. On the new building ships, the digital twin utilising IoTs and satellite communication along with advanced artificial intelligence is connecting different elements of a ship to the onshore control centres. However, in the transition period, there is still no common agreed standard for the development and operation of the new technologies. More often different manufacturers are installing their systems onboard for the first time without any knowledge of adaptability with other systems. Increasing awareness is needed to ensure safe sailing with consequential interaction between distinctive systems. It is expected that systems and software will go through constant updating in the coming years. However, it will come with the cost of the potential compromise of the safety of the ship due to possible error or incompatibility.

ROME research project will study the onboard state of recent new building ships with advanced technologies. The data also will be collected from stakeholders such as shipbuilders, flag states, classification societies, and shipping companies with new ships in operation. Remote Operations Centres like Wärtsilä and Kongsberg have been invited to participate in the research. ROME project will investigate the future of the maritime workplace and the role of marine engineers in remotely controlled ships with consideration for the potential risks. The research will evaluate the future demand for the training of marine engineers and provide recommendations on how it can be materialised in maritime education and training.

ROME-project will answer the following research questions:

1) What will be the workplace for marine engineers in future autonomous shipping?
2) What are the scopes of marine engineers’ roles and responsibilities?
3) What will be the skill, competency, and experience requirements for marine engineers for monitoring, controlling, and troubleshooting the ships’ engines?
4) What are the regulatory gaps and statutory actions required to ensure that the marine engineers will be ready to meet the demands of the emerging shipping industry?

5 Conclusion

Although it is predicted that it will be some time before fully autonomous ships roam the oceans, however, the shipping industry is already witnessing the initial attempts. The workplaces in the newly built ships for marine engineers are incorporating digitalisation and automation on a larger scale than ever before. The transformed engine rooms of ships harboured intelligent systems that could oversee the operation of machinery and systems. In the novel workplace, engineers need a novel competency and skill set to be able to operate their smart ships. These educational requirements need to be kept updated as the engines and systems get modernised to more advanced and smarter machines. The recently built ships with machinery and systems that are well connected and everything is controlled, supervised, handled, and operated using intelligent systems.

So far, the efforts of the industry have been dedicated to the design and manufacturing of the technology with the human element out of focus (Emad, 2021). In the ROME project, we investigate marine engineers in the engine control room of the new ships during the sea trial and interview engineers in Wärtsilä, Kongsberg, ABB, and Steerprop in their workplaces where they design and remotely operate the advanced technologies. The project aims to generate knowledge about the roles and responsibilities of future engineers and how their required competency and skills can be translated into a curriculum.

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