THE PROFESSIONAL PROFILE OF THE REMOTE OPERATOR

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SUMMARY

The need for experienced nautical officers is imminent, the possibilities to work ashore which requires their expertise are plentiful. Now, a new maritime profession is emerging, the remote operator. Again, we require mariners to take that role, resulting in a further increase in the personnel shortage. It is time we consider an alternative to sate the need for qualified persons in the remote operation centers. Before developing a new maritime education for shore-based personnel, we need to understand the professional profile of the remote operator. This paper discusses the different modes of remote operations, what tasks are expected of the remote operator, what other duties await them, risks, challenges, and what they can do during shipboard emergencies. Finally, we summarize the suggested competence requirements for remote operators.

1. INTRODUCTION

It is human nature to jump ahead, at least five steps at a time. We observed the same with the development of MASS (Maritime Autonomous Surface Ships). 'If nobody is on board what happens if there is a fire?' such questions were posed in the conceptual phase of YARA BIRKELAND. The IMO (International Maritime Organization) offered a tool to create a common understanding of concepts and ideas; the four degrees of MASS [1]. It is commonly accepted that Degree One represents the standard of autonomy on conventional ships nowadays [2]. DP (Dynamic Positioning) Systems, ECDIS (Electronic Chart Display and Information System), ARPA (Automatic Radar Plotting Aid), Track Pilot, and even the Autopilot all represent automated systems that support mariners in their watchkeeping routines.
We understand today that the four degrees are too rigid a system, still, it was important to have them initially to draw a pathway in the development of maritime autonomy. Shipboard operations may run fully or party autonomous in one department and conventionally in another. The boundaries have become very soft and may be stretched or indented to fit the needs of a certain application.
Seeing the development of autonomous shipping and the current trend with the commissioning of ROCs (Remote Operation Centers) it seems they will soon start to sprout like mushrooms. To man these with competent personnel, REs (Remote Engineers) and ROs (Remote Operators), fully trained maritime professionals are employed, preferably with years of seagoing experience. This approach ensures a thorough understanding of vessels, ship handling, stability, etc. is readily available. Additional training for remote operations and in-center-time sees them qualified to work in the ROC. However, if we look at the local maritime labor market, there are many more vacancies than applicants. This is reflected in the graphs in Figure 1. In only three years the number of masters and officers holding a valid European CoC (Certificate of Competency) has dropped by approximately 10 %, while the number of vessels worldwide has risen by 6%.

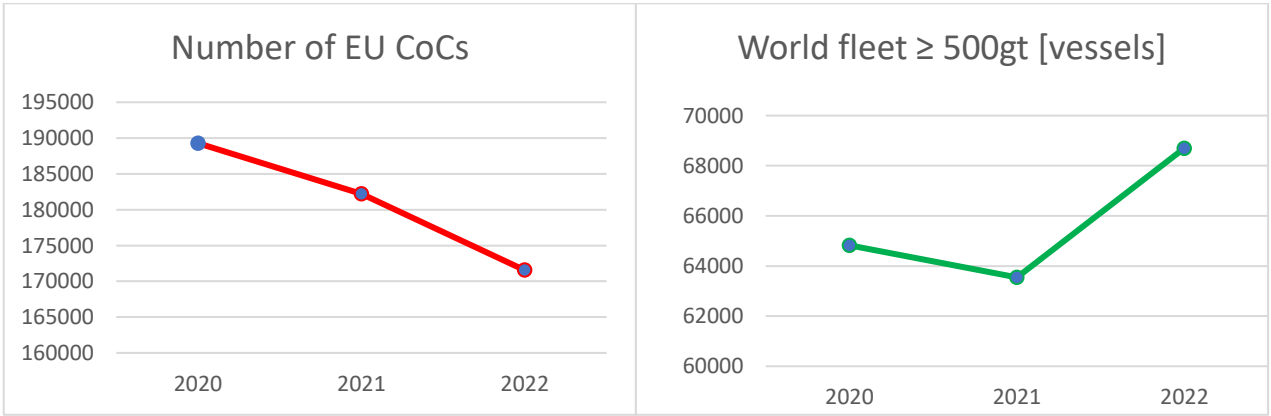

Figure 1: Comparison of European CoC holders [3] versus the number of vessels above 500 GT (Gross Tonnes) [4]

The graphs highlight that the maritime industry in Europe is struggling for mariners. This is not just an interpretation of numbers, but also an opinion by many relevant players. 'Sweden has gone as far as opening an additional course to train nautical officers, without success, as there were zero attendants,' stated one of the interviewees for this study. Further, only a part of the persons completing their maritime education are working onboard to get valuable seagoing experience, which is needed in all areas of the shipping industry. The struggle to find qualified personnel for conventionally crewed

vessels may even be one of the major drivers for autonomous shipping. The same effect is already seen with inland waterway traffic which is presently changed by SeaFar through their agenda to operate remote-controlled vessels [5].
The approach to utilizing certified shipboard crew entails a big problem though. As mentioned above, we already have a shortage of qualified personnel and now we want to take another chunk out of that group and put them in the ROCs. However, autonomous shipping will not replace traditional shipping and the need for mariners. There is even the argument that it will enable companies to go small, meaning that there is not one big vessel with maximum capacity, but several smaller vessels that offer more flexibility in their deployment. They may be manned with a reduced crew and can create more flexible schedules, but still cover the peak times sufficiently. 'We will not replace a good colleague with a robot' was stated by an interviewee. The want for seafarers means that autonomous shipping can be seen as an augmentation to traditional shipping, as a supplement. It will not be a replacement, as an unmanned commercial vessel crossing the oceans is still unviable [6].
It should be a priority for the industry to counteract the increasing discrepancy between available nautical personnel and the needs of the labor market. An example of failure to achieve this is the certification of DP Operators which led to a considerable bottleneck in the crewing of offshore vessels. A dedicated education for remote operators appears to be the logical solution. That does not mean mariners should not be able to pursue this career path. Training them will be valuable and likely they can gain seniority more quickly than a dedicatedly trained RO. But a direct route to the profession should still be available, without mastering another one first.
To avoid the common pitfall of jumping five steps ahead and already designing an educational program for laymen, the first step on this path is to outline the profile of the RO. We need to understand the work environment, primary and additional duties, risks, and challenges of the occupation to get a clear picture of this novel profession, how they work, where they work, and what is expected of them.
To achieve this, a series of qualitative interviews have been conducted with leaders in the industry, education, and certification. The interviews were conducted in a very open manner with only some guided questions regarding the approach to autonomous shipping, and the role and expectations of their personnel, both in everyday and in emergency situations. To analyze the interviews, the method of systematic text condensation was applied in which the topics were reviewed, further fragmented, and sorted. The statements were then condensed and compared for commonalities and differences [7]. This shall ensure that the professional profile of the remote operator is not just a theoretical construct, but reflects the reality as it emerges and already exists.

2. THE WORKPLACE OF THE REMOTE OPERATOR

Shipping companies have invested a lot into automation and information gathering, making more advanced systems commonplace. DP has for example experienced a boom within the last decades, but most traditional companies are hesitant to take the step towards autonomy. Still, the advances in sensor techniques and centralized data processing of data, have provided the possibility of vessel autonomy. However, it is primarily young companies or purpose-founded joint ventures, that endeavor upon this new path. They mostly place themselves within one market segment, i.e. ferries, ro-ro vessels, offshore operations, etc. If that does not hold, they at least stick to a similar technological solution for their ships, and the ROC. The vessels' work scope remains the same though, it just so happens that the manning has shifted to some degree from ship to shore. Diversifying into different market segments or various technology providers early seems to be too great of a risk since both technologically and legislatively we are still in a touch-and-go phase.
Outsourcing the crewing needs of the ROC is not an option for these new players in the industry. Rather they see themselves as a service provider to companies looking for innovation, offering remote crewing and ship management capabilities. With considerable success, for example, ASKO, YARA, and REACH SUBSEA, which have not previously been engaged in ship management, are driving forces in developing autonomous shipping by contracting MASSTERLY [8].

In general, we can distinguish three modes of remote operations:

- Supervision of autonomous systems
- Remote control of vessels
- Remote navigation support

2.1 DIFFERENCES IN MODES OF REMOTE OPERATIONS

Supervision of autonomous systems is the highest degree of autonomy one strives to achieve. A vessel departing, transiting, and docking by itself is an intriguing idea. These vessels are supposed to run on routes defined by the RO, be capable of acting according to COLREG (Convention on the International Regulations for Preventing Collisions at Sea) [9], and maneuver in port by themselves. The role of the RO in this context is multi-tasking orientated, as they will have

to keep an eye on multiple vessels simultaneously. One company is talking about one operator supervising five vessels, another would like to go up to as many as eight, however, they agree that only time and the level and reliability of the autonomy will give a clear picture of the true capabilities. It will be the duty of the RO to recognize situations that require human interference and to troubleshoot in case of failure or breakdown. However, there is no direct control over the vessels. The RO may define waypoints where the vessel should be heading, like a track pilot, or put the vessel into its fallback state, in which it is attempting to maintain position and await further instructions. Correctly identifying the situations when intervention is required will demand a lot of focus and immersion into different situations simultaneously. Therefore, time in the chair while observing a number *n* of vessels, is heavily limited. Supervision of autonomous systems is always done in teams, for now, it is assumed that a team consists of two ROs and one RE. Repeatedly rotating the two ROs in a shift ensures the immersion-heavy nautical situational awareness is limited in time. If a situation is deemed to exist, which requires more focus from the RO, there will always be the second person who can supervise the *n-1* remaining vessels. The application of these vessels will mostly be in short trade. Fixed routes and limited distances are an ideal environment. The situations represent relatively simple traffic situations and the restricted area will quickly be familiar to the RO.

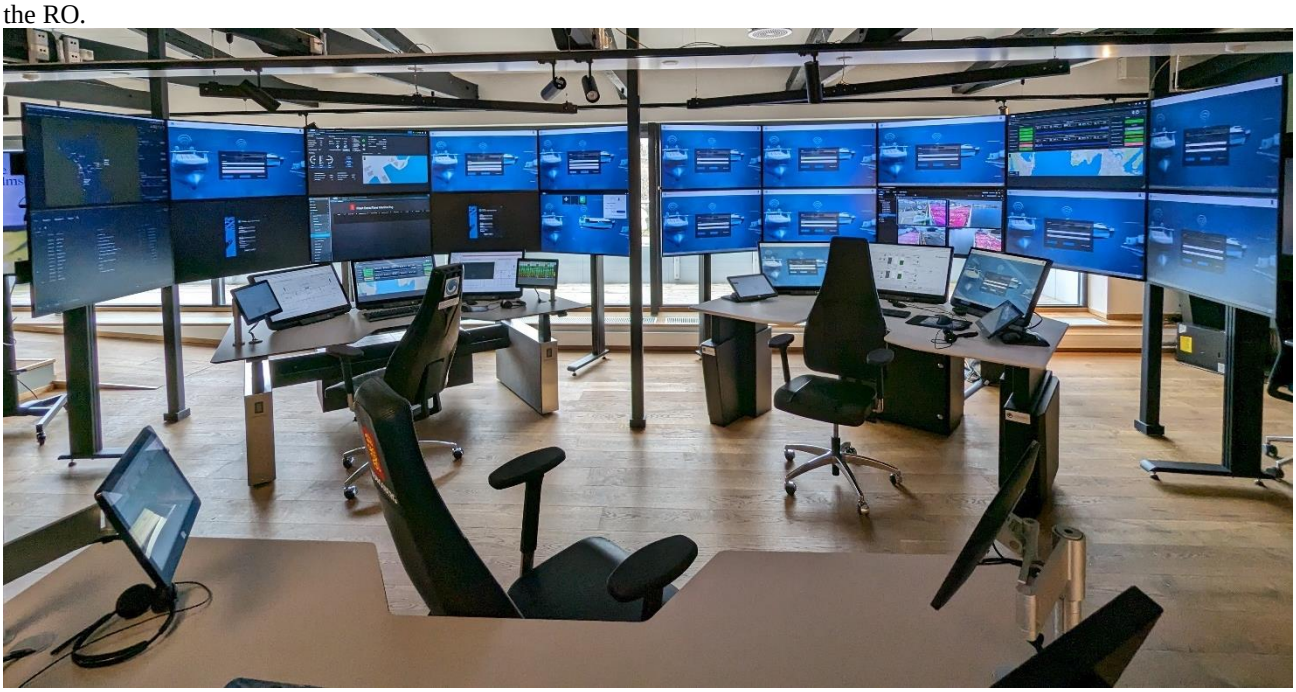

Figure 2: A workspace for supervision of autonomous systems, MASSTERLY's ROC in Horten, Norway

Remote control of vessels is the direct control over a ship from an ROC, either via a joystick or a conventional setup of controls. This method has been used for some time in the operation of USVs (Unmanned Surface Vehicles) as they are small enough not to fall under SOLAS (International Convention for the Safety of Life at Sea) regulations. Operation of such vessels then falls under national legislation, which is easier to change and adapt, compared to the IMO rules. The same applies to inland waterways, where cargo vessels are already being remote controlled. Crew costs and personnel shortages are higher compared to international shipping [10]. In recent years this method has seen a respectable expansion in Europe. One operator exclusively handles one vessel at a time. This approach may also be used at sea temporarily, when in low-traffic areas, to reduce work hours for the onboard crew or when there are not sufficient navigators onboard to operate on a 24/7 basis. The RO and the OOW (Officer Of the Watch) must conduct a detailed handover before the controls may be passed between the ROC and the shipboard crew. Remote control of vessels might also be used when the bridge crew is supposed to be engaged with other duties. For example, on conventional ships, one of the bridge officers cannot be involved in most emergency drills because someone must control the ship. Further, compliance with resting hours may be possible, even in high-frequency port rotations, which at present is often only the case on the records.

Remote navigation support refers to operations with a manned bridge, where the RO takes an advisory or supplementary role to assist the OOW remotely from ashore. This person can log onto a bridge, access relevant navigation instruments, and use a range of cameras. The lookout duties during nighttime or when passing through dense traffic areas can thus be done from the ROC and free up capacities onboard. A company following this remote navigation support approach stated during the interview that these duties are still fulfilled mostly by senior and some junior nautical officers. The reason is that the technology may be updated, and processes and features can be optimized. Another benefit is that they are using the captains of their fleet in the ROC; they will spend some time in the operator's chair and then return to their deployment at sea. This approach is on the one hand building trust in the ROC and the remote operator, on the other hand, it allows

the mariner to see both sides of the operation and this knowledge can in turn be used to update the system. In the offshore industry, it is not uncommon to have client representatives onboard, this necessity is made obsolete, as the representative may observe the vessel's position and actions from the ROC. This will reduce the distraction for the bridge crew, and minimize the representative's time who only must drop by the ROC during relevant times and not spend the whole span of the deployment on board.

2.1 COMMONALITIES IN MODES OF REMOTE OPERATIONS

Despite the differences in modes of operation, we should not fall back into the habit of creating rigid systems where something can be either one or the other. Instead the transitions need to be seen as flowing. Presently, companies are operating either one mode or another, but there is potential to vary a vessel's mode of operation throughout one voyage. In a hypothetical scenario a ship may be departing under manual control, and an OOW takes the navigational watch alone. Due to darkness, restricted visibility, or density of traffic, he asks for remote navigation support. When the lookout is no longer needed, he will relieve the remote support navigator and later, during the deep-sea passage, will switch the system to autonomous with appropriate supervision. Another example is Reach Remote, a vessel with DP capabilities, but without DP notation, navigating to the offshore field autonomously with supervision and then being remote-controlled whilst working with ROVs or conducting survey works in DP-like operations [11]. These two scenarios highlight that the different modes of remote operations are closely related – be it in conjunction with manned or unmanned vessels.

One big challenge for all modes of operation is the flow of information. Modern vessels are equipped with thousands of sensors, that produce a lot of alarms. The flood of alarms is already very much an issue on conventionally crewed vessels [12], if the same continues in the ROCs, it will make it difficult to maintain situational awareness for a remote-controlled ship, not to mention several supervised autonomous vessels. The same also applies in the other direction, a risk of the remote navigation support is to announce too many sightings that are not imminently relevant, leading to a distraction of the OOW and thus deteriorating the situational awareness. Reducing the information flow to the essentials is a prerequisite to achieving a reliable level of situational awareness necessary for competent and safe navigation.
The vessels handled by the RO will vary concerning the crew on board. As indicated earlier, we are moving away from the rigid four degrees of MASS and are looking at more flexible and individual solutions. However, the classical need for familiarization with the vessels must remain a high priority. This can be done by spending some time on board, in case there are still crew accommodations available, or by just visiting the vessel. But even VR (Virtual Reality) is already in use, which offers a complete walk-through of the vessel, including the LSA equipment, as stated by one company. This is particularly useful when the vessel is operating worldwide and there is no chance to physically visit the vessel, without excessive effort.
Something all players agree upon is that when the crew is onboard, it will always have authority over any remote command, the exception is a security protocol that may be engaged in case of hijacking events.
Another requirement for competent remote operations is radio communication. Hailing other vessels on VHF (Very High Frequency) radio, broadcasting Sécurité messages during surveying or towing, and receiving navigational warnings or distress calls are fundamental for safe ship operations. For short trades, a restricted operator's certificate would satisfy the requirements, but for worldwide trading, the ROs will have to comply with the general operator's certificate.

3. ADDITIONAL DUTIES

Looking at the three modes of remote operations, it becomes apparent that the RO will have some time available apart from their main task, i.e. partaking in the vessel's safe transit. In the case of remote control and remote navigation support, those times are when the RO is not actively engaged with a vessel, and in the supervision of autonomous systems, when the vessels are behaving as they should, the second RO has time to engage in other tasks.
Operating a vessel entails much more than just bringing her from A to B. Routes must be planned thoroughly from pier to pier and may need adjusting according to meteorological conditions. Passage planning is something that all players agree, can be done by the RO, not necessarily only for the vessel under one's immediate care, but also for any vessel within the fleet.
Further, the duties of the RO will entail the scope of a regular nautical officer, planning and conducting maintenance, scheduling services, organizing the renewal of certificates, and ensuring that the vessel is upheld and in good working condition. The advantage of the RO taking over these duties is that they are in a hybrid position of ship and shore, effectively making the interaction between the officer and the vessel manager or superintendent obsolete and challenging the classical hierarchy of a shipping company. However, it will likely not be every RO who can place orders, instead, there will still be a person in charge, who may also be fulfilling the role of a RO. Some companies strictly separate ROC personnel from the rest of the office staff, due to the vessel's complex deployment planning and the requirement to not

distract the ROs in their duties. However, a certain level of understanding of planned and condition-based maintenance, organizing services, and renewing certificates may be accepted within their work scope.
Several companies have also indicated that it would be useful to have the supervisors of autonomous systems acting as a VTS (Vessel Traffic Service), surveying and controlling the ship traffic within their area of operation, in addition to the RO's regular duties. Especially for the supervision of ferries, this makes a lot of sense, as they are trafficking repeatedly over a certain stretch of water, which the shoreside crew will be well familiar with. Anticipating the departure time of the ferry and the resulting ship encounters, it seems self-evident that it would not only be possible for the RO to cover such duties but also be beneficial to their situational awareness. Developing close-quarter situations can be spotted early and vessels will more likely adhere to instructions received by a VTS, than a ferry's request to give way. An undertaking aiming to include autonomous ferries into the public transportation network further stated that the RO can function as a traffic manager so that bus and ferry schedules are coordinated to provide smooth transitions for the customers.
None of the interviewees have stated that stability is amongst the duties of an RO, however, they clarified the reason being that either the vessels do not even have a ballast system, or if they do, the stability is always more or less the same. There are not sufficient activities involved for the shipboard crew to justify a remote stability computer or remote ballasting system. However, this does not mean that verifying stability would not be part of the RO's duties in the future. A basic understanding of buoyancy, stability, dangers regarding the lack thereof, and resonance effects of ships must be considered essential for overseeing a seagoing vessel.

4. EMERGENCY PREPAREDNESS

Talking to the partners in the industry has made it clear, that the initial argument of developing autonomous shipping operations to promote safety has moved to the background. The financial aspects dominate the strive for innovation. Safety is a prerequisite to achieve a profitable business case. However, the mantra holds that operating autonomous ships must be at least as safe as a conventionally crewed vessel.
The approach of contingency planning varies significantly. However, there are some commonalities, like the argument that the new vessels are already designed to be safer, thus the threat of fire is regarded to be accounted for by MASS with their fixed firefighting systems. For example, on small work boats, the crew would not conduct firefighting in any case, so the new designs with state-of-the-art water mist and inert gas systems increase onboard safety.
In the case of partly crewed or passenger vessels, it is possible today to launch life rafts and evacuation systems from the bridge. The crew must be familiar with these systems and catering or service staff would still be available to assist passengers. There is then little argument that LSA (Life Saving Appliances) should not be launched from the ROC instead of the bridge.
Assisting in an external emergency like aiding a casualty in the water is considered fulfilled. According to UNCLOS (United Nations Convention on the Law of the Sea) Article 98, there is an obligation to render assistance [13]. The method of how to render the assistance is not further defined. The interviewees agreed that during SAR (Search and Rescue) activities MASS will likely not be retrieving persons from the water but instead be utilized to create a lee, assist in searching using advanced sensor arrays, feed information and potentially even video to the MRCC, and take the role of the OSC (On-Scene Coordinator). Special training should be provided to prepare a RO for such eventualities. Despite these opinions regarding rendering assistance, the current draft of the MASS Code states *"Mass should have […] specific plans, procedures and training and drills for the rescue of persons in distress, […]"* [14]. If such a requirement is implemented in the mandatory MASS Code, companies such as Zelim, offer remote-controlled fast rescue boats [15], which enable also partly or completely unmanned vessels to comply.
Another concern by players in the industry is still cyber security. Arguably, it should not only be a concern for the companies in question but also for all seagoing and port personnel, since a vessel being controlled with malicious intent may cause much harm. ROs must be trained to recognize unwanted interference and to provide appropriate responses to such events.
For a short trade of less than one nautical mile, it is being argued that the best response to internal emergencies is always to reach the closest port. However, this should not relieve them of contingency training. The players agree that any training may be conducted using simulators, or in joint exercises with the shipboard crew. Emergency drills are essential to maintain awareness of emergencies and correct behavior, this applies to traditionally manned and autonomous vessels.

5. CHALLENGES

Of course, there are still a lot of challenges ahead regarding autonomous shipping. We have seen that remote control of vessels works well inland where rough seas, complex multi-vessel traffic situations, and connectivity are less of an issue. However, the traffic is busy in coastal areas, which makes it more difficult to achieve full situational awareness, while in the open ocean, connectivity might be more of an issue, as Japanese test runs have reported occasional problems during field tests [16], also there is an increase in data traffic expected, once the non-mandatory MASS Code will be completed [17] with yet to be seen consequences on the available bandwidth.

Mainly legislative issues are restricting the full potential of autonomous shipping though. Currently, national solutions are being sought and found, and as soon as there is sufficient proof of concept these national solutions can grow into bilateral and multilateral agreements before finally being implemented within the IMO.
In the meantime, there are still challenges to be overcome regarding educating and training the remote operators. A considerable issue in training is to achieve the situational awareness that is inherently adopted by mariners when looking outside the bridge windows. At the same time, the introduction of technology will make it easier to identify objects, judge distances, and even get offered suggestions for positive action. Generically trained personnel, who only know this way of involvement and decision-making, might work more efficiently when using these systems, compared to conventionally educated mariners with an extra RO's training on top.
Nevertheless, it is still likely a good idea to have at least some sea-time experience in a dedicated RO educational program, as putting trust in someone half a world away, without having ever met them, must be well founded. Globalization, and the COVID-19 pandemic, have made cooperation between teams spanning different continents commonplace. When the connectivity is ensured, this is also possible for shipboard operations. However, cooperation onboard ships is very different from many other sectors. The shipboard crew is putting their lives into the hands of the person or the system in charge of the navigational watch. A level of trust is required, which must be built within the bridge team and in the entire profession. Initially, it may be easier to trust someone who you know has received the same training and education you have as a crewmember onboard. Achieving this confidence is a considerable hurdle for future dedicatedly trained ROs, without being a mariner first. Skepticism may be alleviated by spending at least a limited amount of time on board during the education.

6. AVAILABILITY

There is not necessarily a lack of persons interested in working in the maritime sector, but the life of a seafarer is not always easy. Some examples are extended periods far away from friends and family, long working hours, isolation at sea, and confined living quarters. Many drop out early from the education schemes for those reasons, others finish but never sail as an officer. The occupation of the RO opens the possibility of pursuing a maritime career without these inconveniences. Offering two paths, instead of one may be highly beneficial to counteract the personnel shortage. Also, the retention rates might be much longer. If seagoing personnel suffer from a serious illness or an accident, they likely lose their medical fitness certificate. Further, in Europe, females only represent 2.5% of the total CoC holders [18]. They immediately lose their medical fitness certificate when pregnant and after giving birth, the reintegration into the shipboard profession, potentially part-time, is difficult to accomplish. The work in a ROC can accommodate the above needs more easily, offering less restrictions and better chances for reintegration into the labor market [19] leading to a more diverse workforce.
The interviewees also agreed that the ROC crew would not earn less than their shipboard equivalent, likely even slightly more. Whether that is only a snapshot view of the early days of ROC existence or it will be a long-term trend, remains to be seen.
Summarizing, it can be said that ROs will have a more socially oriented work environment, better suited to accommodate diversity. Offering a dedicated education will enable people to work with ships in an interesting environment without being trained as mariners first.

7. SUMMARY OF COMPETENCE REQUIREMENTS FOR REMOTE OPERATORS

Large sums are being invested into ROCs, and the proof of concept will be when not only remotely controlled and supported navigation is viable, but also when safe operations and supervision of autonomous systems are achieved. On the education side, we must recognize and understand this trend, to provide appropriate training schemes for the new profession of the RO.
Summarizing the competencies that are required according to industry leaders provides us with the following list:

- **Basic understanding of vessels** can be accomplished through familiarization in conjunction with onboard experience. The practical training will help to build trust with the crew still onboard. Also, it will avoid detachment from the vessel when making maneuvers. The first author has frequently observed nautical students, without previous bridge experience, making unnecessarily hard maneuvers in simulator training. In real life, this is not only uncomfortable for persons on board, but may even be dangerous to the ship and the cargo.
- **Ship handling** at least to a limited extent, as the amount of direct control will be heavily limited. Whether the current approach of only dedicating waypoints will prevail remains to be seen. Alternative solutions could be joystick control or a limited range of emergency maneuver options.
- **Sensor fusion** is performed by autonomous systems, meaning that the information from different sensors is being overlayed and combined. A thorough understanding of the different systems and their limitations is the key to a correct interpretation of the displayed data.

- **Situational awareness** is the cornerstone of making autonomous shipping work. This will require not only an understanding of the above-mentioned sensor fusion but also extensive simulator-based training.
- **Coordination of traffic situations** is essential for maintaining situational awareness of multiple vessels simultaneously. The ROs can in turn be used to act as a VTS or act as an OSC during SAR activities.
- **Familiarization with the trading area** needs to be addressed, including knowledge of local navigational hazards, expected traffic, and surrounding conditions.
- **COLREG and national rules of the road** must be adhered to. Knowing when and how to react during vessel encounters is key for every manned and unmanned ship.
- **Route planning** may be conducted by ROs when not directly engaged in navigation or supervision.
- **Inspection, certification, and maintenance planning** are other duties for idle periods.
- **Resilience and emergency response training** must be part of both the education and regular contingency training. A takeover during emergencies may be needed and the RO must be competent to ensure the safety of the vessel under critical situations.
- **Cyber security threat recognition and response** need to be schooled, trained, and updated regularly.
- **Radio operator** is a qualification which will enable the RO to correctly convey information and intentions. Knowing and applying correct radio procedures is the foundation for many of the above-mentioned points.
- **Stability** is essential for any vessel of any size. A base understanding of risks and dangerous resonances is a must for any person in charge of conducting a watch, whether onboard or ashore.

8. CONCLUSIONS

It is important to understand that the stated required competencies are mainly reflections of the industry players. Of course, these cannot be the only source, but their insights are relevant to creating an educational scheme for the RO.
Autonomous shipping is an exciting new field in the modern maritime industry which opens the door for a young and more diverse workforce. The different modes of remote operations may be defined as supervision of autonomous systems, remote controlling of vessels, and remotely supporting a navigational watch. In the future ROCs may offer the entire range of remote operations within their fleet or to their clients, so certified personnel should be trained in each operation accordingly. While these applications differ, there are still significant commonalities, making a common education viable. The required trust by the remaining crew and passengers onboard must be built through a comprehensive education of the RO, which includes at least a limited amount of onboard training.
The further development of autonomous vessels will enable the industry to shift from maximum capacity vessels to diversifying and deploying smaller units. To manage these vessels, we need to expand the workforce. A designated educational program for remote operators will lay the foundation for traditional and autonomous shipping to unfold their full potential.
The challenge of defining key competencies and how to involve them in educational programs are being addressed by various research groups [20, 21]. This paper in contrast focuses less on the theoretically needed skills, but on the requirements of the industry. To avoid a tunnel vision of the industry's pioneers, further interviews will be conducted with companies not yet engaged in autonomous shipping, to compare their expectations with the findings of this paper.

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