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Evaluating the existing watchkeeping regulations as a baseline for developing functional requirements and performance criteria for uncrewed vessels

Børge Kjeldstad

Department of Marine Technology, NTNU, Trondheim, Norway. E-mail: borge.kjeldstad@ntnu.no

D. Kwame Minde Kufoalor

Maritime Robotics, Trondheim, Norway. E-mail: giorgio@maritimerobotics.com

Jon Herman Ulvensøen

University of South-Eastern Norway, Tønsberg, Norway. E-mail: jon.h.ulvensoen@usn.no

Ingrid B. Utne

Department of Marine Technology, NTNU, Trondheim, Norway. E-mail: ingrid.b.utne@ntnu.no

The development and deployment of uncrewed surface vessels and vessels with some degree of autonomy is seeing a rapid increase. Use cases cover the offshore industry, aquaculture, seabed mapping, water column monitoring, public transport, cargo freight, security, and more. The expected business opportunities and societal benefits are reduced crew and vessel costs, reduced energy consumption, less HSE exposure for employees, and a potential mitigation to the challenge with less people being willing to take a job at sea. Yet, regulations for such vessels do not exist. This lack of regulations causes challenges for both developers of the vessels and for the authorities who shall approve them. Costs increase, time to market increases, the risk picture is unclear, and the advantages these vessels offer to the maritime sector and stakeholders in the ocean space are not delivered as expedite as possible. The objective of this paper is therefore to evaluate how the existing watchkeeping regulations may be used as a baseline for developing functional requirements and performance criteria for uncrewed and potentially autonomous vessels. The focus is on the conventional lookout and navigation crew functions with sub tasks and duties. These functions are selected because they are assumed to be the most challenging to perform from a remote-control center or autonomously. Methodologically, this paper uses a literature review and expert judgements to assess if there is a potential gap between existing regulations and if there is a need for new regulations for uncrewed vessels. The work in this paper is partly related to the Sundbåten autonomous passenger ferry project in Kristiansund, Norway, involving both industry and academic partners.

Keywords: Uncrewed vessels, Remotely operated vessels, Autonomous vessels, Functional requirements and performance criteria.

1. Introduction

Uncrewed Surface Vessels (USV) and vessels with some degree of autonomy are now in the development phase with momentum and speed. For example, Maritime Robotics – a Norwegian company developing USVs, announced in March 2023 that they had been given approval by the Norwegian Maritime Authority (NMA) to operate an uncrewed vessel in freight service at sea (Maritime Robotics, 2023). Still, regulations for uncrewed and potentially autonomous vessels have not been put in place. The International Maritime Organization (IMO) is working to have a non-mandatory goal-based Maritime Autonomous Surface Ships (MASS) Code ready by the end of 2025 (IMO MASS code), which purpose is to regulate the operation of MASS. As an intermediary solution, authorities in countries where USVs are being developed and commissioned, provide guidance for risk-based approval of USVs. The NMA version of this is the circular (RSV 12-2020, 2020). However, a risk-based approach may be expensive and time consuming to comply with for the parties involved in developing and operating USVs. A challenge is that it is unclear what the outcome of the process may be, i.e., if approval is granted or not, and what the final requirements from the authorities to the system solution will be. These deficiencies may hinder the development and deployment of USVs and delay the potential benefits uncrewed vessels may realize.

The Norwegian watchkeeping regulation (WR) provides rules which apply to Norwegian passenger ships and cargo ships of 50 tons and upwards. The purpose of the regulation is to: "*ensure that a safe continuous watch or watches appropriate to the prevailing circumstances and conditions are maintained in all ships at all times*" (Regulations of 27 April 1999 No. 537). Equivalent international regulations are found in the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs), the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), and the International Convention for the Safety of Life at Sea (SOLAS). As a contribution to the regulative development, and possibly the IMO work on the MASS Code, the objective of this paper therefore is to evaluate the WR as a basis for establishing functional requirements and performance criteria for the safe operation of uncrewed and potentially autonomous vessels.

The background for the paper is experience with the development of concepts of operation (CONOPS) for a USV in compliance with RSV 12-2020. A recent research and industry project concerned the development of an autonomous passenger ferry in Kristiansund, Norway, in which several HAZID workshops with relevant stakeholders were conducted based on the requirements in the WR. RSV 12-2020 requires the CONOPS to provide a description which covers all functions defined by the Norwegian Manning Regulations and the WR. During the project work it became clear that the WR provides a good foundation for describing crew tasks onboard a ship. Hence, it might be possible to use this foundation to evaluate whether the same tasks can be performed safely from a remote control center (RCC), i.e., that the vessel can be uncrewed and remotely operated safely (low Autonomy Level (AL)), and eventually autonomously (higher AL).

2. Methodology

The idea that engineers can use existing international crew and safety regulations as a benchmark when developing uncrewed and potentially autonomous vessels has previously been introduced in (Stones, 2017). (Dittmann, 2021), too, discusses how STCW compliance can serve as basis for the development of an autonomous vessel. The current paper, however, compares the content of the WR with (i) a class society guideline to autonomous and remotely operated ships (DNVGL-CG-0264, 2018), ii) the MASS UK Industry Conduct Principles and Code of Practice (UK MASS Code of Practice, 2021) and (iii) scientific literature related to uncrewed and autonomous vessels.

The aim of the comparison is to investigate if there are crew tasks which the WR do not address, as shown in figure 1. If no additional tasks from (i-iii) are identified, the WR may be considered a good baseline. This paper generally uses the word *task* to describe tasks, duties, functions and even properties the WR requires the crew to do or to have. This is for simplicity, but may not always be semantically correct, nor always fit the context. Sometimes therefore, the word *function* or *requirement* is used instead. Further, the tasks can be considered "datapoints" which then become high-level specifications of required future operational information and potential measurements from sensors, relevant for deriving performance criteria to autonomous ships and an RCC. The advantage with the comparison is that whereas the selected crew tasks originate from maritime regulations, some of the scientific articles are based on interviews with experienced seafarers and thus provide a valuable source for identifying crew tasks.

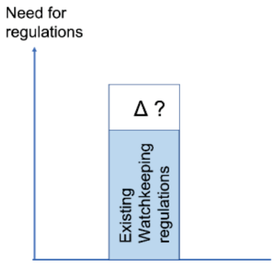

Fig. 1. The potential gap between existing regulations and future regulations for uncrewed vessels w.r.t. required tasks.

The literature search has used the snowball approach, as described in (Størkersen, 2020). Relevant literature was identified in databases, on the internet and in the reference lists of scientific papers. The aim has been to select recent publications with a variety of scopes: technical, operational, and economic feasibility, education, law and regulations, human centered design and Human-Machine-Interface (HMI), and safety management.

3. Analysis and Results

RSV 12-2020 refers to the Ship Safety and Security Act, Manning regulation, WR, Construction regulation, and COLREGs. The WR covers the navigational, machinery, radio, and deck watches. This paper's focus is on the navigational watch. This is because this may be the most challenging overall task for the onboard crew and therefore the RCC. Navigational watch covers the tasks; lookout, navigation, maneuvering, steering and communication, of which this paper focuses on the two former. To limit the scope of this paper, the docking operation is in general not included. Figure 2 shows where the lookout and navigation crew functions belong among the acts and regulations mentioned above.

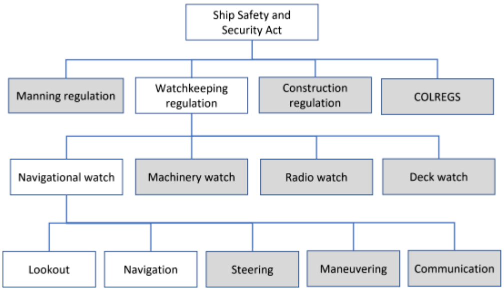

Fig. 2. Schematic overview of how the lookout and navigation crew functions discussed in this paper fit into the hierarchy of Norwegian maritime act and regulations referred to in the circular RSV 12-2020.

3.1. *The watchkeeping regulation*

For the lookout and the navigator, the provisions of the WR states the following:

- Responsibilities
- Applicable regulations
- Task descriptions and procedures
- Factors needed for situation awareness (SA)
- Sensors to be used, i.e., navigational equipment and the senses of trained crew fit for duty
- Risk assessments to be made and the fallback strategies if risk increases, (i.e., request crew or captain to the bridge)
- That being called from out-of-the-loop to duty is a well-established procedure.

3.2. *Review of tasks in DNVGL-CG-0264 and UK MASS Code of Practice*

DNVGL-CG-0264, section 4, concerns guidelines for the navigation function, including lookout. The function is divided into detection, analysis, and planning. Section 6, chapter 4, concerns remote SA and includes a discussion of how human senses play a part in building SA. In general, the guideline lists several tasks, conditions, events, or hazards which must be performed or attended to by the lookout and/or navigator onboard. The same can be said about chapter 9 through 11 in Part 2 of the UK MASS Code of Practice. These listed tasks are used to identify the datapoints in table 1. The right column shows the number of the regulations in Appendix A in the WR which cover the corresponding datapoint. A "B" in front of the number indicates that this is a recommendation found in Appendix B in the WR.

Autonomous systems are characterized by sense, model, plan, act capabilities, in contrast to automated systems with a traditional sense-act control loop. In tables 1 and 2, green is used for datapoints related to sense or detection, purple for model/analysis, blue for planning, and orange for acting, see figure 3.

Fig. 3. Schematic overview of the color coding used in tables 1 and 2 to illustrate the breakdown of a control function.

Datapoints adapted from (DNVGL-CG-0264 and UK MASS Code of Practice)	**WR #**
‘Detect’ datapoints	
Detect and recognize, vessels, lights, shapes, sound, light signals, objects, aids to navigation. Size, color and material of objects.	13.1-3, 21.5.3, 38, 48
Visual detection of other ships in accordance with COLREG rule 22	13-13.2, 21.5.3
Identify location/direction of the sound	13.1
Other senses: balance and acceleration, smell and temperature Vessel movements, including dynamic and static conditions, vibrations, roll, heel,	13.1-2
Ambient conditions, reduced visibility from fog, sunset, strong wind, rough sea state, dangerous waves, strong currents, heavy precipitation	13.1-2, 21.3
Sufficiently early warnings on hazards and upcoming conditions	12, 20, 21.3, 21.5.4, 40-40.10 43
Sense other platforms and systems	13-13.3, 38
Third party data feeds, such as Notice to Mariners	5, 21.5.4
AIS data	27
Environmental Protected Areas	5, 6
Cables	5, 6, 20
Vessel maneuvering restrictions and constraints	5, 6
Recognize all known unsafe operating conditions with no false negatives	13.1-2, 21.3, 21.5-21.5.5, 39
Speed Through the Water	13.1-2, 20, 21.2, 24
‘Analyse’ datapoints	**WR #**
Determine risk of collision	9, 12, 21.5.3
Safe speed	12, 13, 13.2, 45
Traffic situation	13.1-3, 21.5.3
Area of navigation and hazards along the route in relation to vessel characteristics	5, 12, 20
Estimate distances	9, 13.2, 27
Determine the vessel position by use of various and independent methods	24, 27, 47
Situational awareness, analyse a navigational situation and conditions.	5, 7, 13.2, 20, 40-40.10, 43
Conclude on and plan control actions.	5, 7. 24, 43
Assess sensor data’s immediate impact on MASS performance	13.1-2, 40-40.10
Assess sensor data’s effect on safety of the MASS and surroundings	13.2-3, 35.1-2, 43
Determine or forecast safe operating limits for sensor data	17.7, 25
Determine or forecast permitted geographic areas	5, B14.5
Determine or forecast: - Expected water depth in relation to geographic position and time - Expected water current or tidal stream speed and direction in relation to geographic position and time	21.3
Deconflict data from different sources	21.5.1-2, 27, 33, 34.2, 34.4, B5
Determine when an emergency stop command is necessary	12, 13.2, 29, 41, 43
Interpret SA data to assess if an object is a vessel according to COLREGs and if so, its classification according to COLREGs	13.1-3, 21.5.3, 27, 28
Interpret information transmitted on VHF Channel 16, MF installation on DSC 2187,5 kHz (if fitted), VHF DSC channel 70, enhanced group call (if fitted) and NAVTEX	5, 20
Post operation analysis	31, 33, B5.12
‘Plan’ datapoints	**WR#**
Determine actions to avoid collision	9, 12,
Plan the intended voyage in advance, validate a route	5, 6, 7
Make operational decisions based on interpretation of sensor data	9, 12, 29, 41, 43
Select route to follow	9, 12, 29, 41, 43
Calculate maneuvering commands to comply with COLREGs	7, 9, 12

Determine ETAs	5
Identify any handover Lat/Long	5
'Act' datapoints	**WR #**
Intervene before a situation becomes critical	17-17.8, 29, 35.1-2, 40-40.10, 41
Operate in a predictable manner	43
Direct the MASS along a safe route at a safe speed	12, 45
Take the vessel away from danger or to a safe haven	29, 41, 43
Generate waypoints	9, 12, 29, 41, 43
Override the mission controller by setting heading and speed	29, 35.1, 41, 43
React to unknown or indeterminate safety conditions by invoking emergency stop in a timely manner	29, 41
Avoid obstacles	12, 29, 41, 43
Accept externally defined fixed exclusion zones	5, 6, 7, B14.5
Accept externally directed control	18-22
Apply maneuvering commands to comply with COLREGs	29, 41, 43
Act upon information transmitted on VHF Channel 16, MF installation on DSC 2187,5 kHz (if fitted), VHF DSC channel 70, enhanced group call (if fitted) and NAVTEX	5, 7, 20
Handover control	18-22
Alert the operator of any emergency	23.4, 29, 40-40.10, 42
Alert the operator of any changes to the planned mission	23.4, 29, 40-40.10, 42

Table 1. Selected tasks, conditions, events, or hazards adapted from (DNVGL-CG-0264 and UK MASS Code of Practice), which must be performed or attended to by the lookout and/or navigator onboard.

3.3. *Literature review*

Navigation and lookout tasks identified from scientific literature are presented as datapoints in table 2, based on (Lunde-Hanssen, 2020; Dybvik, 2020; Størkersen, 2021; Wennersberg, 2022, Peeters, 2020; Porathe, 2014; Ramos 2019; Yoshida, 2020). Again, the table has a reference to where in the WR relevant regulation for each point is found. Please note that some of the datapoints may also be relevant for maneuvering and for the machinery watch.

'Detect' datapoints	**WR #**
Kinetic and dynamic information: Feeling the sense of balance, body balance (laboring of a ship, centrifugal force), stability (deviations), waves, rolling, pitching, sway, surge, heave, heel, hogging, slamming, shock, vibrations, ship performance when cargo is loaded; how the ship reacts to external (f. i. wind and current) and internal factors	13.1-2, 12, 21.3, 40.8
Smell and touch. Salty air.	13.1
Sound: internal and external. Signals from other vessels. Whistle. Engine of target ships.	13.1
Sight: Weather, sea, wind, visibility (fog, rain, snow), icing and ice, amount of clouds, speed, distances, day/night	13.1
Motion of scenery	13.1
Direction to land	13.1-2
Color of sea surface	13.1
Detect: other ships, change of course of target ships, objects, waves, land, aids to navigation, landmarks, hazards, traffic, underwater rocks, shoals, shipwrecks, navigation lights, icebergs, life saving devices, signal flare, man overboard	13.1, 21.5.3, 43, 48
Appearance of target ships (e.g., bow direction)	13.1-2, 21.5.3
Current weather and sea state, tide situation (speed and direction), water temperature, water depth	13.1-2, 21.2-3, 21.5.5

Thermal sense (humidity).	13.1
Heading, position, speed, course, distance to land, turn rate	9. 21.2, 21.5, 30
Water depth under the keel	9, 21.2, 21.5.5, 40.4-5
Air draft	3, 5, 6
Update weather information	21.3, 40.8
Radar, ECDIS and a provision of "the full picture"	21.5, 27
Vessel inertia	13.1-2
Spatial awareness	13.1-2, 43, 45
Objects which cannot be identified	13.1, 23.4, 28, 38
Monitor the screens	13.1, 24, 27
Listen to alarm	13.1, 40.6
Observe HMI and collect information about own and target ship status	13.1-2, 24, 27
TSS to be followed	5, 6, 15.2
Anchorage areas	5, 16.2,
'Analyse' datapoints	**WR #**
Detect ships with critical proximity or on collision course	13.1, 21.5.3, 43
Classify objects	13.1-3, 48
Assess, diagnose and investigate current situation. Separation from other traffic. Other ships' and objects' trajectory.	7, 9, 12, 13.2
Detailed, current and projected status of a hazardous situation.	7, 13.2, 21.3, 40-40.10, 43
The concept of "ship sense", a sense of "embodiment", proprioception	13.1-2, 21.3, 40.8
The "feeling" with the vessel	13.1-2, 21.3, 40.8
The traffic picture. Traffic density.	21.5.3, 43, 47, 48
Situational awareness and sensemaking	13.2, 21-21.5.5
Know when to alter course or reduce speed	12, 27, 29
How to handle oncoming waves safely	13.1-2, 17.2, 21.3
Study wave patterns	13.1-2, 17.2, 21.3
Comprehend the situation	13.2, 21-21.5, 40-40.10
Identify the important, and priority of, information	13.2, 21-21.5.5, 40-40.10
How dynamic the situation is changing	12, 13.2
Average and peak roll and heave	13.1-2, 21.3
Vibrations that are dangerous to the structural integrity of the hull	13.1, 21.3, 40.8
Identify alarm cause and source	13.2, 40.6
Assess autonomous solution against own ship and target ship status	5, 6, 7
Assess safety status	40-40.10, 43
Recognize necessary information	13.1-2, 21-21.5.5
Confirm accuracy of information	21.5.1-2, 24, 33, 34.2, 36, 43, 44
Understand the effect of sea condition	15.2, 17.2, 21.3, 40.8
Recognize the target ship and other objects with the most significant risk for safety	13.2, 21.5.3, 43
Deviation between current speed and planned speed	45
'Plan' datapoints	**WR #**
Manage voyage plan and deviations	5, 7
Plan on upcoming hazards	20, 21.3, 21.5.4, 35-35.2, 40-40.10, 45
Make rapid decisions	29, 41, 43
Decide strategy – manual or autonomous	5, 17-17.8, 19, 22, 35.1-2
Identify safe path	9, 12, 23.3
'Act' datapoints	**WR #**
Adapt to complex and surprising situations	13.2, 16, 17-17.8, 32, 40-40.10, 45

Bring the ship back to safety	29, 41, 43
Respond to alerts	40-40.10, 41
Put the ship on manual control	17-17.8, 19, 22, 35.1-2, 5
Take appropriate back-up actions	15.3, 16.8, 35.1, 40-40.10

Table 2. Tasks and information needs relevant for the lookout and navigation function. Adapted from (Lunde-Hanssen, 2020), (Dybvik, 2020), (Størkersen, 2021), (Wennersberg, 2022), (Peters, 2020), (Porathe, 2014), (Ramos, 2019) and (Yoshida, 2020).

4. Discussion

The comparison between the WR on the one hand and DNVGL-CG-0264, UK MASS Code of Practice, and relevant literature on the other, has shown that the latter do not contain tasks or requirements for the lookout and navigation functions which are not covered by the WR. Additional regulations may thus not be needed for these crew functions. Rather, existing regulations could be extended to uncrewed vessels. This would particularly necessitate a change in the requirement that the navigational watch shall keep the watch on the bridge. The use of other human senses than sight and hearing are examples of tasks implicitly mentioned in the WR, since the crew is required to be fit for duty and to have all their senses in order. Further, the WR requires that the crew is qualified. This implies that the crew has training in using their senses onboard a ship. Attention should be paid to the concept of "ship-sense". The importance of ship-sense has been highlighted by experienced seafarers who express concerns about losing their ship-sense when operating a vessel from an RCC. The HMI must take this into account, and a HMI design starting point should, as recommended by DNVGL-CG-0264, be the IMO Bridge Alert Management (BAM) concept and the performance standard for Integrated Navigation Systems (INS). From tables 1 and 2 we see that "Detect" and "Analyse" are the control function parts with most datapoints, followed by "Act". Thereby, it may be assumed that these parts also will dominate the functional requirements and performance criteria for design solutions for uncrewed and autonomous vessels.

It should be noted, however, that the literature search made for this paper is not exhaustive and other literature may provide tasks not discussed here. Further, DNVGL-CG-0264 may have used STCW and COLREGs as a source. Since (Lunde-Hanssen, 2020) references DNVGL-CG-0264, potentially there may be coinciding source material. In conducting the literature review the authors have used their extensive experience with uncrewed vessels from work within both industry and academia. Expert judgement has been used to select literature, in assessing the selection as representative, and in comparison between the literature and the WR.

While the WR is a good basis for defining the tasks, the WR does not always clarify how adequately the task shall be done which is important to derive performance requirements. This type of information is necessary when we replace human senses with sensors. For instance: what should the capacity of a camera replacing human sight be? For this particular task though, advice is available in other regulations like: (i) the camera should be able to detect navigation lights at a minimum range in nautical miles as described in COLREGs rule 22, and (ii) the camera should have a field of vision complying with the visibility requirements in SOLAS chapter V (Safety of navigation). In general, performance and capacity requirements to sensors replacing human senses are needed and this could be a topic for further research.

This paper discusses a selection of tasks the WR requires the crew to perform onboard a ship. The main motivation is to focus on the tasks assumed to be most challenging to perform from an RCC. Further work should focus on the remaining tasks. Also, an Assurance Case (AC) (ISO/IEC/IEEE 15026-2:2011) should be built to demonstrate that these tasks can be performed safely for an uncrewed vessel.

5. Conclusion

This paper focuses on the lookout and navigation crew tasks. A comparison between the WR on the one side, and class society guidelines, a code of practice, and literature related to remotely operated and autonomous vessels on the other, has showed that the WR provides a good baseline for developing functional requirements and performance criteria for these tasks. A set of task-related datapoints for the lookout and navigation crew functions has been identified. Such a set will provide important input to this development. It is believed that the crew tasks for steering, maneuvering, communication, and machinery, radio and deck watches can be evaluated in the same manner as has been done for the lookout and navigation. More research is, however, needed to (i) define functional requirements and performance criteria for sensors replacing human senses onboard the USV (ii) develop design requirements to the HMI at the RCC and (iii) to verify that the risks associated with the uncrewed vessels are acceptable, and that they can be safely operated.

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References

Act of 16 February 2007 No. 9 relating to ship safety and security (Ship Safety and Security Act), https://www.sdir.no/contentassets/a7a1a5cc4998405286e99c6fbccc5c8a/ship-safety-and-security-act.pdf (Accessed: 26.03.2023).

Code of Practice. 2021. MASS UK Industry Conduct Principles and Code of Practice, version 5.

Dittmann, K., P.N Hansen, D. Papageorgiou, S. Jensen, M. Lützen, M. Blanke (2021). Autonomous Surface Vessel with Remote Human on the Loop: System Design for STCW Compliance, *IFAC PapersOnLine 54-16 (2021)* 224–231.

DNVGL-CG-0264, Autonomous and remotely operated ships, Edition September 2018

Dybvik H. E. Veitch, M. Steinert (2020). Exploring challenges with designing and developing shore control centres (SCC) for autonomous ships, International Design Conference – Design 2020. https://doi.org/10.1017/dsd.2020.131

IMO MASS code, https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MSC-106.aspx (Accessed: 04.03.2023).

ISO/IEC/IEEE 15026-2:2011, https://www.iso.org/obp/ui/#iso:std:iso-iec:15026:-2:ed-1:v1:en (Accessed: 30.03.2023)

Lunde-Hanssen L.S. (2020), Identification of information requirements in ROC operations room, IFE/E-2020/007.

Maritime Robotics, https://www.maritimerobotics.com/post/world-s-first-uncrewed-freight-route-at-sea-in-the-trondheimsfjord (Accessed: 26.03.2023).

Peeters, G., G. Yayla, T. Catoor, S. Van Baelen, M. Afzal, C. Christofakis, S. Storms, R. Boonen, P. Slaets (2020). An Inland Shore Control Centre for Monitoring or Controlling Unmanned Inland Cargo Vessels, *J. Mar. Sci. Eng. 2020, 8, 758;* doi:10.3390/jmse8100758.

Porathe, T., J. Prison, Y. Man (2014). Situation awareness in remote control centres for unmanned ships. Human Factors in Ship Design & Operation, 26-27 February 2014.

Ramos, M.A., I.B. Utne, A. Mosleh (2019). Collision avoidance on maritime autonomous surface ships: Operators' tasks and human failure events, *Safety Science 116 (2019) 33-34* https://doi.org/10.1016/j.ssci.2019.02.038

RSV 12-2020. 2020. Guidance in connection with the construction or installation of automated functionality aimed at performing unmanned or partially unmanned operations. Norwegian Maritime Authority

Stones, H. (2017). Safely Navigating the Oceans with Unmanned Ships, Marine Navigation - Proceedings of the International Conference on Marine Navigation and Safety of Sea Transportation, TRANSNAV 2017.

Størkersen K. (2021), Safety management in remotely controlled vessel operations, *Marine Policy 130 (2021) 104349.* https://doi.org/10.1016/j.marpol.2020.104349

Watchkeeping Regulations of 27 April 1999 No. 537. https://www.sdir.no/contentassets/41a09b6ad9fe430c84b037d7a872afaa/27-april-1999-no.-537-watchkeeping-on-passenger-ships-and-cargo-ships.pdf (Accessed: 26.03.2023)

Wennersberg, L.A.L., E.A. Holte (2020), Smartere transport – Møre og Romsdal: L3.1 Landbasert kontrollrom, *SINTEF Ocean RAPPORTNR OC2022 A-047.*

Yoshida, M., E. Shimizu, M. Sugomori, A. Umeda (2020). Regulatory Requirements on the Competence of Remote Operator in Maritime Autonomous Surface Ship: Situation Awareness, Ship Sense and Goal-Based Gap Analysis. *Applied sciences 2020, 10, 8751*