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Western Norway University of Applied Sciences

MASTER'S THESIS

Informal agreements between ships now and in the future

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I confirm that the work is self-prepared and that references/source references to all sources used in the work are provided, cf. Regulation relating to academic studies and examinations at the Western Norway University of Applied Sciences (HVL), § 10.

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Abstract

Over the past hundred years there have been great improvements to regulations at sea, worldwide communication systems, and maritime technology. Today we have the international collision regulations (COLREGs), a working GMDSS system, and the technology to enable ships with unmanned bridges in only a few years. Still, there are points of contention. One example is the issue of ships communicating with each other over the radio. Some argue against making informal agreements, while others see such agreements as an easier and better solution – even though that entails bending of the rules (COLREGs).

The aim of this study has been to explore to what extent the COLREG are disregarded, and how the disregarding eventually is substituted for, with the use of other instruments. It has been of interest to explore situations in the present, but also to explore how OOW´s see situations when looking to the future – if unmanned ships are to be a part of interacting situations.

OOW (officers on watch) have been interviewed about a scenario where the intention was to unpack and understand officer's decision making in interacting situations. Also, observations have been made, during simulated scenarios.

The results from the interviews and the observations are discussed against theory, with a following conclusion. The conclusion shows us that most officers will at times use radio communication during interacting situations with a conventional ship. However, most officers would follow the COLREGs unconditionally if the interacting ship were autonomous.

Sammendrag

Gjennom de siste hundre årene har det vært stor utvikling angående reglementet på havet, kommunikasjonssystem verden over, samt innen maritim teknologi. Vi har i dag sjøveisreglene, vi har et GMDSS system som fungerer, og teknologiene som innen få år skal gjøre det mulig med ubemannede skip. Allikevel finnes det påstander som er av interesse å belyse. Et eksempel er kommunikasjon over radio. Noen er sterkt imot informative avtaler, mens andre mener det å lage avtaler over radioen kan være en bedre løsning – selv om en eventuelt må gå imot sjøveisreglene.

Målet med studiet har vert å utforske i hvilken grad sjøveisreglene er tilsidesatt, og eventuelt erstattet med andre instrumenter – både i nåtid, men også når vi forestiller oss fremtiden, og inkluderer skip med ubemannede broer som en eventuell del av situasjonen.

Gjennom studiet har navigatører blitt intervjuet angående et scenario hvor intensjonen var å forstå navigatørenes avgjørelser i samhandling med andre skip. I tillegg ble det gjennomført observasjoner av simulerte scenario. Dette ble gjort som et supplement, for å veie opp for svakhetene til intervjuene.

Resultatet fra intervjuene og fra observasjonen ble diskutert opp mot teori, med følgende konklusjon. Konklusjonen viser oss at de fleste navigatører tidvis vil bruke radioen for å kommunisere med det samhandlende skipet, i situasjoner hvor det samhandlende skipet er konvensjonelt. Allikevel vil de fleste navigatører velge å følge sjøveisreglene ubetinget hvis samhandlingen skjer med et autonomt ubemannet skip.

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1. Background

This chapter contains an introduction of the thesis theme, the purpose, and the research questions that are to be answered.

1.1. Introduction

According to Coe (1993) the first communication form making it possible to communicate from a distance that was too far to bear a human voice, without sending a messenger, was with the use of fire and smoke. This was, as he describes, used for more than 20 centuries, and old ruins of signal towers from this phase are still to be found around in the world. Different smoke, or several fires in a row could indicate different things. It was especially used to alert each other of danger in time of war. This was only the start of distance communication, which has evolved over the years. (Coe, 1993)

In 1855 the first international code of signals was drafted, containing 70000 signals by the use of eighteen flags. These signals are to some extent still in use in the maritime communication today, and the code was later updated to also contain radiotelegraphy. (IMO, 2005) The electric telegraph was invented in the start of the 19th century, but it was not made for use at sea until the start of the 20th century. This was a big evolvement because it finally opened for a ship-ship and ship-shore communication over a longer distance. (ETHW, 2015) This was the start of the development of radio communication, which is much used at sea, and which has advanced with the rest of the maritime technology over the years. In later years, we have gone from the use of electric magnetic radios, to the use of satellite communication. In 1988 The Global Maritime Distress and Safety System was established by IMO (the international maritime organization). This system is described by IMSO (2019) as “the technical, operational and administrative structure of maritime distress and safety communications worldwide”. It contains rules and regulations about required equipment, about the maintaining of the equipment, the use and a plan for shore-based facilities. This is the communication system we know and use today. To summarize this, we can say that the communication at sea has advanced from the use of

semaphores (flags, lights and signs) when in sight of each other, to the use of Morse code via telegraph, and to what we use today; satellite and radio communication.

There are as mentioned requirements for vessels to carry radio equipment. There are disagreements on whether it is really necessary to use radio communication during a normal day of sailing, with no emergencies or other special circumstances. For example, Śniegocki (2009) argues against the use of radio communication in regular navigational situations. He (Śniegocki, 2009) believe that the COLREGs should be followed unconditionally, and that discussions of possible maneuvers over VHF (especially maneuvers not compliant with the COLREGs) could lead to collisions. He discourage to ever make informal agreements that are not compliant with COLREG.

Conventions for preventing collisions at sea have been at place for hundreds of years (Cockcraft & Lameijer, 2004), but until the mid-19th century there were only local understandings, and they differed between nations. (Werner, 2017) There were until this time no rules of statutory force. (Cockcraft & Lameijer, 2004) In the mid-19th century a lot of accidents was a fact, and in addition to the sailing ships there were now also steamships out there. The steamships did not act as predictably as the sailing ships, as they had the ability to sail in any direction and speed they could and wanted, no matter the wind. This led to a need of common understandings. (Werner, 2017) In 1863 a set of regulations written by the British Board of Trade, and consulted by the French Government, came in to action. These regulations where called articles, and where adopted by more than thirty countries by the end of 1864. This was the start of international collision regulations with statutory force, and in 1889 the very first International Maritime Conference to consider the matter of collision prevention was held. Some of the regulations from the “articles” are still recognizable in the COLREG today, and it was in 1972 the COLREG, which is the collision preventing rules we know today, came in to use. (Cockcroft & Lameijer, 2004)

The development over the years has not only mattered for the radio communication and the collision preventing regulations. In general, there has been a massive development in technology. At this time, the ship Yara Birkeland is being designed and built. She is meant to be the first fully autonomous ship in the world. The goal is to have her fully autonomous by 2022. (Kongsberg maritime, 2019) This will be a considerable technological achievement, and with this and others autonomous ships on its way, there is a lot of research on the matter.

In an article by DNV GL (Vartland, Skjong & St.Clair, 2018) it says: *"The main challenge for implementing fully automated systems controlled by remote operators or by algorithms is not to make them work, but to make them sufficiently safe."* Meaning the systems are to some extent already at place, but are they good enough and reliable enough to operate by its own? Can the technology, with time, outclass humans in total?

Some claim that safety of ships can be dramatically increased with replacing crew with robust technologies for automation and autonomy, while others argue that the efficiency and the success of safe ship handling are improved by the crew attending as a factor. (Vartdal et al., 2018) Vartdal et al. (2018, p. 19) states in their report: *"Clearly, the technologies that enable remote-controlled or autonomous ships change traditional safety considerations, introducing new risks and lessening others."* Further they say that any other solution to what we have today, regards the matter of safety, should be at least as safe or preferably much safer.

Even though the matter of safety is much discussed, it is also necessary to mention the matter of regulations. Today, there are no regulations of statutorily force supporting the operation of unmanned autonomous ships. IMO are working with regulatory developments, but these things take time. (Vartdal et al., 2018) The matter of regulations is an important matter for the implementation of autonomous technology at sea.

With the above-mentioned insecurities regarding the autonomous technology at sea, it is necessary to emphasize that the parts of this thesis regarding autonomous unmanned ships,

contains assumptions. We do not know how the regulations will develop, and there are, as mentioned, still questions about for example safety. Therefore, we can only make assumptions, and imagine how situations with unmanned ship are to unfold.

This thesis will not focus on whether technology can outclass humans, such discussions are left to others. This study will focus on officers' thoughts about handling interacting situations, and with the existing discussions regards the use of communication equipment it will be valuable to know something about how officers themselves actually solve or want to solve these situations. It will be useful to get their views on how they prefer to handle situations today, but also for them to discuss an imagined situation, when collaborating with autonomous ships.

1.2. Purpose and question

The goal and the focus of this study is to gather knowledge about how the persons at scene perceive of and handle situations today, but will also include views about an imagined future situation. We will see if the COLREG are fully implemented, or if informal agreements with the use of radio communication are more preferred? Also, we will get a better understanding of what factors influences the OOW´s (Officers of the watch) decision of how to handle crossing situations. With this, the wish is to answer these questions:

(1) How strong are OOW´s opinion about always following the COLREG?
(2) Do OOW´s believe that they need anything in addition to, or instead of COLREG to feel safe in an interacting situation?
(3) Do OOW´s believe they will manage situations with unmanned, autonomous ships differently than when interacting with conventional ships?

2. Theory

Ships are individual components in a larger system on the ocean. Each ship has different preconditions from others, regards to e.g. personnel, technology, ship specific procedures etc. Even though a ship is an individual component, they will, during a life of sailing go in and out of situations where other ships are present, and where the actions of other ships matter for the outcome of the situation. For controlling situations that involve more than one ship we have the international maritime regulations (IMO-regulations), which are applicable for all ships.

In order to explore the use of communication for coordination, we must understand situations where several ships are involved, and how it may be possible to establish some trust between the involved parties. To frame this study, we are using the theory of joint activity (Klein, Feltovich, Bradshaw and Woods, 2004) and the view on "Work as imagined" and "Work as done". (Potter, 2017) In addition, there are some theory regarding COLREG and communication, as well as some input from the ongoing project HUMANE (https://www.hvl.no/prosjekt/591640/).

2.1. Joint activity

A joint activity is an activity where two or more parties cooperate to reach their goal. In the maritime domain, many parties work together in a joint activity. Since the international maritime regulations (IMO-regulations) are applicable to all ships they are also a part of the joint maritime system. According to Klein et al. (2004) Joint activity has three main parts:

- Criteria for joint activity, where the leading criteria is for all involved parties to intend to work together, and to be mutually depended on each other. All parties included in the activity have to somehow act, a joint activity is depending on all parties to participate. A common goal for the activity will give them all a reason to commit.
- Requirement for joint activity, where the main requirements is interpredictability, and sufficient common ground, in addition to the ability to redirect each other.

- Each party of a joint activity has to bear the ability to predict the others intentions, as well as make their actions predictable for others, this to enable effective coordination. To be able to predict and to make own actions predictable, an important basis is common ground; *"…mutual knowledge, mutual beliefs and mutual assumptions that support independent actions in some joint activity."* (*Klein et at. 2004, p. 9)*
- Klein et al. (2004) actually says that to sustain common ground, and by that enable coordination, is one of the key aspects of joint activity. They further describe the key aspects for common ground: *"… 1) The types of knowledge, beliefs and assumptions that are important for joint activity, including knowledge of roles and functions, standard routines, and so forth; 2) Mechanisms for carrying out the grounding process: to prepare, monitor and sustain, catch and repair breakdowns; 3) The Basic Compact committing the parties in a joint activity to continually inspect and adjust common ground."* (Klein et al., 2004, p. 37)

- Choreography of joint activity, a description of how the joint activity is an overall composite of all the phases and small activities during a situation. *"The choreography of a joint activity centers on the phases of the activity." (Klein et al., 2004, p. 12)* For coordination to work, all parties have to be able to recognize each other's changes, predict the next move, and answer or signalize in a way so that all parties know that you understand each other.

To contextualize the theory of joint activity for the present study, it is set up with some examples related to navigational situations:

- Criteria for joint activity: The IMO-regulations provide a common base for all ships involved in a situation. It gives all involved parties a feeling of intended cooperation. In navigational situations all parties have a goal of preventing danger, this is a common goal, and gives all parties a reason to commit. In a situation between two or more ships, all ships want to stay clear of danger. If two ships are at crossing courses both ships will

probably make adjustments or at least monitor the movements of the other ship, this to make sure not to collide. The wish not to collide is the common goal, and is a good reason to commit to the joint activity and to try to predict the other ship's next move.

- Further we have the Requirement for joint activity, a sufficient common ground, along with interpredictability and the ability to redirect each other. At sea, and in situations between ships, there should be a clear common ground. Again, we have the IMO-regulations, and these lay the foundation for an international common ground between ships. Included in these regulations are e.g. regulations about training (STCW) and hereby a minimum level of knowledge of all crew working on board. The COLREG can be seen as "standard routines" or regulations to support assumptions on the conflicting ships´ intentions. All IMO-regulations work as some kind of a minimum common ground, even though there are varieties in experience of the crew, varieties in the interpretation of the regulations etc.

  Therefore, it is important that if one ship senses an insecurity in the progress of a situation, and comes to believe that the other ship has another plan of the handling of the task than first assumed, there has to be room to redirect each other. Each ship should go in to a situation with a prepared plan on what they intend to do. If their intended action is to alter course the job is not finished when the ship is on its wanted course, it is now necessary to monitor the other ship to make sure they share the same understanding of the situation. If the other ship seems to act differently than your assumption it is necessary to e.g. make radio contact or in other ways get back to a shared common ground.

- The choreography of joint activity is the overall understanding of how to handle a joint activity. With common ground, mutual beliefs and assumptions, and with the fact that all OOW´s have the same basic training and knowledge; there should be a common understanding in how to handle a situation; how to be able to work around and redirect

each other if insecurity in the others intentions accrue; how to read each other's signals. If all ships included in a situation have the intention to solve it together, they have an intention to come out of the situation without danger. They should monitor the other involved ships even though their own part of the situation handling is completed; or be able to communicate or make another course alteration if the situation changes again. This way, they are more likely to follow the choreography, have a joint understanding, and by that get out of the situation without danger.

At sea, it is necessary to have what Klein et al. (2004) calls a basic compact, a confirmation that all participants of the joint activity follow the set rules for the situation (in this case, COLREG). With this basic compact, we rely and trust on the actions of the interacting party. Even so, there may be other individual motives to leave this basic compact, and in such situations, it is necessary to signalize your moves so that the other party can understand the joint coordination. You have to be sure that the other party can understand your signalizing. This is why the common ground alone may not be enough to get out of a situation without risks. If all three above mentioned steps of joint activity are followed, there should be a good possibility to get out of the situation safely, even if the basic compact is breached. This can be done if:

- All parties actively take a part in the situation, and try to understand the other participants' actions.
- You need to be aware that the interacting party of the situation may have another view on the situation then yourself, and therefore it is important to monitor and predict the actions of the interacting party. You have a common ground, but you also have the ability to make your own actions predictable if moving in contradiction to the believed common ground.
- You are signalizing your movements, to make the interacting party aware of your insecurity of the situation to repair breakdown of the joint activity.

2.2. Work as imagined – Work as done

Another way to explain a "joint system" is with Potter´s (2017) view on "Work as imagined" (WAI) and "Work as done" (WAD). The concept is used in a study of resilient health care. Legal compliance work and policy are the WAI perspectives whereas the practical work and the clinical patient activity work are the WAD perspectives. Kellogg and Fairbanks (2018) share Potters´ view on the topic. They talk about shift work-fatigue, they explain the reason for why things often go right in safety-critical studies, but also how this leads the WAD to be different than the WAI: *"Part of the reason things go right as often as they do in complex safety-critical systems (such as emergency medicine) is because the experts who work within the system are able to be flexible and rapidly adaptive. This adaptive behavior is a known property of complex adaptive systems; however, it often results in an innocent drift away from the prescribed processes and policies that is unnoticeable to the frontline caregivers themselves. This results in the common situation in which everyday clinical work (work as really done) has become different from that perceived by leaders."* (Kellogg and Fairbanks, 2018, p. 182)

If to relate this to a navigational situation it is possible to say that since the IMO-regulations are a part of our joint-system, they can be seen as the "WAI". If the IMO-regulations are the "WAI", we now think we know the expected or imagined outcome of all "between ship" situations, just because most ships in the world follows these regulations. However, procedures are then made by the companies for each individual ship; including at least the required technological equipment; conducting of drills and maintaining of minimum knowledge in regards to the crewmember's position of work, etc. All companies have to make ship specific systems (safety management systems) according to the international safety management code (ISM-code). (IMO, 2019) The code specifically says that the safety management system has to be in compliance with mandatory IMO-regulations. (ISM-code, 2013) With this in mind, and the fact that each individual crewmember on board all ships again may interpret the ship specific version of the IMO-regulations in their own way, one understands that it will be a bit more complicated than first assumed.

If applying the "joint system" perspective there should not be any doubt of what would be the Work as Intended, and if two ships are on crossing courses it should be easy to handle. But as seen, it may be more complicated because of the ship specifics and the difference in, for example, experience. The joint activity is the task, and the way each ship performs the task is the Work as Done. One ship may assume that the other ship acts completely in accordance with e.g. the COLREG, because this is the intended system. But the other ship may bear a benefit of some saved time. The OOW may have more experience of the area or from similar situations, and expect the conflicting ship to understand his course alteration, and his expected gain of bending the rules. As Kellogg and Fairbanks (2018) example showed, experts within one specific work group are in familiar situations good at adapting, and make in their own eyes "smarter" and maybe more effective solutions.

There is therefore no guarantee that two ships, with the crewmembers they have at hand, have adapted the system equally even though they share criteria, requirement and choreography of joint activity (Klein, et al., 2004). The WAD therefore comes back to how the WAI is adapted and may differ in situations, depending on how big the risk of the situation is.

2.3. COLREG

As mentioned in the background (see chapter 1.) the collision regulations where made because of a need of common international understandings between ships, to prevent collisions. The COLREG have changed since it first got acknowledged as rules with statutory force, both because of the increasing number of ships over the years, and because of technological changes. The latest changes in the COLREG was amendments from 1987 and 1993, these came in to force in 1995. Major rewritings have not been done since 1972 (Belcher, 2002), hereby the name COLREG 1972.

The COLREGS contains regulations about responsibility, about lookout and safe speed, about head-on and crossing situations, about overtaking, about how to act in narrow channels, about action to avoid collisions and so on. (COLREG, 1972) There is more or less a rule for all imagined

situations. But still, all situations can vary, and to have regulations especially fitted for each specific situation is almost impossible. *"…the one overriding problem associated with prescriptive rules is the fact that no rule can exhaustively specify the conditions of its use."*(Belcher, 2002, p. 214) In COLREG they have tried to solve this problem, by making rules as e.g. rule 2, part A, point (b): *"In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger."* (COLREG, 1972) With this rule they leave it up to OOW´s to interpret each situation, and leave it up to them to decide when a situation is out of control, and when it is ok to act against the regulations to try and maintain control of the situation.

According to Corbet and Thomas (1974) many hoped that VHF as a communication facility would be recognized in the latest collision regulations, COLREG 1972. This did not happen. Stitt (2003) says that there is nothing in SOLAS that gives any authority to make own agreements for collision avoidance maneuvers over VHF, especially if the agreements are not according to the COLREG. Even though there are no clear rules on the use of VHF in the regulations, it is possible also here to make own interpretations. In e.g. rule 7, part B, point (a) it is described how all ships are to use all available means to try and prevent and to determine the risk of collision. (COLREG, 1972) One can by this interpret that radio equipment is one of these means, among others. Meaning you are allowed to use the radio equipment to prevent and determine risks of collisions, also if this includes an action working against other rules in the COLREG.

2.4. Communication at sea

Communication is a much-debated theme in the maritime industry, and are much discussed in accordance with accidents and dangerous "between ships"-situations. Froholdt (2015) says that problems in communication have been one of the key factors to increase severities in big maritime accidents. To have the best possible communication at sea, IMO have designed a collection of standard marine communication phrases (SMCP). These are easy understandable phrases that IMO urges all their member-countries to learn and use. They are especially meant

for use between ships, or ship to shore, in situations where language problems occur or may occur, to try and avoid misunderstandings and misinterpretations. (Sjøfartsdirektoratet, 1999)

Śniegocki (2009) is one of many saying that SMCP together with VHF and AIS among other technological means are good working tools, and have many advantages in different situations, if using them wisely. But, they should not be abused in collision situations, and the COLREG is what is most important, the COLREG should be followed unconditionally. Either way, if the VHF is to be used, it is important to carry out the contact at an early point. This to be sure that there is enough time to take action if necessary. (Śniegocki, 2009)

Froholdt (2015, p. 488) says in her conclusion that: *"…spoken interaction is used to create a joint understanding of institutional practices and information that is both automated and verbally provided. Spoken interaction thus enables the verification, the coordination and exchange of all of the information, automated information systems and technological devices and the elimination of this could hinder the practical realization of the pre-script."*

2.5. Studies on the use of radio communication and COLREG

Even though the chapters above (2.1 and 2.2) intend that signalizing or communication may lead to a wider common ground, there is literature both arguing for, but also against the use of radio communication for handling situations where two (or more) ships are on a collision course.

Belcher (2002) does not directly recommend the use of radio communication over the use of COLREG, but he does dismiss the assertion that the most effective way of managing the risks associated with collision avoidance is by good understanding of each other's mutual, non-communicative understanding of the situation at hand, and the following use of COLREG. Also, to prove his point, he presents a simple situation between two ships, where it should be no problem to follow the COLREGs. After the description, some points are noted, these points are about not needing to prescribe any distance for taking action; not needing any timeframe to take action; to handle this situation, there are no specific dictated actions; and, the collision can

be avoided without the use of any ship to ship radio communication. However, there is a second situation described, where it is pointed out that two COLREGs rules suggest or aim to different actions, in regards to resolving the same situation. He describes in detail what rules that may be used instead of or in addition to the two rules, to be able to find a solution that will not lead to any dangers for any of the involved, and still comply with the rules. The note from this description sounds different: *"From this description it is clear that the certainty and predictability of collision avoidance may be called into question."* (Belcher, 2002, p. 217) It is further stated that the solution described was found after quite some time, and not within minutes, which would be needed to in a real-life situation, if one was to follow the rules.

On the other hand, Stitt (2003, p. 76) concludes in his paper with what can be seen as the opposite of Belcher: *"If there is a risk of collision, under most circumstances, the action to be taken is clear from The rules. Hence the use of VHF should not normally be necessary."* These thoughts are also shared by Śniegocki (2009). In his conclusion, he says: *"All vessels should avoid the use of VHF and unconditionally follow the collision regulations. Discussing possible maneuvers by VHF can lead to collisions, especially these maneuvers which are not compliant with COLREG."* They think that the use of radio communication will work against its intention, and make the situation at hand even more difficult and/or dangerous, than it already is.

2.6. The future of shipping, COLREGS and communication

As mentioned in the background, we can only imagine how regulations and other factors regarding unmanned autonomous ships will work, by using the information we have, from research so far. Today the main risks on board a ship, regarded to safety, are related to failure of components, human errors and systems. For autonomous as well as remote-controlled ships the same risks have to be addressed, but the main risk factors for such ships are believed to be sensors, software and communication. (Vartdal et al., 2018) With this, one can see that the human error is not seen as a main risk anymore, this because humans are not directly at scene.

An ongoing research project, HUMANE (https://www.hvl.no/prosjekt/591640/) held a workshop

on the legal implications of autonomous shipping. When analysing the data, it was found that there was an imagined change in the way ships interact with other. The relationship between human and machine would be different, because the machine would be 'learning' or 'intelligent' – a 'robot'. The COLREGs were written with the assumption that there is a human in the loop, making decisions. Humans collaborate with each other and sometimes agree to circumvent the rules – because it is practical or efficient. The robot is assumed to follow the rules to the letter, and would therefore not be open to negotiation of possible actions. This has an effect on the way a manned would interact with an 'unmanned' ship (or a human with a robot); rules would be followed but efficiency sacrificed. It may even lead to greater traffic complexity, as sometimes a small action in contradiction to the rules can greatly simplify a situation. One participant commented "in a situation with many ships we could end up going in circles" (HUMANE, 2019).

3. Methodology

In the following chapter, there is a presentation of the research methods used for this study. The research methods are discussed, their weaknesses are presented, and the conduct of the data gathering is presented. Also, there is an explanation on how the analysis was conducted.

3.1. Study design

To answer the research questions in this thesis it was decided to use a qualitative research approach. According to Jacobsen (2015), a qualitative approach is good for getting people´s understanding and interpretations of given situations. The qualitative approach has advantages like high relevance, meaning that the interview object is the one to define the "correct" understanding of the matter. With a qualitative approach, you are also able to get a proximity, a close relation to the persons you talk with. This close relation, allows you to get a more relevant and rich understanding of the situation, compared with a quantitative approach. A qualitative approach has more flexibility compared with a quantitative method, you are able to make changes and go back and forth between the data collection, interpretation and theory reading. You do not necessarily have to follow a "set" sequence. (Jacobsen, 2015) The advantage with this is that you can change (or adapt) study design underway; you can go back and gather more data, while proceeding with analyzes on the already collected data.

No matter what method is used, validity and reliability are of importance. The meaning of validity is to provide an answer on the questions asked, and make sure there is coverage in the gathered data to make the conclusions. Also, it is important to be aware of how time may affect the validity of generalization. (Jacobsen, 2015) Reliability say something about the study design, and the necessity of a trustworthy method. We want right and relevant results, and this can be gathered by doing the research in a proper way, and by be aware of the weaknesses with the chosen method.

The methods considered for this thesis was interviews or/and observations. Interviews - because a qualitative interview method gives the opportunity to understand the participants´ experience of situations. Observation method was also considered for this study, because an actual observation explores what people do, and not only what they say they do. (Jacobsen, 2015) It is possible to observe what is done in a situation – observations are the best way to see humans´ behavior and their interaction with the surroundings. (Kvale and Brinkmann, 2017; Jacobsen, 2015)

It was first decided to only do interviews. This was due to the available time, and the fact that when observing officers on watch in the field (on board), you cannot plan beforehand which situations will occur during the time you are there. It could have ended up using a lot of time, without much useful data. Instead it was decided to concentrate on the interviews, and gain information about each individuals' thoughts around a given situation.

The decision to use only interviews was changed when an unexpected opportunity occurred; to participate as an observer in another project. The project was to conduct a ship simulator study with a pre-planned scenario – however, we were also invited to include factors of interest to the present study. This was a valuable opportunity, and it provided a possibility to balance the weaknesses of the interview method.

3.1.1. Interviews, Methodological critique

With this method, you get the chance to enter in to the world of the persons interviewed, and see the situations through their eyes. (Corbin and Strauss, 2008) Individual interviews let you explore the interview objects personal views of a situation.

Interviews are time consuming both to perform and to analyze. The time issue limits the amount of participants, and this can be a disadvantage, because it makes the data harder to generalize. (Jacobsen, 2015) Also, individual interviews capture the attitudes and beliefs of each individual person, but there is not much considerations regarding the social context. Each

person's answers are individual, and there can therefore be issues with the validity if one tries to generalize the results. (Jacobsen, 2015) When analyzing the data some details disappear, because comments are simplified. During this simplifying, it is important to retain the content of what was said by the interviewee, and make sure not to add own opinions. (Jacobsen, 2015)

It is important to plan before starting with the interviews. The plan should include participant selection, interview location and timing, information to the interviewees and recordings.

It was decided to recruit duty officers with varying experience and background. This is the natural choice of interviewees as they have experience of the situations of interest to this study, on a daily basis they use the COLREG and VHF as well as other radio equipment. The number of participants was set to fifteen persons, given the limited time to conduct and analyze the interviews, and factoring in possible travel time to reach the respondents, as suggested by Jacobsen (2015) and Kvale and Brinkmann (2017). Jacobsen (2015) says that for interviews like this, a limit of twenty people is usually enough. On the other hand, Kvale and Brinkmann (2017) says that *"Interview as many persons as is needed to find out what you need to know."* They further say that often the number of persons are either too many or too few. If you do not interview enough, it is difficult to generalize the gathered data, but if you interview to many there is not enough time to perform a deep analysis of the interviews. (Kvale and Brinkmann, 2017)

There are two mains types of interview locations; one natural and one artificial. (Jacobsen, 2015) He (Jacobsen, 2015) further says that the context one conducts the interview in can influence the answers. According to Jacobsen (2015), no context is neutral, and no matter the place there will always be some impact. It is not possible to say that one context is better than the other, but it is necessary to be aware of the possible impact from the environment. An artificial context - not the natural context for where the action relevant to the theme of the interview occurs - may cause artificial answers. On the other hand, conducting an interview in a natural context may lead to disturbances. In the case of this study, the natural place would be

on the bridge, where there may be disturbance like talking on the VHF, phones ringing, alarms going off, navigational situations where full attention is needed etc. The choice of location to conduct the interview is important to consider, because the context of where it is carried out usually impacts the content of the gathered information.

The third issue regards information given to the interviewees, whether the purpose of the interview should be known or unknown to the person being interviewed. Usually it does not matter too much, but if the purpose of the interview might be regarded as sensitive to the person interviewed there are ethical considerations related to this. This is assumed not to be an issue in this study, as participants were informed they would be unidentifiable in any published material.

The next issue is how the interviews should be recorded. By sound recording the interviews there is a risk of making the participant uncomfortable. For some, it does not matter if they are assured that the tape will be treated with care, and kept unavailable to others. (Corbin and Strauss, 2008) There is also a risk that the interviewer loses focus, and gets too relaxed during the interview, thinking that they can listen to everything again on tape later. This is misleading, because it is hard and time consuming to navigate through sound recordings if notes are not taken. There are also negative sides to only taking written notes. It can be, that with only taking notes you bear the risk of losing “the good conversation”. One focuses so much on writing notes that it gives you trouble with keeping eye contact with the interview object. (Jacobsen, 2015)

Finally, it is important to remember that interviews only give us information about how the interview objects think they would have acted, and what they think they would have done. It does not actually show us what they do in a real situation.

3.1.2. Interviews, Construction

It was decided to use a semi-structured face-to-face interview. This decision was taken because it gives the interview object a chance to at times speak freely. This again can provide

information that was not considered important in advance. (Jacobsen, 2015) A semi-structured interview-guide should contain pre-made questions, or at least themes. The point is to use the pre-made questions or themes during the interviews, but without having to follow the guide rigidly, from beginning to end. (Jacobsen, 2015)

The guide was designed to include a scenario, to be shown on a drawing (see Figure 1). The scenario was to be presented twice to each participant, with minor changes in the second. The scenarios included crossing ships, the first with two conventional ships, and the second with a conventional ship and an autonomous ship with an unmanned bridge.

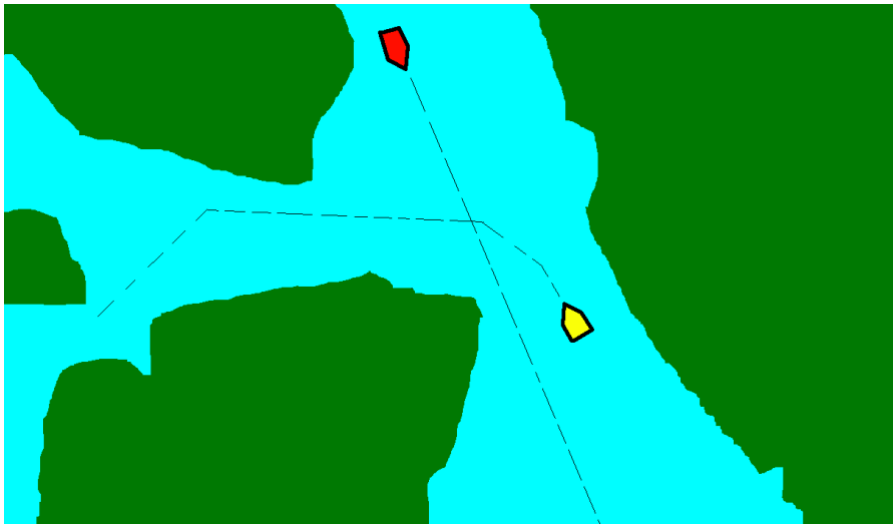

Figure 1 - Chart, interview scenario

The instructions also included information that it was possible to communicate with the ship through a land-station, and that the persons ashore were able to remote-control the autonomous ship. Also, there were instructions regarding the COLREG, and it was pointed out that, in the situation with the unmanned autonomous ship the participant should assume that – the COLREG were updated and working. It was decided to change the order of the scenarios in each interview, to be sure this order did not affect the answers.

Jacobsen´s (2015, p. 155-157) proposal on how to conduct an interview was followed when making the guide, and later when conducting the interview. This included:

- A short introduction, “who am I”, and a short introduction about the purpose of the interview.
- Some preliminary questions, “who are you”, and short about their experience and their current position.
- Listening to the interview object, to let them talk until they have no more to say, then ask the next question.
- Making sure to be an active listener, nod and act affirmative to what is said.
- Taking notes.
- Asking follow up questions. If the interview object is talking about something that is of an extra interest, ask follow-up questions if you want even more information.
- Ending the interview gently. If you feel that you have used to much time, but the interview object is still eager to talk, try and end the interview gently. A way to do this is by e.g. setting a time-limit before you start the interview.

3.1.3. Pilot interview

It was decided to conduct a pilot interview, which has three benefits; experience of interviewing, testing the questions, and ensuring that the interview guide covers the wanted information, and provides the wanted. Dalen (2011) says that it is important for the interviewer to have some experience from interviewing, to get proper results. A person from the maritime industry, with experience as an officer was asked to take part in the pilot interview.

3.1.4. Observations, Methodical critique

There are a number of considerations regarding observations; What can we see, should the observation be hidden, what location is appropriate and the timing.

The main limitation of observation is that we see what humans do, but not what they actually experience or mean. (Jacobsen, 2015) *“Phenomena that are not directly observable, will rarely*

be captured." [1] (Jacobsen, 2015, p. 166) To overcome this, observations can be combined with interviews.

Further there is the question of open or hidden observation. Open observations affect how humans act. Humans have a tendency of changing their behavior when they know they are being observed. To avoid this, it is possible to make the observation hidden. But then you have the ethical consideration to assess (Jacobsen, 2015)

When it comes to the location of the observations you can decide if you want to do it in natural or artificial surroundings. If you are to do it in natural surroundings you have to go to where the event or action is taking place, compared to an artificial context, were the situation is staged. An artificial situation can affect the actions of the persons observed, compared to their actions in natural surroundings. (Jacobsen, 2015) The duration of the observation, will also make a difference on the result. A general rule is that the longer the observation period is, the more valid will the results of the observation be. Even so, we again have to consider the time frame of the project. (Jacobsen, 2015)

3.1.5. Preparing the observation

The observation was to be performed in a ship bridge-simulator. The scenario and plan for the simulation was made by a group of NTNU students in Ålesund. The scenario was constructed to be conducted in the area around Ålesund, and they were in possession of data from the chosen area, to be able to make the scenario realistic. These scenarios included two factors of relevance to this study – the crossing situations in the scenario, and the possibility that the officers would use radio communication.

To prepare their study, the students from Ålesund held a method workshop, to discuss how to gather the wanted data, and how to make sure it was valid and reliable. Since a simulation can be considered an artificial context it was even more important to ensure that the method was

[1] Translated from Norwegian.

valid and reliable (see chapter 3.1.4). It was discussed how the observed officers were to be pre-briefed before the simulation, this was related to the possibility of changed behavior if they knew too much about what data that was wanted. Also, things like how to run the scenario, how many times to run it, how to place the officers, how to observe etc. was discussed.

The participants for the observation were selected by the student in Ålesund, and they were chosen to be officers with 3-6 years experience.

I was invited to join in as an observer at one of the bridges when the actual scenario where to be conducted, in Ålesund. My supervisor was to join as a co-observer. The plan was to gather relevant data from the scenario during the observations, and the entire data set would be available to me to be used for this study.

3.2. Procedure

3.2.1. Conduct of the interview

An interview guide was made, and the plan was followed (see chapter 3.1.2). The guide started with a short presentation of the theme, and some preliminary questions before presentation of the scenario, and at the end a list of possible follow-up questions. (see appendix 9.1) The scenario with the unmanned ship was presented first, every other time, but this seemed to have less impact on the answers than expected. Also, the information about expected frames and regulations considering autonomous ships was included in the guide.

The guide was tested during a pilot interview as planned, and the participant in the pilot interview gave good feedback, including some small changes, but also on how the questions were asked. It was also discussed whether the ethics were ok, especially regarding presentation of the theme of the thesis, to make sure not to misleading the participants.

It was decided to interview maximum of fifteen persons, but a few of the planned interviews never found place. The final number of participants ended up at eleven persons because of busy working days for some of the planned participants, and because of changed sailing route for

others. The eleven interviews that did take place went according to plan, also considering variation in experience and background, where the experience varied from 1-31 years, and with backgrounds from supply, passenger ships, cargo ships, fishing ships etc.

Notes were taken, while the interviewees were speaking, and the plan to not voice record the interviews worked out fine. It appeared that the conversation was balanced, the note taking did not disturb the good conversation, and it was possible to make good written notes while still keeping a good conversation with the participants.

3.2.2. Conduct of the observation

For the conduction of the observation we traveled to Ålesund, where the simulation where to be carried out. They had performed a test run, and a test observation earlier. There were two scenarios made for the same area; further called scenario A and B. Both scenarios ran twice, once with a TSS (Traffic separation system) in the area, and one time without. To prevent the participants from being familiar with the scenario the second time around they had shared the officers in to two groups; further called group 1 and 2. Group 1 conducted scenario A first, then they conducted scenario B with TSS. While group 2 did scenario B first and then they did scenario A with TSS.

The officers were given a very short presentation before starting the simulation. Only brief description was given, and an assurance that personal skills were not being evaluated. The participants were told that further information would be provided after the simulations were finished, and that they at all times were free to change their minds, and leave the research.

Me and my co-observer were two out of four observers on the bridges. There was as earlier mentioned four bridges in use during the simulation, these were all a part of the same scenario, and could at times be at crossing courses. On each bridge, there was a helmsman in addition to the officer, and he was there only to steer after the officers´ command. All bridges had sound recorders, and in addition, one observer was present on each bridge to take notes, and to

remind the officers to at all times “think aloud”. An expert group, invited by the Ålesund group, was observing from the control-room, from where the simulation was controlled.

3.3. Analysis

When the data-gathering is completed, you sit back with a lot of information. All this information somehow has to be sorted to be able to get an overview. Jacobsen (2015, p. 199) have a simple explanation of four stages to analyze qualitative data:

(a) Document

In this stage, the main point is to describe the data gathered throughout the interviews and the observations. It can be good to somehow systematize the information.

(b) Explore

With the descriptions of the gathered data it is possible to see clearer if some information clearly emerges from the “main” descriptions.

(c) Systematize and categorize

During this stage, the point is to reduce the unclear information that always appears in qualitative data. It is possible to make different categories, themes or happening etc.

(d) Bind together

The point of this stage is to compound together contexts from different categories.

These stages were the foundation for the analysis for the data gathered during this project.

3.3.1. Interviews

As earlier mentioned, only written notes were taken during the interviews. The amount of text, after the completion of the interviews was huge, and all notes had to be reviewed. Each interview was reviewed separately, one by one. The descriptions of each participants answers were put in to categories, separated from the other participants by the use of a participant number. By this, it was better systemized, and it was easier to see the eventual counterparts in the participants answers.

When the information was sorted in categories, it was easier to again systemize the descriptions of each category, and each participant. You could clearly see the counterparties of the categories, and also unsystematically comments became much easier discoverable. These categories and the systemizing of each category were again made in to figures, with accompanying descriptions. This was done by analyzing the categories individual, and in groups, by making a context out of what was found

3.3.2. Observation

The analysis of the observations was done by going through written notes taken on the bridges during the scenarios. Notes from the expert group were also reviewed. I did not have direct access to the voice recordings from the simulation, because for ethics reasons they were handled by the NTNU-students in Ålesund. If I had questions regarding the scenario, that were not to be found in the written notes, I asked the students in Ålesund. There is a small possibility that information may have been missed or misunderstood.

When going through the notes, all notes were sorted scenario by scenario, and ship by ship, with and without the TSS. The relevant information for this project was sorted, to get an organized and systemized view of the results. At the end of the result chapter (see chapter 4.), there are a table, followed by some summaries of the listed results.

4. Results

In this chapter, the results from the interviews and from the observation of the simulation are presented. The results from the interviews are presented by the use of figures and text, while the results from the observations are presented with one figure, followed by written explanations.

4.1. Interviews

The results from the interviews are based on answers from eleven OOW´s; two captains, four chief officers and five 2nd officers. Their experience differs from 1-31 years, and there are experience from different trades; Passenger ships, supply, cargo ships, fishing vessels etc. The interviewees are mainly analysed as one group, because they all experience between-ship situations every day at work, when sailing. Even so, it seemed interesting to see if the experience made any difference in the participants answers, this is presented in chapter 4.1.4.

The gathered information was sorted into categories, and the categories presented in figures. The figures have a neutral point in the middle, with opposite opinions on each side. The further from the middle, the stronger the opinion.

4.1.1. The scenarios

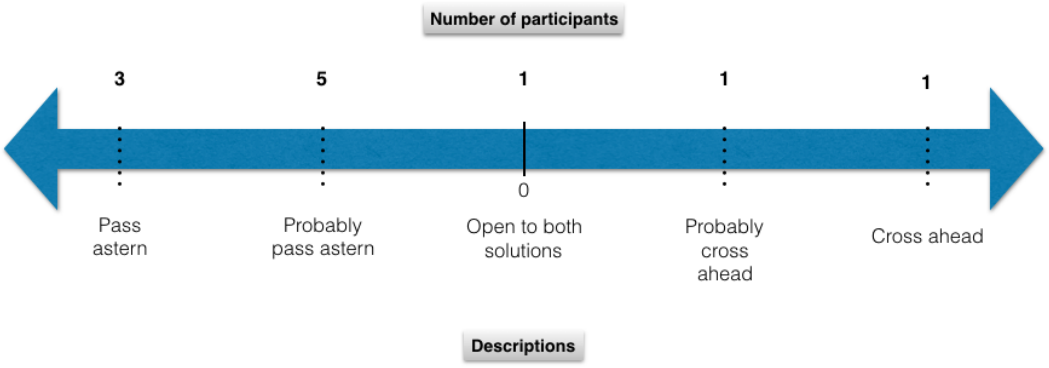

Figure 2 - Conventional ships, pass ahead or astern of the interacting ship.

In figure 2, the results from the scenario with two conventional ships show that seven out of eleven participants are more positive to passing astern of the interacting ship than ahead. Examples of reasons given by the participants on why they would prefer to pass astern of the other ship is that safety matters and a low CPA is risky. A comment from one of the participants was: *"We do not play with these big ships, take the extra minutes if needed."* [1]

The two participants in the middle are open to both solutions. One of these participants gave an answer, and changed the answer within seconds, but the answer felt very honest: *"I would have reduced, and passed astern. Could of course call the other ship on the radio, but for me the language matters. Could have considered making an agreement if the communication was OK. Or, actually, in real life I would maybe just have passed ahead of the other ship. I am not very sure."* [1]

Two participants were positive to crossing ahead of the interacting ship, but both participants would have made radio contact to ask about the crossing before acting. Even though they are positive about crossing ahead of the interacting ship, one of these two participants admit that the best thing usually is to follow the rules.

Figure 3 shows the results of the scenario where the interacting ship was imagined to be an unmanned autonomous ship. It is clear that the participants apply stronger criteria for bending the rules if the interacting ship was to be unmanned, compared to the situation with the conventional ship.

In figure 3 one category is WOULD HAVE CROSSED ASTERN, NO DOUBT, while another said Would have crossed astern. Even though the meaning is the same, it is presented like this to show that some of the participants really underlined their opinion, while others agreed, but reasoned more around their answer first.

[1] Translated from Norwegian.

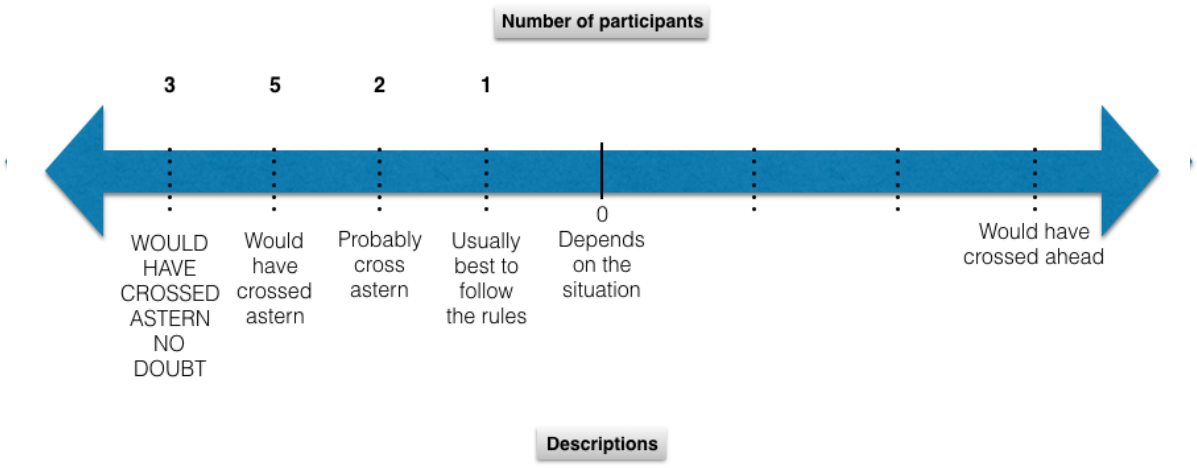

Figure 3 - Autonomous and conventional ship, pass ahead or asternt of the interacting ship.

Trust, communication and visual information are central words used by the participants when they are reasoning, and may explain why the participants are more negative about crossing ahead of the interacting ship in scenario 2 (see Figure 3), compared to scenario 1 (see Figure 2). Two participants are afraid there will be chaos if one person ashore is to handle several ships and possibly several informal agreements at the same time.

Trust is mentioned both in regards to trusting the technology, but also regards to the humans ability to monitor several situations at once. Two participants mention the visual information as a main problem, because they believe that there will be differences between seeing the exact picture out the window and to monitoring a screen picturing the operating area. The participants are negative to communication because they believe that it will take longer to get an answer from a land base, than directly from a ship.

4.1.2. Informal agreements

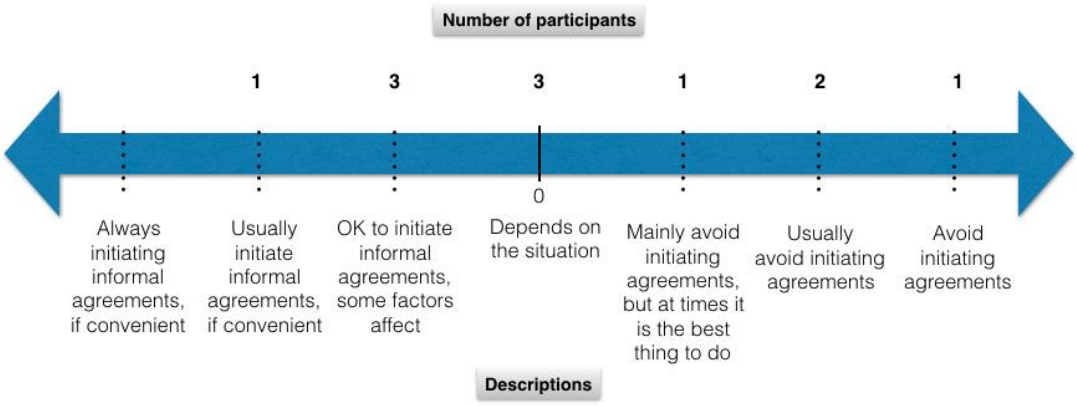

Figure 4 - Would the participants initiate informal agreements?

Figure 4 shows that there is spread opinions from the participants on wanting to initiate informal agreements.

One participant would mainly avoid making informal agreements, although he said that in some situations communication can be a solution to problems that are not possible to solve with the use of the rules.

Another participant said that he would avoid making informal agreements, and believes that there are too much talking on the radio in situations that easily could have been solved by using the rules instead. His perception is to follow the rules, and the situations will solve themselves. He believes that the only time it is necessary to talk on the radio is when to confirm, and not to agree. This belief is shared by one other participant.

On the opposite side, one participant usually initiates informal agreements if it is convenient, as he considers the value of saving time, fuel, environment and money.

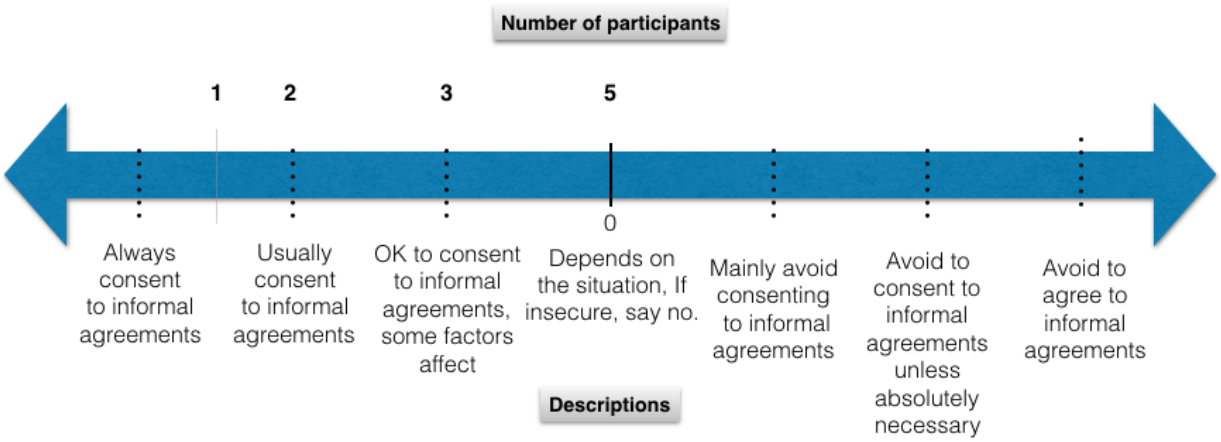

Figure 5 - Would the participants consent to informal agreements?

Figure 5 shows that all participants are positive to consent to informal agreements, and all would at some point say yes to an informal agreement. Some are more positive than others, but none are directly negative.

For the five participants in the middle it was about being sure of the safety of the situation, and the possibility to get out of the situation if something happens. All five participants said that they have to make sure that the suggested manoeuvre is safe, and convenient – not only for the ship asking – but also for themselves before agreeing. The communication factor is about understanding each other. The impact on an eventual later situation is mentioned by one of these five mentioned participants.

Three participants believe it is OK to consent to informal agreements, but said that some factors are of importance for their choice. These factors are communication, CPA, type of trade/ship, speed, and own gain. Although they mention some factors as being important, they never actually said that they would have considered saying no, and the safety matter was not as central in their explanations as with the five earlier mentioned participants.

Furthermore, two participants said they usually consent on informal agreements, and their doubts seem to be mainly related to how expedient the suggested solution was for their own gain.

The last out of the eleven participants is placed in the figure between usually agree and always agree. This is reasoned in the answer: *"If someone first ask, I would often say yes, sometimes even without making a proper evaluation of the situation. It is easy to think that the person initiating the agreement has already considered the dangers of the situation, sometimes I therefore say yes without giving it much thought. But, I know that it is not always the case, therefore I usually say yes, but I try to be better at making my own evaluation first."* [1] His answer was not definite, but the word "often" has been interpreted as being more frequently than "usually", and therefore his response has been placed in-between.

4.1.3. COLREG

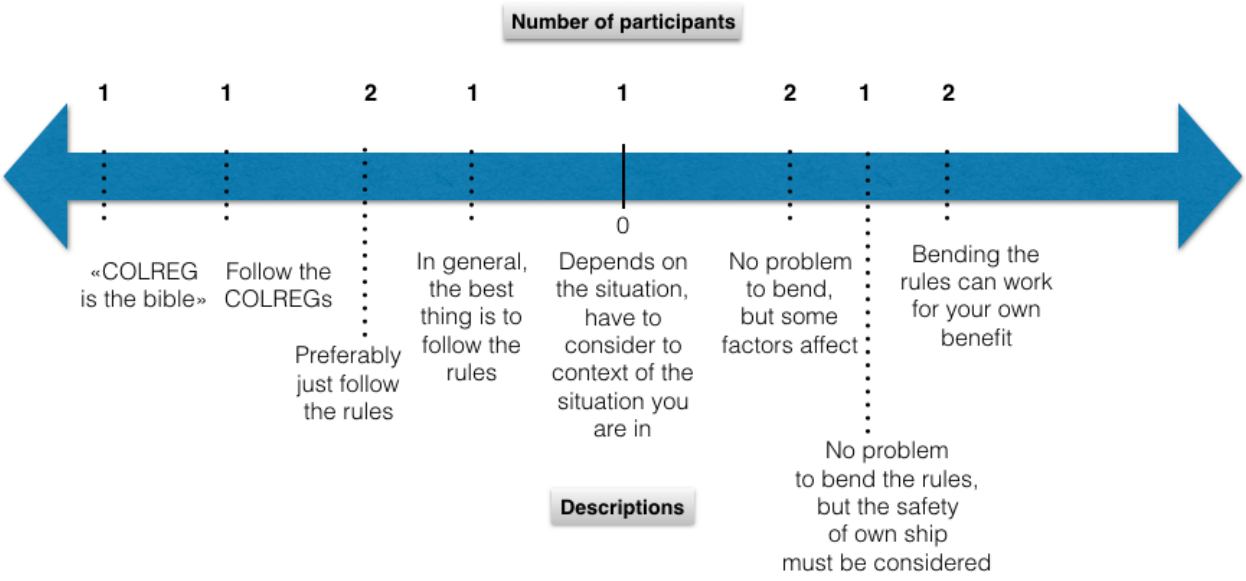

Figure 6 - How strongly do the participants feel about following the COLREG?

[1] Translated from Norwegian.

Two participants placed in the left side of figure 6, describe the COLREG as smart, and together with three more participants they are in general negative to bend the rules. Five participants are placed on the other side of the middle, and here you find comments like: *"As long as there lays an agreement, there is no need for following the rules by word."* [1]

One of the participants who is negative to bending the rules say that the benefit of the rules is that they cannot be interpreted wrong – while one other is fascinated by the use of words, and gives a lot of credit to whom made the COLREG *"Very smart to use phrases like safe speed instead of exact speed, with that the rules are just as useful today as it was earlier, when there was for example only sailing ships."* [1]

4.1.4. Does experience matter?

To decide on who is experienced and who is not, is relative. It is not possible to decide on an exact number of years for such a distinction, with the current data gathered for this project. But it is possible to make some assumptions and discussions about it.

The five most experienced persons have between 5 and 31 years of experience, and an average experience of 14 years (group 5-31). The remaining six persons have between 1 and 3 years of experience, and an average experience of 1,75 years (group 1-3).

If using the same figures as earlier, but grouping the participants answers in accordance with number of years' experience - with group 5-31 or group 1-3, the following picture emerges.

[1] Translated from Norwegian.

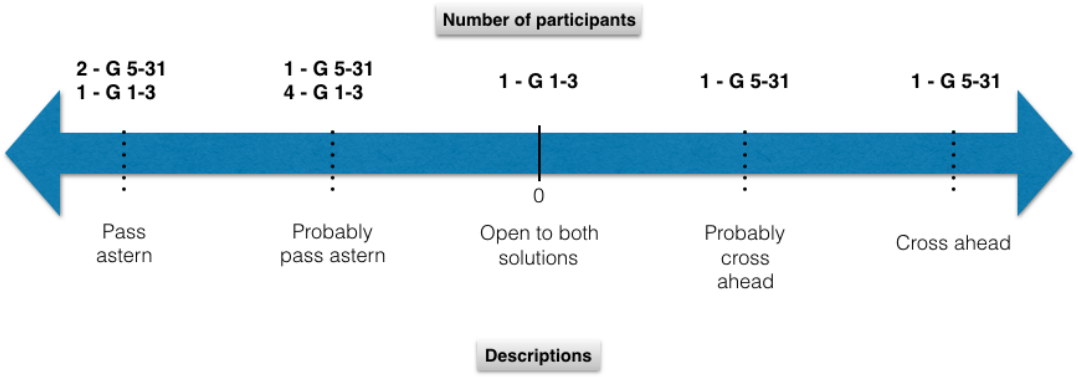

Figure 7 - Conventional ships, pass ahead or astern of the interacting ship, group 5-31 and group 1-3

Figure 7 is one of the figures showing some differences between group 1-3 and group 5-31. You can see that there are only officers from group 5-31 answering that they were positive to cross forward of the interacting ship.

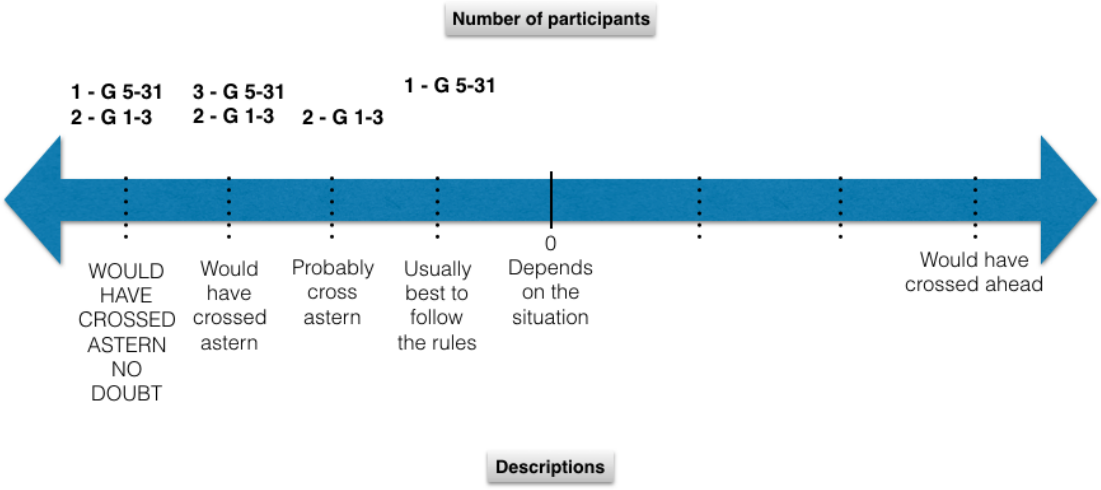

Figure 8 - Autonomous and conventional ship, pass ahead or astern of the interacting ship, group 5-31 and group 1-3

In figure 8, there is little or no difference between the views of group 5-31 and group 1-3, regarding how strong their opinions are about following the rules in situations where interacting with an unmanned autonomous ship.

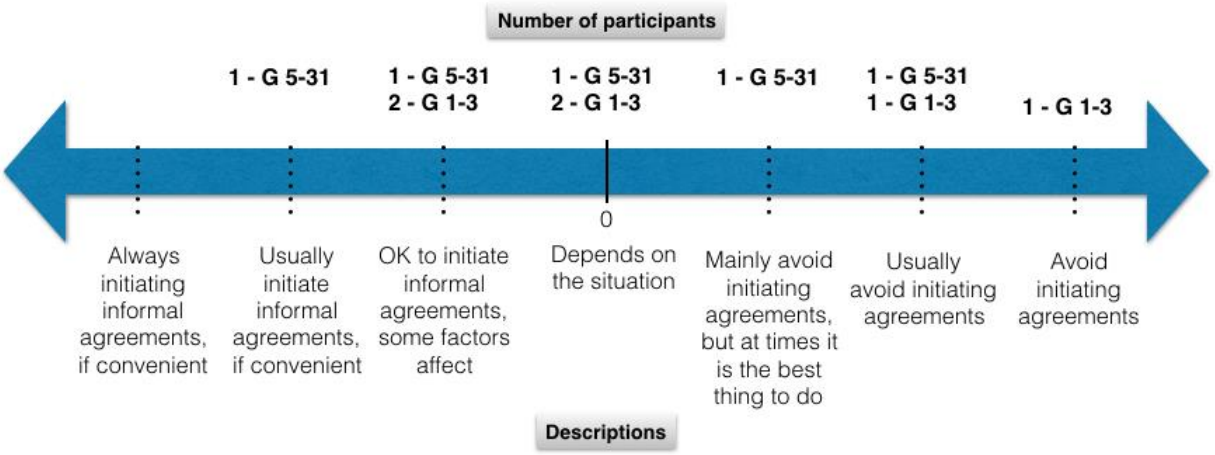

Figure 9 - Would the participants initiate informal agreements? group 5-31 and group 1-3

The experience seems to have a minor effect on the whether the participants would initiate an agreement (Figure 9).

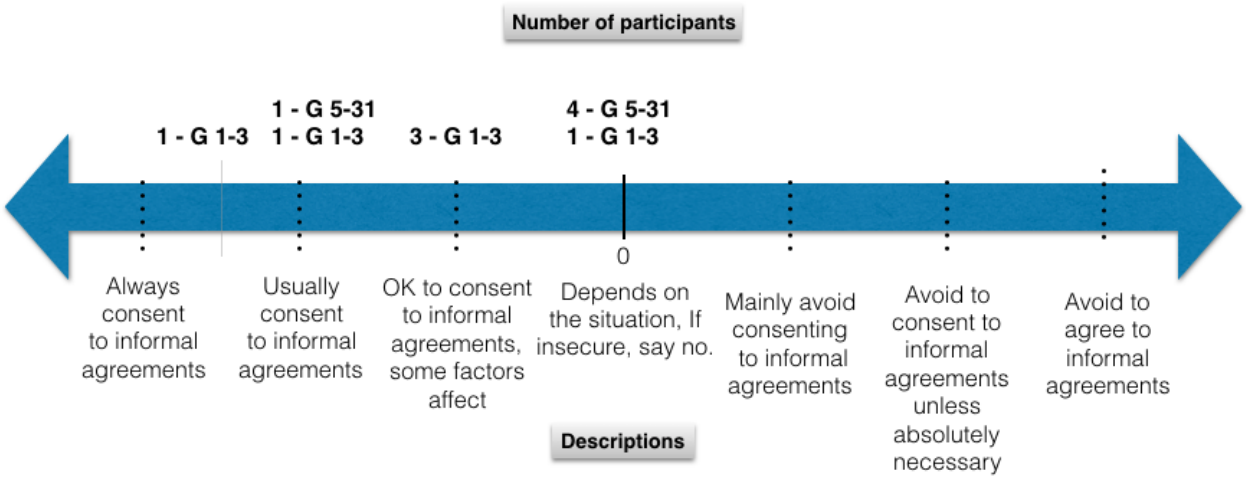

Figure 10 - Would the participants consent to informal agreements? groups 5-31 and group 1-3

By looking at figure 10, and by interpreting the answers shown, one can say that with experience it is more common to say no to informal agreements if you are insecure of the situation at hand. Perhaps it becomes easier?

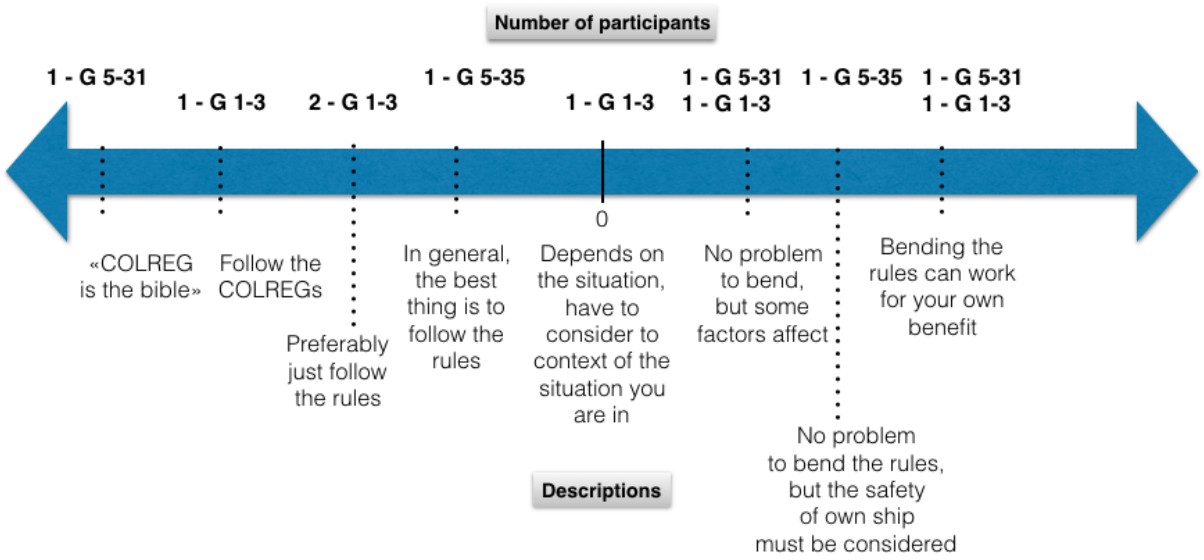

Figure 11 - How strongly do the participants feel about following the COLREG?, group 5-31 and group 1-3

Regarding following the COLREG (Figure 11), there are no large differences between the two groups of experience.

4.2. Observations of simulation

In total eight persons participated in the simulation. They were divided into two groups, with four persons in each, which means four ships were manned in each scenario. All participants participated twice - Group 1 in scenario A without TSS, and in scenario B with TSS; while group 2 participated in scenario A with TSS and in scenario B without TSS.

In addition to these four ships, other targets were added to the scenarios. In scenario 1 these targets were added:

- Fishing vessel (fiskebot on the chart),12 knots, destination: Ålesund

- Pilot boat (Los 1 on the chart), 20 knots, destination: pilot station, Godøy
- Supply 1, 14 knots, Destination: Molde
- Tourist-boat (Turistbat on the chart), 15 knots, destination: Runde
- Bunkers, 11 knots, Hareid
- Yara Ekornes, 10 knots, Ekornes.

And in scenario 2, these targets were added:

- Yara Ekornes, 10 knots, destination: Ålesund
- Kystruten, 18,2 knots, destination: Ålesund
- Ferry 3 (Ferge 3 on the chart), 19 knots, destination: Sulesund, start-time 10 minutes after ferry 1 from same destination as ferry 1.
- Supply 1, 13 knots, destination: Molde
- Supply 2, 13 knots, destination: Bergen
- Container, 14 knots, destination: Florø

The results from the observation have been sorted, and the results are listed in the table placed under. Here, possible number of interactions per ship is listed, the details of their conversations, and the number of how many conversations each ship was a part of, in total. After the tablet, following explanations are stated scenario by scenario, with a summary at the end. Attached (see appendix 9.3 and 9.4) are one chart of each scenario, showing the starting position of all ships, and the area they are operating in.

Scenario - ship	Possible interaction	Ask for clarification	Info given	Info gathered	Initiates informal agreement	Agrees to informal agreement	Total radio activity
A-1	3	2	1				3
A-2	4		1				1
A-3	3		1				1
A-4	4	2		1			3
A-TSS-1	2						0

A-TSS-2	3	1				1	2
A-TSS-3	2	2					2
A-TSS-4	4		3		1		4
B-TSS-1	1	1					1
B-TSS-2	3						0
B-TSS-3	1						0
B-TSS-4	3						0
B-1	1				1		1
B-2	4	1			1		2
B-3	2						0
B-4	3						0

Figure 12: Number of ship-ship interactions and frequency of radio communication in simulation

From the diagram, one can see that all ships have the possibility to end up in interaction situations with at least one ship, and during these situations there are variations in their radio use.

Scenario A:

In this scenario, the radio was used by all participants, there were none agreements in contradiction to the rules, but all ships made informal conversations or clarifying conversations. In total, there were eight situations with total radio activity, out of fourteen possible situations.

Scenario A – With TSS:

One out of four participants did not use the radio at all, three participants made clarifying conversations, and one of these three participants also wished to perform an action in contradiction to the rules. There were eight situations with radio activity, out of eleven possible interactions.

The participant that did not use the radio only used the rules when handling interactional situations. The participant asking to bend the rules was met with an agreement of the interacting vessel who was also one of the participants.

Scenario B – With TSS:

Three out of four participants did not use the radio in this scenario. One participant used the radio, and that was for clarification

The ship that made the clarification was in an overtaking position, he wanted to know the other ships plan to better decide on the safest way to overtake.

There was in this scenario one situation with radio activity, out of eight possible interactions.

Scenario B:

Two out of four participants in this scenario did not use the radio. One out of four participants made calls to clarify the situations in addition to initiating an informal agreement, and the last participant initiated an informal agreement.

Both participants initiating an informal agreement, initiated agreements in contradiction to COLREG, and they both went ahead with it. The agreement was not with other participants, but with two of the additional targets. All together there were three situations with radio activity, out of ten possible interacting situations.

Summary:

If adding the ships together that ends up with a total of sixteen ships. Six out of sixteen did not use the radio at all, nine out of sixteen were involved in clarifying conversations, while two of these, in addition to a third and last person, initiated informal agreements in contradiction to the rules. Also, if adding all the possible situations together, and all the situations with radio activity together, we end up with a total radio use in twenty situations out of forty-three possible situations. This means that radio is used in almost 50% of all possible situations during the observed scenarios.

Even though it is not possible to generalize this it is interesting to note that more than 50% of the participants in this observation need, at times, something to clarify situations in addition to the rules. Also, more than 10% decide to act in contradiction to the rules, while just under 40% manage the situations by using the COLREGs.

5. Discussion

In the discussion, the presented results (see chapter 4.) are discussed against the presented theory (see chapter 2.). This discussion is the foundation for the following conclusion (see chapter 6.)

5.1. COLREG alone, or COLREG and communication?

Both the theory and the results from the interviews and the observations shows that there are many different meanings on how between-ship situations best can be handled.

From the observation results, one can see that nine out of sixteen participants participated in clarifying conversations. In the interviews, even the two participants who were most negative to using communication in addition to the COLREG commented that they would use communication, but only to clarify situations. Therefore, it seems like all interviewees would be open for this kind of communication. With all interviewees open to such conversations, and with more than 50% of the observed participants actually performing such conversations, it appears that the COLREG in itself is not enough to make the participants feel safe in situations of close encounters. There is a need for a supplement – possibly an extra clarification in addition to the COLREG.

The need for an adjustment seems even more needed when looking at how many participants actually "bend" or act in contradiction to the rules. Here, five out of eleven of the interviewees are positive to making agreements in contradiction to the rules. Four out of eleven participants were positive to initiating to such agreements, while all participants agree they would bend the rules at times. Also, the observations to some extent support these results, when more than 10% of the observed participants made agreements where they were bending the rules. One of the interviewees even said, despite his preference of following the rules, that communication can at times be a solution to problems that the rules cannot solve.

This observation was done of scenarios where there were no more than ten ships included in each scenario, in addition to three or four leisure craft. It is striking that even in a scenario this limited, that so many participants feel the need for something to support their decisions in addition to the rules stated in COLREG. If comparing to some of the worlds most trafficked areas, is there then not a reason to believe that in e.g. the Strait of Dover, one of the busiest seaways in the world (Pas-de-Calais le Département, 2019) the need will be even larger? These results cannot be generalized, but it is possible to make some thoughts around it.

Even though many do perform clarifying conversations, there are also participants who really value the COLREG, and this has to be considered as well. During the interviews, five out of eleven participants were more negative than positive to bending the rules. One participant is neutral, and says that the context of the situation matters. As mentioned in the results (see chapter 4.) two participants speak very highly of the COLREGs, they describe it as smart, and one of them terms COLREG as the bible, while the other say that the rules are very clear, and hard to interpret wrong. Also, in the observation, about 40% do get through situations by only using the COLREG, which indicates it may be possible to get through all interacting situations without the need of radio communication.

As presented in Stitt (2003) and Śniegocki (2009) there is strong support for the unconditional use of COLREG, and a belief that communication actually can work against its intention. Even so, Śniegocki (2009) admits that VHF can be a good working tool, but not a tool to abuse in collision situations. Froholdt (2015) on the other hand, is at the opinion that communication can help to create a joint understanding of situations.

The theory of joint activity (Klein, et al., 2004) describe how joint understanding enable us to predict each other's activities in a situation, and by that sustain common ground. This common ground is, as earlier explained (see chapter 2.1.) to some extent in place between ships, because of the overlap in knowledge and the assumption that they follow the same set of rules. However, in a joint activity it is also important to catch and repair breakdowns if the situation

does not act out as expected, and the common ground is lost. So, why is this common ground at times lost? Why does not everyone just follow the rules, and thereby stay in the joint system?

By relating "Work as imagined" and "Work as done" to a navigational situation (see chapter 2.), it has already been explained how the IMO-regulation may not be enough to know the exact outcome of all situations. If that is the case, there is a need to repair the breakdown. With this theory, together with the earlier presented data, it is possible to argue that officers see radio communication as a good tool to retain such common ground, and by that repair breakdowns to be able to get out of interacting situations without danger.

Language and the understanding of each other is also a factor mentioned by the participants as important if to make informal agreements. Even though Froholdt (2015) says that difficulties regarding language and communication has been one of the key factors that have increased severities in big maritime accidents, she concludes that spoken interaction crate joint understanding, and verification, and that to take this away could hinder the practical realization. Together with the presented data for this study, its seems likely that between-ship voice-communication in addition to the COLREG can have some positive impact. The factors of e.g. different language, making this kind of communication prone to misunderstandings, can be resolved with the use of the earlier mentioned standard maritime communication phrases. (see chapter 2.4.), so is this really a problem? Since there are no results in this study saying anything about the use of these standard maritime communication phrases, there is nothing to show that these phrases actually reduce the insecurity of the situation, regarding the language.

5.2. Will unmanned ships change situation-handling between ships?

In the situation presented during the interviews, there were no interviewees positive to crossing ahead of an unmanned autonomous ship, this compared to the situation with two conventional ships, where two participants were positive to cross ahead of the interacting ship, together with two neutral participants – open to both solutions. So why is this?

As mentioned earlier (see chapter 4.1.1.), trust (in both humans and technology), communication and visual information are reasons the participants provide when explaining why they are more negative to the crossing now than earlier. And again, we can explain this with the theory of joint activity (see chapter 2.1.).

Common ground is as mentioned an important part of joint activity, and some of the key aspects for common ground is knowledge, beliefs and assumptions. Further, it is necessary to prepare, monitor and sustain, catch and repair breakdowns, and continually inspect and adjust common ground.

The problem for the participants when the interacting ship was an unmanned-autonomous ship, was that they were unsure whether their signal would be responded to by the persons ashore, and therefore they were unsure whether it was a good idea to leave the basic compact. (see chapter 2.1.) They were unsure what would happen to the monitoring of the situation if they were to leave the basic compact. They were afraid that that the operators at the land-station would not see the exact situation as they do, because of the difference in availability of visual information. The participants also doubted that it would be possible for one person to monitor and manage one specific situation with full attention, if his job is to monitor several ships. They are afraid that if communication is needed, this will be more time consuming, compared to today, since they would not be able to speak with the ship directly. Therefore, they fear that it is not possible, due to a lack of time or other reasons, to repair the eventual breakdown of the situation when working in contradiction to the rules – away from the basic compact.

Compared to the situation with two conventional ships, it now seemed like there was no problem for the officers to follow the COLREG unconditionally, but why? Again, looking at the Joint activity (see chapter 2.1.) it is possible to argue that the common ground and the basic compact are of more importance than in a situation where the interacting ship is conventional. Officers now rely more on the basic compact to be followed, compared to the other phases of joint activity. One can argue that this is due to the absence of direct contact with humans in the

unmanned ship situation. The autonomous unmanned ship in this situation is assumed to be acting with preset functions, and thus does not have a human's ability to adapt to the situation. (see chapter 2.2.)

The OOW´s now believe that following the rules is the better choice – to keep the basic compact, instead of having to manage the situation by addressing the subsequent steps of joint activity; to monitor the situation, or to repair eventual breakdowns.

The data from the HUMANE project, and their following analysis, can provide support regards the changed interaction between conventional ships compared to situations with conventional and unmanned ships. As said in the theory chapter (See 2.6.), humans sometimes agree about working in contradiction to the rules, because this is more effective or for some reason more convenient. Robots, or in our case unmanned autonomous ships, are assumed to follow the rules, and will therefore not negotiate, or make other actions in contradiction to the rules. One can with this argue that an unmanned autonomous ship is more likely to follow the basic compact. However, what will happen if everyone follows the rules unconditionally? Will this actually be a good thing? Will it actually give us a better traffic flow at sea? and will it be safer, than at times act in contradiction to the rules?

6. Conclusion

The goal for this project was to get a better understanding of OOW´s thoughts about interacting situations regards to the use of COLREG, these were the questioned asked:

(1) How strongly do OOW´s feel about following the COLREG?
(2) Do OOW´s feel that they need anything in addition to, or instead of COLREG to feel safe in an interacting situation?
(3) Do OOW´s believe they will manage situations with unmanned, autonomous ships as differently than when interacting with conventional ships?

To conclude, the following points are worth remarking:

- Five out of eleven interviewees were positive to making agreements in contradiction to the rules. Four out of eleven participants were positive to initiate to such agreements, while all participants agree they would bend the rules at times.
- More than 50% of the participants from the observation need, at times, something in addition to the rules, to clarify situations.
- More than 10% of the participants from the observation decided to act in contradiction to the rules.
- Less than 40% of the participants in the observation manage the situations with only using COLREG.
- All interviewees appear to be open to take part in clarifying or informal conversations, even though it is not necessarily in contradiction to the rules.
- No interviewees were positive to crossing ahead of an unmanned autonomous ship.
- The officers seem to rely more on the unmanned ships following the rules and keep the basic compact. For the officers, this seems more predictable than the autonomous ships ability to repair eventual breakdowns that could emerge, if acting in contradiction to the COLREGs. This is supported by the analysis from the ongoing project HUMANE; an

autonomous ship is more reliable to follow the basic compact, compared to a conventional ship.

On the basis of these points it is possible to conclude that:

Even though some participants are negative to bending the COLREGs, all participants are to some extent open to the possibility of acting in contradiction to the rules. The OOW´s are not 100% comitted to the use of the rules.

It appears that in interactions between conventional ships, officers see radio communication as a good tool to retain common ground, if needed, and by that repair breakdowns to be able to get out of interacting situations without danger. Even so, almost 40% of the participants, in the observation done for this project, managed to get through situations without radio communication. Situations can be handled without the use of radio communication, but it is concluded that it will be a good tool as an aid to prevent dangerous situations.

Officers believe that they will not be able to rely on unmanned autonomous ships to repair eventual breakdowns of the common ground, and that the basic compact is more likely to be kept by an unmanned autonomous ship. Officers therefore believe they will be more consistence in following the COLREG if in an interacting situation with such ships. This may not be all positive?

7. Further work

In this project, the focus has been how officers act in given interacting situations, and communication and COLREG have been central themes throughout the thesis. Some points on suggestions for further work can be:

- Include other instruments, if they in any way affect the radio use, or/and the way COLREG is used.
- Perform a wider study, including several nationalities, to get a better understanding of how much language affects decisions in interacting situations.
- Study the time-frame of a situation, and at what time OOW´s seems to pick up the radio when it is used. Is it early in a situation – or is the radio used as a last try to avoid danger?
- Also, the autonomous development and impact on collaboration should be continuously followed up.

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9. Appendices

9.1. Interview guide

9.2. Consent form

9.3. Chart scenario 1

9.4. Chart scenario 2

9.1. Appendix I – Interview guide

Interview guide

SHORT PRESENTATION OF THE PROJECT:

With this interview, I mainly wish to know something about the communication collaboration between ships today, and OOW´s (Officer of the watch) thoughts about how to handle a given situation. But, the industry is changing, and a new vehicle is on its way in to the shipping industry, namely autonomous ships. Because of this, I will also like to know how you believe the situations will change regards to a changed industry. I will present one scenario where conventional ships interact and one where an autonomous ship is included. Your task will be to answer how you would prefer to handle the given situations, followed by some questions after.

Information about you:

1. What is your current position in the company?; How long have you been in this position?
2. How many years' experience do you have as an officer?
3. Can you shortly tell me a bit about your experience, have you been in different trades, which one?

Presentation of the situation, Conventional ships:

In the chart given to you, there are two ships, you are on watch on board the ship marked with a yellow rout. If you continue like this you will pass in front of the red one with a CPA on approximately 0,10 NM.

Describe, and feel free to draw in the chart how you would like to handle this situation. You have all equipment available.

Presentation of the situation, Autonomous ships (every second time make the autonomous question the first question):
We have the same situation as before, but this time the vessel with the red rout is unmanned, and do not have any persons on the bridge.

It is possible to use the COLREGs, necessary changes are made, it works.

Since there are no people at the bridge we assume that any communication would go through a land base station, where the ship is monitored. The land base is able to remote control the ship from shore.

How do you want to handle the situation now? Explain.

Describe, and feel free to draw in the chart how you would like to handle this situation. Again, you have all bridge equipment available. (radar, AIS, radio etc.)

Possible follow-up questions

You say you would have tried to make an agreement over the radio, can you tell me more about why you would solve the situation this way?; What is the benefits of solving it this way? Is there any disadvantages?

Are there other possible ways that this situation could have been solved, can you explain?; Can you explain what you see as the advantages and disadvantages with the different solutions of this situation?

How do you think a beginner would have solved this situation? Can you explain why?

Do you think one with more experience than yourself would have solved the situation differently? Can you explain why?

Do you have any criteria's for agreeing or initiating on an informal understanding, can you explain? (who is the person in the other end; Land base, what trade, nationality etc.)

Explain why you don't see the handling of the situation as different now.

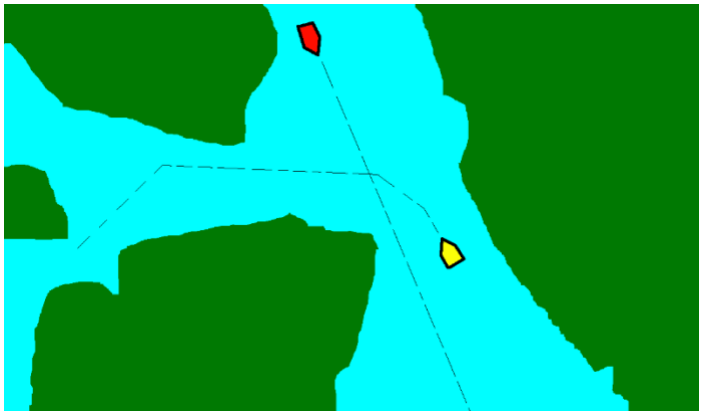
Explain why you now find the situation as different than before, and why you want to handle it otherwise.

Can you explain why you think this way of handling the situation is the best way in both situations?

Do you have anything to ad?

Did you think I was going to ask something else?

THANK YOU FOR YOUR TIME!



9.2. Appendix II – Consent form

Consent form

I, Trude Jacobsen, is a master student and studies Maritime Operations at the Western Norway University of Applied Sciences. In my thesis I want to illuminate officers of the watch´s actions in given situations where their ship interact with other ships. Communication is a key word. I mainly wish to know something about today's situation, but will also present a situation where one ship is unmanned/autonomous.

To gather the mentioned data needed for my thesis, I wish to interview you as a mate/captain, or earlier mate/captain. The selection of interview objects is chosen based on variety in age, variety in background and experience. I plan to interview between 10-15 persons in total. I will during the interview not collect any form for personal information about you, there will be no sound recording, nor any video recording. I will only be taking notes. All gathered information will be treated anonymously, and none of the data used in my thesis can be tracked back to you as an individual. Also, I do not want you to consent on this form by the use of a signature, because also that is seen as personal information. You can consent to this interview by ticking of the box at the end of this form; "the form is read and understood, I consent to participate in this interview." Instead of using your name, each interview object will get their own number, it will be typed in at the end of this form.

It is voluntary to participate on this project, and you as a interview object have the ability to reconsider, and withdraw the consent at any time. All the data gathered from you will then be removed from the thesis. Such a decision will not have any negative consequences for you, either you chose not to participate from the beginning, or chose to withdraw at a later time.

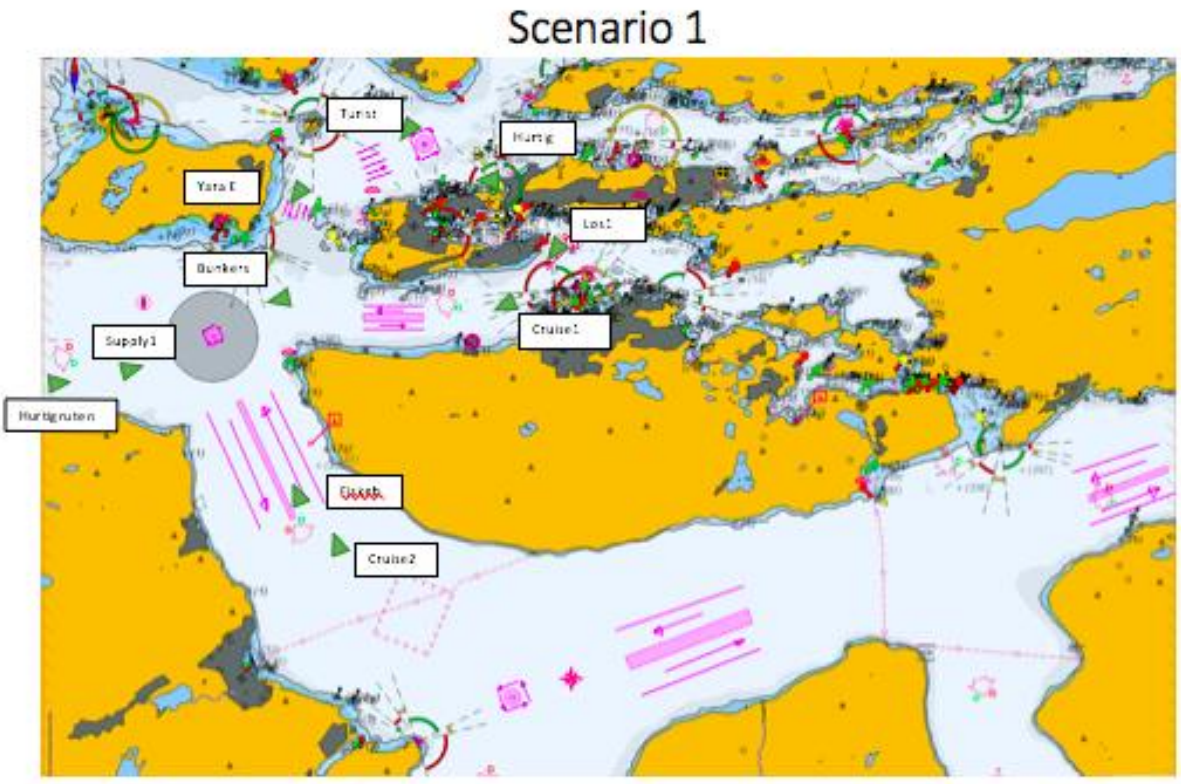
Thank you for taking your time!

The form is read and understood,

I consent to participate in this interview. ☐

Interview object number.: Date:

9.3. Appendix III – Chart scenario 1



9.4. Appendix IIII – Chart scenario 2