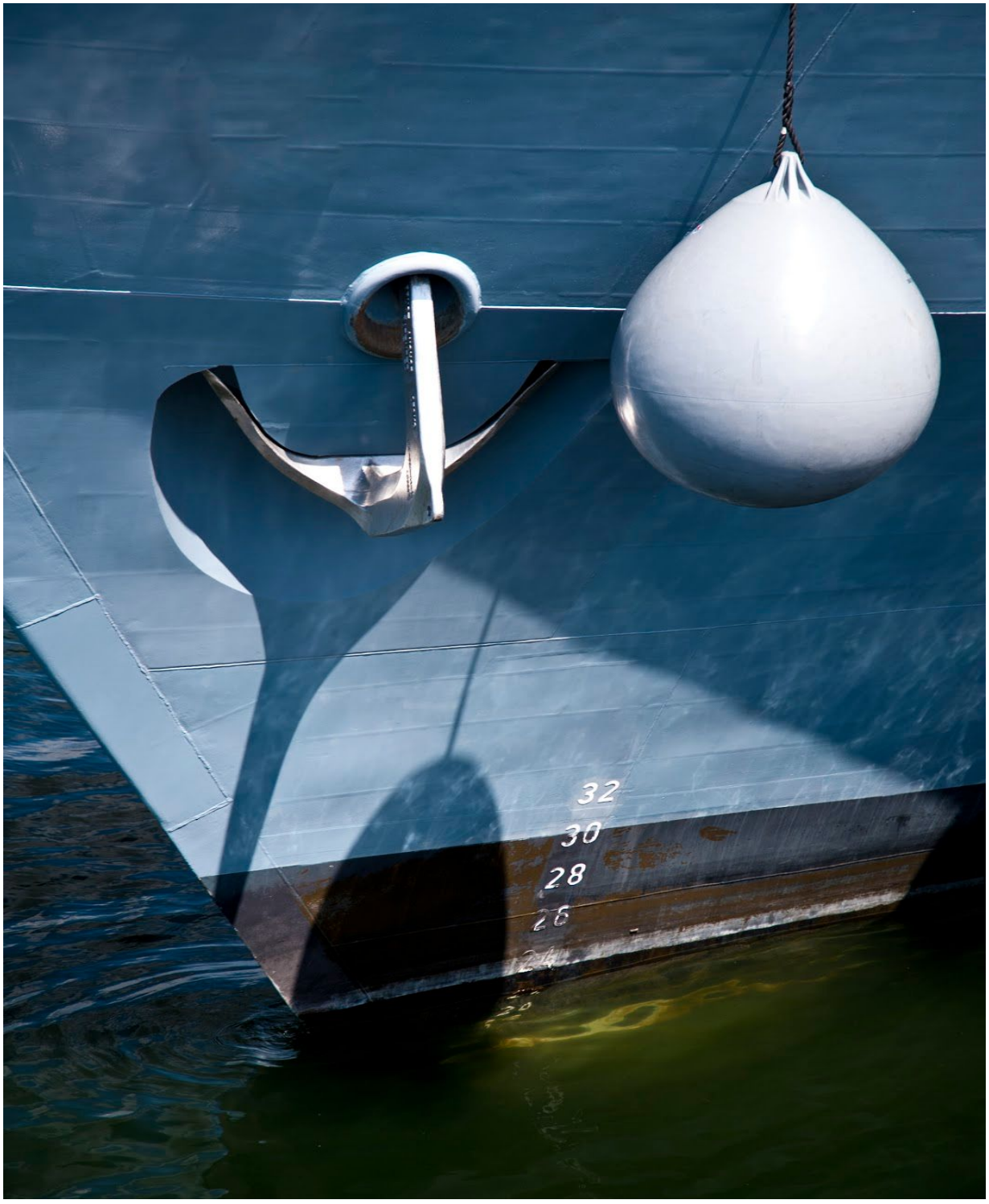

Autonomous Ships

A Techno-Anthropological study of automated vessels

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Abstract

Dette projekt undersøger udviklingen af autonome skibe i Danmark, og udforsker hvad mener nogle potentielle passagerer om sikkerhed. Ydermere prøver projektet at undersøge om, hvis en rationel adfærd kan opnås, og gennem hvilke procedurer denne adfærd kan fremmes i en nødsituation ombord på et selvstændigt fartøj. Hele projekt er baseret på kvalitativ forskning gennem semi-strukturerede interviews. Gennem brug af Actor-Network Theory (ANT) er identifikationen af de forskellige aktører, der er involveret i denne udvikling, mulig, såvel som deres forskellige perspektiver og udtrykte meninger om emnet. Derudover forsøger jeg gennem brugen af Post-ANT at udforske og analysere de forskellige realiteter, som er dannede af de forskellige aktorer vedrørende autonome skibe.

Acknowledgment

I would like to express my sincere gratitude to my supervisor Lars Botin for the advice throughout the thesis. - Thank you for the inspiration.

This master thesis could not have been done without help from people who were willing to share their knowledge and opinions.Thus, I would like to express my gratitude and thanks, to Carsten Møller, Anders Dragsted, Thomas Koester, Jesper Ejdorf Brøsted, Jacob Munk Plum, Mogens Heidtmann and Morten Glamsø, for your time, understanding and patience.

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Introduction

Autonomous vehicles are by this time state-of-the-art in many land based public transportations. There are commonly known examples of self-driving vehicles, and automated railways, including the Metro service in Copenhagen. Although *"fully automatic dynamically positioned vessels became common in the offshore industry in the 1970´s"* (Ahvenjärvi 2016), the development of autonomous ships has been recently a big subject of discussion within the maritime industry.

Automated ships are the next generation of vessels in the maritime sector, which would be able to operate with limited or no crew on board. They would be controlled and monitored by offshore professionals through sensors, detectors, cameras, and satellite systems, ensuring the proper function of ships. Autonomous ships are expected to be more advanced, more profitable and safer that traditionally ships.

Before this master thesis become an idea, there were whispers about this innovative development. Whispers claiming that soon there will be a set of rules covering the approval of such vessels. This was happening while another similar project was prepared. Autonomous ships seemed to have come to Denmark and their development was something that Danish Maritime industry was very interested in. This is also what initiated the interest in this particular thesis.

Autonomous ships are perceived as a new technology in its infant stages of development and implementation in Denmark. Hence, the inspiration for this thesis partially came from the controversy definition presented through Venturini's work *'Diving in magma: how to explore controversies with actor-network theory',* which states that *"(...)every bit of science and technology which is not yet stabilized, closed or "black*

boxed" (...) we use it as a general term to describe shared uncertainty. (Macospol, 2007: 6, emphasis in original) (Venturini 2009).

Therefore one of the aims of this thesis is to identify the different actors and their workings and manipulations in the networks shaped through this development. Since autonomous ships are a new innovative development there are a lot of issues that need to be addressed in order for existing problems to be solved and this endeavor to be stabilized.

This thesis attempts to investigate the existence of different perspectives around safety on board automated vessels, since this covers a big part of the development when it comes to autonomous passenger vessels, and the acceptance of people is something that will probably trouble the maritime industry if not addressed properly.

Furthermore, in this thesis an attempt is made to understand if a rational behavior can be achieved on board an autonomous ship during an emergency situation. Given the fact that passenger automated ships may operate with limited or no crew at all, then the question whether it's possible to promote a rational and intuitive behavior for the passengers, is rising. The analysis of the thesis is based on data collected during a five months research, along with data and information collected through multi-sited ethnography and it will be presented later on in this report.

Background knowledge

A justification for a thesis with such content is essential. An explanation why this subject is interesting and some general facts about the field under study will be presented here.

During previous projects I have dealt with the concept of safety within different contents. During one of those projects, which was made in collaboration with the Danish Institute for fire and security technology, from now on DBI, I came across the common view that the shipping and maritime industry are being conservative and reluctant to changes - even more to changes like autonomous ships. The aim of that intern project was to investigate how the implementation of battery propulsion as an alternative way of power for maritime vessels, affects the users' perspectives about their own safety. Based on the fact that battery propulsion is relatively new technology, and therefore there are no prescriptive rules for its approval, at least during that time, the results regarding safety and the adaptation of users was really interesting. That created the interest for autonomous ships and the safety perceptions around this development. The collaboration with DBI continued and the subject for this master thesis was initiated.

At this moment, DBI is working on the *'FIRST'* project in collaboration with *Rederiet Færgen.* Færgen is designing a ferry that will perform routes from Esbjerg to Fanø island, and this ferry would be case map for this thesis, in the way that the thesis would be shaped by this ferry to create the relative fieldwork.
Therefore , this thesis is done in collaboration with DBI with ultimate goal to create knowledge that could be used in the initial DBI project.

Delimitation

This thesis is based on interactions with just a small part of actors related to the maritime sector. This implies that not a complete overview of the entire field is made. The actors were chosen in regards to their involvement and expertise on the autonomous ships development, although a numerous others could have been participated in the research.

In this project the focus is on national level for practical reasons. A more detailed research can be done in a European level, by expanding the study within countries like Sweden, Norway or Germany, which are also interested in autonomous ships.

A controversy rises

Controversy is every artefact, technology and science that is not stabilized (Venturini 2009). Controversies are involving all kinds of actors without regard to them being human or non-humans. In controversies these actors tend to disagree about everything related to the subject under discussion, which makes it even more difficult to result on a common understanding or even prevent common goals from being achieved.

Controversies display the social in its most dynamic form (Venturini 2009). This means that through discussions about the current issues, alliances may formed that could shape the size of the influence actor have upon decision making processes, implementation of new technologies as well as expectations for new development.
Venturini in *Diving in magma* mentions ,

“ (...) when you look for controversies, search where collective life gets most complex: where the largest and most diverse assortment of actors is involved; where alliances and opposition transform recklessly; where nothing is as simple as it seems; where everyone is shouting and quarreling; where conflicts grow harshest” (Ibid).

Controversies are debated. When replacing something well known and old with something new and different, that’s when discussions and arguments appear. Regarding autonomous ships, even though there are many actors within the maritime industry who voting for the development, on the other hand there are also civilians who

rise against it, concerning for their safety and well being. The difference in opinions is what make the controversy to emerge.
During the process of this thesis I came across a lot of different opinions on the subject of autonomous ships, and even though the consequences of these disagreements have not yet revealed due to the fact that the development of autonomous ships is in its infancy, the awareness of a controversy is rising.

Research question

This section deals with the techno-anthropological question that will be investigated in this master thesis.
Defining the research question for this project has been a process in which different questions, ideas, thoughts and wonderings about autonomous ships, passenger safety, the interaction between human and non-human actors were present. What are the perspectives around safety on board autonomous ships? How passengers perceiving the concept of safety? Could there be a rational behavior followed by passengers in an emergency case on board autonomous ships? How such behavior can be achieved?

After a lot of discussions and thoughts regarding these questions, in relation to the fieldwork, the final decision was made upon the following research question that will serve as a map throughout the project.

"What are the different perceptions around safety on board autonomous ships, and how a rational behavior in an emergency situation can be promoted."

Some explanation for the aforementioned research question is in order. After having thoughts and a lot of reflection upon the subject of autonomous ships and the concept

of safety on board such vessels, the research was based on the different actors that will interact and get influenced by this innovation.
On the one hand there are the public and private sector including organisations like the Danish Maritime authorities (DMA), which mission is to strengthen Blue Denmark's conditions of growth and to promote safety and health on seas (Dma 2018), and the International Maritime organization (IMO), responsible for regulating shipping and Lloyd's Register a technical and business services organisation and a maritime classification society, which helps its clients to ensure the quality construction and operation of infrastructure ((Lloyd's Register 2018), respectively. On the other hand there is the human factor to this innovation. The passengers on board an autonomous ships, the people who will be using this mean of transportation and also those people who need to be persuaded that this innovative step is worth taking. Considering that safety is essential when we are talking about autonomous systems on passenger vessels carrying out routes in the sea, it was included in the research, thus it will be discussed and analysed throughout the project.

Why autonomous ships?

Advantages and challenges

The development of autonomous ships is aiming to create an evolution in the shipping and maritime industry, by increasing the efficiency of vessels and bring forward benefits for the maritime companies which invest in the technology.

Like every new technology, autonomous ships have advantages and encounter many challenges. Regardless whether we are talking about manned or unmanned autonomous ships there are some advantages that may apply for both types of vessels.

Lower emissions, fewer oil spills are some of the major advantages resulting to a more environmentally friendly industry.

In addition, new technology such sensors, radars, cameras, satellite systems, etc., will be developed to accommodate the implementation of autonomous technology on board ships. Therefore, new job positions for highly educated professionals will be created, which will attract more young people to enter the industry. This fact is aiming to ease some concerns regarding the potential loss of jobs due to the introduction of new technologies that replace humans with machines.

Autonomous ships will be monitored and supervised from ashore. This fact creates the need for offshore control centers, which will be operated by humans. Once again this creates the need for new infrastructure offshore, which also will create job positions for highly educated and well skilled professionals. The fact that ships becoming autonomous, does not particularly mean that people will lose their jobs. The necessity for new positions will balance the situation. This is an issue that will discuss further more later on in the analysis.

All these advantages of autonomous ships though, will take a lot of time to come to past. In the meantime, there are also many challenges that need to be taken under consideration.
A vessel that sails on its own might face risks that could question its performance as well as its reliability. These risks may be related to weather conditions, obstacles in the environmental surroundings, even threat from foreign factors such as pirates.
The vessels should be able to prevent for instance unauthorized access by third parties to its systems, but at the same time it should allow the offshore control center to override unauthorized procedures (Opensea.pro).

Therefore, the liability and responsibility issues in case of emergencies should be taken into consideration. Accidents in the sea can happen at any time and responsibility is a

major issue when it comes to autonomous ships, yet alone when there are passengers on board. The liability levels should be addressed and defined clearly, so all the maritime actors to be informed about the subject and to be aware of their options before proceeding to any business cases regarding autonomous vessels.

Theoretical framework

This chapter will present the theoretical framework used in this thesis. In this section the key concepts will be displayed, contextualized and provide useful pieces of the theories that was chosen to applied in this project.

After a lot of consideration about which theory would be more suitable in this project, the most logical call was to use both Actor Network Theory (ANT) and Post-ANT to explore this premature development of autonomous ships. In this section the theories will be introduced and analysed in relation to autonomous ships and how this innovation is formulating so far as well as the direct influenced actors (passengers) and how they perceive safety on board autonomous ships.

The choice of using *multiplicity* approach on the development of autonomous ships in relation to conducting the ethnographic fieldwork was in order to gain knowledge of how the different realities of the different actors in the field exist in different perspectives of how this development will be stabilized, affect the industry and by extension the people who will be using the autonomous ships.

Although for one to comprehend Post-ANT as well as multiplicity there is an essential need to introduce ANT first.

Actor Network Theory

Actor Network theory is a theoretical and methodological approach that was developed by Bruno Latour in collaboration with Michel Callon and John Law in the 1980s. ANT focuses on following the actors even thought this might be difficult since there can be more that one actors in a network and also because some of the actors might disappear

before the network even get completed. There is also always the possibility of some actors' roles to change.

> *"...it is usually the case that ANT looks to the network builders as the primary actors to follow and through whose eyes they attempt to interpret the process of network construction."* (Cressman 2009).

The researcher's struggle is to differentiate between the actor and the network. It is difficult to detect what is the network and who is the actor since all things can be hold as both. *"...-it is simply a matter of perspective.Everything then is an actor-network"* (Pinch and Bijker 1984).

One of the core concepts of ANT is *symmetry* and the fact that the analysis should be characterised by it. This means that the researcher should not make assumptions about who is the one who acts; human or non-human. In ANT both human and non-human are actors whose identity inside the network is defined by their relation with other actors. ANT is concerned not with each actor's interactions but with the different roles they obtain. As Law and Callon made it clear *"...we are not primarily concerned with mapping interactions between individuals...we are concerned to map the way in which they (actors)define and distribute roles, and mobilize or invent others to play these roles"* (Law & Callon 1998 in Cressman 2009:4).

Translation

Another key concept in ANT is *"Translation",* used first by Latour to describe processes through which actors relate to one another. Based on this, *"...actors are not the same from situation to situation, rather they are translated in their movement between practices."* (Bueger and Bethke 2013). The process of translation helps to categorize the workings and the manipulations of the actors in a network. Translation is about how actors are identified by their agency in the network as well as how they redefine their

own and other actors' positions and how they negotiate the scope and limit of the network (Callon 1984).

According to Callon 1984 there are ***four moments of translation*** and are presented below.

Problematization is when in a specific situation the nature of a problem is defined by an actor ,who identifies what other actors are essential for the problem to be resolved, as well as each actor's motivation (Callon 1984).

Contextualizing this to autonomous ships, what are the essential actors for resolving the situation at hand? With a first thought the answer could be really simple and interesting. We have the authorities ready to take the first steps to address prescriptive regulations for autonomous ships by taking into consideration every legal aspect as well as the technological developments in relation to the subject.

In the same place Classification companies which are performing various approval and certification tasks on board Danish ships are also interested in providing approvals for autonomous ships. Another main defined actor in the autonomous ship development is the shipowners who can see business cases in relation to autonomy so they express their interest for such a development. Additionally the different shipyards are network of actor potentially interested in autonomous vessels and business opportunities. Moreover the maritime suppliers and the naval architects play a big role in the development of autonomous ships and help to shape the scene.

Last but not least we can identify the directly influenced by this development when we are talking about autonomous passenger vessels; the passengers themselves, accepting or not this innovation and their perspectives in the matter.

Interessement is 'locking' other actors in the roles that were proposed for them by the actor for resolving the problem. The interessement process can be understood as when a primary actor tries to destabilize another actor relations to others. In the end the relation the second actor has created with other actors will be weakened and the actual

relation with the primary actor will become more and more strengthened. The interessment can be performed by an actor in many ways, so called 'Interessement devices' , which have only the goal to assist in weakening the relations between the secondary and the other actors.

Enrolment is the third moment of translation where the roles of actors are 'locked' into the network by a … *"group of multilateral negotiations, trials of strength and tricks that accompany the interessements and enable them to succeed."* (Callon 1984).
The different roles in the network are defined and allocated to the actors according to their motivation and capabilities.
Each actor is allocated a role in the network. Shipowners have the role of identifying business case of autonomous ships and start building them, authorities have the role of articulate regulations that will apply on autonomous systems, passengers obtaining the role of expressing their opinions and pose weather they'd used an autonomou vessel or not, etc.

The last moment of translation is ***Mobilization*** where an actor-*spokesperson* is present since it speaks not only for itself but also for the other actors in the network as well. Translation occurs for to create order in the network. Through translation the actors are changing into being more or less important for the network and some attempt to turn themselves into representatives who speak on behalf of others. When the process of translation is over then the order in the network is established and we can talk about creating a mutual understanding about the current problem. In this case the network is not yet established since there is still no mutual consensus regarding autonomous ships, regulations, safety and numerous other issues among the different actors.

Scripts

Script is an central concept in ANT. There are times where an actor has a program or script, a typical situation or action to make. In the network actors perform actions while they delegate other tasks to other actors. It depends on the delegation an actor accepts and performs and this Latour calls a *script*. A good example of scripts is the 'Restaurant script' developed by Roger Schank and Robert Abelson where the user of the restaurant is following a sequence of actions. From the moment the user enters the restaurant, walks, sits, orders, until the moment he exits it. This is relevant to this project since the passengers on board a ship follow such scripts from their first move on board until they disembark. When we are talking about autonomous ships , manned or unmanned, the vessel itself obtains some scripts in order to plan a more stable and controlled situation as possible as it can be. When is comes to the design process of an artefact the designers are putting in the initial scripts their assumptions and hopes of who will be the users and how they will use it (Akrich 1992). Contextualizing this to autonomous ships we can say that the designer has intentions how the artefact should interact with the users. These intentions are forming by the ideas of potential use of an autonomous ship. A designer in collaboration with the ship owner's preferences and desires of the new development is putting in action the actual design of the vessel considering the numerous aspects that needs to be added properly in order for the final product to be ready to built. The ship should be designed in a way that allows for technological developments to be implemented as well as promote a smooth and normal experience for the passengers if we are talking about a commercial vessel.

In addition, a big part of the ship's scripts is covered by the technical part of the systems. For autonomous ship to operate there should be a lot of room on the ship's hips for the autonomous systems to be implemented. The systems should provide different options for interacting when it's needed and of course be able to provide safety and promote it if emergency should arised. This means that the autonomous systems

along with the different plans and the actual design of the vessel should be able to operate in a right way but also be able to provide suitable actions and options that will ensure safety on board. A design script intends to affect the user behavior in a particular way. This is something that will be analysed in details later on this project.

Black Box

Latour explains that a network is a 'black box' where the same inputs always generate the expected outputs and we are not familiar with the internal workings. A 'black box' can be the mechanical parts in the automation system of an autonomous ship that start working when the engines are set in motion. More or less it is known how a ship works and moves when you start the engines and put in the navigation system the coordinates for your route and similar procedures for a trip in the sea but it is not well known the actions that are made within the technical part of the ship's systems.
During the time the given network becomes more stabilized and there are agreements on the different terms, thoughts, ideas and objects of the network then we can call the network *'black boxed'.* In order to do that in this case we need to understand at what point stands the stabilization of the development of autonomous ships.

Post-ANT

For this thesis, along with ANT it seems suitable to draw upon Annemarie Mol, a philosopher who is distinguished for her work in Post-ANt which is different but quite relevant to classic ANT introduced by Bruno Latour.
Post-ANT also has the focus on following the actors as classic ANT does but with the differentiation that in Post-ANT the researchers are themselves actors, active enough to

provide and influence the field with their assets while they are getting challenged by other actors who are also active in the network.

It was communicated before that the *'multiplicity'* approach was chosen for this thesis. In *'Cutting Surgeons, Walking Patients: Some Complexities Involved in Comparing'* (Mol 2002a) in Complexities by John Law, Mol presents her analysis on health care practices in Dutch hospitals regarding arteriosclerosis. She suggests that even the disease is a simple phenomenon in practice is done in different ways (Gad and Bruun Jensen 2009). She claims that the phenomenon of arteriosclerosis is enacted in different ways such as the patient's pain to the doctor who takes a look at it and so on. Those enactments according to Mol they create different realities.

Mol focuses on the fact that reality is *multiple*. *"... if reality is done, if it is historically, culturally and materially located, then it is also multiple. Realities have become multiple" (Mol 1999).*

In relation to this Mol presents as an example a story about *anemia. She suggests that even though the whole controversy* around *anemia* is no longer loudly out there in the front line of science, although the critical question '*What is anemia?' has not yet been stabilized or answered* (Mol 1999). Afterwards she demonstrates three performances of *anemia* in order to explain that:

> *"The reality of anemia takes various forms. These are not perspectives seen by different people-...- they emerged at different point in history, but none of them has vanished. So they are different versions, different performances, different realities, that co-exist in the present''* (Mol 1999).

Contextualizing this to our case of autonomous ships we can claim that *multiplicity* is when each actor in the given network has its own reality about autonomous ships. The organisations related to regulations for such vessels, the different classification companies, the shipowners in the maritime industry as well as the potential passengers

have their own realities, opinions and ideas about this development and they enact upon this innovation in their own ways.

Multiplicity-Is it helpful?

While conducting the fieldwork I noticed a controversy rising between the public and private actors around the development of autonomous ships and the potential passengers of the ships. Different opinions and negativity about the subject, as well as uncertainty by the passengers for their own safety on board autonomous ships and untrust and disbelief in the technology that is steadily approaching. Passengers thinking about that by this development people will lose their jobs, people trusting people to do their jobs. By using *multiplicity,* lights can be shed upon the different realities on the upcoming phenomenon called *autonomous ships*.

"And I'll take this situation as an occasion for asking my questions. Questions about the kind of politics that might fit this ontological multiplicity. Four of them:

.

- *Where are the options?*
- *What are at stake?*
- *Are there really options?·*
- *How should we choose?" (Mol 1999).*

'Where are the options?- Unemployment and frustration about the people who will lose their jobs or new opportunities and evolution in the maritime industry?
'What are at stake?'- What will be the consequences of replacing the human factor from a commercial ship with an automated system? Is the trust in the technology something that everyone is voting for? Are there any social groups that are being automatically excluded due to their beliefs and their safety perceptions?

Those questions of Mol could be useful in relation to autonomou ships and this particular project as presented above.

This thesis will use multiplicity to shed light upon the different perceptions around safety that actors having in relation to autonomous ships,therefore their different realities, as well as follow the different actors and their ways of acting upon the subject in order to understand their ways, opinions, ideas and finally obtain knowledge about this innovative development through actors' actions.

Methodology

This section will introduce the methodological approaches applied in order to create an empirical foundation for the analysis therefor for answering the research question. In order to understand the field where the technology and people are interacting it is essential to choose the right method of collecting data. Having in mind that multiple realities are being made, the thought of applying different ethnographic methods in the field does not sound strange. By conducting multi-sited research, the researcher is engaging the created knowledge about the world, as well as influences, and gets influenced by it. As George Marcus (1995) points out, the researcher encounters many different personal commitments that resolves by *"being a sort of ethnographer-activist, negotiating identities in different sites as one learns more about a slice of the world system"* (Marcus 1995).
In the beginning of this thesis there were many thoughts as well as discussions and a lot of brainstorming in order to identify the different actors in the field. This led to the relevant actors for the specific field as well as to the most relevant literature needed.

Literature research

For getting the right literature it was necessary to define the focus of the project. The collaboration with DBI was open and the materials in their disposal were available to this project as well. Keeping in mind that the focus of this master thesis is a new, unstabilised and unboxed idea for now, the knowledge around the subject is limited as well as indefinite.
In order to search for relevant literature keywords were essential which were used to research through Google Scholar ("Google Scholar" 2018) and the online AAU library

("The University Library" 2018) which were related to databases such as SCRIBD, JSTOR,SpringerLink.
Furthermore by using the official sites of the Danish Maritime Authorities (DMA), the International Maritime Organisation (IMO), the Danske Maritime, as well as the official site of the European Commission and numerous other websites the research provided a lot of information and inspiration as well as useful information about the Danish maritime sector, autonomous ships and the human factor part for the project.

The keywords that were used in a variety of combinations were autonomous ships, Danish maritime, human factor, unmanned ships, maritime industry, safety, behavior, etc.

Informants

The difficult part in the beginning if this thesis was to find the most useful actors to talk to along with getting in contact with them and getting access to their knowledge and information on the subject. Once the problem statement was fixed the time had come for gathering information on who would be relevant to talk to and help me with their knowledge, expertise and experiences. Research and Innovation Consultant at DBI, Carsten Møller provided me with a full contact list of relevant to the project actors along with his feedback on my own thoughts and expectations for the fieldwork.
Having in mind that autonomous ships is yet a premature innovation and the knowledge around the subject is really limited, the initial thoughts were to follow the actors that will be directly influenced by this development or the other way around. That included public organisations such as the Danish Maritime authorities, private ones such as Lloyd's Register , the Danish shipping company and shipowners as well as the potential users of autonomous ships.

The communication process was difficult and long since most of the formal actors were busy with their own workload therefore there were delays in communication and even cancellations in meetings.
The result was that I was able to arrange interview meetings with Thomas Koester, Psychologist, Team leader applied psychology at FORCE Technology and his colleague Jesper Ejdorf Brøsted, Psychologist and human factor specialist at FORCE Technology as well, to get their perspective on the subject of autonomous ships and human factors ,as their knowledge around human behavior on board ships could help in the investigation of this thesis. FORCE Technology is collaborating with DBI on the FIRST project. DBI's purpose of this project is to "optimize the fire safety for future autonomous ships" ("FIRST" 2018).

"The project would try to create a holistic fire strategy by providing recommendations for design, training of the crew, passengers and land-based emergency services.Rederiet Færgen is designing a new ferry for the route Esbjerg – Fanø. This ferry will be used as a demonstration project in order to bring documentation and recommendations for partly autonomous domestic ferries." (Ibid).

Another valid informant was Morten Glamsø, Senior Adviser at Danish Shipping ("Forside - Danske Rederier" 2018). Meeting with the Senior adviser was a great opportunity to obtain information about the Danish shipping opinion on autonomous ships, their expectations to the development as well as their perspective on the regulatory part of autonomous ships and the various requirements regarding passenger safety on board such vessels. Jacob Munk Plum, Surveyor at Lloyd's Register ("Lloyd's Register Offer Smart Solutions Shaped With Human Intelligence." 2018) was more that welcome to participate in an interview meeting and he also suggested that Mogens Heidtmann, Fire and Safety specialist at Lloyd's should participate as well. They were both open to questions regarding regulations and they were willing to share their knowledge, expertise and experiences regarding autonomous ships. Finally , a fleet

manager welcomed an interview invitation that took place through a phone call since his time was limited for face to face or Skype meeting.
In addition to the expert interviews a field visit was conducted on board *Sundbusserne,* a passenger ferry carrying out routes from Helsingør to Helsingborg and back in order to interview the passengers regarding their own perspectives of safety on board the ferry, with ultimate goal to obtain knowledge around people's' idea of being safe on board an autonomous ship that will cover the first part of the analysis.

Qualitative Interviews

"Interviewing is an active process where interviewer and interviewee through their relationship produce knowledge" (Kvale and Brinkmann 2009). The interviews mentioned before were conducted in different ways. Face- to- face, through the phone and in some cases in coordination with Anders Dragsted, project manager at DBI. That was because both of us either working for or with DBI had some mutual interest in the same actors. After discussions we agreed on conducting the interviews together in order not to challenge the informants regarding their workload and also sparing them from answering similar questions twice if the interviews were conducted separately.
The interviews were conducted in a semi-structured approach, meaning that interview guides for all the interviews were created, which were categorized in themes , including suggested questions (Kvale and Brinkmann 2009). Although the interview guides were followed as planned there were cases where there was room for discussion during the interviews, so the questions were not followed in order.
This being the case, it allowed a more narrative approach to the data presented at the time. It allowed the informants to feel more comfortable and share eagerly their experiences and perspectives which considered being relevant and useful.
When conducting semi-structured interviews the researcher should obtain some basic skills and experience with the procedure of the interview in order to apprehend and determine which stories are useful and relevant to the research. The conducted

interviews were formed to investigate the present situation around autonomou ships, by allowing the informants to share past experiences and expectations for the development through their own stories.

In the case of the field visit on board the *Sundbusserne* the interviews with the passengers were short and to the point since it was a total trip of forty minutes back and forth, done several times with different passengers on board. The questions were hypothetical since autonomous ships are now yet a reality but the goal here was to make passengers put themselves imagine an emergency situation on board a ferry similar to the one they were on and try answer questions regarding their own safety and behavior in such situation. Even though hypothetical questions create hypothetical answers that may not be representing one's actual opinion and may provide not trustworthy data, eventually provided some fine and useful data regarding passengers' perspectives of safety as well as their realities about autonomous ships.

Recording and transcription

All of the formal interviews were recorded and transcribed because depending only on one's memory and notes sometimes is not enough. Recording the interviews gives the advantage of going back again and again if necessary for relistening the interviewee's opinions. The interviewer must be focus on the discussion in order to follow up with questions.
After conducting the interviews they need to be transcribed. *"Transcriptions are constructions from an oral conversation to a written text"* (Kvale and Brinkmann 2009). When transcribing it is quite important the written text to represent word to word the interviewee's statements. This is also the reason why the transcription process usually takes a lot of time. The researcher needs to listen more than one time the recorded files for putting the actual words spoken in paper.

Anonymity and Approval

The anonymity of the informants was something debatable. Some informants requested to use anonymity in the project and others didn't consider being a issue. *"Anonymity can protect the participants, but it can also deny them "the very voice in the research that might originally have been claimed as its aim" Parker 2005,p.17 in Kvale and Brinkmann 2009 (*Kvale and Brinkmann 2009). The status and title of the informants was an important factor for the statements to stand in the project that is why the anonymity was not possible for some of them. Informants who wanted their identity to remain secret they were granted anonymity.

From the qualitative interviews, quotes were created that were put in a list and sent for approval.

Secondary desk research

Despite the relevant literature found through Google Scholar, the University Library, and the official websites of the different maritime stakeholders, a lot of useful information and documents were obtained through respectable researchers and professionals within relevant fields of research.

Valuable material was obtained through a contact in Lund University, as well as an external partner at DBI.

Useful material regarding human factors, human behavior in emergency situations, possible safety designs and numerous other documents, were shared with me by interesting people willing to provide as much knowledge they could share for this thesis.

All those documents were compared with the collected data gathered from the interviews and the field trip. Thus the documents were treated as a support to the generated field data.

Analysis

In this chapter the research question will be analysed by combining the two theories presented above. The analysis will be based on the interviews and the field trip conducted and mentioned in the methodology chapter. In the first part of the analysis the collected data will be analysed in relation to the first part of the research question ,focusing on the different perceptions of safety on board autonomous ships. The second part of the analysis will focus on how a rational behavior by passengers during an emergency situation onboard autonomous ship can be achieved and promoted.

Actors involved in the autonomous ships development

The concept of autonomous ships in everyday talk and the term of autonomy in particular, is being used confusedly. There are a lot of people who think that autonomous at the same time means unmanned. This is not the case. Autonomous ship means that the vessel can perform defined operations with no presence of trained crew or with reduced level of attention from the bridge. Although, this does not mean that no other crew is present. On the other hand, unmanned ship means that there is no human present on the bridge to operate or supervise the systems. Some crew can still be on board for other services like assisting passengers (Jan Rødseth & Nordahl 2017).
An autonomous ship does not have to be unmanned , but if you have an unmanned ship it should be either autonomous or remote controlled.

Even when we are talking about autonomy a clarification is in order for avoiding misunderstandings and misinterpretations. For that reason Lloyd's Register has defined six levels of autonomy for unmanned, remotely operated and remotely monitored systems ("Lloyd's Register" 2018). The levels being from AL0: Manual steering where

steering and set of course is done manually to AL6: Fully autonomy where all the procedures, navigation as well as the operation of the vessel is done by the system.

The definition of the level of autonomy is an important point at the moment. Due to the many levels introduced, misunderstandings can be made when talking about the subject. During the interviews conducted in this research, when the informants were asked the very first question about autonomous ships, the direct response was *"Well how do you define this, because there are many degrees of autonomy"* (Interview, Fleet manager).

Autonomy levels (AL) adapted from Lloyds Register

Description	Operator role
AL 0: Manual steering. Steering controls or set points for course, etc. are operated manually.	The operator is on board or performs remote control via radio link.
AL 1: Decision-support on board. Automatic steering of course and speed in accordance with the references and route plan given. The course and speed are measured by sensors on board.	The operator inserts the route in the form of "waypoints" and the desired speed. The operator monitors and changes the course and speed, if necessary.
AL 2: On-board or shore-based decision support. Steering of route through a sequence of desired positions. The route is calculated so as to observe a wanted plan. An external system is capable of uploading a new route plan.	Monitoring operation and surroundings. Changing course and speed if a situation necessitates this. Proposals for interventions can be given by algorithms.
AL 3: Execution with human being who monitors and approves. Navigation decisions are proposed by the system based on sensor information from the vessel and its surroundings.	Monitoring the system's function and approving actions before they are executed.
AL 4: Execution with human being who monitors and can intervene. Decisions on navigation and operational actions are calculated by the system which executes what has been calculated according to the operator's approval.	An operator monitors the system's functioning and intervenes if considered necessary. Monitoring can be shore-based.
AL 5: Monitored autonomy. Overall decisions on navigation and operation are calculated by the system. The consequences and risks are countered insofar as possible. Sensors detect relevant elements in the surroundings and the system interprets the situation. The system calculates its own actions and performs these. The operator is contacted in case of uncertainty about the interpretation of the situation.	The system executes the actions calculated by itself. The operator is contacted unless the system is very certain of its interpretation of the surroundings and of its own condition and of the thus calculated actions. Overall goals have been determined by an operator. Monitoring may be shore-based.
AL 6: Full autonomy. Overall decisions on navigation and operation are calculated by the system. Consequences and risks are calculated. The system acts based on its analyses and calculations of its own capability and the surroundings' reaction. Knowledge about the surroundings and previous and typical events are included at a "machine intelligent" level.	The system makes its own decisions and decides on its own actions. Calculations of own capability and prediction of surrounding traffic's expected reaction. The operator is involved in decisions if the system is uncertain. Overall goals may have been established by the system. Shore-based monitoring.

(Source: A pre-analysis on autonomous ships by DTU)

Although the development of autonomous ships is now taking its first steps in the maritime industry , there are many actors talking about it, expressing their opinions, thoughts and even concerns. There is wide range of actors involving into this innovative development. One can identify many stakeholders in the Danish maritime sector involving to the development of autonomous ships with the Danish Maritime Authorities, shipowners, classification companies, suppliers, naval architects, shipyards and potential users being some of them. Behind each actor there is concrete reasons for interest in autonomous ships.

There are two obvious angles guiding this development ; Technical possibility and political pressure. It is known to those who are familiar with the Danish maritime authorities that it is a quite reluctant area that needs long time to come up with prescriptive rules for new technologies and developments.

"So, it is a very long, slow process. I mean, just to try to develop any requirements or rules and make us to allow autonomous ships it may take 5-6-7-8 years; then have it into the legislation as well, this also takes time." (Interview, Mogens).

The technology is developing in really fast paces but the authorities trying to built regulations require a lot of time in order to cover every little aspect and provide the maritime industry with a well structured set of regulations. Based on the prescriptive rules that the authorities will introduce, the designs of autonomous ships will be shaped and the classification companies will have the proper guidelines to approve shipping.

The fleet manager pointed that *"...this is why you have these set of rules, because then you know where to start planning your ship, then you have an overall idea of how to arrange things…"* (Interview, Fleet Manager). So the right formulation of rules will

provide the industry with the opportunity to identify business cases and act upon those, considering among other things, the economical impact of the decisions made.
At the same time regulations for autonomous ships are also the barriers to this development. There are different developments of promoting autonomous technology in Denmark right now according to Morten Glamsø, Senior Adviser at Danish Shipping, who continues saying that he thinks *"it's important to grab this opportunity because there are also some political reasons there"* (Interview, Morten). This statement is well enhanced by Fleet Manager's opinion on the fact that the legislation area is for obvious reasons one of the main barriers to the development of autonomous ships.
"...it is very obvious that we need to reconsider the whole way of how to do things and how to approach things when it comes to regulations." (Interview, Fleet Manager). He goes on adding that as a second main barrier he considers the working organizations due to the fact that there is a concern of potential job terminations (Ibid).
This is the point where the interest shifting to the potential users of autonomous passenger ships. According to the Fleet Manager *" we have to consider our passengers or convince our passengers that it is as safe as having crew on the ship to operate it"* (Interview, Fleet Manager).

On the other hand economical reasons play at least for the time being an important factor when we are talking about autonomous ships and barriers. Since this is a new development then the implementation of the technology is a process that will happen gradually. So turning a passenger vessel into fully autonomous is a concept that requires time, good design and acceptance from the users.
Until this gets achieved the vessels should require the presence of at least a small crew to provide the minimum services to the passengers. At this point though other issues come to mind. If an autonomous vessel should obtain a crew then the question is how much crew? Should the crew be trained to assist except from usual services like drinks and selling food on board, also help with safety issues in an emergency?

"...but then if you like to have some level of service on board for the passengers, you have another concern and then your service crew is also the safety crew." (Interview, Thomas).

When the service crew becomes also the crew that will provide safety in case of an emergency on board a vessel, it should be properly trained and educated to react in a responsible way and also show some level of authority during the procedure. This is a case where further research can be done in order to examine the different personality and performance profiles, so a ship owner who is willing to proceed and build an autonomous passenger vessel will be able to get an overview of what type of personnel should hire.

Human factors

Having in mind the upcoming development of autonomous ships, the thing that triggers an techno-anthropologist curiosity is: *'What about the passengers?', 'What about passenger safety?'* and *'What about emergency situations?'*.

When autonomous ships will be a fact and this will be happening with a fast paced, the industry as well as the public organisations would have to be ready in every aspect.
When we are talking about autonomous passenger ferries the first thing that should come to mind is passengers' safety on board such vessels. Unmanned or not a ferry should be capable to provide safety to the passengers caring.
On the other hand though, human factors are a very important part of the ecuacion. The vessel itself should be initially designed to provide and promote safety on board during a route as well as during an emergency situation. There are a lot of things that can go wrong when traveling by car, train, airplane or ship. The human factors are a main concept that needs to be taken into consideration. For instance a fire on a vessel is one of the most dangerous incidents which can happen. If the fire is detected early the

present crew or in case of an autonomous vessel the fire fighting systems on board the ship can prevent bigger damages. Although there are situations where evacuation is a necessity.
The autonomous ships has to provide with every means possible to its design and disposal safe passage for its passengers. Those means can vary from loudspeakers, monitored offshore to guide passengers and make them follow instructions for their safety, to signs and lights already installed on the ship and pre-introduced to the passengers like the safety brochures on the airplanes.

Nevertheless what are the intentions of the ship and its scripts are, we should always consider that people can respond to dangerous situations in the most unpredictable ways based on the feeling of survival.

Perceptions of safety

According to Cambridge Dictionary *safety* is defined as *"a state in which or a place where you are safe and not in danger or at risk"* (Cambridge Dictionary | English Dictionary 2018). When talking about autonomous passenger ferries, the vessel should be able to provide to its passengers a high level of safety. According to psychologists defining safety is quite difficult. *" We like to try to capture the perception of safety. How safe do you feel?"* (Interview, Thomas). But then again the actual definition of safety can vary from person to person because as I have learned in previous projects about safety is that one can not truly define it when you are not entirely sure how to measure the level of it.

Based on interviews conducted on board a ferry which its passenger capacity is similar to the ferry that *Rederiet Færgen* is designing *the route Esbjerg – Fanø,* a lot of different opinions came to the light regarding how people feel about their own safety on board an autonomous vessel. Although the interviews were based on hypothetical question since

the development is too premature yet, the passengers were showing very firm statements. All the passengers were under the impression that such an innovative development is utopian and it will never happen, at least not in their lifetimes.

Every individual enacted upon this idea of autonomous ships and through a thinking process tried to express their points for the subject. Those opinions have heavy weigh in the discussion of autonomous ships. One way or another in order for the autonomous passenger ships to operate and fulfill their purpose, passengers should accept them and trust them. This research provided data that puts the trust in this technology in very low levels and along with the regulation process, the acceptance of autonomous ships is something that probably will take a long time to achieved.
All lot of passengers on board the ferry when were asked what is their opinion about autonomous ships were determined that *"this is not possible, it's never going to happen..".* (Interview, passenger)

An overall negativity and denial was present. It is hard for people who are not familiar with the maritime sector and the different projects running right now to accept that soon there will be an area when ships will be able to operate on their own and maybe in some cases there will be less or even no crew on board to assist them. *"With the captain on the helm, yes I feel safe. I have to trust the captain as I trust the pilot in the airplane"* (Interview, passenger).
People are putting their trust and faith in the professionals on board the ship that will keep them safe and will assist them as best as they can in case of an emergency. A passenger also responded the she feels safe during her trips with the ferry because of the crew and she added *"...if anything bad happens, I know that the crew is well educated and trained to guide us in a right and risk free way"* (Interview, passenger). The level of trust people putting in the professionals is remarkable considering that the fact that 80% of accidents at sea are caused by human errors or human related factors (Ventikos 2013).

Furthermore, the passengers firmly believe that the level of automated technology is not yet ready for creating an autonomous system that could be implemented on board ships and could replace humans in daily ship operations. *" I don't believe that the technology is there yet. There should be a test period first before putting the technology on board with people"* (Interview, passenger).
However, this is not the case. At the Danish Maritime Technology Conference held in May 2018 members were stating that *"Technology is not the issue. It is already here"* ((Danish Maritime Technology Conference 2018)). Although there were passengers that believe that autonomous ships will be a reality and yet, have a positive attitude towards this development.

" In the future maybe there will be autonomous ships and maybe all vehicles will become autonomous.I think it's a good idea but I can put it in 25 to 30 years. I mean, the technology will develop and it will be even safer than it is today with the captain and the crew on board" (Interview, passenger).

At this point it comes to mind the relatively new case of vessels operating with batteries. When the implementation of the batarries was firstly introduced there were discussions about whether it is safe to have a ship operating on electric energy instead of old fashioned fuel propulsion engines. The opinions contradicted with a lot of people discussing that it is less safe and the risk of something going wrong was high. However this didn't stop the authorities or the classification companies, nor the shipowners to proceed with the construction or redesigning of such vessels. It is proven that people will adjust to any technological change given time and proof that the systems work as they are suppose to and passengers' safety considers a top priority.

People are putting a lot of trust into the means of transportation they are choosing to use when traveling. Even though humans adapt really fast to new technology nowadays, a change upon something they consider a top priority such as their own safety, could shake their beliefs and threaten their values. When the passengers on

board the ferry were asked if the ferry they were using was to become autonomous would be a reason to change their perspective about their safety, a large number responded positively with some exceptions. A middle-aged woman stated, *" I suppose in the beginning it will be strange and it will affect my opinion ,but after a while I think I will adapt like I did with the airplanes, if you think about it"* (Interview, passenger), when at the same time a 28 years old woman firmly declared her opinion would stayed the same as she would not go on board a ship that is automated and has no crew or limited crew.

Safety is the feeling you get when there is no chance of any risk around. It is obvious that in order for autonomous ships to be accepted by the potential users, a more detailed definition should be introduced. Even though I had explained to the ferry passengers the difference between autonomous and unmanned, during the interviews it was clear that their interpretations of autonomous meant unconsciously unmanned.
Their reality of autonomous ships refers to vessels that will operate on their own, with no crew to take care of them if needed. Even the idea of such vessel made most of the ferry passengers to react both positively and negatively.
A 60 years old woman explained:

" I feel not that strange really. It's going to happen! I suppose there will be some kind of control over the systems, someone can overwrite it from the shore or something like that, like a light tower or a control room, etc." (Interview, passenger).

On the other hand, the constant disbelief in technology and the trust in humans and their skills is always present.

" ...I would feel unsafe.What if another ship run into this one or fuel is leaking out, or fire breaks out? You put your trust to the crew because you know that in bad situation some will be there to supervise and they are ready to take action" (Interview, passenger).

Another aspect that is present and shows one of the multiple realities that passengers have given to autonomous ships, is the one where with the development of autonomous ships, a lot of people will lose their jobs. This is quite clear from a statement made by a passenger on board the ferry saying that *"...operating on its own; well this makes me feel unsafe and sad at the same time because there will be people who will lose their jobs."* (Interview, passenger).

This statement is challenged by the opinions shaped by professional actors in the maritime industry. Jacob Plum ,Surveyor at Lloyd's Register claims that *"... for the seafarers I think that at least for a while there will still be jobs, but there will be other jobs instead."* (Interview, Jacob) and he elaborates on that by saying that

> *" we can see actually that manual operator might go away, but you will see a technology, a service provider coming instead. So you will take the hard manual work out but you will put a trained technician or other kind of supporter instead."* (Interview, jacob).

The same opinion shares the Fleet Manager who states *"... until they realise that there are new opportunities in new kinds of jobs, because there will still be somebody who operates the ships, there will still be somebody who is supporting the ships and so on…"* (Interview, Fleet Manager). The same statement is made by Digital Services Manager at ABB, who commended *"Staff reduction has been coming on for a while. It's not a new thing. The increase in computing power accelerated the trend, and now cheaper sensors and connectivity are driving it even faster."* ("Shipping 4.0 - The People In The Picture - Generations | ABB" 2018) and he also noted that already a big amount of ships operating on autopilot, something that actually made the maritime industry much safer. Remote technology can assist humans by replacing crew from difficult and dangerous positions (Ibid).

Summary

The implementation of autonomous systems on ships is an ongoing development at this time in the maritime industry. A lot of parameters should be taken into consideration in order for autonomous ships to be a reality in the coming years. The necessity for regulations that will address autonomous ships is a priority that is followed by the necessity of classification approval for the vessels as well as the acceptance of the potential users. An overall consensus upon the different levels of autonomy covers a big part of the ongoing discussions in the maritime industry. Furthermore the different perceptions of safety regarding autonomous ships should be consider and a reassuring approach should be taken in order to convince the public that the autonomous technology on board ships is something that will not affect to the minimum the level of passengers' safety, on the contrary will enhance it.

When it comes to autonomous passenger ships clear definitions should be introduced for the potential users to be able to comprehend and adapt to the development and feel safe all the way through. Up until now, given the collective data of this project there is clear disbelief and disapproval of autonomous ships from the passengers since they are not well informed and they are not yet in a position to differentiate between autonomous and unmanned ship. This is something that affects their perspectives of safety and makes them suspicious towards autonomous ships.

The scripts of the ship

The design of an autonomous ship is a very big issue when we are talking about passengers' safety on board. Although the navigation systems and the automated operations as well as the monitoring of the ship from ashore are crucial subjects that

need to be addressed through this development, another major subject is the actual design of the ships.

When a ship is unmanned the designers can put themselves in a position where they can arrange the layout of the vessel according to the legislation but also they are capable of taking advantage of the absense of the crew. If there is no crew on board certain features of today's ship design can be altered. For example there is no need for crew quarters, ventilation systems, or heating, and sewage systems (Levander 2017). This will contribute in making the vessel lighter and will reduce the wind resistance, which will have as a result the reduction of fuel consumption; one of the major factors influencing every developed industry.

That being mentioned above the design of unmanned autonomous ships could also affect the way the ship is protecting itself. The ship can be designed and built in a way making difficult for pirates to board allowing the security systems on board the ship to notify the remote control position quickly, making easy for the authorities to control the situation at hand.

However, an autonomous ship carrying passengers, manned or unmanned is a different case. The design of the ship should be done in a way that ,in any case of emergency, will provide clear and comprehensive instructions to the passengers carrying.

Humans can react in the most unpredictable ways when it comes to protecting themselves and loved ones. In emergency situations such as fire on board or a necessary evacuation of the ship, passengers may react irrational, based on their survival instincts and even become danger for themselves or others around them. Although passengers may be aware of dangers involving a ship, they are not necessarily familiar with evacuation procedures.

For this reason except for the navigation systems on board,and the monitoring systems and even the fire detecting and fire fighting systems, the interior of the ship should be designed in a way that promotes safety in emergency situations. This is a point that is enhanced by Jesper Brøsted, Human factors Specialist at FORCE Technology. He also

noted that even though there is a lot of data related to how people navigate and how people perceive going on board a vessel, the best case scenario for their job would be to produce knowledge and be able to provide recommendations on better designing of signs and best practice of instructions so,

" ...when emergency happens people will be helped the most in order for them to react spontaneously as they would do normally, but the signs and the stripes in the floor will help this emotional spontaneous intuitive response the best way it can, so that people don't have to think a lot but they can react the way they would do spontaneously anyway." (Interview, Jesper).

When the passengers on the ferry were asked what they think would first pay attention to while boarding on a ship that is autonomous there was a diversity to their responses. Some of them claimed that they would notice to the different information displaying around, whether there is a crew and even escaping routes and emergency exits.

" I would like to know about the weather before , and of course learn about safety routes and find signs that can lead me to safety if something happens. I would like to have easy accessible instructions like on the airplane where you have safety leaflets in the front seat about how to evacuate, oxygen mask etc." (Interview, passenger).

The data showing that people are at some level willing to adjust as long as they are fully informed about the different procedures.

Even though there are still people who believe that autonomous ships are just an not feasible development, when during the interview the ferry passengers were asked about their first reaction to an emergency on board, a big amount responded that they would try to find instructions in the surroundings, find emergency exits ,and even try to encounter the difficulties on their own until help arrived. *" I would try to find exit, I would look for emergency buttons and I would grab my phone to call for help"* (Interview, passenger).

Wayfinding systems

It is important to make passengers aware of their surroundings on board a ship, let alone on board an autonomous ship that operates on its own and perhaps operating with limited or no crew at all. In case of evacuation, one of the most common reasons slowing the procedure, is wayfinding issues (Boer and Skjong 2001). If no crew is present, then the passengers should be able through signs, to find their way to the different muster areas on the ship. Although every vessel is equipped with readable and standing out signs according to IMO legislations, if the signs are not well designed and put in the wrong positions on board the ship, the result could be troublesome for the passengers in an emergency situation. For instance sings pointing arrows that indicate which way to go if emergency happens, should be clear and easy to comprehend otherwise, they could confused the passengers and that may cost precious time during an evacuation procedure. According to Boer 2001, any incident includes chaos where no one actually knows what is going on or how to react (Boer and Skjong 2001) and this is something that can influence one's judgement and mental capacity, *"... so that means that your mental capacity to understand instructions, to understand directions, to understand signs, is more limited than on your normal everyday life."* (Interview, Thomas).
In this case the signs pointing to assembly or muster areas should be properly designed and placed in noticeable places on the autonomous ships to guide the passengers in case of an emergency ,when crew is not present.

Muster area signs

The same importance to the wayfinding systems, must be conveyed to the muster areas signs on board an autonomous ship as well. Beyond the fact that in case of an

emergency independently of whether there is crew on board to assist the passengers or not, there should be different and effective ways of mobilizing the carrying passengers to follows instructions and proceed to the muster areas on the different levels of the ship in order for safety procedures to begin. Emergency alarms and possible pre-recorded messages,or messages announced by the control center offshore through loudspeakers, is one way to do it. A loud, clear and calm voice motivating passengers to follow safety instructions is something that can be easily designed and implemented in autonomous ships, reassuring the passengers that even with limited or no crew on board, there is always someone monitoring the systems and is aware of the situation. This is something that was also noted by human factor specialist at FORCE Technology. He suggested that "*Maybe it doesn't take that much of design establishment to give that same notion that people are still there to help you; even though it's a loudspeaker call, we know that on shore they have cameras, they can see what is going on, they can tell us the correct instructions.*" (Interview, Jesper).

On the other hand, the concept of *'muster area'* is not part of people's common vocabulary. During an emergency situation where people are worried and concerned about their safety, there is a big chance that they might not understand complex instructions such as for example: *"Please proceed to muster area B",* because it is something that doesn't cover their everyday vocabulary. *" … you have loudspeakers saying all passengers must go to muster area B and people would think, where is that because it is not part of their normal vocabulary if you go on board to ship."* (Interview, Thomas).

Instead, if muster areas correspond to different places on the ship, which are well known to the passengers, is preferable to use those as a indicated point. "*But if B is located in the cafeteria it is better to say people need to go to the cafeteria because they know where the cafeteria is"* (Ibid).

During an emergency situation on board an autonomous ship that carries passengers, valued time can be lost due to misunderstanding of instruction signs and mistakes in the

layout of wayfinding systems. The chance of errors occuring due to wayfinding causes is really high. Those errors may be related to visual or psychological reasons. Thomas psychologist and human factors specialist at FORCE Technology, pointed out that psychological issues like stress and fear can enhance a more unpredictable reaction to danger:

"... I would be most afraid of ...., just people going crazy on board and this happens from time to time. There is nobody, except other passengers to intervene and you don't have any way of escaping that situation." (Interview, Thomas)

Therefore, a proper design of the ship could be assist in the most efficient way during an emergency on board. The different indicating signs should be clear for improving human visual perception. For instance, direction symbols like arrows and location signs should provide adequate guidance and their display if designed correctly could allow longer visibility even if conditions like smoke during an emergency occur (Boer and Skjong 2001).

In addition, inadequately placed signs can mislead passengers or confuse them about which way to go during an emergency. For example, if an arrow sign is directing to a muster area through a staircase without clarifying up or down, passengers could be confused about their decisions ,something that could make them lose meaningful time.

The signs if not put in the right places, there is a chance of fading into the presence of other signs. To elaborate on this, we could imagine a muster area sign, or an arrow sign placed next to a large advertising poster. Small signs lose their visibility next to other not relevant displays. *"If competing against advertisements, they will lose the battle for the attention of passengers"* (Boer and Skjong 2001).

Summary

As it comes out from the analysis at this part of the project, a rational behavior during an emergency situation on board an autonomous ship, which operates with limited or no crew on board, is possible. It will take time and a lot of consideration and reflection upon this, but with the right design and planning when it comes to the safety of passengers it will be feasible. From the data collected it is obvious that passengers will need time to comprehend and persuaded that autonomous ships will be safe to use.

Reflection upon what people consider dangerous and risky, can be help in developing designs for autonomous ships that will be flawless and will promote passenger safety in a clear, satisfied way.

Adequate provided information, instructions and help is the most important thing when we are talking about autonomous ships. If the vessels are from the beginning in a position to reassure their passengers' safety ,then a gradual acceptance by the public will be at hand.

Discussion

While processing the collected data and with the research question in mind, this master thesis gained knowledge on how the different actors within the Danish Maritime sector enact their interpretations and expressing their opinions on the development of autonomous ships. Furthermore the master thesis gains knowledge on what are the different perspectives of safety formed by potential passengers on board autonomous passenger ships, as well as how they think this development will affect their safety perceptions when the autonomous technology is eventually implemented.

The aim of this thesis in the beginning was to explore what are the passengers' perspectives about autonomous ships and their beliefs about their own safety on board such vessels. Hence, by conducting multi-sited ethnography, the project gained understanding of the multiple realities the actors involved shaping, as well as revealing a lot of different opinions ,concerns and doubts about the autonomous ships development.
However, the initiation of the project was delayed due to obstacles with the listed informants. Even though Danish Maritime Authorities play a major part in this development, they were holding back to express their opinions on the subject. As we have seen through the project, Maritime authorities are very conservative and actually prefer not to provide information since they do not obtain enough knowledge on the subject yet.
Regardless to this, through a field trip conducted on board a passenger ferry on the route from Helsingør to Helsingborg, an awareness of a rising controversy was revealed, which led to the understanding that the endeavor of developing autonomous ships that will carry passengers is not yet stabilized and it will probably take very long time before it does.

Gaining knowledge and data for this thesis has been relatively easy, as the informants have been willing to provide information and share their knowledge along with relevant documents. Likewise, the ferry passengers were more than willing to share their beliefs and opinions through short interviews during their trip on the ferry.
Thus, during this thesis no kind of resistance was encountered towards the fact that a researcher was entering the informants' territories trying to gain information about their involvements in autonomous ships.
That is why I am so grateful to all the informants for participating in the data collection and for trusting their insights to this thesis.

The decision of using Actor-Network Theory (ANT) and *multiplicity* as the main theoretical approach in this thesis, have served the research by exploring the different actors involved in the autonomous ships development, as well as the multiplicity of how their interpretations and thoughts are affected by the implementation of autonomous technology on board ships.

Further research

On the causatum of this thesis it seems reasonable to look upon another theoretical perspectives that could have been used, along with potential future research.
In this project the focus is on national level for practical reasons. A more detailed project can be done, taking into account the wider European territory and expand the research in other countries such as Norway, Germany or Sweden, since those are some of the countries, which their maritime industries are interested in autonomous ships.

The interpretations of safety are an important and interesting part in this thesis. Another theoretical approach that could have been used giving the current state in maritime industry is that of Social Construction of Technology Theory (SCOT). SCOT argues that technology does not determine human actions but instead human actions shape technology. By using SCOT, the research could have been focused on identifying the *relevant social groups* that are involved in shaping the relevant technology, as well as explore the levels of the technology's stabilization.

Afterwards, ethnographic fieldwork would be necessary in order to collect information about the subject. A creative way to make use of the knowledge gained in this thesis would be to organize workshop where the different maritime stakeholders from Denmark, Norway, Germany and Sweden including passengers of autonomous ships, could participate. A way for the workshops to run would be for the stakeholders to express their opinions about safety on board autonomous ships by answering general questions and later let them reflect upon them.

The outcome of these workshops could be a mutual understanding of safety on board autonomous ships, as well as the formation of well structured prescriptive regulations for autonomous technology.

Conclusion

In this master thesis the development of autonomous ships in Danish level was investigated by interviewing relevant stakeholders involved in the Danish Maritime sector, as well as commuters whose interpretations of safety constitute a major part of the current research. The approach of the field was made through multi-sited ethnography research. *Multiplicity* was used as a tool in order to critical analyse the autonomous ships development. Autonomous ships are understood as multiple, but by examining just a few perspectives, it is certain that an extensive description of what autonomous ships are or will be, has not be given. The results of this thesis are just a piece of an enormous development, which takes its first steps into the maritime sector.

Through the investigation a conclusion of different realities enacted upon the autonomous ships unveiled. The actual problems resulting to a long term process until the stabilization of the technology are the lack of prescriptive regulations for autonomous ships, a reassuring proof to the potential users that the technology can guarantee their safety, as well as a mutual understanding and clear definition of autonomous ships. According to the collected data, there is a common and misguided opinion about autonomous ships. People are putting their trust in people and this is something that we can see clearly from this research. Through the data we can see that the public is trusting the human factors on board a ship. It comes naturally to them to express their belief and trust into the existing crew and professionals like the captain and the chief engineers, instead of trusting that automated technology will perform without problems and will carry out a human's job.

People are under the impression that autonomous at the same time means unmanned, and that is something that affects their perspectives regarding automation and influences their perceptions of safety. This is a major factor that could affect the development, at least when it comes to autonomous passenger ships, until there is a

clear statement that will ensure the safety of the passengers in any situation on board an autonomous vessel.

In addition to this, from the data collected, it results that people are concerning about the fact that with this upcoming development of autonomous ships, many individuals will lose their jobs due to the implementation of automated technology on ships. However, stakeholders related to the maritime industry, made it clear that there will still be positions that needed to be filled by humans for the time being, as well as there will be new job positions requiring expertise. This is something that could create possibilities for usage of high educated people in specific places.

The thesis also concludes, a rational behavior is something that can be achieved during an emergency situation on board an autonomous vessels , as long as there is appropriate infrastructure to support it. A well structured design that will be based on the regulation introduced for autonomous ships, is one of many ways to support the achievement of rational behavior in an emergency situation. The designers should take into account the fact that passengers given the situation may get confused and uneasy, that can result to undesirable reactions that can result to being dangerous. The right placement of instructions, signs and safety equipment is a major factor regarding passenger safety on board a ship, let alone if the ship is autonomous with limited or no crew on board to assist.

The authorities, the industry as well as the numerous stakeholders in the area are making efforts to create a mutual understanding of autonomous ships, but it is clear that since the development is an infant, it will require a long time for all the existing problems to be solved in order for the development to be black boxed. This is because even though there are actors related to maritime industry that are persuaded and ready for this technological development, the need for prescriptive regulations is a major issue, and it’s the first one to be solved. This procedure takes more time than usual because

we are talking about a new implementation. Every aspect of possible scenarios should be considered in order for the authorities to provide full, well structured and comprehensive prescriptive rules for autonomous ships.

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