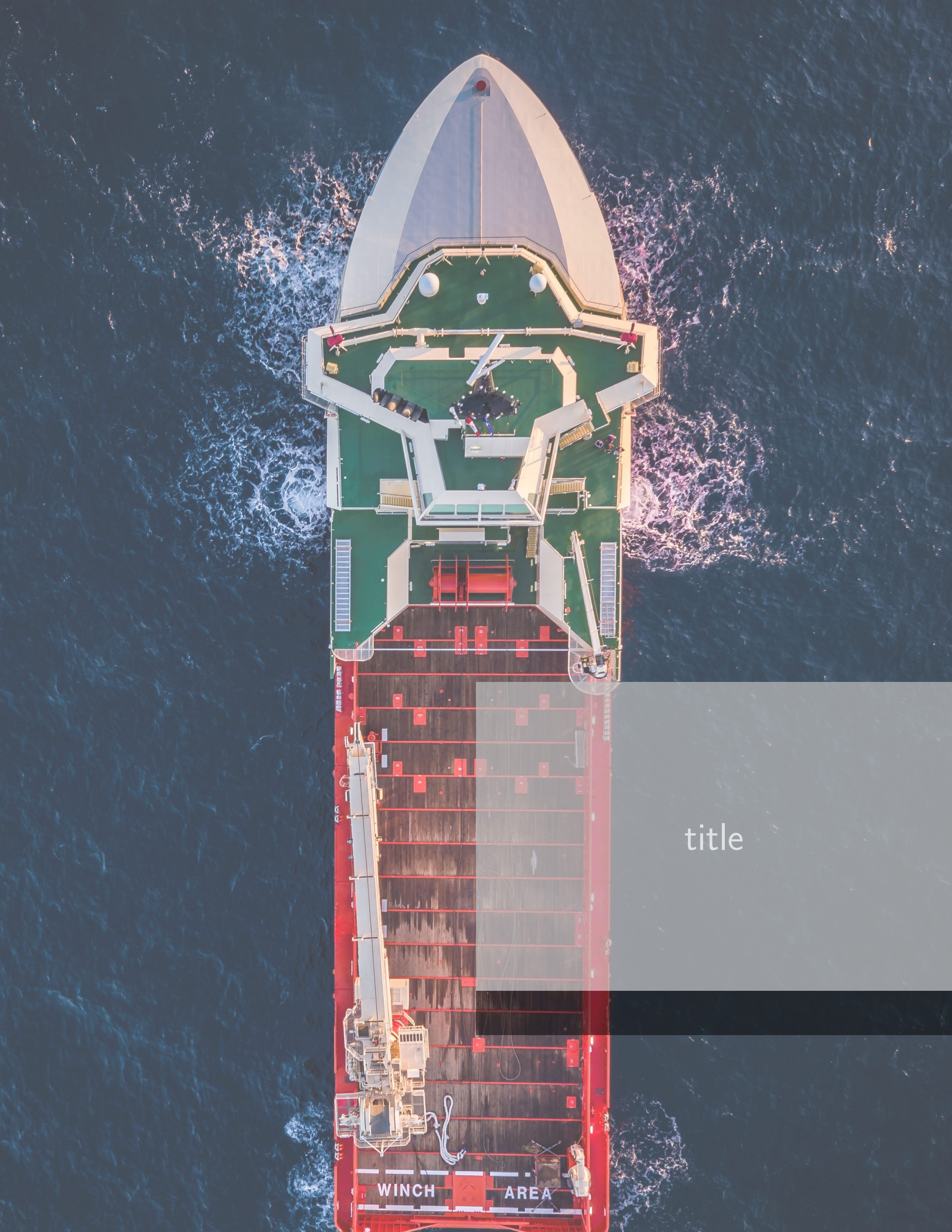
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MSc Thesis - Current Knowledge

Model for the complexity of maritime operations

Ingmar Wever (4161041)

November 14, 2017

Notes

Check if this is really the structure . . . 1
citation and maybe a bit more info . . . 2
Add report on accident with merchant vessel and loss of situational awareness . . . 2
Describe in short what will be discussed in future of shipping section . . . 5
Praat met Boudewijn Baan - Sales Manager - involved vanuit Damen bij Gouwenaar . . . 6
In short keywords discussed in this chapter . . . 7
Check if I mention everything, and write down tought process of crew, using one or more known mental model methodologies . . . 8
extend which licenses and the amount of experience needed . . . 8
Add part on type of change, related to course on behavioural change, including difference between stressfull and normal situations . . . 8
What will be discussed in this chapter . . . 10
Add pictures of bridge and different dashboards on screen, separated for different vessels sizes . . . 11
add years for steam, steel, technological developments . . . 11
add information on cognitive seafarer model . . . 12
add more research on bridge design (Myrthe Lamme) . . . 12
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Which regulations are leading, IEC code . . . 12
How is a map build, S-57, .BSB; how to import and modify, preferably with python . . . 12
Make short user stories for the captain and other crew. Also based on the mental model and thought process of the crew. Which tools do they use in that case. . . . 13
write the scope of the project . . . 15

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Abbreviations

AIS Automatic Identification System

AMS Alarm Management System

CAM-HMI Central Alert Management Human Machine Interface for presentaiton and handling of alerts

DP Dynamic Positioning

ECDIS Electronic Chart Display Information System

MARPOL International Convention for the Prevention of Pollution from Ships

SOLAS International Convention for the Safety of Life at Sea

STCW International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

TEU Twenty foot Equivalent Unit

UID User Input Device

VHF Very High Frequency radio

Introduction

This document will function as a starting point for my research. Summarizing current knowledge, projects and papers, which gives insight where opportunities are to create new knowledge. The main subject of the research will be: Modelling the complexity of maritime situations, to determine the probability of failure, improving the situational awareness of the crew.

As described in the Dutch National Research Agenda a fundamental question we have to ask ourselves is: How do we get grip on unpredictability of complex networks and chaotic systems? Within the Netherlands Top consortium for Knowledge and Innovation (TKI) exist to support innovation by connecting companies, governmental organizations and research institutes to work together in so-called Joint Industry Projects. TKI Maritime has four main themes for these projects. This research will be related to the smart and safe sailing theme. Which aims at lowering crew and maintenance cost, while maintaining a safe working environment. Developing a system which supports the crew during navigation by adding giving more insight into the complexity of a situation, and where hazards occur. This goal is met.

This research will have two main tracks. The first part is related to the Design track of Maritime Technology. Where I will try to specify a scale for the complexity of a situation, which is correlated with the probability of failure. The second part of the research will be for the Interactive Intelligence department of computer science. Focussing on the interaction between computers and people. In this case more specific, which information does the crew currently get and what information do they need. To improve their situational awareness and make better decisions during operation.

First projects will be described who are the frontiers and which are seen as the future of shipping. After that, a literature review is done on subjects like situation awareness, decision making, and mental models. This will be the foundation of the research for computer science. Followed by a research into the physical world of the ship, why does it behave like it does, and which forces work on the ship. Using this information a model will be created where also route-planning and collision avoidance are discussed. Information on how information for the model is acquired is the next important step. The model should finally lead to a cost function and this will be presented to the crew. At last, a discussion about the scope is being presented to really demarcate where my research will focus on and what potential iterative steps are.

Check if this is really the structure

1 Reported accidents

As mentioned in the introduction is there a desire from the scientific community to do research into the topic of modeling complex systems to improve safety. But to get support from companies a practical application is desirable. The clearest case for non-sufficient safety measures is of course accidents. Accidents have often been incentives to adapt rules. For example the leading international treaty for safety of life at sea (International Convention for the Safety of Life at Sea (SOLAS)) has been adopted in response to the Titanic disaster.

1.1 Titanic

Multiple things went wrong. Among others did the crew ignore warnings to reduce speed from other ships, because of ice packs and ice bergs in the area. When the accident occurred, the ship was sailing almost at top speed, as the captain did not believe the ice was a serious risk to this ship. Thereby did the last minute manoeuvrer failed, causing more damage than a head-on collision. And after the accidents were the distress signals not received by the nearest ship, as the radio operator was off duty and they did not respond to the flares. With the new regulations and technologies, this chance of this happening all over again has been reduced.

citation and maybe a bit more info

1.2 Accident merchant vessel

Add report on accident with merchant vessel and loss of situational awareness

1.3 USS Fitzgerald and ACX Crystal

A more recent well known collision was between the USS Fitzgerald and ACX Crystal on 17th June 2017. The US destroyer hit the larger Philippines container vessel resulting in the death of 7 US Sailors. An illustration of the accident is shown in figure 1. According to the accident report did failures occurred on the part of leadership and watch-standers. There were failures in planning for safety, adhere basic navigational practice, execute basic watch standing practice, proper use of available navigation tools and wrong responses.

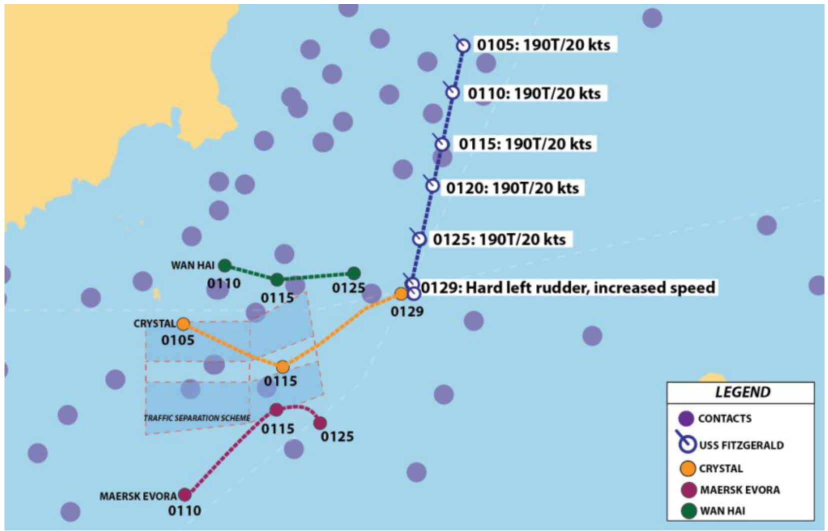

Figure 1: Illutstration map of approximate collision location

In accordance with international rules the USS Fitzgerald was obligated to manoeuvrer to remain clear from the other crossing ships. The officer of the deck responsible for navigation and other crew discussed whether to take action but choose not to, till it was too late. While other crew members also failed to provide more situational awareness and input to the officer of the deck. Did the officer of the deck, exhibit poor seamanship by failing to manoeuvrer as required, failing to sound the danger signal and failing to attempt to contact CRYSTAL on Bridge to Bridge radio. In addition, the Officer of the Deck did not call the Commanding Officer as appropriate and prescribed by Navy procedures to allow him to exercise more senior oversight and judgment of the situation. This was prescribed to an unsatisfactory level of knowledge of the international rulles of the nautical road by USS Fitzgerald officers. Thereby were watch team members not familiar with basic radar fundamentals, impeding effective use. Thereby were key supervisors not aware of existing traffic seperation schemes and the expected flow of traffic, as the approved navigation track did not account, nor follow the Vessel Traffic Separation Scheme. Secondary was the automated identification system not used properly. []

1.4 USS John S McCain and Alnic MC

Even more recent is the collision between the USS John S McCain and Alnic MC on 21st August 2017. The US Destroyer hit the Liberia flagged oil and chemical tanker. Resulting in the death of 10 US Sailors. An illustration of the accident is shown in figure 2. According to the accident report did the US Navy identify the following causes for the collision: Loss of situational awareness in response to mistakes in the operatoin of the USS John S McCain's steering and propulsion system, while in the presence of a high desnity of maritime traffic. Failure to follow the international nautical rules of the road, which govern the manoeuvring of vessels when risk of collision is present. Watchstanders operating the John S McCain's steering and propulsion systems had insufficient proficiency and knowledge of the system.

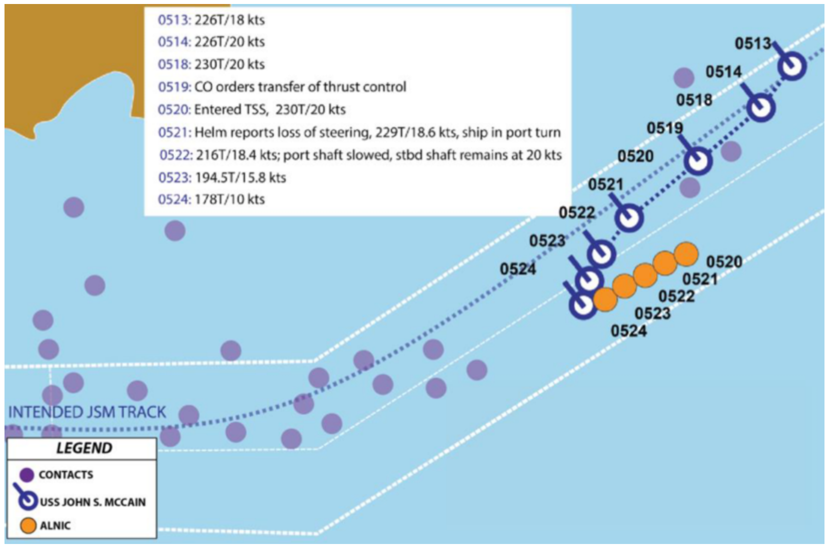

Figure 2: Illutstration map of approximate collision location

Leading up to the accident did the commanding officer notice that the helmsman had difficulities maintaining course, while also adjusting the throttles for speed control. In response, he ordered the watch team to divide the duties of steering and throttles, maintaining course control with the Helmsman while shifting speed control to another watchstander known as the Lee Helm station, who sat directly next to the Helmsman at the panel to control these two functions. This unplanned shift caused confusion in the watch team, and inadvertently led to steering control transferring to the Lee Helm Station without the knowledge of the watch team. The commanding officer had only ordered a speed control shift. Because he did not know that steering had been transferred to the Lee Helm, the Helmsman perceived a loss of steering. Steering was never physically lost. Rather, it had been shifted to a different control station and watchstanders failed to recognize this configuration. Complicating this, the steering control transfer to the Lee Helm caused the rudder to go amidships (centerline). Since the Helmsman had been steering less than 4 degrees of right rudder to maintain course before the transfer, the amidships rudder deviated the ship's course to the left. Additionally, when the Helmsman reported loss of steering, the Commanding Officer slowed the ship to 10 knots and eventually to 5 knots, but due to the configuration did the two shafts start working in opposite direction. Causing an un-commanded turn to the left (port). The commanding officer and others on the ship's bridge lost situational awareness. They did not understand the forces acting on the ship, nor did the understand the Alnic's course and speed relative to USS John S McCain. Three minutes after the reported loss of steering, was it regained, but already too late to avoid collision. No signals of warning were send by neither ship, which are required by international rules of the nautical road. Nor was there an attempt to make contact trough the Very High Frequency radio (VHF) bridge-to-bridge communication. Many of the decisions made that led to the accident were the result of poor judgemenet and decision making of the commanding officer. That said, no single person bears full responsibility for this incident. The crew was unprepared for the situation in which they found themselves through a lack of preparation, ineffective command and control. Deficiencies in training and preparations for navigation were at the base of this. []

Why would we change the current situation? Investigation reports

2 Future of shipping

The shipping industry is traditionally driven by regulations. Digitalization and de-carbonization are watch words for the coming decade. Those will be leading so the shipping industry can become safer, more efficient and at the same time reduce its environmental footprint [].

Describe in short what will be discussed in future of shipping section

2.1 Steps to be taken

Focussing on the digitalization, ships will become more sophisticated. More data is generated by sensors, improved connectivity and new ways to visualise data. This enables ships to continuously communicate with managers and traffic controllers. At first this can be used to analyse data and give better advice based on expected weather, fuel consumption and arrivals at bottlenecks like ports and bridges. Later on this can results in unmanned vessels. Either remotely operated from shore, on autopilot or completely autonomous, as shown in figure 3. The different projects around the world follow this same path. Below some of these projects are mentioned with their current status.

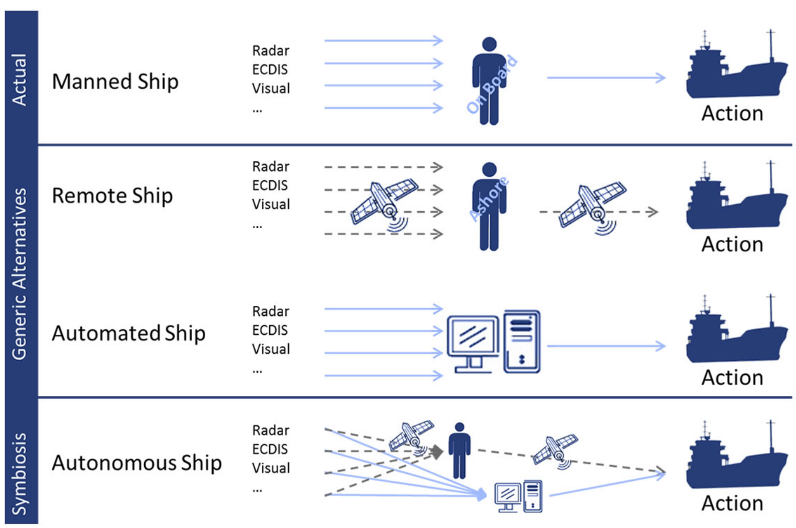

Figure 3: From manned to autonomous ships

The research project MUNIN consists of a constortium of shipbuilders and scientists. The name is an abbreviation for Maritime Unmanned Navigation trough Intelligence in Networks. They did an initial research. Focussing on different elements of an autonomous concept: The development of an IT architecture. Analyse tasks preformed on today's bridge and how this will be on an autonomous bridge. Examine the tasks in relation with a vessel's technical system and develop a concept for autonomous operation of the engine room. Define the processes in a shore side operation centre required to enable a remote control of the vessel. Thereby taking into account the feasibility of the developed solution, including legal and liability barriers for unmanned vessels. They concluded that unmanned vessels can contribute to the aim of a more sustainable maritime transport industry. Especially in Europe, shipping companies have to deal with a demographic change within a highly competitive industry, while at the same time the rising ecological awareness exerts additional pressure on them. The autonomous ship represents a long-term, but comprehensive solution to meet these challenges, as it bears the potential to: Reduce operational expenses and environmental impact. An concept was developed for a bulker vessel, enabling the consortium to do a financial analysis. Showing the viability, but admitting the limited scope of the project [].

2.2 Current industry projects

Rolls-Royce Marine is involved in different projects which are in some way follow-ups on the MUNIN project. Well-known are the videos of the virtual bridge concept and the Electric Blue. Electric blue is a concept ship, based on a standard 1000 Twenty foot Equivalent Unit (TEU) feeder. The ship is very adaptable, it can sail for example on both diesel and electricity. The modularity enables it to adapt for specific routes and meet environmental requirements now, and in the future. Keeping in mind the way towards autonomous, will it have a virtual bridge, housed below the containers. Utilizing the opportunities of sensors for safe navigation, employing radar, camera, IR camera, lidar and Automatic Identification System (AIS). The roadmap for this concept is to have partial autonomy by 2020, remote operation between 2025 and 2030, starting with a reduced passive crew on board. And be fully autonomous in 2035 []. To make these steps they were aware from the start on, that the control room is the nerve centre of remote operations. Using an interactive environment with screen for decision support and improving situation awareness with augmented reality. With these developments does their vision look very promising. However it is still in a concept phase.

Just like MUNIN did this project also originate from WATERBORNE, an initiative from the EU and Maritime Industries Forum, supporting cooperation and exchange of knowledge between stakeholders within the deep and short sea shipping industry. Since June 2017 is Rolls-Royce also involved in the unmanned cargo ship development alliance, which is initiated by Asian companies and classification bureaus. Many of the projects where Rolls-Royce is involved, has DNV GL also a role. But beside these projects they are involved in other projects which look very promising.

First the projects on Norwegian ferries, which are likely to start sailing automated from 2018, just like an automated shuttle service for offshore installations. Already a step further is the Yara Birkeland, and 120 TEU container ship. This vessel will initially operate as fully electric manned vessel, but plans are that it will sail autonomously in 2020. Operating between different Yara facilities, transporting fertilizers and raw materials. Kongsberg is responsible for the development and delivery of all key enabling technologies. Including the sensors and integration required for remote and autonomous operations, in addition to the electric drive, battery and propulsion control systems [].

Where most of the previous projects were focussed around developing a vessel which has to operate in the current environment. Does the smart shipping challenge focus on combining technological developments within different parts of the inland shipping industry. This will help to steer ships remotely, smarter sharing of information and optimisation of waterway maintenance. A good example are the new vessels from Nedcargo, the Gouwenaar 2 and 3. These vessels will be able to transport more containers, while reducing the fuel consumption. This will not only be acquired by improving the hull shape and machinery, but also by sailing smarter. For example by optimising the speed, based on opening times for bridges and availability of the quay [].

Praat met Boudewijn Baan - Sales Manager - involved vanuit Damen bij Gouwenaar

3 Knowledge of the crew

Seafarers are a group which are protected by international maritime treaties such as SOLAS, International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and International Convention for the Prevention of Pollution from Ships (MARPOL). Despite the regulations does human behaviour still lead to most accidents at sea. This complex multi-dimensional issue affects maritime safety and marine environmental protection. It involves the entire spectrum of human activities, performed by ships' crews, shore based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all of whom need to cooperate to address human element issues effectively []. Fortunately a lot of research is preformed around human behaviour, there is thus an opportunity to keep improving the way people are involved. And there capabilities are utilized while mitigating there vulnerabilities.

In short key-words discussed in this chapter

3.1 Situation awareness

Experience is key to improve the skill to scan for hazards. This is known as the situation awareness []. Hereby is important to notice that situation awareness is not limited to perceiving, but has multiple levels. This is known as the Endsley model (figure 4), the three levels are []:

- *Perception*. Data is merely perceived.
- *Comprehension*. Interpretation of data, enabling understanding of relevance in relation to tasks performed and goals to be attained. Forming an holistic picture of the operational environment. Identifying the significance of objects and events in that environment.
- *Projection*. Making a forecast for likely future states of the situation . This is based on the interpreted data, experience and knowledge.

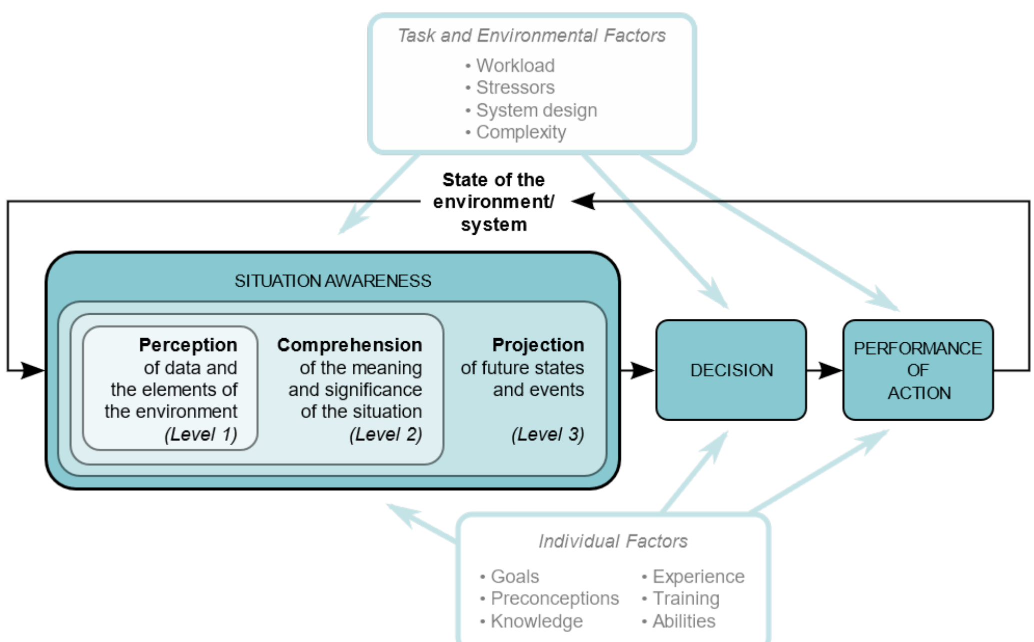

Figure 4: Endsley model for Situation awareness

3.2 Mental model

To explain why someone predicts a future state that will occur, it is important to get insight in the mental model of the crew. The mental model is the mechanism which describes elements in the environment within a volume of space and time. Giving explanations of system functioning, observed system states, and predictions of future system states. Done for a specific representation of the real system, for only selected concepts and relationships []. The selected concepts and relationships are based on the background of the person. This is the reason why an economist and an engineer will have completely different mental models when looking at a ship. Where the economist sees it as an investment with related cost and returns. Will the engineer focus more on the way how it sails, propels itself and stays upright. The focus of the crew will be on the state of the vessel and the environment. Does the machinery work, what is the operational status of the vessel, what is the speed of the vessel, what is the wind and current speed, will they encounter bad weather, are there other vessels, does the vessel follow the planned route, etc. This means that a well designed bridge and a high quality planning are needed, to be able to understand the risks and know which information is desired when. When this does not happen loss of situation awareness occurs. This is according to Sandhaland, based on accidents at the north sea caused by: inadequate design, planning failure, communications failure, distracting elements and insufficient training. The consequences have been failure in monitoring the vessels status. For example if the steering was on auto-pilot or manual, detecting obstacles during bad visibility, or not receiving the right thruster status. In some cases it went a level deeper in situation awareness, where the crew received the information. But did not make the right decisions based on this. This was often because the crew was not aware of the risk involved and the effect of operating with the system configured in a specific way. For example when a thruster was deselected, redundancy was lowered, which finally led to the accident. [].

When the crew was not aware of the risk involved, they had a wrong mental model of the system. The best way to improve someone's mental model is by training. This training is mostly focussed around acquiring experience in specific situations. The decision process during these situations is often dynamic, biased by individual perspective and goals, conditioned by previous experiences, including many system components and nonlinear relationships. This is also why it is hard to learn from normal data sources such as books or video. But experience have to be acquired to store situations directly in the mental model of the crew. Consequently failures and conflicts are needed to improve these processes. As they show boundaries for decision making. This can be done using scenario-based training environments using virtual reality. It has been shown that training in those environments will lower stress and enhance professional performance in real-life situations [] [].

3.3 Crew development in practice

Check if I mention everything, and write down tought process of crew, using one or more known mental model methodologies

extend which licenses and the amount of experience needed

3.4 Possible improvements

Add part on type of change, re-

3.5 Information overload

The reason not too add another screen is to avoid information overload. While Sandhaland already mentioned how information overload is one of the main reasons for loss of situation awareness. As in most failure cases the right information was somewhere on the screens. But was not perceived correctly by the crew.

4 The bridge

In section 3 is discussed, how situation awareness is created by monitoring the vessel. The crew monitors the vessel from the bridge. The development of the bridge design is driven by technological advancement and regulatory demands. Which has increased the amount of equipment on a ship's bridge []. Leading to all different components giving more and more data. As described by Speier are nowadays new technologies the primary reason for information overload. Not only because it produces more data, more quickly. But also that this information is disseminated more easily to people who do not need it [].

What will be discussed in this chapter

4.1 Bridge elements

The bridge of a vessel has four elements according to DNV-GL. The human operator, procedures, technical system and the human-machine interface. The safe operation of the vessel can only be assured when these are aligned. In figure 5 the different elements and their key factors are shown. Regulations aim to regulate these factors to ensure a safe performance of the bridge system to ensure system reliability in various modes of operation under different operating conditions. []

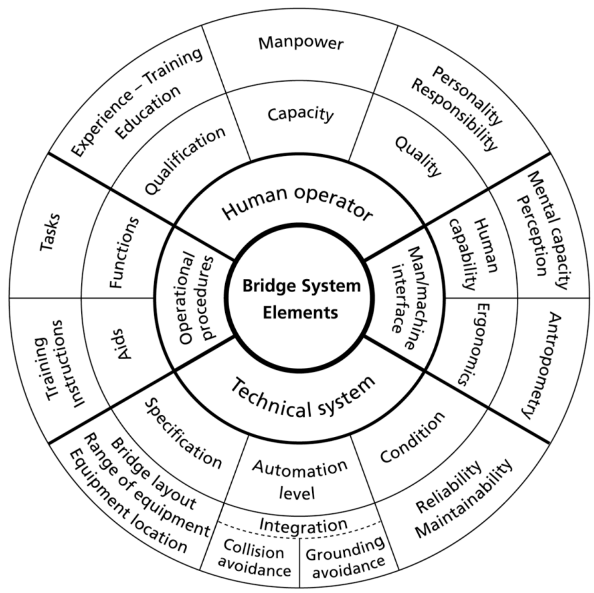

Figure 5: Bridge system elements according to DNV GL

4.2 Instruments and equipment

Depending on the different station at the bridge certain equipment must be installed and within reach. But at least the following instruments and equipment shall be installed: navigation radar with radar, propulsion control, manual steering device (with take-over), heading control, Electronic Chart Display Information System (ECDIS), steering mode selector switch, VHF unit, whistle and manoeuvring light push buttons, internal communication equipment, central alert management system User Input Device (UID)s, general alarm control, window wiper and wash controls, control of dimmers for indicators and displays, steering UIDs, propulsion, emergency stop for propulsion machinery, gyrocompass selector switch and steering gear pumps.

These different systems have indicators with information on: propeller revolution, speed over ground, windspeed and direction, rudder angle, rate-of-turn, heading, steering mode, steering position in command, depth indicator, clock, Central Alert Management Human Machine Interface for presentaiton and handling of alerts (CAM-HMI), alarm panel related to unmanned machinery space, alarm panel related to steering control system and steering gear, sound reception display and warning of surveillance period elapsing.

Depending on the vessel some extra instruments can be for track control, steering control station selection, thruster UIDs and emergency stop for thrusters. Which give information on the thrust, pitch and when provided a conning information display. []

Add pictures of bridge and different dashboards on screen, separated for different vessels sizes

4.3 History of bridge design

add years for steam, steel, technological developments

A brief history of bridge design starts at the transition from sailing ships to paddle steamers in the 19th century. Where the captain's sight could not be obstructed by the paddle houses, and engineers needed a platform from which they could inspect the paddle wheels. A raised walkway was created between both paddle houses, literally a bridge. The name bridge stuck, even when ships started using screw propellers. From the bridge, commands were passed via officers to the different stations. Where physical actions were carried out to control the ship. As technology did not exist to remotely control the ship. The helmsman or coxswain operated the ship's wheel from the enclosed wheelhouse, and engineers received commands in the engine room via engine order telegraphs. Where the bridge was often open to the elements, a weatherproof pilot house could be provided, from which the navigation officer could issue commands.

With the development of steel ship, came also the requirement of a compass platform. Sited as far away as possible from ferrous interference. Later this was solved with a binnacle. But this was another system which was introduced. In modern vessels, most of the stations for physical control have been moved to the bridge. The rudder and throttle can be operated directly from the bridge. Due to previous accidents, it is even common to have unmanned machinery spaces during operation in smaller ships. The technological developments have also lead to a variety of systems as mentioned above. Starting with radar at the start of the 20th century. ECDIS was another major step forward, where it was accepted in 1995 by IMO as an up-to-date chart as required by SOLAS. Later made mandatory in 2009 by SOLAS, where STCW requires ECDIS competence for navigational officers and masters. This added an extra screen. Continuously adding other instruments for meteo, AIS, echo sounder, different compasses, etc. First, the different instruments had all a separate analog instrument. Nowadays these are often displayed together at the conning display. While having the separate instruments at less convenient places.

4.4 Future of bridge design

This conning display already gave the opportunity to develop a more user oriented-bridge environment. But with the continuous development of different sensors. A new revolution is coming for bridge design using among others: sensor fusion, new ways of visualization and decision support. These are known as integrated bridge systems.

The development of future bridge designs goes parallel to the research into autonomous vessels. Both can be traced back to the changes in philosophy on human-computer interaction. Below some of the concepts are explained where often a combination of classification societies, research institutes, and commercial companies are involved.

4.4.1 Concept designs

Within Damen, there is the desire to make the bridge design more standard and create more of a brand identity. An integrated design is desired in this case, where suppliers deliver the back-end. Similar projects which already show a future vision of ship design are the Ulstein Bridge Vision concept and Rolls Royce oX bridge. Where augmented reality in the windows and adapting user interfaces are key. With early warnings, decision support for economic sailing, environmental analysis, and having the ability to use the windows as a screen to simulate operations. While it is clear that here lies the future of bridge design, they did not yet come with clear solutions. Although in projects like Waterborne some steps are made when it comes to the user interface. [] []

4.4.2 Research projects

The CASCADe project has already been more research-oriented and towards a practical solution. They have tried to develop a bridge system which adapts displayed content on the user interfaces to the current situation, relevant procedures and the needs of the crew. Using a virtual simulation platform which enables analysis of the cooperative bridge system purely based on models, in particular, Cognitive Seafarer Models which mimic decision making and situation awareness processes of real human seafarers. The virtual platform allows a very careful evaluation of the Adaptive Bridge System to research solutions for adaptation which provide benefits (e.g., increase situation awareness) that outweigh their costs (e.g. cognitive disruption). []

add information on cognitive seafarer model

4.4.3 Suppliers

add more research on bridge design (Myrthe Lamme)

But currently bridges are already built and the companies developing these are also not standing still. But present more realistic their current status. The Kongsberg K-Master work environment integrates already different systems in one user interface. Dynamic positioning, manual propulsion and thruster control, alarm monitoring and remote control of machinery, central bridge alarm system, the operation of auxiliary bridge systems and chart, radar, autopilot and conning displays are all combined. Where this system was originally only for the aft bridge, is it now used for a variety of vessels. [] Many of the Damen vessels sail with the Dutch integrated bridge systems, which is the first step towards are more user centered design. Examples are Praxis' Mega-Guard IBS or Alphatron's AlphaBridge. Both modular bridge systems use in-house developed instruments. Combining Radar, ECDIS, conning, alarms, other ship systems and AIS. Other major players in the development of integrated bridge designs are Sperry Marine with the VisionMaster FT, Raytheon Anschütz Synapsis NX and for yachts Admarel.

Check systems Damen is using

Which regulations are leading, IEC code

4.5 Manoeuvring display

The CASCADe project already showed the advantages of an adaptive bridge system. Key in most of these systems is a modification to the overlay in the ECDIS system. This is also chosen as starting point for bridge modifications in this project. As it is already possible using the ECDIS system to add alarms and layers. The developed model will be a white box approach, this will help to define alarms and mark forbidden zones. Thereby need to be taken into account, the rules and regulations for the ECDIS system as defined by the international hydrographic organization.

How is a map build, S-57, .BSB; how to import and modify, preferably with python

4.6 Bridge users

Make short user stories for the captain and other crew. Also based on the mental model and thought process of the crew. Which tools do they use in that case.

5 Model

5.1 Physical models

5.1.1 Manoeuvrability

How does the inertia of ship work, and movements due to props and rudder.

Abkowitz defined in 1964 a simple model where position (X, Y) and rotation (N) depends on speed, accelation and rudder angles. Including hydrodynamic forces and moments. This is needed to calculate the path.

5.1.2 Environmental forces

How are we going to model the wind, wave and current forces

5.2 Route planning

What are key issues in optimizing the route Model predictive control - Tor Arne Johansen

5.3 Cost function

5.4 Monitoring

5.4.1 Environment

5.4.2 Ship

6 Conclusion

Wrap-up

6.1 Desired result

With the knowledge from the previous chapters a framework can be formed for my research. Hereby taken into account what has already been done and how this can be used. To have a goal the result of will be defined upfront. This result can be separated into two parts too. The first part is for the department of Maritime Technology and Transport. Where I will try to specify a scale for the complexity of a situation, which is correlated with te probability of failure. As a white box

The second part of the research will be for the Interactive Intelligence department of computer science.

6.2 Scope

write the scope of the project, already in graduation project plan.docx

6.3 Timeline

Table 1: Timeline

Bescrhijving	Start	Deadline
Project plan met initiele planning		6 okt
Samenvatting gerelateerde projecten en onderzoeken	4 okt	20 okt
Plan van aanpak met opzet voor rapport	9 okt	3 nov
Inlezen in papers en projecten en vertalen naar current knowledge	20 okt	19 nov
Definieer well-clear op basis van regulations en company policy	1 nov	19 nov
Plan van aanpak definitief maken	20 nov	26 nov
Programma van eisen voor tool opstellen en test voor CS	26 nov	17 dec
Onderzoek naar cost functie en modellen benodigd vanuit MT perspectief	17 dec	10 feb
Opzet voor onderzoek met crew	5 feb	10 feb
Ontwikkelen van GUI en tool op basis van programma van eisen	12 feb	5 mar
Testen met crew	5 mar	2 apr
Tool verbeteren op plekken waar meer detail nodig is	19 mar	6 apr
Opnieuw testen en vergelijken met eerdere tests	2 apr	13 apr
Vergelijking maken tussen theorie en praktijk	16 apr	30 apr
Rapport CS en MT finaliseren	30 apr	4 jun
Artikel schrijven	4 jun	29 jun
Presentatie	24 jun	6 jul

6.4 Research questions

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