Enhancing Situational Awareness

A research about improvement of situational awareness on board of vessels

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Research report
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Summary

“Situational awareness” is a term that simply means understanding the current situation. It is the ability to look at a huge variety of data, determine what is relevant, synthesize the data, and act on it. (Sciences, 2015)

When for some reason the officer of the watch misses vital information about these objects, he is suffering from a lack of situational awareness, which is the cause of many accidents each year. This problem has multiple causes, for example fatigue and an overdose of information.

In order to prevent a lack of situational awareness, these causes must be eliminated. Eliminating fatigue is impossible, as there are numerous factors contributing to it, varying from medical to psychological and lifestyle related causes. Monitoring fatigue is the best way to prevent it from causing accidents. For this, eye-tracking is the best solution, although it might require changing a bridge's lay-out, as this system does have some limitations. However, this system only monitors fatigue, without doing anything to prevent it.

To prevent fatigue, using blue light at night is a possibility, as it influences the melatonin levels in someone's body, which in turn influences the sleep pattern. Blue light does have some side-effects, so further in-depth research is certainly required.

Another way to prevent a watch keeper from lacking situational awareness is to change the way the information from the outside is presented to him. This is done by data processing, which means the combining of data received from all the different on board-systems such as GPS, Radar and AIS and presenting them to the watch keeper in a clear way. This can be done by using augmented reality, which makes it easier for the officer of the watch to respond to the information he is given, increasing his situational awareness.

The best way to reduce situational awareness is by combining all these system in a new bridge layout, as this will tackle the issue of situational awareness from both sides: the way information is given (data processing) and the way it is received (reducing fatigue).
Preface
This project was launched with the intention to improve safety in shipping. We decided to do our project about enhancing situational awareness on board of seagoing vessels. Because situational awareness is important to the safety on board. We hope to improve the situational awareness in order to enhance safety.

We would like to thank everyone who helped us during this project. First of all we would like to thank Mrs. van der Drift and Mr. Blankenstein, for successfully guiding and helping us to make this project into its final form and Mr. van Kluijven for all the help around the project.

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Mr. Hurkmans, Imtech marine, data processing
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Rotterdam, 13th March 2015
Mauro Pico, Dennis Hoogervegt, Rutger van Basten Batenburg, Robbert Bik and Sjoerd van der Wiel
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**Introduction**

In the maritime industry situational awareness is a hot topic. Especially the lack of situational awareness is, according to the IMO, very important for the safety on board a ship. Human error is the cause of 90% of casualties in the maritime sector. (Human Factors in Maritime Applications, 2014) The lack of situational awareness is a big contributing factor to this percentage. A lack of situational awareness can be caused by multiple factors, for example fatigue, lack of overview and stress. (MayoClinic, 2014)

For example, officers have an eight hour watch cycle. This means that they have a navigation watch of four hours two times a day. In-between watches officers have an eight hour rest period, also two times a day. One of these eight hour rest periods is often used to do paperwork and other businesses. So in theory officers have eight hours of sleep a day. In practice these eight hours are almost never met due to unforeseen problems and an extra amount of paperwork. (vocsite.nl, 2014). This means that over a period of several weeks (the time an officer is usually on duty) fatigue starts to play a big role aboard vessels. When fatigue kicks in a person’s response time and the ability to make decisions rapidly declines.

In the maritime sector many stakeholders are affected by this problem. First of all the crews aboard vessels who are in danger because of the increased chance of accidents. Second are the shipping companies whose cargoes have the chance of being damaged and have to pay extra insurance money.

The lack of situational awareness has many factors. In this report these factors will be elaborated and solutions will be suggested to counter these factors. One of the main factors is fatigue and the monitoring of fatigue.

Another cause of a lack of situational awareness is an overload of information which makes it likely for the watch keeper to miss vital information and is not able to divide unimportant information from important information, such as other vessels approaching him or a buoy in his course. The desired situation is that fatigue will occur less, and that when it occurs it is quickly noticed and action can be taken. Every possible human factor has to be controlled, because the human factor is still the largest contributor to accidents.

Problem definition: aboard of vessels the amounts of mistakes made by humans due to a lack of situational awareness is too large and needs to be reduced. The objective of this project is to find solutions on a technical and automation level, which will improve the situational awareness on board.

Situational awareness is a broad topic; due to this it is necessary to establish boundaries. This project has not looked into the development of augmented reality. Also it has not researched the costs of the solutions provided, as well as the costs of the solutions provided. Also this research has only looked into the integration of the provided solution on a conceptual level.
Main question:
How can situational awareness be improved in order to improve safety aboard vessels?

Sub questions:
What is situational awareness?
Definition
History
How does the human factor contribute to accidents?

What causes the lack of situational awareness aboard vessels?
Fatigue
Information overload
Track line attachment syndrome

How can situational awareness be improved using eye tracking?
How does the current watch alarm work?
What are other methods of measuring fatigue?
What is eye-tracking?
How could eye tracking be implemented on vessels?

How can blue light improve situational awareness?
How does blue light influence the sleep pattern?
How could blue light be implemented on the bridge?

How can situational awareness be improved using data processing?
How does it improve situational awareness?
How could it be implemented on board of vessels?
How does data processing improve situational awareness?

How does a possible bridge layout look like after implementation of the new systems?
What is required regarding equipment on the bridge?
What will the new bridge lay-out look like?
Research methods
During this project information has been gathered in different ways. This chapter will explain the ways information was gathered per sub question.

What is situational awareness?
This question has been answered by means of qualitative desk research.

What causes the lack of situational awareness aboard vessels?
This question has been answered by means of qualitative desk research. Also there has been an interview with Mr. Remko Kloos from Anthony Veder.

How can situational awareness be improved using eye tracking?
This question has been answered by first doing desk research. After the desk research the field research consisted of an interview with Mart Hurkmans from Imtech Marine and Cees Pieters from the Rotterdam Mainport Innovation Centre.

How can situational awareness be improved using data processing?
This question has been answered by first doing desk research. After the desk research the field research consisted of an interview with Mart Hurkmans from Imtech marine and Cees Pieters from the Rotterdam Mainport Innovation Centre.

How can blue light improve situational awareness?
This question has been answered by doing desk research. This desk research mainly consisted of gathering information about the effects of blue light.

What does a possible bridge layout look like after the implementation of the new systems?
This chapter made use of the research done in the other chapters.
Chapter 1: Situational awareness

This chapter will answer the sub-question: “what is situational awareness?” and the question: “How does the human factor contribute to accidents?” contributing to the completion of the sub-question. These questions give an insight about situational awareness’s definition, history and the related human factor.

Definition of situational awareness

“Situational awareness” is a term that simply means understanding the current situation. It is the ability to look at a huge variety of data, determine what is relevant, synthesize the data, and act on it. (Sciences, 2015)

History

The concept of situational awareness was first proposed in World War I by Oswald Boelcke, a German fighter pilot. His concept was about getting awareness of your enemy prior to your enemy getting awareness of you. A few years later the United States Air Force returned from war in Korea and Vietnam saying good situational awareness is the decisive factor in air combat engagements. However in that time the world had no interest in such a concept and it was not until the last century’s eighties that situational awareness started gaining new interest by researchers of different scientific fields (aedic). In the 1990’s situational awareness was widely adopted by human factor scientists. From this point situational awareness gained a lot of interest in the aviation industry.

More recently the study of situational awareness has been applied on more than just aviation because it has far reaching applications as it is needed for teams and individuals to function effectively in their environment. An example of an area where situational awareness is applied is air traffic control. In air traffic control a primary and secondary radar are used to enhance a controller’s situational awareness within his assigned airspace. Usually a Flight Data Processing System manages all the flight plan related data and distributes this data to modern operational display systems, making it available to controllers. (Wikipedia, 2014) The next step is to study and enhance situational awareness in the maritime sector on board ships looking at other diverse areas like air traffic control and making use of already made progress there.

The human factor

Situational awareness on board ocean going vessels is one of the most important aspects regarding safety. Currently navigation officers have to focus on a lot of different aspects when sailing on seas and in ports, for example: paying constant attention to the active surroundings, keeping the ship on course and doing administration. A primary reason for having a closer look at situational awareness is the fact that human beings are not very good at long repetitive tasks. Which is of course what keeping watch on a long ocean voyage is. Lapses in concentration will easily lead to unsafe acts, near misses, incidents and accidents, like the ship getting into a collision or running aground. Accidents and disasters like this are usually caused by human factors and only rarely by internal factors such as internal ship breakdowns and/or external factors such as bad weather conditions. So it is safe to say that the human factor is the main concern when it comes to reducing accidents. (Catherine Hetherington, 2006)
The top ten most common root causes for accidents are:

1. Procedures and regulations
2. Design and arrangement
3. Maintenance
4. On-board organisation
5. Communication
6. Fatigue
7. Error-enforcing circumstances
8. Incompatible goals
9. Defences
10. Crews negligence

(UK P&I, 2012)

Because fatigue is the cause of 11-25% of accidents in the shipping industry (TNO, 2008). Therefore this research will focus on the prevention of fatigue. It will also try to reduce error-enforcing circumstances by using data processing.
Chapter 2: Causes of the lack of situational awareness aboard vessels

This chapter will answer the sub-question: “what causes the lack of situational awareness aboard vessels?”

Fatigue

Fatigue is a main cause of the lack of situational awareness. Fatigue occurs in two different categories: temporary fatigue and chronic fatigue. Temporary fatigue has an easy to find cause and remedy. Such as more sleep.

Chronic fatigue is longer lasting and more thoroughgoing than temporary fatigue. It characterises itself by a state of constant weariness that increases on a longer term. It decreases your mental capacity and that is the problem for officers on board vessels. When the mental capacity is lower, the assessment abilities are also lower and therefore the chance you make a mistake is higher.

Fatigue is not the same thing as sleepiness, although it is often accompanied by a desire to sleep and a lack of motivation to do anything else. (MayoClinic, 2014) The definition of fatigue is: a reduction in physical and/or mental capacity as the result of physical, mental, or emotional exertion which may impair nearly all physical abilities including: strength, speed, reaction time, coordination, decision making or balance. (TNO, 2008)

Most of the time fatigue can be cured by changing some of your routines in order to give personnel more rest. However it can also be part of something bigger than just a routine issue. In that case it is caused by a medical condition such as a heart disease.

The causes of fatigue can be divided in 3 types: lifestyle conditions, psychological conditions and mentioned earlier medical condition. Lifestyle conditions are conditions caused by the way we live. For example drinking a lot of coffee to stay alert. Psychological conditions are conditions caused by mental problems like depression. Medical conditions are caused by illnesses like COPD and Cancer. (A list of all the causes sorted by condition can be found in appendix 1.)

In order to reduce the influence of fatigue on situational awareness it is important to be able to take action against fatigue in an effective way. After field research it became clear that the crew’s negligence might be part of the problem. At Anthony Veder the resting time of the crew is monitored, but not the sleeping time. Resting time includes eating, reading, sleeping and so on. It is possible that someone who has 10 hours of resting time will just sleep for 5 hours, simply because they are doing something else with their time. (Kloos, 2014)(Interview in appendix 3)

Also the watch cycle is a problem, because if you have 2 times ±6 hours resting time it is very hard to get enough sleep, because it is nearly impossible to fall asleep instantly. When the watch cycle will be like 8 hours work, 8 hours rest, 4 hours work, 4 hours rest, the person will have a longer continuous resting time where it is easier to get your sleep and a short resting time where it is possible to read or something else. But this unfortunately could not work, because of a Dutch ARBO law called ‘pauzeregeling’ or pause control in English. The ‘pauzeregeling’ states that every continuous working time over five and half hours and under 10 hours requires a brake of at least 30 minutes (Arbo, 2015). So it is not possible yet to use this new watch cycle without changing this law. (Kloos, 2014)
Information overload

When an officer has his watch he is obligated to always use every possibility to check if there is any danger. Modern technology such as: radar, Ecdis, Navtex, ARPA and VHF provide a lot of information. Looking outside and the amount of information can together become too much to handle. This only occurs in crowded seas.

Because of all the procedures that have to be done by the officer, it is possible that mistakes happen due to the amount of information disseminated over the bridge. The stream of information could have the result that the officer of the watch does not see a danger in time to take action or he could overlook the danger.

In conclusion, information overload can cause reduced situational awareness in two ways. The first one is causing fatigue by having information overload for a longer period. The second one is missing the information needed by presenting less useful information on the equipment.

Track line attachment syndrome

Track line attachment syndrome (TAS) is the tendency of navigators, commonly younger mates, but sometimes even seasoned captains, to develop an unhealthy and obsessive need to place and keep a pictorial representation of their vessel upon a track line or series of lines presented on a computer monitor. (global cargo consultancy management, 2015). When a ship has to alter her course to prevent collision, the vessel will go from the track line. Although it is really easy to make a new track line from the current position, navigators with this syndrome have to get back on the old track line. This often leads to not using other navigational aids than the ECS/ECDIS such as radar and looking outside. The syndrome is a reason of loss of situational awareness, because of the tendency of not using the other navigational-aids. In that way the officer is less aware of the vessels in the surrounding area, that possibly are on a collision course.

Having TAS for a longer period can lead to Track line Separation Anxiety Disorder (TSAD). TSAD is a danger to the navigation. It leads to a very obsessive way of following their track line and loss the idea of GPS malfunction. In this way a person can sail aground without knowing it till it happens.

In short TAS or TSAD lowers the situational awareness; because it lowers the use of all the equipment, accept of the ECDIS, what leads to not using everything possible to ensure safety.

Trust and educate

Another possible cause is a lack of trust in the people below the officer. This happens mostly to the crewmembers with higher ranks, like captains or first officers. What happens is that the higher ranked crew member does not show trust in the lower ranked crew member and spends a lot of extra time to make sure everything goes according to plan. In this situation education and trust have to be carried out. This is where you educate the person with a lower rank and then trust them that they will do their job as expected. It may be difficult, but otherwise the higher ranked officer has to spend a lot of time ensuring no mistakes are being made.
Conclusion

One of the major problems of this time is fatigue, because fatigue can be caused in a lot of ways, like data overload or other factors.

Also Track line attachment syndrome is an actual problem, because the new generation has a higher chance of getting the syndrome. This influences the whole shipping industry in a bad way, by not using the provided information sources, what is mandatory by the IMO.

After the interview the field research. It became clear that the current ways to suppress fatigue are not used in a proper way. Also the current watch cycle is not the desired situation. The current watch cycle does not provide a long continuously rest period where the officer can sleep for a long enough period. Even if the person has a long enough resting period he will not always use it for sleep. The officer could also use the time for gaming, reading, etcetera.
Chapter 3: Eye-tracking

This chapter will answer the sub-question: How can situational awareness be improved using eye tracking? It will answer this question by answering the following sub-questions: How does the current watch alarm work? What are other methods of measuring fatigue? What is eye-tracking? And how could eye tracking be implemented on vessels? To answer these questions this chapter will be composed as follows: first the current watch alarm and its workings will be explained. Then other methods of measuring fatigue are introduced. Finally the eye tracking system will be explained.

The current watch alarm

A Bridge Navigational Watch Alarm System is an automatic system which sounds an alarm if the watch officer on the bridge falls asleep or is absent for too long a time. This system is automatically engaged when the autopilot is activated.

When the autopilot is engaged, the bridge officer is required to signal his presence every 3 to 12 minutes by pressing a button. When the officer fails to press that button, an alarm will sound on the bridge, and if there is still no signal after 15 seconds, also in the captain’s and the first officer’s cabins. One of them must then go to the bridge and cancel the alarm. If neither the captain nor the first officer cancels the alarm within a specified time period, an alarm will sound in locations where other crewmembers are available. This system will decrease the risk of collisions.

However this system does not guarantee that a watch-keeper is mentally fit. Ships fitted with watch alarms have already crashed into islands and others ships. It will not notice and help a tired watch-keeper that makes small errors; the chain of errors can lead to a catastrophe. (BYM Marine& Maritime news, 2011)

Other methods of measuring fatigue

The current watch alarm is not the only way in which fatigue can be monitored/prevented, as a system measuring a person’s heart rate could be used to. Each of the methods has their own pros and cons.

To measure a person’s heart rate, a bracelet could be worn. Fatigue greatly influences the heart rate of a person, which can be measured by the bracelet after which a signal can be send to a computer, setting of an alarm. The major benefit of this system is the flexibility and mobility of it, as it doesn’t restrict the watch keeper’s movement. The major downside of this way of measuring fatigue is the fact that a bracelet can be taken off easily, and thus relies on a person’s willingness to wear said bracelet. Some people might be uncomfortable wearing a device around their wrist; others might be too stubborn to wear the device.

An Australian company called Seeing Machines has developed eye-tracking technology that tackles one of the biggest safety issues in the mining and construction industries: driver fatigue. Shifts can often be 12-hours long, with drivers taking "micro sleeps" when suffering from fatigue. (Seeing machines, 2014) As seeing machines seems to be a more reliable, comfortable and mostly innovative solution to prevent fatigue, it was decided that this system will be explained thoroughly in this report. By discovering the way the system works and how it can be adjusted to allow a watch keeper to walk around the bridge while still being able to keep track of the eyes of the watch officer.
### System Advantages Disadvantages

<table>
<thead>
<tr>
<th>System</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current watch alarm</td>
<td>Already in use, easy to use</td>
<td>Only checks every 3-12 minutes, can be switched off</td>
</tr>
<tr>
<td>Heart monitoring bracelets</td>
<td>Constantly on, flexible, does not restrict movability</td>
<td>User has to wear a bracelet all the time, Bracelet is removable</td>
</tr>
<tr>
<td>Eye tracking</td>
<td>Always on, user does not have to do/wear anything</td>
<td>Hard to implement, new bridge layout is required</td>
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**Eye-tracking**

Eye tracking is a system that can track the movement of a person’s eyes by making use of hardware and software. (encyclo.nl, 2015) The system features an in-vehicle rugged PC with GPS, an accelerometer, a camera and two infrared light sources. The computer vision algorithms track human eye and eyelid behaviour, looking for the frequency of blinking, duration of blinks and the velocity of the eyelid. It also analyses the head position, which generally starts to drop between six and seven seconds after the eyes close.

If drivers close their eyes for longer than expected (longer than 1.6 seconds) an alarm goes off in the truck, combining a noise and the vibration of a motor positioned in the seat. If it happens a second time, the dispatcher or controller will be alerted to the problem. They will then be able to that to the driver over the radio to see if they are OK and whether they need a break. A third alarm generally means that the driver should be taken off duty to avoid accidents.

The system can counteract for the Sun’s glare and even sees the eyes through sunglasses.

Besides mining industry the technology has applications within the automotive sector, long-haul trucks and airlines. Our goal is to make a concept of the implementation of this system on vessels. This system will improve the situational awareness by noticing fatigue so that the watch-keeper can be replaced. Hereby there will be less navigational information lost or not to be noticed. This will reduce the risks for collisions or other human failures. (Seeing machines, 2014)

![Figure 3: how the computer sees the eye](image)

**Implementation of eye tracking**

Eye tracking systems are currently already in use in trucks and other machinery such as mining equipment. Implementing the same system onto the bridge of a ship proves to be very complicated. The biggest problem that needs to be tackled is the difference between working conditions on a truck or a vessel. A truck-driver is constantly seated in a chair, which makes it easy to have one camera aimed at the driver’s eyes. On a vessel’s bridge however, the watch-keeper is hardly ever in the same position. Walking around to various pieces of equipment is a common thing, which makes it very difficult to use eye tracking on a ship's bridge.
On modern ships however, all necessary equipment such as digital charts, the ship’s controls and all necessary info displays are more and more concentrated around one single spot. This allows the head of the watch to stay in the same chair/position during his entire watch. This makes the bridge much more suitable for eye tracking devices. 

On ships with a bridge lay-out that requires walking around, it is likely multiple cameras would have to be installed. In case this does not work, another way of eye-tracking could be developed.

On future vessels the bridge could be designed in such a way that it is suitable for eye tracking, by creating one central working spot where the watch keeper will stay during almost his entire watch. Using a device like google glass to track eyes is not a viable option due to the fact that the device has to be worn by the user. Therefore it is likely the device is not worn at all times, which decreases the effectiveness of the system.

The major advantage of eye tracking is the way it doesn’t influence the watch keeper in any way, allowing him to work without even noticing he is being monitored for fatigue

**Conclusion**

Eye tracking has a lot of potential to replace or improve the current watch alarm. It is a technology that has been proven to work in other branches, and there isn't a concrete reason as to why it could not be used in the shipping industry.

Unfortunately copying the system from a long-haul truck directly onto a vessels bridge is impossible. This is due to the different working conditions on a vessel's bridge in comparison to e.g. a truck. The major advantage of eye tracking is the way it doesn’t influence the watch keeper in any way, allowing him to work without even noticing he is being monitored for fatigue. The major downside however is the way the current systems work, as these heavily restrict a person's mobility as the devices need to be able to see the officer’s eyes at all times.

On modern ships the current system will be easier to implement, as these often have bridges where all necessary equipment is centred around one central spot. Eye tracking is a system that could be taken into account in future vessels by designing the bridge in such way that it is suitable for eye tracking devices. If this system can be implemented effectively it will possibly reduce the risk of incidents caused by fatigue, up to 90%.
Chapter 4: Blue light

When keeping watch at night the battle against fatigue is hard, due to the darkness around. Recent studies have shown that a certain spectrum of blue light emitted by mobile devices such as mobile phones, tablets and computer screens affect the sleep pattern. This chapter will further research the use of this blue light in order to keep the watch keeper awake. This solution will increase the situational awareness drastically.

How does blue light influence the sleep pattern?
How could blue light be implemented on the bridge?

Influence on the sleep pattern

Studies (Blue light has a dark side) have shown that light has a negative effect on the sleep pattern. It is well established that blue light has the most influence. The blue light from screens influences the production of melatonin, the hormone that controls the day-night cycle. (melatonin, 2014). A reduced production of melatonin results in not being able to sleep. There is a specific wavelength that influences the production of melatonin the most. In the graph below the wavelength of mobile devices, blue LED’s and the effect of orange tinted glasses. Blue light will not reduce fatigue. It will only postpone the tired feeling of the watch keeper. In order to reduce the side effects, the watch keeper needs to sleep after his watch to catch up the sleep that he missed.

This diagram shows that the colour blue has the most effect on the production of melatonin. Therefore this colour has most effect if used on the bridge.

Implementation of blue light

To be able to use the blue light effect aboard vessels it is important to establish a number of key points:
- The view outside may not be hindered.
- It has to have a measurable effect.

On the bridge there has to be a balance between being able to look outside and the light having effect. Therefore the most promising solution comes from simple LED light strips attached to the ceiling of the bridge. These LED’s will have to emit the right wavelength of light at a set strength, for maximum results. When determining the strength of the light it is important to take into account that the view outside may not be obstructed.

As well as installing this system on the bridge it can also be used when preparing for a watch, for example the officer of the watch sits in a room with the blue light before his watch, in order to wake him up/ reduce his melatonin levels before his watch starts.

Studies have also shown that a low melatonin production can be dangerous. It is known that a shortage of melatonin can cause diabetes, heart disease, obesity and cancer. (Blue light has a dark side)

Therefore it is key that when using this system the watch-keeper is getting enough sleep before or after his watch has ended in order to keep his melatonin levels on a safe level.
Conclusion
As stated above blue light could be used to battle fatigue on ships. However there are a few problems that may need further research. The effects of the light have to be investigated more. The biggest problem is that installing the light on the bridge will reduce the visibility in a way that the officer of the watch’s view is obstructed. The next big problem is that this blue light will affect the day/night cycle of the crew, which can lead to more fatigue and side-effects. This idea has some disadvantages but will (if it is good implemented) help the watch keeper by not falling asleep during his watch. It will not reduce fatigue. The watch keeper needs to sleep for an extended period of time after his watch to catch up sleep that he missed.
Chapter 5: Data processing

This chapter will answer the sub-question: How can data processing improve situational awareness aboard ships? It will answer this question by answering the following sub-questions: What is data processing? How can data processing be implemented on board of vessels? And how does data processing improve situational awareness?

Data processing is the collection and manipulation of items of data to produce meaningful information. (data processing wiki, 2014) On a ship there are a lot of systems to track its position, course and the position and the course and position of ships around it. Currently the processing of data is limited to combining Radar and AIS systems into an ECIS. By expanding the processing of data with other data such as: radar data, depth, draught and weather conditions, data processing can do much more than only give information.

Implementation of data processing

Before looking at implementations aboard ships, it is wise to look what other transportsations sectors already use data processing, and determine if there are systems already available. Especially in the aviation and mining sector, data processing is already implemented. For example in aviation there are systems which give aid in the processing of emergencies, telecommunication and information. By giving the operator clear instructions about what to do in certain situations, the operator is less likely to overlook something thus improving situational awareness. (flight data processing, 2014)

On a ship there are many systems providing the officer of the watch information. Systems as radar, ECDIS, AIS and GPS. The goal of data processing is to make the decision making and monitoring process easier for the watch keeping officer. In order to do that all the data from all the different systems should be offered to the officer conveniently, for example on one screen, or by using augmented reality. (Risk-Based Information Integration for Ship Navigation)

For example the computer gathers data on the position, course and speed, draught of the ships around it and the depth of the water. When the computer knows where other ships are and where they are going, it can help the officer of the watch with the implementation of the colregs.

Also the computer can make preliminary calculations in order to give the officer a list of more than choices. These choices are the most likely to be the solution to a situation. The processed data will now be used in a decision support system.

When all useful information is provided in a simple and interactive way, the officer of the watch has more time to look out and pay attention. The idea is that by using the data processing system the officer will no longer be spending unnecessary time plotting vessels, he has a more controlling role. He checks if the computer is doing its job and he only has to make the final decision and execute it.
Advantages and disadvantages

The data processing system has advantages and disadvantages. See the table below. One of the advantages is that the officer of the watch has all his necessary information in one place. Also the decision support system can reduce the chance of accidents. Finally the main advantage is that there is a way smaller chance of information overload. With a complicated system there are always disadvantages. Firstly the system is difficult to produce, there are allot of factors that affect the design and working of the system. Second the system depends on information received from others. This means that when there is faulty input the output of the system will be faulty as well. The industry calls this garbage in garbage out. Finally a big disadvantage is that officers may not thrust the system and won’t use it or are constantly busy doubting and checking the information provided by the system.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>All information in one place</td>
<td>Complicated to produce</td>
</tr>
<tr>
<td>Less chance of accidents</td>
<td>Dependents mostly on data from others and other systems (garbage in, garbage out)</td>
</tr>
<tr>
<td>No more information overload</td>
<td>Officers may not trust the system</td>
</tr>
</tbody>
</table>

After doing field research a lot of new concepts came into view. The concept of data processing/decision support can be extended a lot. Not only can data processing help the officer of the watch, but data processing can also be of valuable aid when: loading/ discharging (IMDG), making voyage preparations (Already exists in programs such as SPOS, but can be enhanced to not only take the weather into account, but also piracy etcetera.) and the implementing of legislation of solving problems in the engine room.

Data processing is necessary to improve situational awareness. As stated in chapter two of this report situational awareness is influenced by many factors such as: stress, training, fatigue, but also by data overload. Data overload is when someone gets so much information presented that his brain cannot handle the amount. Data processing is an effective way to reduce the chance of data overload.

To establish where data processing is needed the question: where is data processing needed? Data processing is needed in places and situations where the chance of data overload is the greatest. On a ship this place is mainly the bridge, but also the engine room and deck have situations where large amounts of data are presented to the crew.

In the following chapter the possibilities and reasons of implementing data processing on the bridge, on deck and in the engine room will be explained.

Last but not least future possibilities for data processing will be given.
Data processing on the bridge

The chance of data overload on the bridge is the biggest when manoeuvring, sailing at night, entering a harbour and sailing in busy waterways. To improve situational awareness a data processing/ decision support system can be implemented on the bridge.

This data processing system will gather information that the instruments on the bridge provide such as radar/ARPA, GPS, AIS, ECDIS, satellite and Navtex and present it in a clear way so the watch keeping officer can easily receive the information and distinguish between primary and secondary information. The decision support system can also help the officer of the watch think clearly by using algorithms that present the officer with choices. These choices have been formed in a way that only viable options remain and the best/safest option is listed on top for example with al collregs situation, where two ships are in a crossing situation. The system first gives the officer all relevant data such as the other vessels speed, course, CPA and time CPA. Thereafter the system gives the officer a couple of options to choose from in this way there is no room for misconceptions to take place and cause stress or data overload. This is especially useful when there is a situation where multiple ships are involved.

Besides using data processing during sailing, it can also be used in voyage preparation. The data processing system plots the voyage in a way the current program SPOS does. SPOS plots the route taking weather and efficiency into account, but not giving information about the ports and routs themselves. Therefore the data processing system can add to the information given by SPOS it will provide the officer with all data from the port from not only the pilot guide but also legislation.

Presentation of data

The presentation of data is not a subject to be overlooked. Over the years the generating of data on a ship’s bridge has made great leaps, but the presentation of this data has not. A great way to present the gathered data to the user is to use augmented reality. (For more information about augmented reality on the bridge, please consult the report about augmented reality from the 2014 maritime symposium) (augmented reality, 2014) Besides the means of presentation is important, because presenting the watch officer with too much information is just as bad as or even worse than not presenting enough.

Too much information can lead to data overload, which is just what the data processing system is trying to avoid. (Pieters & Hurkmans, 2015)(Interview appendix 4)

Apart from using augmented reality, eye tracking can also be of use, for example the eye tracking system can detect if the officer of the watch has read an incoming message and automatically acknowledge that the message has been read. This prevents the officer from having to go up to his screen/console and acknowledge the message manually. This form of acknowledgement saves time, and increases the time the officer can look outside.

A similar system has already been tested in the aviation industry (Christian Berth, 2008)

So data processing is a viable way to improve situational awareness on the bridge especially when it is combined with augmented reality and eye tracking. Because it helps the watch keeping officer to separate the important from the unimportant information. Also by providing an easy access to port information the officer is better prepared. So the chance of the officer getting data overload and the look down time is decreased. (Pieters & Hurkmans, 2015)
Data processing in the engine room
In the engine room data overload usually happens when there is a malfunction. When a small part of the system breaks down it can have big consequences for the whole engine room. For example a faulty thermal valve in the ships seawater system can cause serious damage due to overheating of the cooling system. But the current way the alarm system in the engine room is set up. The faulty valve is not the thing to send of an alarm but the first alarm set of is overheating of some secondary system such as oil cooler.

De data processing system will have to take in all the incoming alarms and produce a list of possible fault in form of a checklist. The engineer will have to investigate only these options saving time spent thinking up possible faults.

In the engine room data processing will not directly improve situational awareness but will make the engineers more aware of what is going on in the engine room. It could speed up the finding of malfunctions, which will prevent damage and improve safety.

Data processing on deck
On deck data processing will mainly be of use when loading/discharging. During the loading/discharging process allot of information will be directed at the officer in charge. Information such as what goods are being loaded and the draft and trim of the ship. Just as on the bridge the information can be given by some form of augmented reality, or by using a google-glass/ windows hologlens type device. Through these glasses the system provides a holographic overlay of the deck officer. Through this overlay an officer by example is warned earlier when loading dangerous goods and important procedures. With this technology the chance of making life threatening mistakes on board is decreased.

Future possibilities
In the last decade the possibilities in automation have increased dramatically. There are now cars in development that can drive themselves and brands like Tesla have cars that can detect corners and make the turn themselves. Also the cruise control is able to detect slowing traffic ahead and respond to it.

In the future is would be nice if ships can also sail themselves. By making use of data processing and adapting software written for cars it would be possible for ships to make trans-ocean voyages autonomously. This meant that the crew only needs to be on board during the approach procedures and busy sea straits like the Dover and Malacca strait. For this next step in data processing to work it is a requirement that the ships computers have to communicate with each other. (Pieters & Hurkmans, 2015)

Conclusion
Data processing is a technology that has a great potential to make shipping safer by enhancing the situational awareness on ships. The improvement mainly comes from preventing data overload. On the bridge this means that the data processing system provides the gathered information in a clear and useful way, and is able to distinguish between primary and secondary information streams.

In the engine room the system is more an aid helping with problem solving and maintenance etcetera. On deck it will mostly be augmented reality providing information about cargo being loaded and checklists for procedures to be carried out.

Data processing has many future possibilities, such as reducing crew size and creating autonomous sailing ship.

Before all of these concepts can be implemented there needs to be more research into the exact specifications of the data processing system and ways to combine it with augmented reality.
Chapter 6: Bridge Layout

This chapter will answer the sub-question: “How does the possible bridge layout look like after the implementation of the new systems?” It will answer this question by answering the following sub-questions: What is required regarding equipment on the bridge? And how will the new bridge lay-out look? The knowledge gained in the other chapters will be merged in this chapter. A new bridge lay out will be designed implementing the new systems that will enhance situational awareness.

Bridge equipment

To design a bridge layout for a seagoing vessel, one first needs to determine what equipment is required. According to the classification bureau “Germanischer Lloyd” the following equipment should be standard on a ships bridge. Equipment such as a radar, echo sounder, compass repeaters etcetera (For the full list see appendix 2.)

Concept of new bridge layout

There are two ways for a single spot control. The M shape and the upside down U shape. The M shape is the most convenient, because it provides the most space for the instruments and a possible second officer to be seated. (Pieters & Hurkmans, 2015) (See the picture below for an impression)

![Bridge layout diagram](image)

Figure 6: example of a bridge layout (maritimebyholland, 2014)

In this bridge layout the eye tracking system, data processing system and the blue light could be implemented. In this way the three systems could be combined with the existing instruments on the bridge. Combining the new and the old systems will give the officer of the watch all he needs to stay situationally aware.
Conclusion

The main question of this project is: How can situational awareness be improved in order to improve safety aboard vessels? In order to answer this question first had to be determined what the causes of the lack of situational awareness aboard vessels are. Fatigue turned out to be the major cause and fatigue itself can be obtained in a lot of ways, for example by a distorted medical, lifestyle or psychological condition. Another cause of the loss of situational awareness is the Track line Attachment Syndrome (TAS) in which officers tend to focus more on ECS/ECDIS and less on other navigational aids like radar and looking outside. An interview with Mr. Kloos from Anthony Veder taught us that the current ways to suppress fatigue are not used in a proper way due to multiple factors, like the current watch cycle aboard vessels.

A solution to enhance situational awareness aboard vessels lies in monitoring and preventing fatigue. To do so there is the current watch alarm, which turns out to be ineffective. Eye tracking has a lot of potential to replace or improve the current watch alarm. The major advantage of eye tracking is the way it doesn’t influence the watch keeper in any way, allowing him to work without even noticing he is being monitored for fatigue. The major downside however is the way the current systems work, as these heavily restrict a person’s mobility as the devices need to be able to see the officer’s eyes at all times. Eye tracking is a system that could be taken into account in future vessels by designing the bridge in such way that it is suitable for eye tracking devices, meaning all necessary equipment centred around one central spot. If this system can be implemented effectively it will greatly reduce the risk of incidents caused by fatigue.

Another solution to enhance situational awareness aboard vessels is the implementation of blue light on the bridge. Blue light has a negative effect on the human sleep pattern and when implemented on a ship’s bridge it should keep the watch keeper awake. However this is only a temporarily and unsuccessful solution as it doesn’t solve the problem of fatigue, but merely postpones the tired feeling of the watch keeper, which could result in more fatigue. Another problem that comes along with the use of blue light is that it reduces the watch keepers visibility when looking outside. So blue light is an effective way to keep a watch keeper awake during his watch, but the disadvantages make this system ineffective to use.

Data processing is a technology that has a great potential to make shipping safer by enhancing the situational awareness on ships. The improvement mainly comes from preventing data overload. On the bridge this means that the data processing system provides the gathered information in a clear and useful way, and is able to distinguish between primary and secondary information streams. In the engine room the system is more an aid helping with problem solving and maintenance etcetera. On deck it will mostly be augmented reality providing information about cargo being loaded and checklists for procedures to be carried out. Data processing has many future possibilities, such as reducing crew size and creating an autonomous sailing ship. Before all of these concepts can be implemented there needs to be more research into the exact specifications of the data processing system and ways to combine it with augmented reality.

Chapter 6 shows a concept bridge layout, in which all necessary equipment is centred around two central spots (seats) and in which all three systems could be implemented, i.e. the eye tracking system, data processing system and blue light. Combining these new systems with old, existing systems will make the officer of the watch more situationally aware.
Recommendations

Our main recommendations are:

- The Eye tracking system needs to be implemented on the bridge.
- The Blue light needs to be implemented on the bridge.
- The Data processing system needs to be implemented on the bridge.

Our secondary recommendations are:

- There needs to be more research into the effect of the watch cycle on the rest times of the crew.

- There needs to be more research done into the other possible causes of fatigue besides the causes described in this report.

- The effectivity of the blue light system and the possible effects of the system need to be investigated.

- There needs to be more research into how the eye tracking system reacts to the measured subject walking around.

- Before data processing can be implemented there needs to be more research into the exact specifications of the data processing system and ways to combine it with augmented reality.

- There needs to be more research into the new bridge layout, especially concerning the necessary equipment and the possibilities of implementation.
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Appendix I: A list of the causes of fatigue sorted by condition

Lifestyle conditions:
- Alcohol use or abuse
- Caffeine use
- Excessive physical activity
- Inactivity
- Lack of sleep
- Medications, such as antihistamines, cough medicines and cold remedies
- Unhealthy eating habits

Psychological conditions:
- Anxiety
- Depression
- Grief
- Stress

Medical conditions:
- Acute liver failure
- Anaemia
- Cancer
- Chronic fatigue syndrome
- Chronic kidney disease
- COPD
- Emphysema
- Heart disease
- Hyperthyroidism (overactive thyroid)
- Hypothyroidism (a thyroid disorder)
- Medications, such as prescription pain medications, heart medications, blood pressure medications and some antidepressants
- Obesity
- Restless legs syndrome
- Sleep apnoea
- Type 1 diabetes
- Type 2 diabetes

(MayoClinic, 2014)
Appendix 2 Bridge equipment list

Section 4

Bridge Equipment

A. General

1. Ships shall be equipped in accordance with SOLAS 1974, as amended, Chapter V, Regulation 19 and 20.

2. With reference to SOLAS V 18.1 required navigational systems and equipment shall be of a type approved by the Administration. Navigational systems for Class Notation NAV-INS shall be of a type approved by the administration according to the related standards.

All electrical and electronic equipment on the bridge or in the vicinity of the bridge, where a type approval is not required, shall be tested for electromagnetic compatibility.

3. Systems or equipment as listed in the GL Rules for Electrical Installations (I-1-3), Section 21, E shall be GL type tested. E.g. Steering gear control system.

B. System Requirements

1. Class Notation NAV

Ships shall be fitted in addition to the carriage requirements with a:

- Second Electronic Position Fixing System (EPFS – e.g. GPS, GLONASS, GALILEO, etc.)
- Central alert management system including alarm transfer system
- ECDIS and back-up ECDIS
- Second gyro compass, ships of 10.000 GT and upwards
- Heading control system (HCS)
- Second HCS or track control system (TCS), ships of 50.000 GT and upwards

2. Class Notation NAV-INS

In addition to the equipment required in 1. one of the following alternatives applies:

2.1 For Class Notation NAV-INS the following tasks and control functions from the IMO performance standard MSC.252(83) shall be provided:

- Collision avoidance
- Route planning and monitoring
- If a Track Control System (TCS) is installed it shall be of category C
- Central alert management (Module C)

2.2 Alternatively the following systems, equipment and functionalities shall be provided:

- If a Track Control System is installed, it shall be of category C
- Sensor data management to collect and distribute navigational and control data. Data shall be checked for validity, plausibility and latency.
- Consistent common reference system to ensure the consistency and integrity of data. A single consistent common reference point shall be used for all spatially related information. For consistency of measured ranges and bearings, the recommended reference location should be the conning position. Alternative reference locations e.g. the pivot point for heading or track control systems may be used.

- Central alert management and alert transfer system

- Central display for the indication of navigation and control data (conning display).

C. Sensor Requirements

1. The following sensors and functionalities shall be provided independent from the carriage requirements:

- ARPA functionality shall be provided for all installed Radars on the bridge.
- At least one Radar shall be capable to display parts of Electronic Navigation Charts and other vector chart information to aid for navigation and position monitoring. Alternatively at least one ECDIS shall be capable to display a Radar overlay.

- Two gyro compasses to determine, display and transmit heading information. (Applies to all ships of 10.000 GT and upwards).
- Speed and distance measurement equipment (SDME) to determine, display and transmit the

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1 IMO Res.A.694(17), IMO Res. MSC.191(79), IMO Res. MSC.252(83), IEC 60945, IEC 61162 Series, IEC 61924-2, IEC 62288
speed and distance through the water and the speed and distance over ground information (SDME for ships of 10,000 GT and more).

– At least one of the EPFS shall be a DGPS or other GNSS receiver with the same or better accuracy and availability.
– Anemometer to indicate the relative and true wind speed and direction information.

2. A loss or a failure of one sensor shall not keep in a loss of the redundant sensor or fall-back arrangement.

3. A bidirectional alert interface shall be provided by each required sensor to indicate any required alert on an external central alert management system. Each sensor shall have the capability for an immediate remote acknowledgement, except category A alerts, and temporarily silence from an external alert management system.

4. The following back-up and fall-back ar-rangements shall be observed:

<p>| Table 4.1   Back-up and fall-back arrangements |</p>
<table>
<thead>
<tr>
<th>Sensor</th>
<th>Data</th>
<th>Back-up</th>
<th>Fall-back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyro</td>
<td>Heading</td>
<td>Gyro 2</td>
<td>Magnetic compass</td>
</tr>
<tr>
<td>EPFS</td>
<td>Position, Time, Date</td>
<td>EPFS 2</td>
<td>Dead reckoning and radar bearing</td>
</tr>
<tr>
<td>SDME (WT)</td>
<td>Speed</td>
<td>SDME (BT)</td>
<td>EPFS</td>
</tr>
<tr>
<td>Echo sounder</td>
<td>Depth</td>
<td></td>
<td>ECDIS and/or Paper Chart</td>
</tr>
<tr>
<td>RADAR</td>
<td>RADAR 2</td>
<td>AIS</td>
<td></td>
</tr>
<tr>
<td>Data interface</td>
<td>Data interface 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 4.1 Example for a sensor configuration
D. Arrangement of Equipment

1. Navigating and manoeuvring workstation

The following tasks and control functions shall be accessible and within the reach of the officer of the watch from his bridge chair (see Section 1, Fig. 1.1):

1.1 9 GHz ARPA radar with operation controls

The 9 GHz radar shall be inter switchable with the 3 GHz radar at the monitoring workstation and shall be supported by an UPS.

1.2 ECDIS with operation controls and radar overlay

1.3 Heading and track control system with manual override

1.4 Control of main engine(s), incl. emergency maneouvre and emergency stop

1.5 Control of thruster(s)

1.6 Steering mode selector switch for steering gear

1.7 Rudder pump selector switch for steering gear

1.8 Intercom to docking workstations (if the distance is greater than 10 m)

1.9 Call system for master and navigation officers (telephone / internal communication system)

1.10 VHF equipment including GMDSS distress alarm management (external communication)

1.11 Automatic Identification System (AIS) terminal, if it’s a stand alone system

If the AIS information is shown in the radar or ECDIS it may be positioned within the perception area of the officer of the watch.

1.12 Control of whistle and maneouvreing light

1.13 Acknowledge push button for watch alarm system (BNWAS)

1.14 Control of centralized alert management system

1.15 Control of general alarm

1.16 Control of window wipers in front of workstation

1.17 Control of console lighting

1.18 The following indication and equipment shall be provided near the navigating and maneouvreing workstation within the perception area of the officer of the watch. It can be achieved by stand alone instruments in the conning or bridge console or by a centralized multifunction display which is recommended.

- Gyro compass heading
- Rate-of-turn, if available
- Rudder angle
- Propeller revolutions
- Pitch, if a pitch propeller if fitted
- Thrust force and direction
- Speed
  (longitudinal and lateral for ships of 10,000 GT and more)
- Water depth
- Position
- Time
- Wind direction and speed
- Sound reception device, if totally enclosed bridge
- NAVTEX, if without printer

The following indication and equipment (items 1.19 - 1.24) shall be provided within the perception area of the officer of the watch from his bridge chair:

1.19 Whistle automatic control system

1.20 Navigation- and signal light controller

1.21 Emergency stop of installations to be stopped in case of fire (air condition, ventilation and refrigerating installation)

1.22 Remote control and monitoring of watertight doors, external openings and fire doors (open/closed), if available

1.23 Remote control of emergency fire pump

1.24 Anti-rolling device, if available

2. Monitoring workstation

The following tasks and control functions shall be accessible and within the reach of the monitoring officer from his bridge chair (see Section 1, Fig. 1.1):

2.1 ARPA radar with operation controls

The 3 GHz radar shall be inter switchable with the 9 GHz radar at the navigating and maneouvreing workstation.
2.2 Control of whistle and manoeuvring light

2.3 Acknowledge push button for watch alarm system (BNWAS)

2.4 Control of window wipers in front of workstation

2.5 Intercom to docking workstations (if the distance is greater than 10 m)

2.6 Call system for master and navigation officers (telephone / internal communication system)

2.7 VHF equipment (external communication)

2.8 The following indication and equipment shall be provided within the perception area of the monitoring workstation:
   – Gyro compass heading
   – Rate-of-turn, if available
   – Rudder angle
   – Propeller revolutions
   – Pitch if a pitch propeller is fitted
   – Thrust force and direction
   – Speed
     (longitudinal and lateral for ships of 10,000 GT and more)
   – Water depth
   – Time
   – Wind direction and speed
   – Sound reception device, if totally enclosed bridge Equipment or indication mentioned under paras. 2.2 to 2.8 and which is required at more than one workstation, shall be arranged so that it can be easily reached respectively observed from all relevant work-stations. If this is not achievable such equipment or indicators/displays shall be duplicated.

2.9 Central alert management system

3. **Manual steering workstation**

The following equipment shall at least be provided within the reach of the helmsman:

3.1 Steering wheel or other means of controlling the heading of the ship manually

3.2 Control of window wiper in front of workstation

3.3 Intercom to docking workstations (if the distance is greater than 10 m)

3.4 Dimmer for indicators listed in 3.5.

3.5 The following indicators shall at least be provided within the perception area of the helmsman:
   – Rudder angle
   – Gyro compass heading
   – Magnetic compass heading
   – Rate-of-turn, if available

4. **Docking workstation**

The following equipment shall at least be provided within the reach of the operating officer:

4.1 Control of main engine(s)

4.2 Control of thruster(s)

4.3 Control of rudder(s)

4.4 Control of whistle and manoeuvring light

4.5 Intercom to workstations for navigating / manoeuvring, monitoring, manual steering.

4.6 Acknowledge push button for watch alarm system (BNWAS)

4.7 If the ship has a totally enclosed bridge: control of window wipers in front and aft of workstation

The following indication shall be provided within the docking workstation:

– Rudder angle
– Propeller revolutions
– Pitch, if a pitch propeller is fitted
– Thruster speed
– Gyro compass heading
– Rate-of-turn, if available
– Speed
  (longitudinal and lateral for ships of 10,000 GT and more)
– Wind direction and speed if totally enclosed bridge

A conning display or multi function display may be used and is recommended.
5. **General bridge equipment within wheelhouse**

4. A Bridge Navigational Watch Alarm System (BNWAS) including alarm transfer system shall be provided for the following unacknowledged alerts:

5.1 Main control unit of BNWAS

5.2 Control of window washing and heating system

5.3 Control of wheelhouse air-conditioning

5.4 Main control unit of whistle

6. **INS tasks and functions**

6.1 Collision avoidance Radar ARPA, AIS

6.2 Route planning, route monitoring ECDIS, echo sounder

6.3 Navigation control data or navigation status and data display HCS, TCS, EPFS, SDME, Gyro compass
   – Failure HCS
   – Sensor failure, wheel over line and cross track failure TCS
   – System failure gyro compass
   – Loss of position EPFS
   – System failure SDME
   – Depth alarm from Echo sounder
   – Aggregated steering gear alarm
   – Imminent slow-down or shut-down of propulsion system
   – Failure / loss of navigation lights

F. **Power Supply**

1. The radio and navigational equipment and systems shall be directly supplied from both the main source of electrical power and the emergency source of electrical power with automated changeover by separate power supply circuits with provision to preclude inadvertent shut-down, and

2. In addition to the following equipment / systems should be supplied from a transitional source of electrical power for a duration of not less than 45 s:
   – one 9GHz (X-Band) Radar including transceiver and antenna
   – Gyro compass systems
   – EPFSs
   – ECDIS
   – SDME
   – Echo sounder
   – Sensor management

3. The radio and navigational equipment and systems shall be directly supplied from both the main source of electrical power and the emergency source of electrical power with automated changeover by separate power supply circuits with provision to preclude inadvertent shut-down, and

4. In addition to the following equipment / systems should be supplied from a transitional source of electrical power for a duration of not less than 45 s:
   – one 9GHz (X-Band) Radar including transceiver and antenna
   – Gyro compass systems
   – EPFSs
   – ECDIS
   – SDME
   – Echo sounder
   – Sensor management
Appendix 3 Interview Remko Kloos

Q: What is your function at Anthony Veder?
A: I started at this office as safety and quality employee. About 5 years ago I switched to Human resource Management. Back then we were given the task to prepare our department for rapid growth. In the following five years we went from 12 to 27 vessels.

Q: How does your company deal with fatigue?
A: Onboard of our vessels we have a rather large crew. Larger, in fact, than the government prescribes us. Our ships make relatively short trips, often coming into port on a daily basis, in Antwerp for example. During these port visits pilotage can be needed for sometimes up to 12 hours. This makes our crew relatively vulnerable to fatigue, which is why it is a very big issue for us.

Q: What are your personal experiences with fatigue?
A: When it comes to experience during ‘real sailing’ my knowledge dates 13 years back, so it might not be very relevant for you.

Out here on land however, we do a lot when it comes to monitoring working- and resting hours in a certain system. When doing this it is very important to keep in mind that there is a major difference between resting- and sleeping hours.

I personally believe there are many wild and false stories going round about lack of sleep and hard working, while people are getting more sleep than they think or say they do.

Luckily however, research has been done to this by a former student of the same school you are in. She gave crewmembers an acti-watch, which allowed her to measure precisely when they were sleeping or not. This allowed us to get a much clearer view on sleeping hours and fatigue.

I’ve hear about the short-shipping industry being interested in this method, as they are struggling with their watch-cycles and fatigue. They are currently using a 6 hours watch cycle, which is terrible for your resting-pattern.

That is why they would like to switch to a combined 8 and 4 hour cycle, as this allows the longest resting period to be much longer. That is why they are currently co-operating with the Dutch government and Nautilus, the seafarers’ labor union, to prove the benefits of this system.

Q: What do you think are causes of fatigue?
A: I think there are multiple causes for fatigue.

On our vessels for example, we have one captain and 3 bridge officers. You would say that is plenty for each of them to get enough rest. Sometimes however, the first mate feels too much responsibility and wants to attend everything that happens on the ship, which makes it impossible for him to get proper sleeping time.

Another scenario is when an officer below the first mate is too inexperienced too work alone, causing the first mate to feel obliged to stay by this person’s side all the time. That is why so-called ‘Educate and Thrust’ is very important. You need to educate your crewmembers, so you can thrust them to do work by themselves, which allows the first mate to get the rest he needs.
This is also the reason why we choose for our first mates to be at the bridge at times when a pilot is present. During certain conditions, such as foggy weather, pilotage can take hours. It would be nearly impossible for the captain to stay by the pilot’s side this entire time. The captain needs to learn how to give control to someone else, even though he remains the person in charge, who carries all responsibility for his ship. He needs to realize that accidents could also happen when he is on the bridge.

Another solution for fatigue is proper protocols and planning. For example: when you’re told you need to wait outside the harbor at the roadstead for many hours, you are likely to continue working as you can catch up sleep during these waiting hours. Now imagine upon arrival at the roadstead you are immediately told to proceed into port. This would completely ruin your planning, and thus your resting-cycle.

To put it short: what the law prescribes isn’t really related to fatigue. You could easily break the rules sometimes by working longer, and catching up later, causing you not to suffer from fatigue. Or you could perfectly get all our resting-hours, but refuse to sleep, which would still make you suffer from fatigue.

And don’t forget life-style factors such as abundant coffee or alcohol consumption, that’s why we have banned all alcohol from our vessels.

Q: What do you see as solutions for fatigue?
A: I already mentioned a couple, such as ‘Educate and Thrust’ and proper planning. Other solutions are the quality of the crew, which relates back to ‘Educate and Thrust’, as a low quality crew requires more supervision by higher officers. I also think the size of the crew plays a big role. On some of our larger vessels we have decided to add an extra 3rd officer. The amount of work to be done on board doesn’t grow equally with the size of the vessel, but sometimes it’s just necessary to add this extra person.

Q: We have come up with eye-tracking as a way to prevent fatigue, what do you think of this?
A: Personally I think that if everyone would just stick to the rules properly, this whole system wouldn’t be necessary. The current watch system is often turned off or not used in accordance with the law, so I think it is likely this new system wouldn’t be used the right way either.

Q: It is however a system that doesn’t require any interaction from the watch keeper, and doesn’t have to be turned on or off. Does this change your opinion?
A: Not really, I think the crew on board has enough technical knowledge to be able to find a way to get around or turn of the system. The current systems are fine if we would just use them properly, so let’s start by doing so, as a first step.

In the end I think it’s the most important to look at the causes of fatigue and prevent those, not find a system to react to it.

Q: We’ve also found out that an overdose of information on the bridge might lead to fatigue, what are your ideas on this?
A: I don't really have any experience with this, as back in my days we didn't have as many systems as there are now. For this I think it would be better for you to speak to one of our captains, as he can help you out way better with this than I can.
Appendix 4 Interview Pieters and Hurkmans

This interview/brainstorm session took place on the 21st of January.  
Mr Mart Hurkmans is manager of research and development at Imtech Marine and offshore B.V.  
Mr Cees Pieters is professor Mainport information at Hogeschool Rotterdam.

Q: How would you arrange a data processing system?  
A: Data processing starts with data generation, which has increased a lot lately. After generation the data needs to be processed, and finally the processed data needs to be presented. The presentation is not something to be overlooked. A good way to present the data might be using augmented reality and game engines.

Q: Where and when do you think data processing is required on ships?  
A: To answer this question you should first ask yourself why data processing is required. In order to know where and when data processing is required one needs to know where and when the stress moments are.

Together we drafted a list of stress moments and how they can be resolved:
On the bridge:
- Busy waterways such as the English Channel and Malacca strait.
- Approaches to harbours.
  - Decision support system
  - New bridge concept
On deck:
- During loading and discharging
  - Have the data processing system help with procedures and legislation
In the engine room:
- When there are malfunctions
  - Have the data processing system help with trouble shooting.

Q: What would be the future of data processing on ships?  
A: In the future the data processing could be the start of automated ships and reduced crews. For example the ship is crewed from Rotterdam trough the Dover strait, and after passing England the crew will be lifted off the ship and the ship will than sail itself to New York. And a day or so before reaching the harbour the crew will be lifted on the ship again to guide it into the harbour again. In this way you could have one crew that manages multiple ships.

Q: What do you think about the eye tracking system?  
A: Eye tracking is a useful system; it is already used in the JSF. In the JSF it is used to auto acknowledge alarms.

Q: Do you have any other tips?  
A: Yes:
- Use and refer to the augmented reality research of last year’s symposium.
- Look into the risks of technology and the dangers of automation.