MOTION SICKNESS AT SEA

Final report

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Management review

The first people ever crossing the ocean suffered from the consequences of motion sickness at sea. Nowadays people still suffer from motion sickness. A sailor suffering from motion sickness at sea experiences a feeling of discomfort and struggle with symptoms as dizziness or (extreme) nausea. This main goal of this research is finding a decent prevention method to suppress this feelings, and thereby enhancing the safety of the whole maritime world. This management review gives a short resume about the research in its entirety. To find out all recommendations read this research.

What are the causes of motion sickness at sea?

Motion sickness at sea occurs when a vessel is rotating on its width and length axes (pitching, rolling and yawing) and therefore they are in most cases the cause of seasickness. The brain uses information from the vestibular system in the head and from proprioception throughout the body to understand the body’s dynamics and kinematics. When a vessel keeps moving there will be a conflict in the brain which causes the symptoms of seasickness.

What are the external factors which increase the vulnerability to motion sickness at sea?

Motion sickness at sea is a complicated malady; these are some factors which influence the way motion sickness manifests itself. It is challenging to say when exactly the symptoms of seasickness occur or how they are triggered. Internal factors like inherited vulnerability or a well-functioning vestibular system greatly increase the chance of suffering from motion sickness all the time. Research has shown however, that there are certain external factors which increase the probability of suffering from motion seasickness at sea, or even worsen the symptoms. Avoiding these could assist a sailor to conquer the symptoms and continue his duty without the uncomfortable symptoms of motion sickness.

What are the consequences of seasickness regarding the work circumstances?

To conclude, the consequences of seasickness regarding the work circumstances, as explained above could lead to major incidents and claims. There are several symptoms of seasickness that could lead to terrible accidents at open sea. For instance disorientation, lack of concentration and dehydration cause great danger during all kind of activities on board of a sea going vessel. Practical observation proved that the consequences of motion sickness at sea can form a danger for anyone on board of a sea going vessel, especially when this individual carries responsibility for the proper execution of certain tasks on board. When a crewmember feels sweaty and the need to vomit appears practical observation demonstrates that the person is not able to do their tasks in a proper and safe manner. This could lead to serious damage or leads to a shortage of crewmembers. To reduce the likeliness of experiencing the negative side effects of motion sickness at sea it is recommended to follow the basic advice as can be read throughout this research. Make sure the body is well rested and hydrated. Try to keep an eye on the horizon and do not underfeed yourself.

Which prevention methods are there and are they effective?

To conclude, there are many different resources on the market that help to reduce or seasickness, or claim to do so, however, a real effective solution yet has to come. Partly because motion sickness is a discordance which appear when one’s internal organs are working properly and are reaching their limitations. As elaborated above there are several tablets to help reducing the symptoms of seasickness. Effectiveness varies from person to person. The most effective solution to seasickness will be an anti-motion sickness display which visualizes the movements relative to the horizon, in all six degrees of freedom.
Preface

This research focusses on the development of motion sickness at sea and how the symptoms that come with it can be effectively suppressed. The objective of this research is to use the gained knowledge to relief a seafarer from the symptoms caused by the effects of motion sickness at sea. We gathered our information by means of extensive desk and field research. Sailors from all over the world have contributed to the development of this research. Expert opinions and literature guided us through the biological aspect of the research, which is important to get a true understanding of what motion sickness is. This research aims at suppressing the main symptoms of motion sickness at sea. If a cure or solution is found, the whole seafaring world would feel the benefits that come with it.

This research will help the researchers to accumulate more profession, specific knowledge relevant to our future responsibilities and hopefully come with a solution for an unsolvable problem.

We would like to pay tribute to the supervisor’s miss M. van der Drift for her guidance and feedback, and in special, mister P.C. van Kluijven for his input during the lessons and colleges.

Youri Brongers, Gerben Boers, Ricardo van Heijningen

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Introduction

All over the world seafarers suffer from the symptoms of seasickness. Seasickness occurs at rough sea when a vessel in motion rolls about the length and width axis. A sailor suffering from seasickness experiences a feeling of discomfort and struggles with symptoms like dizziness or (extreme) nausea. Seasickness is a form of motion sickness which appears when the brain receives contrary signals from the balance organs in the ear and the visual system of the eyes. These mixed signals are caused by the rolling motion of the ship while the eyes perceive a fixed horizon. This can be very dangerous when sailing with a limited crew, as someone who is quite seasick hardly pays attention to the environment and is virtually no longer able to do the assigned duty properly. For instance, an engineer working in the engine room will be vulnerable to nausea due to the fumes and warm, fusty engine room conditions. This may cause the engineer to vomit uncontrollable and thus can’t do his assigned duty.

Crew should be able to work without being held back by the uncomfortable symptoms of seasickness. There are external factors (e.g. narcotics, consumables, and conditioning) that influence the severity of seasickness. Other external causes are the size of the vessel, weather conditions and personal experiences. Internal causes will not be taken into account in this research. Internal factors include the cognitive system, digestive system and the particulars of the vestibular system of an individual.

At this very moment seasickness is causing seafarers all over the world to experience symptoms which disable the proper working abilities of the crew. This causes problems since crewmembers who suffer from seasickness are not able to do their duty in an efficient and more important, safe manner. Seasickness is a form of motion sickness. People suffering from seasickness experience a feeling of nausea, supressed appetite, or even vertigo. Seafarers are not able to do their duty properly due to these symptoms.

The IMO aims to improve the safety, secureness and efficiency of shipping on clean oceans. A cure for motion sickness at sea will definitely assist in reaching this goal. Therefore the International Maritime Organization will be extremely satisfied if a cure for seasickness is found. Crewmembers who suffer heavily from the symptoms of seasickness will feel great benefit when an effective cure or relief is presented. As a result of this, the shipping company has a better functioning crew. This improves the overall safety and efficiency of the shipping process. Seafarers are the biggest stakeholders and indirectly the shipping company will benefit from a cure to figh motion sickness at sea. This research focusses on elucidating motion sickness at sea and finding an answer to the main question. The sub questions will be researched prior to answering the main question which will contribute towards finding an answer to the main question.
Problem definition

At this very moment seasickness is causing seafarers all over the world to experience symptoms which disable the proper working abilities of the crew. This causes problems since crewmembers who suffer from seasickness are not able to do their duty in an efficient and more important, safe manner. Seasickness is a form of motion sickness. People suffering from seasickness experience a feeling of nausea, suppressed appetite, or even vertigo. Seasickness is caused by the rocking motion of a watercraft. The human body has different ways to maintain balance. When on board of a watercraft which is in motion, conflicting signals are received by the human senses. The eyes see a fixed ship, and thus the brain thinks the vessel is not moving. The equilibrium sensors in the ears however, register a constant movement of the ship. This discordance causes the brain to send a general alarm to the body, stopping all activities. Seafarers are not able to do their duty properly due to this discordance.

Problem definition:
Seafarers are unable to perform their duty as intended due to the symptoms of motion sickness at sea.

Objective:
How can the symptoms of motion sickness at sea be suppressed or prevented?

Sub questions:
What are the causes of motion sickness at sea?
What are the external factors which increase the vulnerability to motion sickness at sea?
What are the consequences of seasickness regarding the work circumstances?
Which prevention methods are there and are they effective?

Objective

The objective of this research is to use the gained knowledge to relief a seafarer from the symptoms caused by the effects of motion sickness at sea. This research aims at solving the main symptoms of motion sickness at sea. If a cure or solution is found, the whole seafaring world would feel the benefits that come with it. During field research contact with experts, companies (TNO) and seafarers provided helpful experiences and opinions. A survey is created and has delivered adequate data from (personal) practical situations. This research focussed on eliminating known causes of seasickness. When the cause is eliminated, the consequence will no longer be. Motion sickness at sea is a complex correlation between physical, mental, and environmental factors. Expert medical knowledge is required to really investigate the internal causes of seasickness. The researchers major in Maritime Operations and not Medical Knowledge, and thus, focus will be laid on external factors which trigger or intensify the symptoms of motion sickness at sea.

The following chapters consist of in depth research regarding the sub-questions. In the first chapter the causes of motion sickness at sea are explained. Then the external factors are described which may increase the risk of getting seasick. The most used prevention methods are described in chapter three. The consequences and the impact on working conditions aboard a vessel will be discussed in last chapter.
1. The causes of motion sickness at sea

Introduction

What are the causes of motion sickness at sea? Motion sickness is the feeling one experiences when the motion you sense with your inner ear is different from the motion you visualize. It is a common condition that occurs with some people who travel by car, train, airplane or vessel. Although pregnant women and children are more susceptible to motion sickness, almost anyone who is traveling is vulnerable to motion sickness. For those people who travel on vessels, seasickness can be considered a form of motion sickness. Other risk factors include the person's fear or anxiety about traveling, the mode of travel, poor ventilation in the traveling vehicle, and the inability to see out of a window to aid orientation. (Motion sickness, 2015) To get a better understanding of what motion sickness is, and how it develops, the causes that stimulate this development have been researched. All information below is obtained by means of literature research and practical experiences by seafarers from all over the world.

What are the causes of motion sickness at sea?

Ship motions

Seasickness is almost always related to the motions of a vessel. Ship motions are defined by the six degrees of freedom that a ship, vessel or any other craft can experience.

Linear Motion

**Heave** is the linear vertical (up/down) motion; excessive downward heave can swamp a ship.

**Sway** is the linear lateral (side-to-side or Port-Starboard) motion, which does not present much of a challenge for most modern ships.

**Surge** is the linear longitudinal (front/back or Bow/Stern) motion imparted by maritime conditions. (Figure 1.1)

![Figure 1.1](Ship motions, 2015)
Rotating motions

There are three special axes in any ship, called vertical, lateral and longitudinal axes. The movements around them are known as roll, pitch and yaw. (Figure 1.2)

**Pitch** is the Up/down rotation of a vessel about its lateral/Y (side-to-side or Port-Starboard) axis. An offset or deviation from normal on this axis is referred to as 'trim' or 'out of trim'.

**Roll** is the tilting rotation of a vessel about its longitudinal/X (front-back or Bow-Stern) axis. An offset or deviation from normal on this axis is referred to as list or heel. Heel refers to an offset that is intentional or expected, as caused by wind pressure on sails, turning, or other crew actions. List normally refers to an unintentional or unexpected offset, as caused by flooding, battle damage, shifting cargo, etc.

**Yaw** is the turning rotation of a vessel about its vertical/Z axis. An offset or deviation from normal on this axis is referred to as deviation or set

(Ship motions, 2015)

Sea state

The state of the sea plays a big role in the development of seasickness in one’s mind. The range between the conflicting signals only increases as sea state deteriorates. Heavy seas will cause violent ship motions as described above. This causes the symptoms of seasickness to become worse and stay for an extended period. Seafarers will also feel the symptoms of seasickness earlier on when the state of sea is rough. (Zeeziekte is vreselijk, 2013)
The vestibular system

The vestibular system, in most mammals, is the sensory system that provides the leading contribution about the sense of balance and spatial orientation for the purpose of coordinating movement with balance. As movements consist of rotations and translations, the vestibular system comprises two components: the semi-circular canal system, which indicate rotational movements; and the otoliths, which indicate linear accelerations. The vestibular system sends signals primarily to the neural structures that control eye movements.

The brain uses information from the vestibular system, which is located in the inner ear, and from proprioception throughout the body to understand the body’s dynamics and kinematics (including its position and acceleration) from moment to moment. (Vestibular system, 2015)

Relation between visual input and inner ear

Motion is sensed by the brain through three different pathways(7) of the nervous system that send signals coming from the inner ear (sensing motion, acceleration, and gravity), the eyes (vision), and the deeper tissues of the body surface (proprioceptors).

When the body is moved intentionally, as can be experienced in an accelerating vehicle, the input from all three pathways is received and coordinated by the brain. When there is unintentional movement of the body, as occurs during motion when sailing a vessel (or any unexpected motion), the brain is not coordinating the input, and there is thought to be discoordination or conflict among the input from the three pathways. It is hypothesized that this conflict among the input from multiple senses is the primary cause for the development of motion sickness. (Figure 1.3)

The development of motion sickness is complex however, and the role of conflicting input is only a hypothesis for its development. Without the motion-sensing organs of the inner ear, motion sickness does not occur, suggesting that the inner ear is critical for the development of motion sickness. This means that a deaf person, with a non-functional inner ear system, does not develop the symptoms of motion sickness.

Visual input seems to be of lesser importance, since blind people can develop motion sickness. Motion sickness is more likely to occur with complex types of movement, especially movement that is slow or involves two different directions (for example, vertical and horizontal) at the same time.
The conflicting input within the brain appears to involve levels of the neurotransmitters (substances that mediate transmission of signals within the brain and nervous system) histamine, acetylcholine, and norepinephrine. Many of the drugs that are used to treat motion sickness act by influencing or normalizing the levels of these compounds within the brain. (Motion Sickness (travel sickness): Causes, Symptoms, 2015)

Motion sickness is a very common disturbance of the inner ear that is caused by repeated motion such as from the swell of the sea, the movement of a car and the motion of a plane in turbulent air.

In the inner ear (where the vestibular system can be found), motion sickness affects the sense of balance and equilibrium and, hence, the sense of spatial orientation. About 33% of people are susceptible to motion sickness even in mild circumstances such as being on a boat in calm water, although nearly 66% of people are susceptible in more severe conditions. According to our own survey, at least 50% of the respondents was prone to seasickness under some conditions.

![Figure 1.4](Wikipedia, 2015)

There is no difference between motion sickness and seasickness. Some individuals experience nausea and even vomiting when with an airplane, automobile, or amusement park ride. This condition is generally called motion sickness. Many people experience motion sickness when riding on a boat or ship. This is commonly referred to as seasickness, even though it is the same disorder. Individuals and animals without a functional vestibular system are immune to motion sickness. (medicalnewstoday, 2015)

Histamine

In many cases motion sickness is caused by a histamine surplus. A histamine surplus is usually partly caused by a deficiency of the enzyme diamine oxidase DAO, this enzyme breaks down histamine. (Reiszietke, 2015) Sedating anti-histamine medications such as promethazine works quite well for motion sickness, although they can cause significant drowsiness and other negative side effects. (Motion sickness, Wikipedia, 2015) The destruction of the histamine-producing neurons of inhibiting of the histamine synthesis leads to less alertness in (unknown) situations. Histamine is responsible for working properly, extremely vigilant and alert in (unknown) situations. (Histamine, 2015)
Motion sickness due to virtual reality

Motion sickness due to V.R. is very similar to simulation sickness and motion sickness due to films. In virtual reality, however, the effect is made more acute as all external reference points are blocked from vision, the simulated images are three-dimensional and in some cases stereo sound that may also give a sense of motion. The NADS-1, a simulator located at the National Advanced Driving Simulator, can accurately stimulate all senses related to motion, being capable of movements in all 6 degrees of freedom with a 360-degree horizontal field of view. Studies have shown that exposure to rotational motions in a virtual environment can cause significant increases in nausea and other symptoms of motion sickness. (Motion sickness wikipedia, 2015)

Conclusion

To conclude: motion sickness at sea occurs during conditions where the motion of a vessel as experienced by the vestibular system (rotary and longitudinal) conflicts with the visual input perceived by the eyes. The brain uses information from the vestibular system in the inner ear and from proprioception throughout the body to understand the body’s dynamics and kinematics. This continuous stimulation of the nerves inside the semicircular canals seem to lead to an increase in histamine production. When this information conflict and histamine production does not cease to exist for a prolonged amount of time, the body is likely to develop the symptoms of motion sickness. The relation is complex however, and to this day, no methods have been developed to overcome this sensory conflict.
2. Increased vulnerability to seasickness

What are the external factors that increase the vulnerability to motion sickness at sea? This research will take a look at some of those factors that increase vulnerability to seasickness. Many people prone to seasickness are so because they inherited it by one of their parents. Internal factors like heritage and personal variables will not be taken into account for this study. This research will focus on the external factors that increase the vulnerability to seasickness. Can a sailor take some prevention methods to become less prone to the symptoms of motion sickness. Or, what has to be avoided to decrease the chance of getting seasick. To answer these question, information has been obtained by means of literature research and practical experiences by seafarers from all over the world, collected and organized with an online survey as well as oral examinations with crewmembers laying on the quayside at the Port of Rotterdam.

**What are the external factors that increase the vulnerability to motion sickness at sea?**

**Exposure time**

The time one is experiencing the rolling and heaving motions of a rough sea is also an external factor which increases the vulnerability to seasickness. A sailor can easily encounter a few heavy waves without feeling nauseous. If this, however, continues for a prolonged period, even the most experienced sailors will suffer from it and feel the consequences. (Zeeziekte is vreselijk, 2013)

**Fatigue**

Being fatigue stimulates the symptoms caused by seasickness. The body is not fully rested and so is more vulnerable to motion sickness. This is especially noticeable when other stimulating factors are present, like a rough sea for an extended period of time. (Zeeziekte is vreselijk, 2013) (Zo voorkom je zeeziekte, 2015)

**Alcohol**

If alcohol is consumed the day before departure, one is likely to become more prone to motion sickness. Excessive amounts of alcohol cause a feeling of nausea and dehydrate the body. The feeling of nausea is amplified by the ships rolling and heaving motion and can trigger uncontrollable vomit sessions. This dehydrates the body and makes it harder for the body to recover. For more information about dehydration see the information given at sub question 3. (Zeeziekte, hoe voorkom je het?, 2014)

**Coffee**

Coffee has the same negative effect on the body as alcohol. The coffee liquid can be irritating within the stomach and thus trigger nauseous feelings.

**Environment**

One should take care of the environment when facing seasickness. The symptoms of seasickness are likely to develop within closed environment with no visual referential to the horizon. The closed, fumy engine room should be avoided. Time within the superstructure of the ship should be limited as well. The sensory conflict between the eyes and balance system has to be avoided. Focus your vision on the horizon, instead of the inside of the vessel. The eyes will recognize the vessel moving. (Haverkamp, 2012)
Internal factors

Although internal factors will not be taken into account for this research, it is worth mentioning certain internal factors increase the vulnerability to seasickness. First of all, one can acquire vulnerability to seasickness by inheriting it from their parents. When the parents were prone to seasickness the child is likely to be so as well. Since motion sickness is directly related to the vestibular system, young children who have not fully optimized their vestibular system, are more vulnerable to develop motion sickness, since they experience sensory conflict more intensely.

Simulator

TNO has developed a Desdemona research simulator. (as seen in figure 2.1) Desdemona research simulator is able to simulate situations which approach the reality as much as possible. The simulator cabin can rotate about all axes and so being able to reach all 6 degrees of freedom. To train crew for tasks, simulation is an solution for training on board. More important simulation offers the possibility to practice certain scenarios in a safe condition. Simulation can also be used for training of dangerous situations. The use of a simulator can also prove its worthiness, when a sailor who is very prone to motion sickness, conditions slowly in this simulator. Therefore the body gets more used to the sensory conflict, reducing the symptoms of motion sickness.

![Figure 2.1](image_url)

Conclusion

To conclude, these are some of the factors which influence the way motion sickness manifests itself. It is challenging to say when exactly the symptoms of seasickness occur or how they are triggered. Internal factors like inherited vulnerability or a well-functioning vestibular system greatly increase the chance of suffering from motion sickness all the time. Research has shown however, that there are certain external factors which increase the probability of suffering from motion seasickness at sea, or even worsen the symptoms. Avoiding these could assist a sailor to conquer the symptoms and continue his duty without the uncomfortable symptoms of motion sickness.
3. Consequences of seasickness regarding the work circumstances

What are the consequences of seasickness regarding the work circumstances? The answer to this sub question is based on gained knowledge with the trip on the tall ship Eendracht during heavy seas and seafarers personal experiences. Field research has been done to get more reliable information and knowledge about this sub question. This information is collected and organized with an online survey with over 100 respondents. Visits to ships, and discussions with seafarers who experience seasickness during work circumstances have led to the information which is explained in the next chapters.

Dangers during work circumstances

When a person suffers from the symptoms of seasickness and has been vomiting for a couple of days, dehydration is the biggest problem, as explained below. When a crew member suffers the consequences of seasickness the work ethic decreases enormously. The probability of an accident increases extremely as a disorientated crew member could easily fall overboard. During the daily work activities serious injuries to crew members could happen because of the consequences of seasickness. (Nederlands militair geneeskundig tijdschrift, 2008) On board of a large vessel it is highly important that everybody is able to do his/her job in a proper manner. One mistake cause a possible disaster for instance a collision.

![Figure 2.2](image)

Do your work activities suffer from the symptoms of seasickness?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Other (Please Specify)</th>
<th>Standard Deviation</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Data</td>
<td>31</td>
<td>41</td>
<td>5</td>
<td>21.01</td>
<td>104</td>
</tr>
</tbody>
</table>

![Yes](Yes) ![No](No) ![Other (Please Specify)](Other)

Practical research confirms the prospects concluded from the earlier desk research: It is a true fact that work activities suffer from the symptoms of seasickness. Concentration is highly important during all kind of operations on board. For example during maintenance in the engine room, since crewmembers aren’t able to get some fresh air or see the horizon. This contributes to the nauseous feeling and therefore lead to a lack of concentration which could have disastrous results. Figure 2.2 shows that more than 50% of sailors from all over the world suffer in one way or another from the consequences during the work circumstances.
Which symptoms did you experience during the seasickness? (multiple answers possible)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>All Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sighs</td>
<td>15 (15%)</td>
</tr>
<tr>
<td>Yawning</td>
<td>45 (44%)</td>
</tr>
<tr>
<td>More saliva</td>
<td>10 (10%)</td>
</tr>
<tr>
<td>Listless feeling</td>
<td>28 (25%)</td>
</tr>
<tr>
<td>Sweats</td>
<td>35 (35%)</td>
</tr>
<tr>
<td>Loss intestated</td>
<td>25 (25%)</td>
</tr>
<tr>
<td>Hyperventilation</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>Whitening</td>
<td>27 (26%)</td>
</tr>
<tr>
<td>Breathing</td>
<td>49 (48%)</td>
</tr>
<tr>
<td>Flatulence</td>
<td>12 (12%)</td>
</tr>
<tr>
<td>Gagging</td>
<td>24 (24%)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>63 (62%)</td>
</tr>
<tr>
<td>Complete exhaustion</td>
<td>19 (19%)</td>
</tr>
<tr>
<td>Other (Please Specify)</td>
<td>14 (14%)</td>
</tr>
<tr>
<td>Responses</td>
<td>102</td>
</tr>
</tbody>
</table>

*Figure 2.3*
As can be seen in figure 2.3, there is a wide variation of symptoms where even the most experienced sailors suffered from. All of these symptoms do not contribute towards a good working environment. The most common symptoms are sweating and vomiting closely followed by unceasing yawning and sleepiness. All of these symptoms can be linked with the fact that one suffering from seasickness is unable to perform his work activities as he should, regarding whether he has a backup or not.

**Dehydration**

Dehydration is a physical condition that occurs when the loss of body fluids (mostly water) exceeds the amount that is taken in. When the normal water content of your body is reduced, the balance of minerals in your body is upset. These minerals are salt and sugar. Two third of the human body exists out of water. It is essential for most vital organs and processes in the human body. For instance, it lubricates the eyes, detoxes the body and it keeps the skin healthy.

There are several signs to recognize dehydration:

- Feeling thirsty
- Dry mouth
- Tiredness
- Dark urine

Usually dehydration is caused by not drinking enough, in case of seasickness dehydration is caused by vomiting or sweating. (Medicinenet, 2015).

There are certain foods and drinks that influence dehydration, for example alcohol consuming alcohol causes a slight dehydration itself. Combined with the effects of seasickness, it is not responsible to consume a high amount of alcohol as this stimulate the dehydration of the body.

**Navigational activities**

During navigational activities it is highly important to be concentrated and well-focused. A lack of attention could have disastrous consequences. When a crewmember suffers from the symptoms of seasickness, it is hard to concentrate and pay attention. The person in question is exhausted, dehydrated, and has to deal with disorientation as explained below, while the crewmember is responsible for a safe navigation the vessel.

The symptoms of seasickness cause that the Officer of the Watch is unable to concentrate on the environment and his situational awareness deteriorates quickly. Concerning the navigation this can cause great dangers. One moment of inattention during navigational activities can cause missing a shoal. Or even worse the possibility exists that there is another vessel at collision course.

**Disorientation**

When a person becomes dehydrated as a result of seasickness, it is likely that the person gets disorientated. As a result of disorientation it is very hard to stay focused and to concentrate on the duty assigned duty. This can lead to dangerous situations, for instance, the towing accident whereby a tugboat captain, who suffered severely from the symptoms of motion sickness, was unable to perform his duty as intended. This resulted in the towing connection disconnecting from the towed vessel, leaving her rudderless and adrift. (Koopvaardij, 2013)
Maintenance at the engine room

It is important that the work circumstances in the engine room are optimal. When the engineer suffers from the symptoms of seasickness it means that the engineer is not able to do the tasks in a proper manner. The engine is the most important part of the vessel, when the engine shows flaws this could be a tremendous problem for all crewmembers, including the shipping company. When the engine is inoperative the vessel is not under command. This ensures a delayed delivery of the cargo, or even worse the engine could become inoperative. This has to be prevented at all costs. As explained above, a skilled and healthy mechanic is one of the most members important on board.

Conclusion

To conclude, the consequences of seasickness regarding the work circumstances, as explained above could lead to major incidents and claims. There are several symptoms of seasickness that could lead to terrible accidents at open sea. For instance disorientation, lack of concentration and dehydration cause great danger during all kind of activities on board of a sea going vessel. Practical observation proved that the consequences of motion sickness at sea can form a danger for anyone on board of a sea going vessel, especially when this individual carries responsibility for the proper execution of certain tasks on board. When a crewmember feels sweaty and the need to vomit appears practical observation demonstrates that the person is not able to do their tasks in a proper and safe manner. This could lead to serious damage or leads to a shortage of crewmembers. To reduce the likeliness of experiencing the negative side effects of motion sickness at sea it is recommended to follow the basic advice as can be read throughout this research. Make sure the body is well rested and hydrated. Try to keep an eye on the horizon and do not underfeed yourself.
4. Preventive and suppressive methods

Motion sickness has been present since mankind started travelling. The very first sailors encountered the consequences of motion sickness at sea. Nowadays, there are still seafarers from all over the world who have to deal with the negative consequences of motion sickness at sea, and thus it is highly important to find an effective solution or prevention method for motion sickness at sea. This chapter of the research includes existing prevention methods such as the relief band and the promising Horizon Glasses. A variety of the most used precautionary measures and medicines have been examined on reliability, functionality, side effects, and perhaps the most important factor of all: personal experiences from seafarers. There are many different resources on the market that help to reduce the symptoms of motion sickness. None of these actually succeed in removing the cause of motion sickness, namely the sensory conflict between what one experiences and visualizes. All information on this sub question is obtained by means of literature research and experiences from seafarers who use preventive methods. To verify and discuss this information, there has been a visit to TNO Soesterberg and expert knowledge from professor Jelte Bos helped to find and analyze existing methods as well as more innovative methods.

Which prevention methods are there and are they effective?
The most widely used prevention medicine to combat seasickness can be found in appendix I; the survey provided valuable information about the prevention methods seafarers use at sea and how that influenced their personal experience with motion sickness.

| Are there any facilities on board to prevent or suppress seasickness? |
|-------------------------|--------|-----------------------------------|
|                        | Yes    | No                      | Other (Please Specify) | Standard Deviation | Responses |
| All Data               | 46 (44%) | 54 (51%)               | 5 (5%)                   | 21.46               | 106       |

Figure 2.4
With heavy pitching and rolling of the vessel even the most experienced seafarers suffer from the consequences of seasickness. Therefore, shipping companies have decided to take some precautionary measures for their crew as figure 2.4 shows. Not all of the submissions are from sailors working on board of a large vessel owned by a shipping company. Therefore they are responsible themselves for executing the use and storage of precautionary measures. Not everybody decided to do so because they didn’t suffer from motion sickness at sea, or it faded away after some hours. Practical research confirmed that most shipping companies try to suppress or prevent seasickness, as shown at the image above. The most common used medications are Cinnarizine and Meclizine, which are further elaborated in appendix I. (Figure 2.5)

There are experienced seafarers with their own methods to suppress or prevent seasickness. Particular food and drinks could lead to decrease or increase of the symptoms, therefore seafarers conducted their own methods to oppose the obstinate causes of motion sickness at sea. Some of the comments include:

- ‘In case of severe seasickness, I consume a small piece of gingerroot. Works better than any medicine.’
- ‘Don’t eat too much - but do eat before.’
- ‘Try to eat dry food only (not sure if it helps but it does for me)’
- ‘Board the vessel as soon as possible to get used to the rocking motion.’

One submission even claimed that eating bananas helps to fight the symptoms while providing energy to last the day. And in case it didn’t help, at least ‘they slide out easily’

<table>
<thead>
<tr>
<th>Cinnarizine and meclizine tablets</th>
<th>Cyclizine tablets</th>
<th>Dramamine tablets</th>
<th>Spooloderm patches</th>
<th>Other (Please SpecIfy)</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 (40%)</td>
<td>4 (5%)</td>
<td>5 (7%)</td>
<td>2 (3%)</td>
<td>45 (62%)</td>
<td>73</td>
</tr>
</tbody>
</table>

Figure 2.5
**Horizon glasses**

This is a concept in the world of preventive measures proudly introduced several years ago. Research has proven that a person who suffers from motion sickness at sea regularly, benefits from a constant view on the horizon to anticipate future movements. It happens more than often that a seafarer is unable to keep the horizon in sight at all time for example under bad weather conditions or when inside the vessel. To stop being deprived of the horizon all the time researches invented a solution to this problem, the so called Horizon Glasses. (Figure 2.6)

![Figure 2.6](image)

The Horizon Glasses is an ingenious piece of wearable equipment which ensures a constant view on an artificially created horizon. The glasses are manufactured with four so called Boarding Rings® filled with colored liquids and so they basically visualize the vestibular system of the inner ear. As explained earlier in this research, motion sickness at sea is primarily caused by the eyes perceiving a fixed environment, while the vestibular system sense motion. Because the liquid in the circular tubes centers according to the ship motion, one is always able to see the motion of the ship relative to the horizon, and thus, visualize the motion at that instant. This removes one of the most important causes of the development of motion sickness at sea; the sensory conflict which occurs when the brain receives contrary signals from the vestibular system (which is now visualized by the Boarding Rings®) and the visual system of the eyes.

**Effectivity and functionality**

The manufacturer tested the Horizon Glasses thoroughly and they claim that the device effectively reduced symptoms to acceptable norms of 95% (!) of the test group in just twelve minutes of wearing the device. (How to use Boarding Ring) The manufacturer stated that as soon as one feels discomfort caused by motion sickness at sea the device will suppress the symptoms within a short time and afterwards hold back the symptoms for hours. This is a very promising success rate, however, no external source is available to confirm these rates and they seem to be unreliable. For the glasses to be truly effective, one has to sit down because movement with the head also causes the liquid to adjust to that motion. It is worth mentioning that the Horizon glasses can be worn over regular glasses and there even is a solar version on the market. Also, an elastic cord can be attached to the glasses to ensure the device stays on the head of the wearer, even when performing labor.
Downside

It should be mentioned, that the Boarding Rings are not a solution of the problem. When moving on the longitudinal axis the horizon should stay leveled. Due to the mass-acceleration of the liquid the pitch of the fluid will change while the glasses are still leveled with the horizon. Moreover, the most challenging movement of all, about the Y-axis, is not visualized.

Relief band

The relief band (Figure 2.6) is a wearable tech which has the same design as a watch. It relieves the feeling of nausea associated with motion sickness. The relief band functions trough neuromodulation: It uses a proprietary technology that uses the neural pathways of the human body to help regulate the triggers that cause nausea. What this basically means is that, when operative, the device pulses against the underside of your wrist, and these signals travel to the central nervous system and to the part of the brain that sends out signals of nausea. It then modulates the pathways between the brain and stomach, which is supposed to provide a sense of relief. The strength of the pulses can be arranged with the button. (Wikipedia/ neuromodulation, 2007)

Field research has shown that the relief band suppresses the feeling of nausea which occurs during motion sickness, furthermore, practical experiences show that the relief band generally suppressed the feeling of nausea. Pregnant women use it to prevent morning sickness. A side effect does not occur in contrast with pills the most common prevention method on board of a vessel.

Figure 2.6
Anti-motion sickness display

A breakthrough in the battle against motion sickness must definitely be the new innovative idea of the anti-motion sickness display. Motion sickness is generally caused by not being able to correctly estimate one’s self-motion. In the case of crew in the command center of a naval vessel, a nauseating conflict exists between what they see (the stable interior of the ship) and what they feel (the motion of the ship). To reduce the conflict TNO has designed and tested an ‘anti-seasickness display’ presenting visual motion in the opposite direction of the ship’s motion, thus effectively presenting an Earth-fixed frame of reference. Fourteen subjects completed a number of 20-minute trials in TNO’s motion simulator Desdemona, which reproduced a realistic ship motion. The anti-seasickness display consisted of a three-dimensional virtual world of stars. It was presented on a laptop monitor in the background of a partially transparent demanding computer task in a number of conditions, and on a panoramic screen in front of the participant in another. The task was added to also study a possible effect on task performance, either negatively by interference of the stars with the computer task, or positively by the anticipated reduction of motion sickness. Sickness severity was rated at fixed intervals. Results show that the anti-seasickness display reduced sickness due to ship motion, whether presented on the computer monitor or on the panoramic screen. No effect on task performance was found, thus the graphics of the anti-seasickness display did not interfere with the task used in this experiment. Research shows that this anti-seasickness displays providing a spatial Earth-fixed reference to correctly estimate one’s self-motion, appear to be a promising solution to reduce seasickness. (Bos, 2010)
Application

An application can help seafarers to anticipate ship motions. This application gives seafarers the option to see the weather, wind and current etc. The information the app will show you.

Notification from the bridge to the engine room.

- Changes of course
  - All changes of course
  - Relative to the present direction of current
  - Relative to the present course

- Present sea state
  - Direction of current
  - Velocity of current
  - Waves relative to the present course

- Present weather
  - Velocity of wind
  - Direction of wind
  - Direction of wind relative to present course

- Weather forecast
  - Velocity of wind
  - Direction of wind
  - Direction of wind relative to present course
Nowadays technology is a vital component of life, therefore the idea of a useful application came up. A simple application which could assist a sailor in taking precautionary measures. The application is based on data as the weather forecast for a particular area, course changes, present sea state and medical advice. When a crewmember suffers the symptoms already the application is able to provide another crewmember to get a quick advise in order to help his mate. As seen at the mockups (figure 2.7 and 2.8). The application has several icons every icon stands for an advise.

The application has several icons of which every icon stands for a menu. Take for instance the medicine icon. A crewmember who is suffering from the symptoms of seasickness can now use this application to try and relief himself. In order to get a proper advise this application is been made. Click on the medicine icon, match the symptoms and the application gives a matching medical advice.

Every other icon has the same purpose. The goal is to gain quick and easy knowledge about motion sickness. There also is a map icon where live feedback from current weather conditions is implemented so that a sailor can better anticipate to future ship motions.

**Conclusion**

To conclude, there are many different resources on the market that help to reduce or seasickness, or claim to do so, however, a real effective solution yet has to come. Partly because motion sickness is a discordance which appear when one’s internal organs are working properly and are reaching their limitations. As elaborated above there are several tablets to help reducing the symptoms of seasickness. Effectiveness varies from person to person. The most effective solution to seasickness will be an anti-motion sickness display which visualizes the movements relative to the horizon, in all six degrees of freedom.
Conclusion

How can the symptoms of motion sickness at sea be suppressed or prevented?

The symptoms of motion sickness at sea cannot be completely suppressed or prevented. This is because the sensory conflict caused by contrary input, is a reflex of the body and a clear marking of the limitations which exist within the human body. There are several external and internal factors that increase the vulnerability to motion sickness at sea:

- The time one is experiencing the rolling and heaving motions of a rough sea
- Being fatigue stimulates the symptoms caused by seasickness. The body is not fully rested and so is more vulnerable to motion sickness.
- Excessive amounts of alcohol cause a feeling of nausea and dehydrates the body. The feeling of nausea is amplified by the ships rolling and heaving motion and can trigger uncontrollable vomiting sessions.
- Coffee has the same negative effect on the body as alcohol. The coffee liquid can be irritating within the stomach and thus trigger nauseous feelings.
- Individuals with a non-functional vestibular system are invulnerable to motion sickness.

There are many different resources on the market that help to reduce seasickness. But the real solution has yet to come. The anti-motion sickness display seems to be a very promising prevention. Remarkably about this display is that it is able to visualize all 6 degrees of freedom and thus fully visualizes ship motion so that the eyes can better anticipate to the motion. This reduces the conflict inhibited by motion.

Several recommendations to reduce vulnerability to motion sickness at sea:

- Focus your vision on the horizon, instead of the inside of the vessel. The eyes will recognize the vessel’s movement. The person is then actually forced to orient him- or herself better to the environment, on the horizon and actively anticipate future movements; this way it is easier to predict the movement of the ship due to the waves. Doing this takes the discrepancy between what one feels and looks, and thereby also increases the physical malaise away.
- Make sure you are well rested.
- Food and drinks could lead to decrease of the symptoms
- Don’t eat too much but do eat
- Reduce alcohol consumption to a minimum
- Be on board of the vessel as long as is possible before departure.
- When using medication, use them long before symptoms arise.
- Do not panic about getting seasick, just the normal day duty and try to be in contact with fresh air.

Final recommendations:
- More research in anti-motion sickness display
- Investments in motion simulation
- Download our application
- Acknowledge the cause
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Appendix I

Cinnarizine tablets

*Figure I.1 (Apotheek.nl, 2015)*

**Action**
Ensures that you do not get nausea and queasiness. Prevents most of the effects of histamine on smooth muscle tissues of the gastrointestinal tract, the large blood vessels and bronchi.

**Symptoms**
By movement during driving, boating or flying, your vestibular system be upset. This stimulates nausea and queasiness.

**Adverse effects**
- Reduced reaction and concentration
- Sedation,
- Somnolence
- Dizziness
- Poor coordination
- Dry mouth

**Effectiveness**
Operation time four to six hours.
Cyclizine

Figure I.II (Apotheek.nl, 2015)

**Action**
Cyclizine reduces nausea.

**Symptoms**
By movement during driving, boating or flying, your vestibular system be upset. This stimulates nausea and queasiness.

**Adverse effects**
- Reduced reaction and concentration
- Sedation
- Somnolence
- Dizziness
- Poor coordination
- Dry mouth
- Gastrointestinal complaints, such as stomach pain or constipation.
- Burning eyes

**Effectiveness**
Operation time four to six hours.
Dramamine

*Figure I.III (Apotheek.nl, 2015)*

**Action**
The active ingredient dimenhydrinate reduces the stimulation of the vestibular system by unusual movements.

**Symptoms**
By movement during driving, boating or flying, your vestibular system be upset. This stimulates nausea and queasiness.

**Adverse effects**
Often there is only a small risk of side effects. However, there are also medications with a relatively high risk of side effects.

**Effectiveness**
Operation time twelve to twenty-four hours.
Scopoderm patches

**Figure I.IV (Apotheek.nl, 2015)**

**Action**
Scopolamine patches prevents nausea and vomiting.

**Symptoms**
By movement during driving, boating or flying, your vestibular system be upset. This stimulates nausea and queasiness.

**Adverse effects**
- Reduced reaction and concentration
- Somnolence
- Dizziness
- Dry mouth
- Burning eyes

**Effectiveness**
Operation time twelve to twenty-four hours.
Appendix II

Fishbone diagram

Figure II.1
The causes of motion sickness at sea

Appendix II

Figure III.1
Appendix IV

Increased vulnerability to seasickness

Figure IV.1
Appendix V
Consequences of seasickness regarding the work circumstances

Figure V.1
Appendix VI

Which prevention methods are there and are they effective?

Figure VI.I
Appendix VII

Survey seasickness

We are students of the Rotterdam Mainport University and follow the bachelor Maritime Officer. We do research on seasickness. This survey is created to gain information for the research about seasickness. We would like you to answer the questions as accurate as possible. The data will be kept confidential and will only be used for the research. Filling in your name is purely optional. We would like you to fill in the particulars of your vessel. We also want to ask you always to fill in an answer, even if you are unsure. Completing the questionnaire will take approximately five minutes. The progression of the research can be followed online: motionsicknessatsea.nl

For further questions please contact: rvanheijningen@hotmail.com. Thank you for your participation:

Name: ___________________________________________________________________

Age: ___________________________________________________________________

Company: ___________________________________________________________________

Name vessel: ___________________________________________________________________

Tonnage: ___________________________________________________________________

1. Do you suffer from seasickness?
   ○ Yes
   ○ Sometimes, only ___________________________________________________________________
   ○ No

2. When do the symptoms of seasickness appear? (multiple answers possible)
   ○ Upon seeing the vessel
   ○ In the engine room
   ○ Calm seas, Beaufort 0-4
   ○ Moderate seas, Beaufort 1-5
   ○ Strong seas, Beaufort 6-9
   ○ Storm seas, Beaufort 10+
   ○ On the bridge
   ○ In your cabin
   ○ Other, namely, ___________________________________________________________________

3. Did you take any precautionary measures?
   _________________________________________________________________________________
   _________________________________________________________________________________
4. Which medications do you use? (multiple answers possible)
   - Cinnarizine and meclizine tablets
   - Cyclizine tablets
   - Dramamine tablets
   - Spododerm patches
   - Other, namely ___________________________________________________________________

5. Do you need time to recover after the voyage?
   - Yes, about _____ days, _____ hours, _____ min
   - No

6. Which symptoms did you experience during the seasickness? (multiple answers possible)
   - Sighs
   - Yawning
   - More saliva
   - Listless feeling
   - Sleepiness
   - Less interested
   - Hyperventilation
   - Whiteness
   - Sweating
   - Flatulence
   - Gagging
   - Vomiting
   - Complete exhaustion
   - Other, namely ___________________________________________________________________

7. Do your work activities suffer from the symptoms of seasickness?
   - Yes, __________________________________________________________________________
   - No

8. Are there any facilities on board to prevent or suppress seasickness?
   - Yes, __________________________________________________________________________
   - No

9. Are any precautionary measures taken by the shipping company?
   - Yes, __________________________________________________________________________
   - No