UiT
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UNIVERSITY
OF NORWAY

Faculty of Science and Technology: Institute of Engineering and Safety

Fatigue Awareness

Introducing fatigue awareness devices as a part of FRMS in an airline

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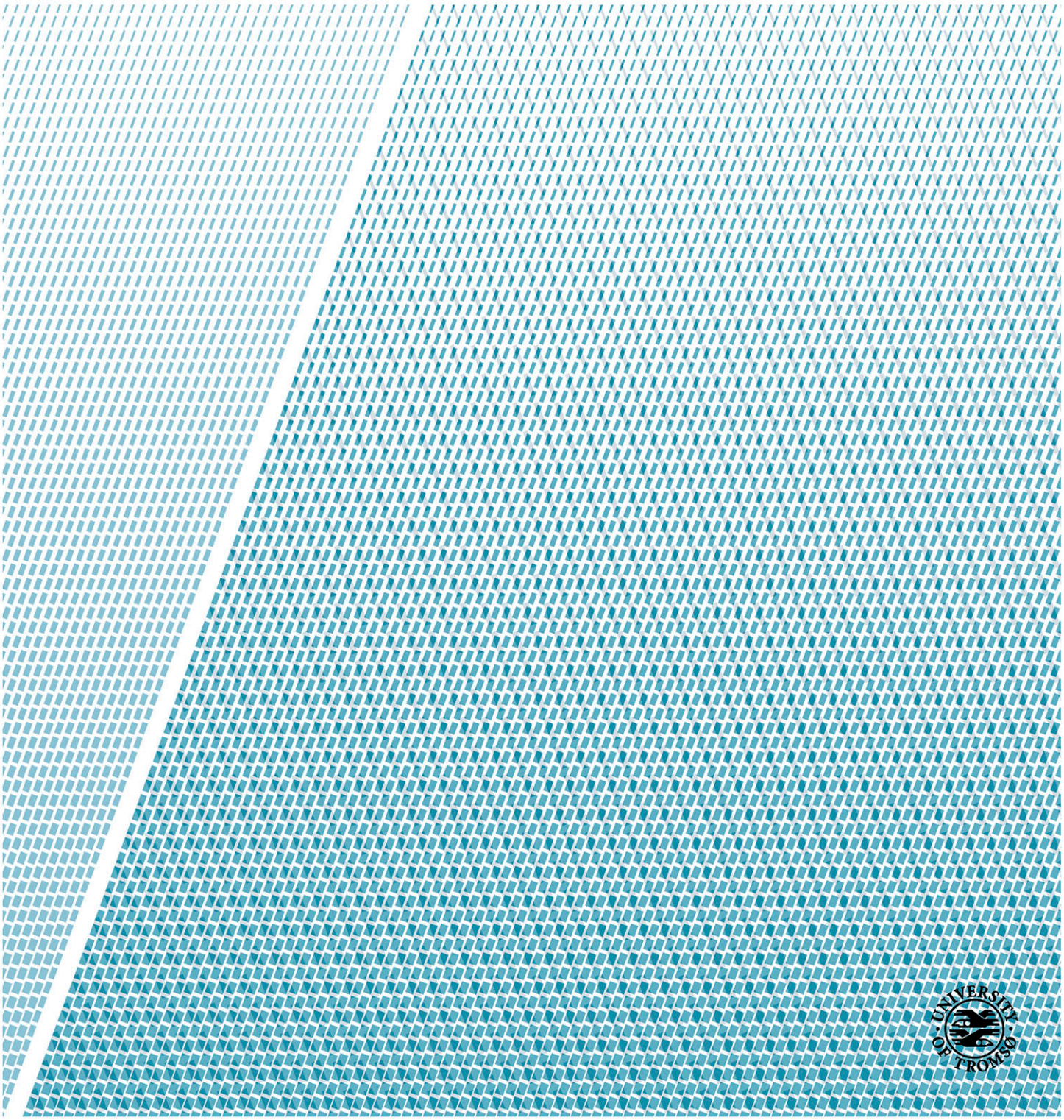
Master thesis in Societal Safety – Safety end Emergency Preparedness in The High North

June 2016
Number of words: 23 737



Acknowledgement

This master thesis is the final work of the two-year master programme in Societal Safety at the University of Tromsø.

These last two years in Tromsø has been amazing, and writing this thesis has been difficult, fun, interesting and a great learning experience.

I really want to say a big thank you to the management of Lufttransport that made it possible for me to write this thesis. Another great thank you to all of the respondents who answered the questionnaire, both while on work and in their free time – without you guys this would not have been possible. A special thank you to the pilot and HEMS-crewmember who took time in their busy days to help me with the questionnaire. Your feedback and allowing me to ask the stupid questions really helped me!

Without my supervisor, Vegard Nergård, writing this thesis would not be possible. You started this project and allowed me to go out and explore a world I had no knowledge about. I have really appreciated all you feedback and good advices while writing this thesis. Thank you!

To all of my classmates: I have had two great years with you guys! Without you guys these two years would not have been half as fun as it has been! I have learned more than I ever believed I ever would. A super big hug goes out to my friends who has proof read and encouraged me in this process. You guys are awesome!

Tromsø, June 1. 2016

Hege Weines

Summary

Fatigue has become more of broad and current interest, and has been claimed to be a contributing factor in several aviation accidents and incidents (European Cockpit Association, 2010; Flin, 2008). The International Air Transport Association (ICAO) changed one of their annexes in 2012, allowing fatigue risk management systems (FRMS) instead of prescriptive flight time limitations. From 2018 there are new rules, which requires all Helicopter Emergency Medical Services (HEMS) -operations to incorporate FRMS as a part of their safety management system (ICAO, 2012).

This thesis focuses on FRMS and its implementation in an airline. The thesis had Lufttransport RW as its area of study and the research question is: *"How has the introduction of fatigue awareness devices as a part of Fatigue Risk Management System in an airline affected awareness of fatigue among crewmembers?"*

During the summer of 2015 Lufttransport Rotor Wing (RW) introduced fatigue awareness devices on all of their HEMS-bases. Pilots and HEMS-crewmembers had to state their felt level of fatigue before and after a mission.

Methods: The thesis used a quantitative method combined with one qualitative interview. A questionnaire was sent out to all helicopter crewmembers working with HEMS in Lufttransport RW. Out of 22 pilots and HEMS-crewmembers, 18 answered the questionnaire. The questionnaire asked about how the crew perceived the user friendliness of the device, if there was any change in awareness of fatigue and if there had been any behavioural change due to the device being introduced. As a follow up an interview was conducted with a manager in RW where the management's perception on how the device had led to any change within the organization.

Result: The empirical findings show a slight increase in awareness of fatigue. The crew discussed fatigue more after the device was introduced. The rate of how often the crew thought about fatigue has somewhat increased. The management had noticed an increase in the willingness to report issues regarding fatigue.

Conclusion: The finds in this thesis shows that the fatigue awareness device could be somewhat effective in regards to increasing awareness of fatigue. There has been an increase in awareness of fatigue in RW – but it is difficult to pinpoint if it is because of the device or other parts of the FRMS.

Supervisor: Vegard Nergård

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1. Introduction

The purpose of this thesis is to explain and bring attention to a method of organising Fatigue Risk Management Systems (FRMS) in an airline. The thesis focuses on the introduction of fatigue risk management in Helicopter Emergency Medical Services (HEMS) where Lufttransport AS has been the research arena. During the summer of 2015, The Lufttransport Rotor Wing (RW) department implemented their FRMS, where fatigue awareness devices were a part of FRMS. The thesis seeks to answer if and how the devices have increased awareness of fatigue. The thesis will also address whether there are other reminders or systems that can be implemented in the FRMS to increase awareness of fatigue.

The research question this thesis seeks to find an answer to is the following:

> *"How has the introduction of fatigue awareness devices as a part of Fatigue Risk Management System in an airline affected awareness of fatigue among crewmembers?"*

To answer this question the use of quantitative methodology has been applied, by using a questionnaire to ask pilots and HEMS-crewmembers in RW about the user friendliness of the devices, awareness of fatigue and behavioural change due to the devices. A qualitative interview has also been conducted to get the managements experience of the device.

1.1 Background and context

The European Cockpit Association (ECA) conducted from 2010 to 2012 a study about cockpit fatigue that resulted in the report: "The 2012 Barometer on Pilot Fatigue". Questionnaires were sent out to member associations of ECA, and more than 6000 pilots were asked about fatigue (European Cockpit Association, 2010). Over 50 % of the pilots reported fatigue was an impairing factor in their ability to perform well while on duty. The study also showed that 70-80 % of the respondents would not file a report or state that they were "not fit to fly" due to fear of reprimands from the management. The report stated that: "*pilot fatigue is common, dangerous and an under-reported phenomenon in Europe"* (European Cockpit Association, 2010, p. 3).

The International Civil Aviation Organization (ICAO) changed their Standard and Recommended Practices (SARPs) for Annex 6 in 2011. Prescriptive flight time limitations are

still required, but national states can change regulations and allow Fatigue Risk Management Systems instead of prescriptive flight time limitations (Gander, Mangie, Van Den Berg, Smith, Mulrine & Signal, 2014).

In 2012, The International Air Transport Association (IATA), ICAO and the International Federation of Air Line Pilots Association (IFALAP) published the "Fatigue Risk Management System (FRMS) Implementation Guide For Regulators" and the "Fatigue Risk Management System (FRMS) Implementation Guide For Operators". These joint publications goal was to introduce Fatigue Risk Management System (FRMS) to operators and regulators and as a result improve aviation safety in regards to fatigue (ICAO, 2011).

ICAO defines FRMS as:

> *"A data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness"* (ICAO, 2012, p. 1-1).

FRMS is being introduced due to an increased focus on fatigue and new knowledge about fatigue and its causes (ICAO, 2011). The aim is to use scientific research to make schedules instead of the more traditional prescriptive option of planning from a maximum of hours of service (HOS) per day. With introducing FRMS the goal is to take fatigue into account when planning shifts, and as a result hope to limit fatigue.

By 2018, all Helicopter Emergency Medical Service (HEMS) -companies are required to implement a FRMS in their Safety Management System (SMS) (ICAO, 2012).

The risk of accidents and incidents increases with fatigue (Mallis, Banks & Dinges, 2010). It is therefore important to reduce fatigue and hinder fatigue from occurring. Fatigue has been one of the involved factors in several serious incidents and accidents in aviation (European Cockpit Association, 2010; Flin, O'Connor & Crichton, 2008).

1.2 Previous research

A study performed on the New Zealand Aviation industry concluded that there was a strong need to increase the awareness of fatigue in all levels of commercial aircraft operations (Signal, Ratieta & Gander, 2008).

Caldwell & Caldwell (2003) lists the typical effects and risks associated with fatigue. They mention mood and attitude deterioration, difficulty with performing activities, which should be easy to do while not feeling fatigued. Other effects mentioned are impairment of the

ability of logically reasoning and lower and inconsistent performance (Caldwell & Caldwell, 2003). Fatigue effects more than that a person is feeling sleepy, it is affecting all of the activities a person takes part in, especially decision making. There is a proved link between fatigue and an increase in accidents and incidents (Dawson, Searle & Paterson, 2014).

Dawson et al. (2011b) presents two ways of dealing with risks associated with fatigue. They suggest to either implement fatigue reducing measures or implement measures, like biomathematical models, that aim to manage fatigue (Dawson, Noy, Härmä, Åkerstedt & Belenky, 2011b). Since it is impossible to prevent fatigue, FRMS can be seen as a good measure to reduce fatigue since it takes factors like circadian rhythm and sleep debt into consideration, but a clear picture of what factors are the cause of fatigue is still necessary to make a good FRMS (Dawson, Chapman & Thomas, 2011a).

Caldwell (2004) stated that there have been few changes in how work shifts are being scheduled for crews, even with more scientific research in the topics of sleep and circadian rhythm. Caldwell claimed that regulators have failed to incorporate this new knowledge in scheduling (Caldwell, 2004). The change Caldwell called for, are in many aspects in line with FRMS.

Cabon et al. (2012) discussed in their paper how to provide a scientific basis for implementing FRMS for a French regional airline. The paper concluded that being aware of fatigue could lead to strategies that could hinder fatigue. The paper stated the following: *"Therefore, other models have to be considered to account for the complex relationship between fatigue and safety. One of the key factors that could explain this complex link would be fatigue awareness"* (Cabon, Deharvengt, Grau, Maille, Berechet & Mollard, 2012, p. 44). This quote opens for a discussion on how awareness of fatigue can and should reduce fatigue.

1.3 Structure of the Thesis

Chapter 1 consists of the research question, background and context and previous research of the topic. Chapter 2 describes Lufttransport AS and their implementation of FRMS. Chapter 3 consists of the theoretical framework used to analyse the empirical findings. Chapter 4 explains the methodological explanation and choices made to write this thesis. Empirical findings from the questionnaire and interview can be found in chapter 5. The discussion of findings and theory are in chapter 6. Chapter 7 contains the conclusion of this paper. References and appendixes are found last in this thesis.

2. Lufttransport AS and Rotor Wing

Lufttransport AS is the largest aviation company in the Nordic countries offering air ambulance services (Lufttransport, 2016). The company is divided into several subparts. The Fixed Wing department operates air ambulance aircrafts, LT-Tech is in charge of maintenance and the Rotor Wing (RW) department operates the air ambulance helicopters/HEMS services. Lufttransport RW works on a contract with the National Air Ambulance Service of Norway, giving them the responsibility for three HEMS (Helicopter Emergency Medical Services) bases. These helicopters are situated in Tromsø, Brønnøysund and Ålesund.

Lufttransport RW faces challenges - which are unique to other helicopter operations. They are called out and requested to respond when there is a need for immediate response regardless of the weather conditions - or search and rescue missions if requested by the Joint Rescue Coordination Centres Southern Norway and Northern Norway. The decision to accept or decline missions is conducted by the crew. They also have many landings on unprepared areas but also on helipads (Lufttransport AS, 2015). At all times, the crew need to perform at the highest level of competence and professionalism. The crew members never know when they are going to be called out, it could be during the day, or it could be at night – it can also be that they are not called out at all. This makes the crew at risk for fatigue and fatigue related risks. Especially, since there are no planned scheduled flights except for training missions. Regardless, they have to be ready to perform at a professional level at all times. In turn, this exposes the crew to fatigue and it make it necessary to implement a fatigue risk management system. Lufttransport describes implementing a FRMS in their operations manual as the best way to tackle issues regarding fatigue management and risks.

The Lufttransport organization has committed itself to promote and renew their FRMS and incorporate it, in line with their Safety Management System into their Operations Manual. The FRMS has to be implemented in careful consideration to the Operations Manual Part A (OM-A) Chapter 7 – flight time limitations (FTL). The company has also committed itself to ensure that the personnel are made aware of the symptoms of fatigue, and enable the awareness of job and personal life related to fatigue. In the OM defined safety culture, Lufttransport aims to achieve a so-called just culture. A just culture means an organization where employees are trusted, and encouraged to bring attention to safety related questions, both good and bad. It is also important that bad outcomes natured by good intentions are not penalized (Reason, 1997). The aim is that personnel should feel safe to report, learn and improve fatigue management. The company aims to have zero missions where the crew are

fatigued. They also want to proactively enhance their awareness and understanding of fatigue through innovative and scientific methods of data gathering (Lufttransport AS, 2015).

A Rotor Wing air ambulance operation the crew consists of a licenced pilot, a HEMS-crewmember[1] and a medical doctor. Lufttransport hires the pilot and HEMS-crewmember, while the local hospitals provide the doctor. When referring to crew later in this thesis, the focus lies on pilots and HEMS-crewmembers, e.g. those hired by Lufttransport. Doctors and nurses are not included, since they follow schedules provided by the local hospital they are situated in. These schedules are often different from the one Lufttransport applies to its employees. Lufttransport organizes the shifts so that the crew works one-week shifts with one week off. After two duty periods they have two weeks off. HEMS-crewmembers change every Monday, while pilots change every Wednesday. While on duty, they have to be available 24-hours a day (They can work a maximum 2000 hours per year). When the crew has worked a maximum number of hours which are described in their FTL, the base is "turned off" – a set number of hours where the crew rests and cannot be asked to do any missions until the crew "turns the base on" again. This is to avoid fatigue and ensure that the crew get adequate rest.

2.1 Fatigue awareness devices as a part of Lufttransport RW FRMS

During the summer of 2015 the Rotor Wing department of Lufttransport implemented their FRMS. A part of the implementation of FRMS was placing fatigue awareness devices on the bases. These devices asked the crew for their felt level of fatigue before and after missions. This meant that the crew was forced to stop for a second to consider their own level of fatigue before entering the helicopter. Other measures included in Lufttransport RW FRMS were fatigue promotion posters, fatigue knowledge training and Actiwatches that monitored activity and sleep patterns. The data collected from these were analysed at the fatigue meetings (Lufttransport AS, 2015).

From June to October 2015 fatigue awareness devices were placed at all the HEMS-bases. Lufttransport chose to use HappyOrNot as hardware for their fatigue awareness devices. HappyOrNot is the system, also used by Avinor, where they ask travellers how happy they were with the service going through security. The electrical store Elkjøp also uses

[1] A HEMS-crewmember is a critical care paramedic or nurse with at least two years experience who holds the theoretical part of a PPL-A or PPL-H license (private pilot license). In addition a HEMS-crewmember has multiple other functions, like knowledge about mountain climbing, evacuation and SAR. He can be winched down to help extract patients in areas difficult to reach by foot or by landing the helicopter (Regjeringen, 2010).

the HappyOrNot system to ask their customers about how satisfied they were with the customer service in their stores. Lufttransport used these devices to ask the crew about their felt fatigue.

The device served the purpose of working as a barrier to prevent missions where the crew felt fatigue after a mission had been accepted. This could be divided into three parts:

1. Ask the crew about their felt fatigue at that point of time
2. Increase awareness of fatigue
3. Potentially stop missions where crew felt too fatigued

The first objective of the device was to ask the crew about their felt fatigue. It was meant to ensure that they stopped to contemplate their own state of fatigue before going on a mission. The second objective of the device was to increase the awareness of fatigue. The assumption was that being asked about fatigue regularly would increase awareness of fatigue. The third objective was to potentially stop missions where the crew were too fatigued to conduct the mission in a safe manner.

Each base had two devices, one to use before each mission and one to use after each mission. Lufttransport decided to use the Karolinska Sleepiness Scale (KSS) as a point of measure of the crews felt fatigue. KSS is a subjective measure of fatigue, scaled from 1-9- 1 being extremely alert while 9 being extremely sleepy, fighting sleep (Åkerstedt, Anund, Axelson & Kecklund, 2014). The device had four "smiley faces" or emoticons, which the crew could choose from. The smiley faces were linked to the possible categories in the KSS. Lufttransport chose not to use the possible answer "extremely sleepy, fighting sleep", meaning that the crew could choose between "extremely alert", "alert", "neither sleepy nor alert" and "sleepy, but no difficulty remaining awake". Above each device there were posters describing the aim of the devices and what each smiley face meant. Posters and information about the devices and FRMS was distributed around each base and posters were hung on areas were they often would be spotted.

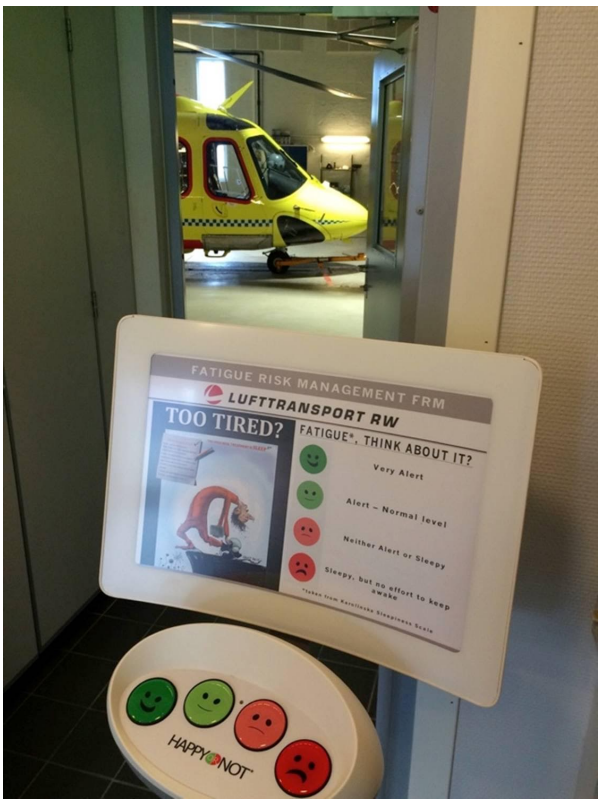

Figure 1: Photo illustration of the placement of the device

3. Theoretical Framework

This chapter presents the theoretical framework used to explain and discuss the empirical findings of the thesis. The theoretical framework presented in this chapter aims to contribute in answering the research question: *"How has the introduction of fatigue awareness devices as a part of Fatigue Risk Management System in an airline affected awareness of fatigue among crewmembers?"*

Topics that will be explained in this chapter are fatigue, fatigue risk management systems, situational awareness, risk management, attitude change and safety culture.

3.1 Fatigue

Fatigue is a subjective measure of how a person is feeling. Fatigue is often associated with tiredness, drowsiness and feeling sleepy (Flin et al., 2008). Flin et al. (2008) lists stress, extreme temperatures, vibration and physical work as factors that are fatiguing (Flin et al., 2008). There are many definitions suggesting what fatigue is, and it can be difficult to find one that describes fatigue and all its components (Caldwell & Caldwell, 2003).

The International Civil Aviation Organization (ICAO) has defined fatigue as:

> "*A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety-related duties"* (ICAO, 2012, p. 1).

The definition from ICAO focuses on the circadian phase, loss of sleep and the extent of the workload. It is specific on the causes of fatigue, and it focuses on the experience of fatigue while working. The definition also connects fatigue to safe operations in aircrafts.

However, Caldwell & Caldwell (2003) uses the following definition of fatigue: "*fatigue is the state of tiredness that is associated with long hours of work, prolonged periods without sleep, or the requirement to work at times that are 'out of sync' with the body's biological or circadian rhythms"* (Caldwell & Caldwell, 2003, p. 15). This definition focuses on the feeling of sleepiness. It connects fatigue with being sleepy, while also mentioning the circadian factors, which decides the level of wakefulness a person has. Caldwell & Caldwell's definition is similar to the one Dawson, Searle & Paterson (2014) presents, where they define fatigue as; "*sleepiness resulting from the neurobiological processes regulating sleep and circadian rhythms* (Dawson et al., 2014, p. 141). They further state that fatigue is affected by

the prior amount of sleep, the time awake since sleep and the time of day (Dawson et al., 2014) Sleep, the amount of sleep acquired, and the time of day are the factors that affect the sleepiness, or level of fatigue for a person.

Gander et al. (2011b), when explaining fatigue, goes into detail:

> *"Fatigue is the inability to function at the desired level due to incomplete recovery from the demands of prior work and other waking activities. Acute fatigue can occur when there is inadequate time to rest and recover from a work period. Cumulative (chronic) fatigue occurs when there is insufficient recovery from acute fatigue over time. Recovery from fatigue, i.e., restoration of function (particularly of cognitive function), requires sufficient good quality of sleep"* (Gander, Hartley, Powell, Cabon, Hitchcock, Mills & Popkin, 2011b, p. 574).

This is a very long, but albeit detailed definition, which manages to incorporate several of the aspects regarding fatigue. The problem with defining fatigue is all the issues and sources of fatigue. This definition also mentions cumulative fatigue, which is when a person has several nights with inadequate sleep (Gander et al., 2011b). Furthermore, Caldwell & Caldwell stated that *"95 % of fatigue results from inadequate amounts of sleep"* (Caldwell & Caldwell, 2003, p. 27). This really underlines the fact that sleep is one of the most influencing factors on fatigue, and that it is important to keep in mind when dealing with fatigue related issues.

In conclusion, when referring to fatigue, I will use the definition presented by ICAO. Mainly, because it focuses on the main problems within aviation and HEMS-operations. These problems could be fatigue due to extended wakefulness, for example like having to work long shifts and staying awake for longer periods of time. Also circadian phase since the crew are highly likely to be called out on missions in all the phases of their circadian rhythm and workload, especially since it is impossible to predict their workload. The crew could have a quiet week when they are on shift, or they could have a busy one, all depending on the amount of missions they are called out to. The other definitions are mentioned in this chapter to underline the variances in the different definitions that exists.

3.1.1 Circadian Rhythm and the Homeostatic Mechanism

The amount of sleep, the homeostatic mechanism and the circadian rhythm regulate when we feel awake and sleepy (Flin et al., 2008). This in turn affects our alertness and sleepiness (Caldwell & Caldwell, 2003).

The circadian rhythm is our internal bodily knowledge of time, which regulates when we feel awake and when we feel sleepy (Caldwell & Caldwell, 2003; Mallis et al., 2010). The circadian rhythm follows the earth's 24-hours cycle (Mallis et al., 2010). Many physiological and neurobehavioral functions in a person are impacted by their circadian rhythm, moreover the rhythm reaches a high and a low during the 24-hour cycle. The high is when the person is feeling awake, and the circadian low is when a person is feeling sleepy, usually the circadian low occurs at night-time between 0300 and 0600 (Mallis et al., 2010). Our internal body clock is the second greatest influencer on fatigue (Caldwell & Caldwell, 2003). The human body is physiologically wired to be awake when there is daylight/light outside and to be asleep when it is dark outside (Caldwell & Caldwell, 2003). Melatonin is the best marker to measure the circadian rhythm by (Paul, Love, Hawton & Arendt, 2015).

Homeostatic sleep pressure is the time a person has been awake since the last period of sleep was acquired. The amount of time since the last period of sleep is one of the biggest influences on fatigue (Caldwell & Caldwell, 2003). This mechanism functions accordingly; the need for sleep is low immediately after waking up and increases as the time since the last sleep period increases (Caldwell & Caldwell, 2003). The homeostatic sleep pressure is also influenced by the quality of sleep and whether or not the person has fragmented sleep (Mallis et al., 2010).

Together, these two mechanisms work together to keep a person awake and alert throughout the day, or in other words, they promote wakefulness during the day (Caldwell & Caldwell, 2003; Mallis et al., 2010). During the night, the reduced circadian level and the homeostatic mechanism keeps a person tired and sleepy, and in turn, sleeping (Mallis et al., 2010).

Circadian desynchronosis is what happens when the circadian rhythm is disrupted. This could cause fatigue, sleepiness and insomnia (Caldwell & Caldwell, 2003). Circadian desynchronosis occurs when there is a difference in what the circadian rhythm tells the body to feel and what the environment tells the body to do. An example of this would be working at night or waking up too early, during the circadian low (Caldwell & Caldwell, 2003).

Everyone has a limit of sleep that is required for a person to function at ones best. This is a biological sleep requirement. It is a common misconception that one can learn how to or adjust to functioning optimally on less amount of sleep (Caldwell & Caldwell, 2003). Adults between 26 and 64 years of age require between 7 and 9 hours of sleep daily (Randolph, 2015).

Cumulative fatigue is the level of fatigue, which builds up over several days. There are two factors affecting the cumulative fatigue. Firstly, the sleep debt, which has accumulated in the last 24 hours. Secondly, the amount of sleep a person has gained in the same timeframe (Caldwell & Caldwell, 2003). Caldwell & Caldwell (2003) state the following *"... most of the 'fatigue problem' could be resolved simply by ensuring that everyone gets enough sleep"* (Caldwell & Caldwell, 2003, p. 141). Even if sleep is the most important factor influencing ones level of fatigue, it is important to keep in mind that there are other influencers.

One of the HEMS-bases used in this thesis, namely Tromsø, is placed within the arctic region. Above the Arctic Circle the daylight conditions vary throughout the year. In Tromsø, the sun never rises above the horizon from November to January, while from May to August the sun never sets (Meteorologisk Institutt, 2012). Which means that the crew working at the Tromsø base could experiences deviations in circadian rhythm throughout the year. Since the circadian rhythm follows the earth's 24-hour cycle, this means that the people living in the arctic region experience a continuous mismatch with circadian rhythm and earth cycle due to the midnight sun and lack of sun in the winter-time (Friborg, Rosevinge, Wynn & Gradisar, 2014, p. 798). Friborg et al. (2014) conducted a study about sleep timing in the Arctic and the study showed that sleep efficiency was the poorest and that sleep timing was delayed during winter-time, such as when the days were mostly dark (Friborg et al. 2014). Paul et al. (2015) concluded in their study that the participants experienced 50 minutes less sleep during the summer time (Paul et al., 2015). These two studies can show that amount and timing of sleep can be affected by exposure to daylight/lack of daylight. And that people working in the Arctic region are especially effected because of the mismatch concerning the circadian rhythm.

3.1.2 Effects and Consequences of fatigue

Dawson et al. (2011b) divide the consequences of fatigue into two categories. The first category is short-term risk, where they state the consequences as poor safety outcomes. The second category is the long-term risk where the consequences are described as reduced physical/physiological health (Dawson et al., 2011b).

Fatigue has a negative effect on motor skills, cognitive performance and communication- and social skills (Flin et al., 2008). As sleep debt increases, the cognitive function of a person decreases, which in turn can have an impact on the amount of errors, judgement, decision-making and safety (Ferguson, Paech, Sargent, Darwent, Kennaway & Roach, 2012). One night of no sleep can decrease the cognitive performance as much as 25 % (Frakes & Kelly, 2007). Long-term effects of fatigue can culminate to physiological problems and an increase in physical problems (Dawson et al., 2011b). Physical problems related to fatigue could be loss of appetite, irritability, digestive problems and increased susceptibility to illness (Canadian Centre for Occupational Health and Safety, 2012)

Just as little as 2 to 3 hours of sleep loss can have impairments on real world tasks (Dawson et al., 2011b). Further on, more extensive sleep loss can amount to impairments that are similar to consuming small amounts of alcohol (Dawson et al., 2011b).

The effects of sleep loss are easiest to observe at neurophysiological and neuro-psychological levels. Imaging of the prefrontal cortex of the brain and functioning performance testing can show the brain being affected by fatigue (Dawson et al., 2011b).

The Norwegian Public Roads Administration (NPRA) has since 2004 had a campaign called "Stop and Sleep". The aim is to have sleepy drivers stop and sleep for 15 minutes before continuing driving. The result of this campaign was an increase in drivers stopping to sleep, from 13,5 % in 2003 to 24,5 % in 2006. NPRA states that the campaign reminding sleepy drivers to stop and sleep has led to behavioural change in sleepy motorists. The objective of the campaign was to reduce the number of drivers falling asleep behind the wheel from 11 % to 8,25 % by 2020 (Løtveit, 2007).

To conclude with words from Flin et al (2008): "*The only way to recover from fatigue is sleep*" (Flin et al., 2008, p. 196).

3.1.3 Measure of fatigue

There are no biochemical markers to measure fatigue. One cannot test fatigue like one can test whether or not someone is driving under the influence of alcohol (Flin et al., 2008). One can however look at changes in brain function, subjective experience and behaviour, which are factors that can be measured as fatigue (Gander et al., 2011b). Lastly, to measure fatigue there is a need to use other subjective measures, behavioural, physiological or cognitive tests (Flin et al., 2008).

Nevertheless, "Fitness for duty"-tests does exist. They test the performance of a person before shift on neuro-behavioural tasks, usually hand-eye coordination. However, these tests

only say something about the level of fatigue at the time the test is executed, and does not contribute information about the progress of fatigue as the shift goes on. To say anything about fatigue during the entire shift, the person on shift needs to retest during the shift (Dawson et al., 2014). Also, the connection between fatigue and performance must be discussed. Poor performance on such a test might occur because of other factors than fatigue.

In some professions "fitness of duty"-tests are performed to assess whether or not a person is fit to start their work shift. Pilots have the term "fit to fly" which they state when they are flying. If they are not fit to fly, they should not fly and the management accept that.

Subjective measures of fatigue are based on the individual personal experience and currently available information (Ferguson et al., 2012). In other words, the subjective measures of fatigue take into account how the person's level of felt fatigue, in the moment they are being tested or asked is.

Lufttransport chose the Karolinska Sleepiness Scale (KSS) as their chosen method of assessment, which is a 9 level scale where the subjects tested states, their felt level of sleepiness in the last 10 minutes. The scale measures situational sleepiness (Shahid, Shen & Shapiro, 2010). All of the values from 1-9 can be chosen, but only 5 have a verbal description. The scale of KSS is the following: 1 = "extremely alert", 3= "alert". 5= "neither sleepy nor alert", 7= "sleepy, but no difficulty remaining awake" and 9="extremely sleepy, fighting sleep". Numbers 2, 4, 6 and 8 on the scale do not have a verbal description (ICAO, 2011).

Other subjective measures of fatigue include the Ephworth Sleepiness Scale and the Stanford Sleepiness Scale (Shahid et al., 2010).

3.2 Fatigue Risk Management System

ICAO defines a Fatigue Risk Management System as:

> *"A data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness"* (ICAO, 2012, p. 1-1).

The aim of a fatigue risk management system is to ensure that the crew operates on a satisfactory level of performance (ICAO, 2012). This is being introduced due to an increase in accidents caused by fatigue issues and new flight time regulations (ICAO, 2012). The aim is

that a FRMS shall maintain a level of safety with regards to fatigue in aviation that will meet requirements in Europe (Cabon et al., 2012).

A FRMS is another way to organize shift length and working hours, different from the prescriptive approach such as Flight Time Limitations (FTL) or planning from Hours of Service (HOS) (Dawson & McCulloch, 2005; Signal et al., 2008). A FRMS takes three factors into consideration. (1) It considers that the functioning capacity of a person is variable, (2) some of this can be predicted from sleep and the circadian levels and that (3) systems are needed to maintain the safety due to the impairments due to fatigue and the resulting consequences of this (Gander, Graeber & Belenky, 2011a).

One of the arguments of implementing fatigue risk managements systems instead of FTL or maximum hours of service is that FTL is not able to take in the complexity of dealing with fatigue (Cabon et al., 2012). Some researchers claim that FRMS can relieve fatigue, while at the same time be more flexible than the traditional approach of FTL and HOS (Darwent, Dawson, Paterson, Roach & Ferguson, 2015; Steege & Dykstra, 2016). Darwent et al. (2015) also suggest that it is easier to accept long working periods or shifts in professions where the consequences of disrupted services can be greater than the risk of fatigue. This is usually not accepted within aviation where disrupted service might, as an example, not be as severe as for a surgeon. This shows that regulators have difficulty distinguishing a shifting point between safe or unsafe length of shifts, when making regulations (Darwent et al., 2015).

It is impossible to eliminate fatigue from aviation, due to the unpredictable schedules, early and late report times and night flights. This is why a significant and valid FRMS is needed (Mallis et al., 2010). Darwent et al. (2015) underlines that an alternative approach might be to monitor the sleep behaviour of employees (Darwent et al., 2015).

There are three different areas of responsibility concerning the implementation of FRMS. Firstly, it can be a regulatory responsibility that falls on the state or nation it concerns. Moreover, this means that the state or nation are responsible for regulation the implementation on either national or international level (Gander et al., 2011b). Farther down this hierarchy, are the responsibilities that befall the industry or company. The consequence of this is that the responsibility of the implementation of FRMS has to be a share cooperative venture between the management of said company and its employees (Gander et al., 2011b). Lastly, the third area focuses on the individual responsibility. Meaning that the individual or employee is responsible to follow what is implemented as a part of FRMS (Gander et al., 2011b). The requirement stated by ICAO, regarding its member states, states that FRMS has to be implemented at the highest level of this hierarchy (international agreement). However, it

also requires the implementation to occur at a company level because all companies are responsible for creating, implementing and following a working FRMS customized to their company (Gander et al., 2011b).

The aim of a FRMS is to limit the workers' exposure to factors that are fatiguing. This is done by regulating the duration of a continuous task, taking the circadian rhythm into consideration when scheduling work time, regulating the time which is necessary to be awake for work and take fatigue into consideration when making schedules (Gander et al., 2011b). As opposed to prescriptive rules, that do not consider sleep and circadian rhythm, a FRMS takes these factors into consideration (Signal et al., 2008). This way of organizing, FRMS is more flexible than a shift-time regulation (Gander et al., 2011b).

One of the weaknesses associated with FRMS is the necessity for those in charge of implementing the FRMS to have knowledge of the complex relationship between fatigue and safety (Gander et al., 2011b) Furthermore, it is difficult to link fatigue to incident reports, which is a challenge for the FRMS (Gander, et al., 2011a).

Easyjet was one of the first airline companies that implemented FRMS. They have reported that the implementation of FRMS has reduced fatigue (Mallis et al., 2010).

The strength of shift length regulation is that it limits the time a person has to be awake for and limits the duration a person can be continuously at work. Shift length regulation also ensures a minimum time off, where the employee has time to sleep (Gander et al., 2011b). This can also be done with FRMS. Shift time regulation has a few weaknesses as well. It does not take circadian rhythm into consideration when planning. For example, working at night and reduced sleep quality during the day due to the circadian rhythm is not being taken into consideration (Gander et al., 2011b). Based on the way shifts are planned, it might be difficult to recover sleep debt since the duty period cycle is not taken into consideration either. At last, the time to get to and from work is not taken into consideration when planning shifts (Gander et al., 2011b). And this in turn might prolong the employees time awake and worsen their sleep debt and sleep quality.

3.3 FRMS and Defences in Depth

James Reason (1997) explains how barriers or defences can work together as a shield to prevent or stop mistakes from becoming organizational accidents. He makes a distinction between soft and hard barriers, or "defences" as he calls them. Soft barriers are regulations, typically paperwork or certificates, which should regulate in such a way that dangerous situation are avoided (Reason, 1997). Hard barriers, on the other hand, are physical barriers

like keys or structural designs that aim to hinder accidents and incidents (Reason, 1997). Together the soft and hard barriers constitutes layers of safety features, and, in turn, make defences in depth system, since different ways to deal with risks are combined, and in that way creates a more robust system (Reason, 1997).

Dawson & McCulloch (2005) suggest using Reasons (1997) "error trajectory" to build a good working safety management system, and, in turn for it to be used as a company's FRMS (Dawson & McCulloch, 2005). Dawson & McCulloch have made defences in depth system with five layers that describe how a fatigue related accident can occur, with hazard assessments and control mechanisms (Dawson & McCulloch, 2005).

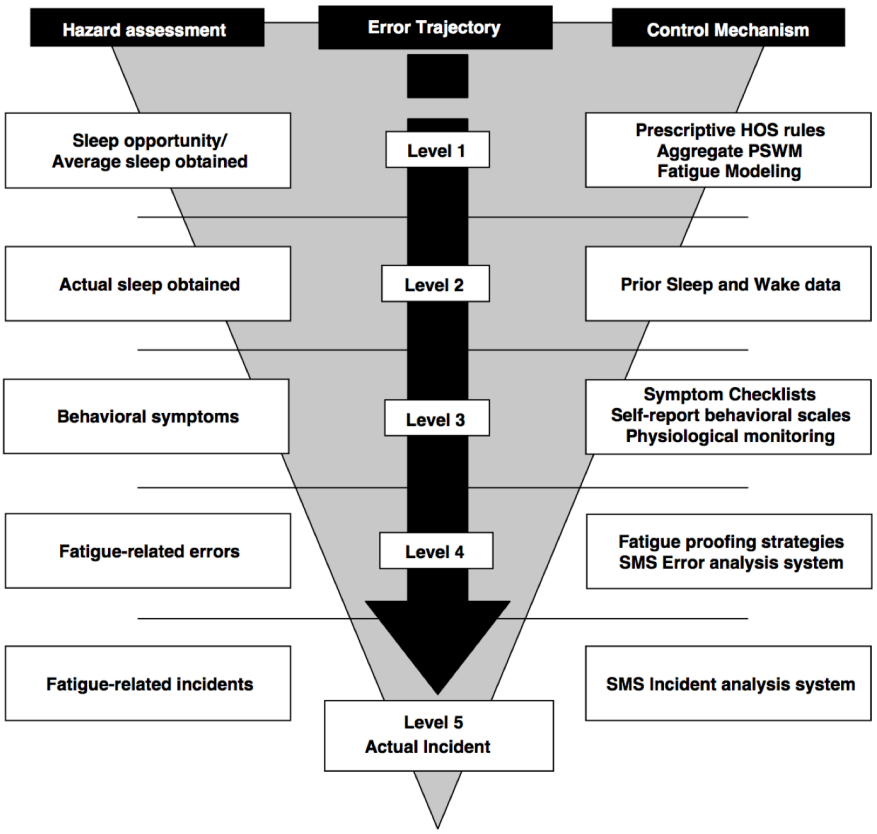

Figure 2: Fatigue-Risk Trajectory (Dawson & McCulloch, 2005, p. 369)

The first level of the trajectory describes sleep opportunity and average sleep obtained as its hazard assessment. The control mechanism on the other side of the trajectory, on level 1 is, prescriptive HOS rules; aggregate prior sleep/wake models and fatigue modelling (Dawson & McCulloch, 2005). As the opportunity to obtain enough sleep decreases, the risk of fatigue, and, consequently, fatigue related incidents increase (Dawson et al., 2011b). This could be the case concerning aviation where shift work is normal, and shifts are set outside the circadian rhythm. Lack of sleep opportunities can make the scenarios further down in the trajectory more likely to occur (Dawson et al., 2011b). Use of bio-mathematical models can be put into

this level of the trajectory as a control mechanism to model fatigue as a basis (Dawson et al., 2011b).

The second level in the trajectory assess as a hazard the actual sleep obtained and control mechanism is stated as prior sleep and wake data (Dawson & McCulloch, 2005).

On level 3, behavioural symptoms are described in the hazard assessment and control mechanisms suggested are symptom checklists, self-reported behavioural scales and physiological monitoring (Dawson & McCulloch, 2005).

Fatigue related errors are described as hazards in the fourth level of the trajectory. As a control mechanism fatigue proofing strategies and safety management system-error analysis systems are suggested (Dawson & McCulloch, 2005).

The fifth level, which is the actual fatigue related incident has fatigue-related incidents as its hazard assessment. A SMS incident analysis system is suggested as a control mechanism (Dawson & McCulloch, 2005).

If a fatigue-related error manages to pass the trajectory it is possible to believe the person making the mistake suffers from fatigue (Darwent et al., 2015).

A FRMS needs to focus on the lead indicators that are high frequency and low consequence events, since these are easier to identify and might prevent fatigue relates incidents and accidents later (Dawson et al., 2014).

To summarize the trajectory, level 1 consists of providing opportunities for sleep, which are adequate. Level 2 is to in some way confirm that adequate sleep has been accomplished. The third level is to establish systems which intercepts behavioural symptoms of fatigue, and the fourth level is the to establish system which detects fatigue related errors. The fifth and final level is to make a process that investigates incidents linked to fatigue (Gander et al., 2011a; Dawson et al, 2014).

3.4 Situational Awareness

Endsley defines situational awareness (SA) as ”*The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future*” (Endsley, 1995, p. 36). Endsley underlines that SA is a state of knowledge, and that the process of achieving situational awareness can be called situation assessment (Endsley, 1995). Flin et al. (2008) and Endsley (1995) have a simplified explanation of SA: *“knowing what is going on around you”* (Flin, 2008, p. 17, Endsley, 1995, p. 36). Their explanation can be said to summarize SA as a concept.

The process of achieving SA can be divided into three levels. Level 1 simply regards the perception of elements in their environment. Level 2 is about the comprehension of the current situation. Level 2 reflects a higher understanding of SA than level 1 because, in addition to being aware of the surroundings, the person needs to understand the significance of the elements that are present. Level 3 is about the projection of the future status; being able to anticipate how actions will play out in the future. Each of the three levels reflects a higher level of SA than the other. Level 3 SA involves a greater SA than level 2 SA, and level 2 involves a greater SA than level 1 SA (Endsley, 1995).

SA is also connected to memory. All the information a person perceives is processed in the brain. When a person perceives too much information simultaneously the brain is not able to process everything at once, due to the huge information flow. The environment surrounding the person has part in determining what should be processed – e.g. light, sounds etc. (Flin et al., 2008). The working memory is what is called our *"conscious awareness"*. The capacity of our working memory is limited; it can hold about 7 types of information at the same time (Flin et al., 2008). If a person gets interrupted or distracted, like someone approaching the person and striking up a conversation, some of the information in the working memory can get lost (Flin et al., 2008). New information is, instead stored in the working memory. After a while, when a skill becomes a regular task or an automatic response, performing an action of that sort does not take parts of the working memory (Flin et al., 2008). The long-term memory contains stored information that has been collected throughout our lives, this is where our personal memories and knowledge is stored. The connection this information about memory has to SA is that when retrieving memories from the long-term memory to the working memory or to a higher level of availability, some things might be easier to remember than other things (Flin et al., 2008)

Situational awareness is important to mention in regards to fatigue. As mentioned earlier, fatigue could affect cognitive performance and communication- and social skills. Those are factors that are important for a shared SA. Shared SA is when a crew has the same SA and therefore a similar understanding of a situation (Endsley & Jones, 1997). Fatigue could therefore be an impairment on shared SA among crew, which can cause accidents and hazardous situations.

Perception is explained as how we are aware or perceive physical objects or social situations based on our sensory expression of that point of time (Eid, 2006). About 80 % of the information a person obtains is gathered visually (Orlady & Orlady, 1999). How a human being perceives a situation or the world around them is based on a complex process of the

situation itself, and our previous knowledge (Eid, 2006). Eid further explains attention as a resource that supports cognitive aspects such as perception, the ability to learn, and our memory (Eid, 2006). Attention can further be divided into selective attention, shared attention and sustained attention (Eid, 2006). Shared attention refers to an operator having to focus on atleast two tasks at once. Sustained attention requires the operator to have to monitor or have sufficient focus over a long period of time. Mistakes can often be explained in terms of the ability to hold a sufficient level of focus over time (Eid, 2006).

The pushing of buttons on the device can be explained as a new procedure that was implemented temporarily at the bases. When establishing a procedure it is important that it is easy to use and realistic. Poor compliance with established procedures can be explained in terms of the procedures themselves being poor (Orlady & Orlady, 1999).

3.5 Risk Management and Safety Culture

Renn (2008) describes how managers can implement risk management systems. The implementation is divided into several phases: (1) Option generation, (2) option assessment, (3) option evaluation and selection, (4) option implementation and (5) monitoring and feedback (Renn, 2008). The phases that are relevant for this thesis will be described. When a risk management option is chosen it is vital that it is implemented. In the case of Lufttransport the installing of the fatigue awareness device on all the bases and informing crew of its intent and purpose, was considered a possible and the most suitable and effective way of implementation. The last step is monitoring and feedback. This is according to Renn a systematic monitoring of the result the device is producing. This phase also generates feedback about effectiveness and information or warnings about potential risks (Renn, 2008). In the case of Lufttransport this means evaluating the result from the device and listen to any feedback from the users e.g. the crew. Risk management is closely linked to risk communication. Risk management is dependant on leadership. Leadership influences safe performance (Flin et al., 2008). "*Leaders are often perceived as being inspirational or charismatic figures who can unite and motivate followers by offering shared visions and goals (*Burns, 1978 in Flin et al., 2008, p. 139). There are two words in this definition of leadership which are important to remember: inspirational and followers. The leaders inspire the followers in the organizational hierarchy (the followers refers to the employees – who follow the way the leader stakes out). The decisions of a manager imprint onto the employees or in this case, management leads the way for safety culture that the crew follows.

Another issue worth mentioning regarding risk management is the use of warnings. Turner and Pidgeon (1978) discuss the use of warnings in their book about man-made disasters. They discuss how repeated warnings like tornado warnings or tsunami warnings influence the public. The research they refer to proved that repeated warnings did not lead to decreased willingness of cooperation in the actions the warnings required (Turner & Pidgeon, 1978).

Safety culture is a theoretical perspective that I have chosen to use in the discussion that follows. This is because the device being implemented by the management to the crew, it is of interest to have a look at how culture and safety culture unfolds through an organization. Schein (1992) defines culture as:

> ”*A pattern of shared basic assumption that was learned by a group as it solved its problems of external adaption and internal integration, that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems”* (Schein, 1992, p. 17).

Culture, then, is the common understanding that would form in a crew. Everything from how to perform tasks to how they relate to each other as members of a crew is relevant to their culture.

Pidgeon (1991) defines safety culture as: ”*The set of beliefs, norms, roles and social and technical practices that are concerned with minimising the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious“* (Pidgeon, 1991, p. 132).

The goal of a safety culture is to create a culture that focuses on parts of the organization that holds risks or potential risks of accidents and incidents. A constant vigilance against the elements that may create risks helps to reduce the risk of accidents.

Reason (1997) identifies four components that together create a safety culture; a just culture, flexible culture, reporting culture and learning culture (Reason, 1997). These four components focus on different parts of an organization, but the idea is that if you manage to achieve all four sub-components in an organization and have safety in focus, you achieve a more secure organization.

To form a just culture there has to be clear principles within an organization for what is considered acceptable and what is not. One should accept that people can make mistakes, but one should not be penalized if one's good intentions lead to an undesirable result. A just

culture takes into account that mistakes happen, but at the same time management should encourage the actions performed on the basis of good intentions (Reason, 1997).

A flexible culture means that that organization is able to handle change. For example, change can be the change of demand of products or new technology (Reason, 1997).

The goal of a reporting culture is to form a culture where employees can report errors and issues that can be of concern without fear of being punished or blamed. Often those working in the part of the organization that directly handles the factors that may contribute to accidents have greater knowledge about this than the management. Therefore, all employees must be met with interest and openess from management in order to form a good reporting culture (Reason, 1997).

The last item Reason discusses is learning culture. Having a learning culture means to learn from the day-to-day experiences and take appropriate decisions and act based on these. Reason divides learning culture into four elements: observation, reflection, planning and execution. The first three parts are easy to implement, however making changes is difficult to achieve in an organization because achieving a lasting change requires effort from both management and employees at the sharp end who work where risks may occur. It is therefore important that all elements of a safety culture are implemented (Reason, 1997).

3.6 Attitude change

When a person modifies the evaluative perception of a stimulus, an attitude change is what is occurring (Cacioppo, Petty & Crites Jr., 1994). This means that changes in how a person feels about an object or person is an attitude change. However, changes in knowledge or education does not apply to attitude change (Cacioppo et al., 1994). "*Attitude change, therefore, represents a specific form of self-control and social control that does not rely on coercion"* (Cacioppo et al., 1994, p. 261). Kelman (1958) states that attitude change due to social influence can be divided into several levels: compliance, identification and internalization. These different levels could have different impacts on how a person accepts the influence that causes the behavioural change (Kelman, 1958).

Compliance refers to when a person accepts an influence because the person hopes to obtain a positive reaction from another person. A reaction could be a reward or punishment. In the case of Lufttransport the other person would be the management (Kelman, 1958).

Identification refers to when a person accepts an influence or change because the person desires a self-defining relationship with another person in the same group (or in this case, the management). The new behaviour occurs because the person associates the

behaviour with the desired relationship (Kelman, 1958). This could be connected to what Nergård discusses in several articles how in aviation, attitude change is deeply connected to adopting airmanship. Airmanship is factors like behaviour, social and emotional abilities and attitudes that constitute a skilled pilot. What Nergård discovered is that young pilots often goes through an attitude change when developing airmanship (Nergård, Hatlevik, Martinussen & Lervåg, 2011; Nergård, 2014; Nergård, 2015).

Internalization occurs when the new behaviour is accepted because it is associated with an intrinsic reward. New behaviour is compatible with the value system the person holds (Kelman, 1958).

Repeated exposures towards an unfamiliar object have shown a positive attitude towards that stimulus, even if the stimulus does not result in rewards or punishment (Cacioppo et al., 1994). The fatigue awareness device could be compared to a repeated measure of exposure with no reward or penalization.

3.7 Analytical framework

In this chapter several different theoretical perspectives have been presented. Fatigue and FRMS are terms that are described since it is of importance to this thesis to have a good understanding of them. Especially, since the consequences of fatigue can be severe and FRMS is a way of organizing shifts in a way that tries to limit fatigue in the best way possible. FRMS and defences in depth are used later in this thesis to describe how the fatigue awareness device can be implemented as a part of FRMS. Situational Awareness is used to discuss how the fatigue awareness device can help achieve the different levels of SA. Attitude change is included since the questionnaire asked questions about behavioural change. At last, risk management and safety culture is used to discuss how the presence of the device could affect the safety culture within Lufttransport RW.

4. Methodology

In this chapter the process of choosing a research question and what type of research method used will be discussed. This chapter aims to explain how this thesis has been written, and the choices made in the process. The first part of this chapter consists of a description of the research strategy, followed by a description of how the questionnaire was designed and distributed and how the interview was conducted. A subpart about data collection, and analysis of the collected data follows. Lastly, the evaluation of methodology, where critique of methodology, reliability, validity and ethical considerations are discussed.

4.1 Research strategy

To choose a method in a research project means to choose which path to follow to achieve the answer to the research question. In other words, the choice of method concerns itself with how a researcher proceeds to gather information and eventually analyses this information (Johannesen, Tufte & Christoffersen, 2010). There are two different approaches to choose from, namely qualitative and quantitative methods (Ringdal, 2013).

A qualitative study is suitable when it is possible to be close to the topic of phenomena that are being studied. Usually a qualitative study aims to describe a social construction of a world and the respondents are being studied in their natural setting (Ringdal, 2013). A quantitative study is suitable when the population, which is being studied, is further away from the researcher (Ringdal, 2013). A quantitative method uses numbers and statistics to describe differences and findings in a population while a qualitative method makes a description of a social setting (Blaikie, 2010).

In the case of this thesis, both qualitative and quantitative methods could be used to answer the research question. Qualitative interviews could have given a deeper and more detailed answer to the questions that this thesis revolves around. However, if interviews were to be done, it would have taken over a month to collect information from all the respondents due to the nature of the respondents work (namely, shift rotations). Furthermore, the risk of the interviews being cancelled due to missions and need for rest made it clear that a quantitative approach was more appealing and possible within the timeframe of the thesis. Such a study would also require a lot more time to process the data collected from all the respondents. Most probably I could only have interviewed a small part of the population using qualitative method. In this thesis a quantitative approach was chosen since it was possible to reach the whole population in Lufttransport RW with a questionnaire in a shorter timeframe than interviews could have presented. A questionnaire would also require less of the

respondents. Firstly, since answering the questionnaire was estimated to take about 10 minutes. Secondly, since the questionnaire could be answered when the crew themselves felt they had time and energy for it. I chose to use quantitative methods because I felt that it was the best way to gather information that could help in answering the research question.

However, one qualitative interview was performed. This was done after the questionnaire to get the managements perspective on the fatigue awareness device and the effect it had on awareness and behavioural change. The decision to do an interview was based on the manager being the only one in that population and that he was more available to do an interview than the crew was.

4.2 Questionnaire

The questionnaire was sent to all employees of Rotor Wing in Lufttransport working at the HEMS-bases. This was either as pilot or as HEMS-crewmember. At the time when the questionnaire was distributed, the population consisted of 11 pilots and 11 HEMS-crew members. The questionnaire was sent to a total of 22 respondents, where 18 of those answered the questionnaire. The respondents were informed in the information letter that participation was voluntary.

The questionnaire consisted of 15 questions, which were categorised in 4 different categories. These categories were: (1) user friendliness of the devices, (2) awareness of fatigue, (3) behavioural change and (4) other questions.

The questionnaire had a semi-structured design, with 13 closed questions and 2 open questions (Biggam, 2008). The combination of open and closed questions was chosen since the closed questions gives an answer, while the two open questions ask for a deeper meaning or the respondents opinion which is not possible to achieve with closed questions (Biggam, 2008).

On the closed questions as a rating scale a Likert scale was used to rank the answers (Johannesen et al., 2010). This means that the answers follow the ordinal scale. Thus the answers follow a rank order (Johannesen et al., 2010). For example, the first Likert scale used this scale: 1 = “I strongly agree,” 2 = “I agree”, 3 = “I neither agree nor disagree”, 4 = “I disagree” and 5 = “I strongly disagree” follow a logical order. This Likert scale aimed to measure the respondents’ level of agreement with the statements they were presented in the questionnaire. The other Likert scale measured how often the respondents did whatever the time related questions asked about. This Likert scale followed this scale: 1 = “Very frequently (daily while on duty)”, 2 = “frequently (a few times per duty period)”, 3 = “Occasionally (one

time per duty period)", 4 = "rarely (not on every duty period)" and lastly 5 = "never". The definition in the brackets was chosen so the respondents could have a measurement that was more precise. This scale was also chosen so that me as a researcher could gain a deeper insight into what they actually meant when they answered the question.

The Likert scales, were as mentioned ranked. One answer is "higher" or "lower" than the other. This means comparisons can be done, but since there are no equal difference between the categories and since they do not have a fixed zero point, it means some mathematical addition cannot be applied (Phelps, Fisher & Ellis, 2007). Having five different values opens for a more advanced statistical analysis, while at the same time there is not too many different values for the respondent to choose from (Johannesen et al., 2010). Since the answers are ranked logically, and measures a feeling, it is possible in this case to employ some mathematical analysis that usually is impossible with ordinal values (Johannesen et al., 2010).

The user friendliness category was designed to see how the respondents perceived the user friendliness of the devices. The respondents were asked 1; if they used the devices, and 2; were the placement of the devices good in regards to where it would be the most effective. 3; Was the device easy to use? 4; Did the use of smiley faces make sense and 5; did the device take away mission focus prior to the mission? The objective of this category was to collect data that gave information about how the crew experienced the use of the device.

The second category contained four questions regarding awareness of fatigue. The respondents were asked if they discussed fatigue as a crew before the device was installed, and then if they discussed fatigue as a crew after the device was installed. They were asked about how often they thought about fatigue, and if they thought more about fatigue after the device was installed. The objective of this category was to gain insight about whether or not the device had any effect on awareness of fatigue.

The third category focused on behavioural change. Firstly, they were asked if they have declined missions while feeling fatigued after the device was installed. Then they were asked if they have accepted missions while feeling fatigued after the device was installed. Lastly, they were asked if the device had made them evaluate their actions while on mission, in respect to fatigue. The aim of this category was to see whether or not the device has led to behavioural change.

The fourth category; other questions, contained three questions, which did not fit into the other categories but still was of interest for this thesis. The respondents were asked if the device had increased their willingness to report to the management issues regarding fatigue.

They were asked what factors they believed led to fatigue and lastly they were asked if there was other measures or reminders, which they think can be implemented to better the FRMS.

Before the questionnaire was distributed I had two informal meetings with a pilot and a crewmember on one of the HEMS-bases. They reviewed the drafts of the questionnaire, and we discussed all of the questions in regards to the wording used – was the terms I used the same ones that they used in their day-to-day life on shift. I also asked about their understanding of the questions; I needed to be sure that they understood them the way I intended them to. After these meetings, the questionnaire was revised and sent to the leader of RW for his input as well. After the second revision I had another informal meeting with the same pilot and crewmember where we again discussed the draft of the questionnaire. This was done to ensure that the respondents understood what they were asked about, and that I used the right terminology and wording.

The web-based survey tool Questback was used to distribute the questionnaire. This seemed more secure than open sources like Google Docs. Also, the possibility of transferring the data directly to SPSS without having to do it manually was extremely time saving and ensured that there were no errors in the transfer. Choosing to use a web-based questionnaire was, amongst other factors, due to the convenience it led to for the respondents. Had the questionnaires been printed and sent to all of the bases the collection of data would have taken much longer since the respondents would have needed to be on duty to answer the questionnaires. This way, the questionnaire could be answered on the respondents off time, saving time for data collection.

The two open questions was in the questionnaire because they were questions which could not have been put into a Likert scale and it was of interest for the thesis to see what the respondents beliefs about the theme were.

4.3 Qualitative Interview

The interview was conducted with the manager of Rotor Wing operations. The main objective of the interview was to figure out whether or not the management had detected any increased fatigue awareness after the devices was introduced. The interview was carried out in the office facilities of Lufttransport and lasted for 20 minutes. The manager agreed to, and was informed that the interview was recorded and then later described before it was analysed. His participation was voluntary.

The interview was conducted after the results of the questionnaire were collected. It was therefore a semi-structured interview, since some questions were prepared, but in general

the interview guide consisted of topics to discuss (Johannesen et al., 2010). This made it possible to ask questions for clarification, or if the pilots and crew members used abbreviations and terms which I, as a researcher, was unsure about the meaning of. The interview also addressed the management view or perception of the fatigue awareness device and the effect it had on the organization.

4.4 Data Collection and Analysis

The link to the questionnaire was sent to the manager of RW in Lufttransport. He distributed the questionnaire to all the HEMS crewmembers and pilots in RW. The respondents received a deadline of 14 days to complete the questionnaire, and all of the respondents were informed that participation was voluntary. When the 14 days had passed, 14 of 22 had answered the questionnaire. An email was sent to the group of respondents reminding them to answer the questionnaire. In the end 18 of 22 had answered the questionnaire. This results in an answer rate of 81,8%. When conducting a survey a high answer percentage is desirable, a response percentage of 50 % is considered to be good (Johannesen et al., 2010). An answer percentage of 80-90% is therefore considered to be high (Johannesen et al., 2010). Since this thesis had a small population, a high answer rate was needed to ensure a valid and reliable analysis of the data.

The data collected for this master thesis is for the most part primary data. This means that the data is collected an analysed by the researcher responsible for the thesis (Blaikie, 2010). The primary data is collected from a questionnaire and one interview with the leader of RW-operations. The strength of thesis is that the data is not analysed by someone else, because the researcher controls the data (Blaikie, 2010).

Secondary data is information collected by another party, but delivered to the researcher as raw data. That means it has not been analysed, but delivered to the researcher by someone else than the researcher himself (Blaikie, 2010). In the case of this master thesis this data is the information gathered from the fatigue awareness devices. Lufttransport collected this information, and I was provided with the log in details for the HappyOrNot system, where I could download information gathered from the devices. The drawback of secondary data is that the purpose of the data collection might have been different to the purpose of the researcher (Blaikie, 2010). In this case, since the thesis goal was to find out whether or not the device can be a part of a good FRMS, this was not assumed to become an issue.

To analyse the data collected in the questionnaire the Predictive Analytics SoftWare (PASW statistics) was used. This programme was previously known as SPSS – Statistical Package for the Social Sciences. The qualitative interview was recorded then later transcribed.

When analysing the quantitative data I have focused on the mean values, which shows the centre of distribution. Mean values are usually used to explain variable, which are continuous. The data I have collected are at an ordinal level, but since these are ranked and linked to a number it is possible to calculate a mean value of the answers (Ringdal, 2013). To explain the spread of the distribution of answers I have used standard deviation as a measure. Standard deviation has the same issues as the mean value, typically it is used in regards to continuous variables, but since I have 5 values, and they are ranked, I can use this as a measure of spread in the distribution (Ringdal, 2013). Mostly descriptive statistics has been applied to the data collected.

Since the questionnaire was distributed via a link, it is impossible for me as a researcher or the manager who distributed the link to access who answered which questionnaire. The respondents are assured full anonymity. The manager, which was interviewed, is anonymised.

4.5 Evaluation of methodology and ethical considerations

This subchapter aims to explain the methodological choices made, especially with discussing the way the project has been planned and conducted – critique of methodology. The reliability and validity of the thesis will be discussed followed by some ethical considerations.

4.5.1 Critique of methodology

This project had a small population. The consequence of a small population is that it limits the ability to draw lines to other industries, but the empirical findings reveals something about the situation in Lufttransport RW at the time when the questionnaire was distributed. Since a high percentage of possible respondents answered I can say something about the trend inside the RW-part of Lufttransport, but I cannot generalize on to other companies or aviation in general.

In retrospect, it becomes evident that some of the questions on the questionnaire should have been rephrased, or changed. Due to time constraints the questionnaire needed to be distributed at the time that it was, and it is not certain, that given more time, the wording of the questions and the questions themselves would have been different. A change in how some

of the questions was designed could have made it possible to apply more advanced quantitative analysis to the answers. Still, the questionnaire produced the information needed to answer the research question. The interview with the manager was meant to clarify what was uncertain after reviewing the results from the questionnaire. It is still important to keep in mind that the manager and the employees have different points of view, but the manager still provided useful insight.

As mentioned, the questionnaire was sent out via a manager in Lufttransport. This is a drawback of the survey, because the respondents might have felt forced to answer since one of their bosses sent it. The informants, however, were informed in the information letter where the link to the questionnaire was provided that participation was voluntary. Sending the link out via the manager ensures anonymity since I did not receive any names and do not know who has answered what on the questionnaire. The manager could not in any way access or see who had answered the questionnaire either. This meant that when the manager reminded the pilots and crewmembers to answer the questionnaire that the ones who had already answered the questionnaire received an email as well to ensure anonymity.

A drawback of distributing the questionnaire via a link access means that the respondents could distribute the link to the questionnaire further - to outsiders. I believe that was not in the respondents' interest. The impression I got when visiting the base was that they were interested in participating and the result. I could have printed the questionnaires and sent them to all the bases and had them sent back. This would have been more time consuming and I feel that distributing the questionnaire via a link ensures anonymity to a greater extent because it gave the informants more freedom in terms of when they wanted to answer it and the leisure of not having to post it.

The use of a five point Likert scale can be discussed. There are several ways of designing questionnaires, and with a five point Likert scale the respondents are also handed a neutral answer of "I neither agree nor disagree". This is a drawback to the survey since it makes it possible for the respondents to choose not to take a stand (Ringdal, 2013). This option was chosen because the gap between "I agree" and "I disagree" might be too big.

4.5.2 Reliability

Reliability considers the correctness of the data collected. This regards what type of data, how this data is being used – for example how this data has been collected and how that data has been analysed (Johannesen et al., 2010). Good reliability means that if someone did

repeated measures of the phenomena with the same tool of measurement, they would receive the same result (Ringdal, 2013).

The use of the web based survey tool Questback ensures reliability of the data collected in the questionnaire. The information gathered in Questback was transferred directly into SPSS, ensuring no punch errors from the researcher. There is, of course, a possibility that the respondents could have ticked the wrong box when answering, but I do not think a high percentage of wrong answers is a concern for this thesis.

To ensure reliability concerning the questionnaire, I had meetings with two employees and a manager where the design of the questionnaire and how the questions were phrased was discussed. This ensured that what I intended to ask the respondents about, was, hopefully, interpreted in the way I intended it to.

The qualitative interview was recorded. This ensured that I could cite the information provided by the manager in the empirical findings chapter correctly. I have tried to explain all the choices I have made while writing this thesis in this methodology chapter to make it as transparent as possible, and in that way increase the reliability of my findings.

4.5.3 Validity

The validity of a project refers to whether or not I have measured what I intended to when I started working on this thesis. High validity is dependent on high reliability (Ringdal, 2013).

Jacobsen (2005) explains internal validity as a question of; *"have I gotten the information I was searching for?"* (Jacobsen, 2005, p. 214). Internal validity questions if there is a connection between the data collected, and the phenomenon that is being studied (Johannesen et al., 2010).

The study completed during this thesis can be called a cross-sectional study, the data I have collected gives a description on how the situation about the device is at the time of the study. Cross-sectional studies can reveal something about the correlation between phenomenon's at the time of the study, but it is difficult to conclude about connections over time (Johannesen et al., 2010). Since I have done a cross-sectional study it is unnecessary to make assumptions about internal validity (Johannesen et al., 2010).

Since the questionnaire was sent to all the HEMS-employees the whole population has had the chance of participating in this study. 81,1% of the population answered the questionnaire. From that I can conclude that requirements for statistical validity have been fulfilled (Johannesen et al., 2010).

External validity concerns whether or not the results from my study can be transferred to other similar contexts (Johannesen et al., 2010). The context of this study is quite limited, since HEMS operations is a very specific branch of the aviation industry. One the other hand, if the framework for FRMS implementation was the same, the same study could be performed in other companies in the HEMS sector both in Norway and outside Norway. Still, this project has no aspiration to generalize outside the population that was the aim for this study.

4.5.4 Ethical considerations

When conducting a research project there exist some ethical considerations that need to be taken into account. The research can affect the respondents involved in both a positive and negative way, and it is important that the respondents are informed about what they are participating in and how the data collected is intended to be used. It is important that the respondents are participating on a voluntary basis and that the researcher treats the respondent and his/hers answers with respect (Johannesen et al., 2010).

This project was reported to and approved by "Norsk Samfunnsvitenskapelige Datatjeneste" (NSD) (See appendix 4).

In the information letter sent to all the respondents they were informed that participation was voluntary and that their anonymity was ensured. It was briefly explained how the data collected was to be used, especially in regards to that no single person was to be identified but the objective was to look at the data as a whole and that the trends within the group was of interest. The respondents were informed that they gave consent to participate in my project by clicking the link that led them to the questionnaire. Since the questionnaire was sent via a manager it is possible to believe that the crew could have felt forced to answer the questionnaire. Hopefully that has not affected their answers.

The master project is conducted in cooperation with Lufttransport, and the result from this project will be presented to the organization. However, it is important to state that they have in no way put any restrictions on or led the way of the research. It is important to underline that Lufttransport in no way have commissioned or ordered this master thesis or it's content. Lufttransport have given access to their organization and their Fatigue Risk Management System. The research question and research strategy was composed by me. Nevertheless I have taken the feedback I have gotten from Lufttransport into careful consideration.

5. Empirical findings

This chapter presents the empirical findings from the questionnaire sent to the employees of Lufttransport RW and the interview with a manager in RW. This chapter is divided into six sections. The first section describes the results regarding the user friendliness of the device. The second explains the results regarding awareness of fatigue. The third section contains the empirical findings about behavioural change. This is followed by a segment explaining what the respondents answered on the question about what other reminders or measures that could be implemented as a part of FRMS. Lastly, is a short summary of the data collected in HappyOrNot as well as a comment on the most important empirical findings in this thesis. Following is a table, which is intended to remind the reader about the Likert scale used, and the numbers associated with each value.

Table 1: Likert Scales used in the Questionnaire

Likert scale used for level of agreement	Likert scale used for time intervals
1 = "I strongly agree"	1 = "Very frequently (daily while on duty)"
2 = "I agree"	2 = "Frequently (a few times per duty period)"
3 = "I neither agree nor disagree"	3 = "Occasionally (one time per duty period)"
4 = "I disagree"	4 = "Rarely (not on every duty period)"
5 = "I strongly disagree"	5 = "Never"

5.1 The user friendliness of the device

The first part of the questionnaire has an objective to explore how the crew perceived the user friendliness of the device.

First off, the respondents agreed with the statement saying the device was user friendly (M = 1,61; SD = .502).

The questionnaire asked if the crew had used the device, most of the respondents answered that they used the device on almost every mission, while a few answered that they used the device on all of the missions.

The fatigue awareness device that was used prior to the missions was placed just in front of the entrance to the hangar. The device, which was used after the missions, was placed on the other side of the door – just in front of the exit from the hangar. The respondents were asked about their opinion regarding where they thought the device should have been placed to

work the most effectively. In general, the respondents thought that the placement of the device was best were it was placed originally.

The two first questions did not directly relate to user friendliness – but it was important to check if the device was used, and if the respondents had any concerns about the placement of the device. Had the device not been used, and the respondents answered that the placement was inadequate – the answers on the rest of the questions could be explained by those two factors.

The device contained four different smiley faces, ranking from red to green. Over the device there was a poster with the Karolinska Sleepiness Scale (KSS), explaining the scale and the meaning of each smiley face connected to the scale. The greenest smiley was connected to 1 = "extremely alert" on KSS. The next green one connected to 3 = "alert" on KSS. The first red smiley was connected to 5 = "neither sleepy nor alert" on KSS. The reddest smiley was connected to 7 = "sleepy, but no difficulty remaining awake". In the interview with the manager in Lufttransport it was explained that they choose not to include the last verbal description from KSS, 9 = "extremely sleepy, fighting sleep" since they believe that if someone was feeling extremely sleepy they should not be going out on a mission at all. The manager explained that the reason for choosing the Karolinska Sleepiness Scale (KSS) was based on the limitations of the hardware of the devices. The terminology used in that scale was considered the best because of its simplicity on a day-to-day basis. Other scales were reviewed, but in the end KSS was chosen because it was the most fitting choice. When the crew pushed the buttons, they saw what the explanation of what each button meant. The respondents were asked how they perceived the use of smiley faces as a reference to their felt fatigue. The respondents agreed with the statement that the use of smiley faces made it easy to report their level of felt fatigue (M = 2; SD = .485).

The manager in Lufttransport RW who was interviewed said he perceived the user friendliness of the devices as good. He became aware of the HappyOrNot system through the devices placed after the security control at the airports. *"...and when I looked in to it, the devices are excellent because there are no cables, no batteries, its automatic reporting and, you have seen the reporting system, the way you can adjust them. It seems to be very good".* Furthermore, he stated that he, of course, would like more information about fatigue concerning the crew with more data, questionnaires, sleep diaries and so on. But then he explained why he perceived the devices as such a good idea: "*But my thing was not to implement fatigue risk management as something, which gets in the way. Not a hassle, so I*

tried to give the "hassle free – don't affect operations but improve awareness of fatigue " – version""

Since the objective of the device was to make the crew take a stand on their own felt fatigue at the time just before and just after a mission, they were asked if they felt that the device took away any mission focus prior to the missions. In general the respondents answered that the device never took away focus prior to missions (M = 4,89; SD = .323).
What these answers show is that the device was perceived as user friendly. The crew understood the meaning of what they were asked, and when asked, they agreed with the statement saying that it was user friendly. The fact that the device did not take away focus prior to missions could be explained by the fact that it was an easy task - which did not interfere with other activities the crew were required to do before a mission.

5.2 Awareness of fatigue

The second part of the questionnaire contained questions that had as an objective to underline how awareness of fatigue had potentially changed due to the fatigue awareness device.

The respondents were asked how often they discussed fatigue as a crew before the device was introduced. The answers to this question was distributed around occasionally / one time per duty period (M = 3; SD = .907).

Thereafter, they were asked how often they discussed fatigue as a crew *after* the device was installed. The answers on this question was distributed around frequently / a few times per duty period (M = 2,33; SD = .970).

To check if there was a significant difference in how often fatigue was discussed before and after the device was installed a Paired Samples t-test was performed. This showed a significant difference between before and after the device was introduced ($t(17) = 4.\ 123\ p < .001$), which indicates a significant increase in how often the crew discussed fatigue after the device was installed.

The respondents were also asked about how often they think about fatigue. There was a considerable variation on this question, but the answers centered around the crew thinking about fatigue occasionally / one time per duty period (M = 2,7; SD = 1,127).

The respondents were then presented with the statement "I think more about fatigue now than I did before the device was introduced". The respondents somewhat agreed with this statement (M = 2,39; SD = .778).

During the interview, the manager was asked whether or not the management had noticed if the introduction of the fatigue awareness boxes had affected awareness of fatigue. He explained that he felt it had been a massive increase in awareness of fatigue. The automated weekly and monthly reports from the devices went directly to the management group and flight safety officer. The manager explained: "…*that alone has really put fatigue on the top of the list"*. The management also involved the safety manager, accountant manager and the chief pilots in reviewing the reports from the devices.

The reports generated from the fatigue awareness devices were monitored and the management group had meetings where the reports were discussed. The manager said that the flight safety officer often questioned the content of the reports. The manager also clarified that they tried to monitor the trends of the reports, not just the specific "button pushes" which were entered into the devices. What they had noticed were that the crew generally had a good awareness of fatigue and that the company seemed to be managing the risks related to fatigue.

> *"Yeah, I would say definitely. When I go and do the base visits. Visits to the guys, they are always talking about them (*the devices*), so just the fact that they are talking about fatigue is good. And my real goal is, if you like, was the placebo effect. If they were empty boxes I still know that in the middle of the night, from personal experience, you sometimes just need to be reminded, and to have that device there to, even if it pauses them for two seconds, I hope it makes them think about fatigue. So I believe it is a positive effect"*

The quote above was the manager's response to if he thought that just by placing the devices on the bases and forcing the crew to take a stand on how they were feeling at that moment had increased awareness of fatigue.

What these answers show is that awareness has somewhat increased after the device was installed. The crew discusses fatigue among themselves more and the rate of how often they think about fatigue has increased some. If combined with the perception the manager has about awareness of fatigue it could be said that awareness of fatigue has increased since the device was introduced. What these data do not show is if the increased awareness is a result of the introduction of the fatigue awareness device or of the fatigue risk management system as a whole.

5.3 Behavioural Change

The third category of questions on the questionnaire aimed to ask questions which could relate to behavioural change as a result of the fatigue awareness device.

The respondents were presented with the following statement "I have declined missions while experiencing fatigue after the devices were installed". The answers were centred around "I neither agree nor disagree" (M = 3,28; SD = 1,074). As the standard deviation shows, the answers to this question varied.

The respondents where then presented with a similar, but different statement: "I have accepted missions while experiencing fatigue after the devices were installed". The answers to this question were distributed around "I disagree" (M = 3,5; SD = .924). The answer to this question was also spread on the scale, but not as much as on the previous one. This means that the respondents somewhat disagreed with the statement, claiming that they had accepted missions while feeling fatigue after the device was installed.

When asked if the device has made the pilots and HEMS-crewmembers evaluate their actions while on mission, in respect to fatigue, their answers were centered around "I agree" (M = 2,47; SD = 1.007). This means that the device has in some degree made the crew evaluate their actions while on mission.

The last question in the behavioural change category revolved around if the device had lead to an increase in the willingness to report issues regarding fatigue to the management. The answers was in-between "I agree" and "I neither agree nor disagree" (M = 2,44; SD = .784). The manager was also asked if he had noticed any change in the willingness to report to the management. He answered *"...since we have introduced the fatigue risk management we've had, for the first time with helicopters, we've had three reports of fatigue"*. He further explained that they had never received any reports regarding fatigue before. The manager also mentioned that one of the reports had highlighted a part of their chapter 7 in their OM, which could lead to confusion and possible mistakes. So these new reports had led the management to make changes. The manager underlined that they, so far, were happy with the progress of introducing fatigue risk management in Rotor Wing.

Although they were happy with the progress of FRMS, the manager said it was difficult to tell if the device had led to any behavioural change. He said there had been an improvement related to fatigue in behaviour, like discussions, but whether there had been a significant change was difficult to tell. He then explained that he felt more of a cultural change; such as the crew being willing to report issues regarding fatigue. *"Now guys are*

willing to report, before they would never talk about fatigue or schedules or anything like that".

5.4 Other reminders or measures which can be implemented to make a successful FRMS

The respondents were asked if there were other reminders or measures that could be implemented to make a successful FRMS. 8 of the respondents answered *"no"* to this question or "*I don't know what that can be"*. The rest had suggestions on how to implement reminders to increase focus on fatigue.

One respondent answered that he believes that the same schedule for the whole crew will work better to reduce fatigue. Today the situation is that the HEMS crewmembers change crew every Monday while pilots change crew on Wednesday. His suggestion was that the pilots and HEMS-crewmembers change shift on the same day. Another respondent answered "*Our schedule today is the best tool to make every working period very little stressful, as long as we at any given time are allowed to report "off duty" when reaching our limit within the work period"*. This means that they can close the base to sleep/rest when they have reached their limit while on duty.

One respondent suggested putting up posters with "chapter 7 for dummies" on the bases. Chapter 7 is the chapter in the operations manual that contains the flight time limitations. There are national and international regulations in which they have to be compliant with. In addition, at the company level, they have to agree with the type of operations and the union. Chapter 7 sets out the working conditions and limitations for Rotor Wing. It also has to be approved by the Civil Aviation Authority in Norway. The manager explained it in these terms: "*So it is a balance between saying you can work a maximum of x number of hours per day versus then all of the variables… and all of a sudden it becomes twenty pages"*. The variables are for example driving the car for doctors, doing administrative work, briefings, flight time checks and so on. He said that lately they have made a lot of improvements to their chapter 7, the latest revision, from September last year, really shortened it and made it easier to understand, but that he considered a "chapter 7 for dummies" as a good idea. Another respondent suggested using biometric watches during the duty period.

One suggestion for an improvement of today's system was "*Better flight duty time registration and awareness. We should get a warning automatically when the system detects that we have exceeded our duty time"*. Today they get a warning when they have exceeded their flight time, but to check beforehand they have to access their accumulated flight time on

their system. Another respondent had a similar suggestion *"A rigid IT system that will advise in colours when you are approaching the fatigue limit in regards to regulation (yellow), and also the system should turn RED when the limit is exceeded. Exceedance should prompt a report in our reporting system."* The manager was presented with this statement. His reaction was that there already is a warning system in place, but it might work more as a notification system. The system, as it operates today, generates an automatic warning or exceedance when the crew passes their flight time limit. They do not get a warning beforehand, or when they are getting close to their limit. The manager further explained that *"They can access the report but it does involve two clicks of a mouse"* He was open to the idea of working towards a more visual presentation of accumulated flight time: *"maybe improving that into more of a picture or a graph would be an enhancement in the system so I agree with that"*.

Other suggestions that were presented was better education about fatigue, better sleeping facilities and better ways of communicating fatigue among the crew. One respondent answered that it is difficult to come up with a suggestion for reminders since fatigue is on the agenda at all times.

The manager was asked if he thought there were other reminders that could be implemented as a part of their fatigue risk management. He stated: *"Yeah. I think so, we are all human. So we have habits, good and bad. And variety is an important one"*. He then explained how the devices were taken away after four months, and explained how they have had posters as reminders and lately awareness training. *"So I believe variety is key"* as an answer to how to keep crew reminded about fatigue.

Night-time flying, winter and bad weather was mentioned by several respondents as the factors that were the most fatiguing. Some factors on the bases which caused fatigue was mentioned; noise in the daytime due to people working on the base, noise due to construction work, bad soundproofing and poorly ventilated bases. Also other duties in addition to missions, like training and paperwork was mentioned as fatiguing.

5.5 Results and trends from HappyOrNot

In the months when the device was placed at the bases a total of 1780 punches was registered into the HappyOrNot-system. 988 of the punches (55 %) was on the greenest smiley – extremely alert. 709 punches (40 %) was registered on the second greenest smiley – alert. 69 punches (4 %) was registered on the first red smiley face – neither sleepy nor alert - while 14 punches (1 %) were registered on the reddest smiley – sleepy, but no difficulty remaining awake.

The colours in the table below are taken from the HappyOrNot system. The above greenest one means “extremely alert”, the less bright green means “alert”. The salmon one means “neither sleepy nor alert” and the red one means “sleepy, but no difficulty remaining awake”.

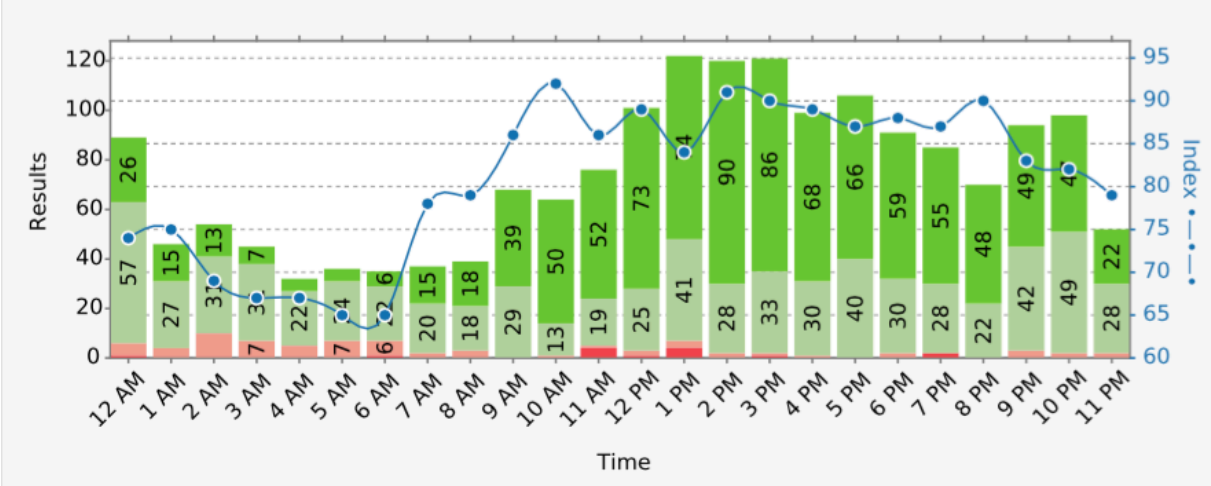

Figure 3: Overview of punches in HappyOrNot distributed by time of day

As the figure above illustrated, most of the punches of the two red categories were registered at night-time. Most of the greenest / alert answers where registered during the day – when a person according to the circadian rhythm and homeostatic rhythm should be awake.

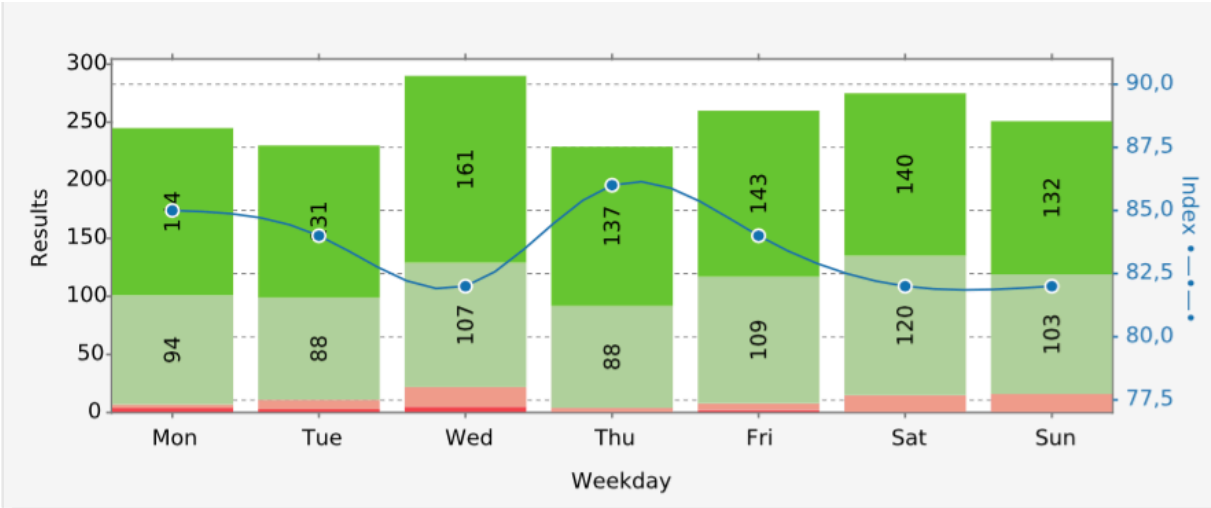

Figure 4: Summary of punches in HappyOrNot distributed by weekday

When the data from HappyOrNot was divided by weekday, it was possible to see some trends: Wednesday, Saturday and Sunday were the days that the crew reported the highest levels of fatigue.

In 2015, the three bases had a total of 2358 requested missions (794 in Tromsø, 648 in Brønnøysund and 916 in Ålesund). The crew denied 552 of these requests. A total of 16

missions (1 in Tromsø, 15 in Ålesund) was declined due to maximum flight time having been reached, meaning the base being shut off. During 2015, a total of 1808 missions were accepted at the three bases. Some of these were cancelled due to other transportation options or a change in medical needs.[2] If we take into consideration that the crew consisted of two persons, and that the device was used both before and after a mission, we could assume the device was used on 445 missions in the period it was placed on the bases.

5.6 Summary of the empirical findings

The device was used and perceived as user friendly. There was a significant increase in how often the crew discussed fatigue after the device was installed. The interview with the manager showed that he felt like the crew discussed fatigue more often now, than they did before.

There was not a significant increase in how often the crew thought about fatigue after the device was installed. The questionnaire did not show any significant increase in willingness to report issues about fatigue, but the management had noticed an increase in reports relating fatigue issues. Before the devices were installed they had never had reports regarding fatigue. The device has in some way made the crew evaluate their actions in relation to fatigue.

To conclude, there has been an increase in awareness and the behaviour has in some way been changed. If this is due to the device or the implementation of FRMS as a whole is difficult to say.

[2] Email correspondence with Pål Madsen in the National Air Ambulance Service of Norway 20/05-2016

6. Discussion

So far in this thesis the theoretical framework and empirical findings have been presented. The objective of the following chapter is to connect these to make a discussion that should help in answering the research question: *"How has the introduction of fatigue awareness devices as a part of Fatigue Risk Management System in an airline affected awareness of fatigue among crewmembers?"*

6.1 Fatigue and Issues Concerning Fatigue

There are several factors that affect fatigue, for instance biological factors and also factors outside those of which a person can manage. High demands from work and inadequate rest influences the feeling of fatigue. The trends from HappyOrNot displayed what could be interpreted as a circadian rhythm: Most of the red buttons were pushed at night-time, while at the same time most of the green buttons were pushed during the daytime. For missions at night – when the circadian rhythm is low and the body is wired to be tired – the device might be a good tool for the crew to assess their level of fatigue. Having to make a stand on felt level of fatigue might have the crew assess their actions in a way they might not have done had they not been reminded about fatigue. The body is wired to be sleepy at night, and the device works as a reminder of fatigue at night-time, which might make the crew evaluate their actions if they are tired, but not too tired to cancel the mission. Bad weather and night-time flying was mentioned by the respondents as the factors that influenced fatigue the most. Like stated in the theoretical framework – 95 % of fatigue results from inadequate amounts of sleep – flying at night-time could therefore have a great impact on fatigue. Ensuring enough sleep opportunities should be one of the primary goals of a well functioning FRMS. Due to the nature of the work of a HEMS-operation it is not possible to ban flying at night-time, even if that could reduce fatigue.

An issue to mention in regards to the use of the device and measuring fatigue is that fatigue is a subjective measure. There are a lot of definitions of fatigue. All of them focuses on different elements of the feelings and mental states of fatigue. Some definitions focuses on the causes, like ICAO who mentions heavy workload and extended wakefulness. Dawson et al. focuses on the neurobiological processes, etc. The point is, the crew could also have different opinions on what they believe is fatigue.

The use of the Karolinska Sleepiness Scale informed them about what each smiley meant, but this focused solely on sleepiness. There are other factors to fatigue than just feeling sleepy. Fatigue affects people differently, and can affect decision-making, motor skills

and the ability to communicate. The crew might have had different opinions as to what they felt as fatigue and the effects of fatigue could affect each person in the crew in a different way. A person also has an individual need for sleep, even if the average person requires between 7 and 9 hours of sleep per night, the need might vary in a crew. This needs to be considered when evaluating the data from the device, since each member of the crew could have perceived fatigue different from other crewmembers.

Another issue to mention is differences at the bases. The Ålesund base is placed south of the Tromsø base. Meaning that the Tromsø base is more affected by the disruption in circadian rhythm due to the midnight sun and continuous darkness in the wintertime. The respondents mentioned flying at night-time, bad weather and winter as the most fatiguing tasks. If all the factors that are fatiguing, like the severe disruption in circadian rhythm, were to be included in accepting or declining a mission had to be considered, it would not have been possible to run a base in Tromsø. Therefore could FRMS be of use, since it opens for taking these special conditions into consideration when planning operations. The device could here be of purpose as a reminder. For example to remind the crew before flying at night-time in June, that even if it is light outside and the circadian rhythm is disrupted, fatigue could be a factor to remember. The crew could be fatigued – if it is daylight at night.

6.2 Safety Culture in Lufttransport

It is difficult to measure if a safety culture within a company is good or bad. That also goes for Lufttransport. Nevertheless, the fact that the RW crew reported, and used the device corresponds positively to what Reason refers to as a good reporting culture. The crew are encouraged to self-reporting with the device. The crew are the ones who are directly in contact with the factors that cause fatigue. With the introduction of the fatigue awareness devices, it could be said that the management in Lufttransport opens for, and encourages a reporting culture. While at the same time, not being out to punish the ones who report negative aspects of fatigue or concerns related. This is of great importance when establishing and maintaining a reporting culture. The managements' intentions were to use the data collected to learn and change factors that might be fatiguing – not finding someone to blame for fatigue. This is associated to what Reason calls a learning culture – the experience the crew makes in their day to day life are used to change procedures which are not optimal or may lead to mistakes. For instance, the example the manager explained where a report about fatigue received after the device was installed lead to the discovery of a fault in their chapter

7. No one was punished or penalized for this, but the organization learned and changed their chapter 7 accordingly.

The device used smiley faces to connect the scale from KSS to each button on the device. The respondents agreed with the statement that the use of smiley faces made it easy to report their level of fatigue. But two questions could arise from the use of smiley faces. First, did the smiley faces affect their decision? The use of a red smiley face for "neither sleepy nor alert" and "sleepy, but no difficulty remaining awake" could make the crew perceive this as more negative than it was intended to do. Extremely sleepy was perceived by the management of Lufttransport as a state of fatigue in which the crew is not fit to fly. The four other categories are still recognized as a state of fatigue in which it is still safe to operate. This was communicated to the crew when the device was introduced. The most tired category on KSS was not included on the device, but did the crew feel like they could state their felt level of fatigue without fear of the consequences? This leads us further to the second question; if the respondents felt they could answer honestly on the device. Or did they answer what they felt the management wanted them to answer? 95 % of the punches in the HappyOrNot system were on the two green categories. Was it correct that the crew felt that awake 95 % of the time or did they answer what they thought the management wanted to hear? The management group evaluated the reports from the devices, and when there were weeks in which the trend of the answers was aligned towards to more fatigue – the management had to figure out why. Still, the fear of reprimands should not affect the crew to answer honestly on the devices. The answers were anonymous, both the HEMS-crewmember and the pilot used the same device, so management could not afterwards point fingers at anyone. In theory – the device should be perceived as something that aimed to work as a reminder about fatigue, and not as something that were "out to get" crew that felt fatigued.

What Reason describes as a *just culture* is something the management should communicate to the crew – that they accept that people make mistakes and do not penalize employees for good intentions that had an undesired result. In other words, they should encourage the crew to report, even mistakes, without fear of penalization. In that way everyone can learn from mistakes or reports. It is difficult to be certain if what the crew pressed on the device were how they actually were feeling at that time. Lufttransport states in their operations manual that they aim to achieve a just culture. If they have managed to implement that in the organization it is possible that the crew felt safe to report their actual state of fatigue on the fatigue awareness device. If the management of Lufttransport has not managed to communicate their just culture to their employees, an issue could be that the crew

just pressed a random button on the device and got on with the mission. To verify each punch into the device it had to be compared to data from the actiwatches and eventual sleep diaries. That was not possible for this thesis, but it needs to be established that there is a high probability that some of the punches on the device might not have been correct. I believe the crew had good intentions and made their mind up about their level of fatigue before pressing the button on the device – but probably the wrong button was pushed by mistake every now and then. No system is immune to mistakes.

It is important underline that the device was in fact used, over 1700 punches were registered into the device. The answers from the respondents showed that they used the device on almost every mission. For the device to work as a reminder of fatigue, it had to be used by the crew. In an ideal world the device would have been used on every mission. Since it was placed in a setting which could sometimes be classified as stressful, it understandable that it could have been forgotten every now and then. What Schein defines as culture can be connected to this, if the common understanding amongst the members of the crew was to use the device, then the crew might have reminded each other to use the device. Aviation is an industry with a lot of procedures and the fact that they followed this new procedure of pressing the button on the device can be explained as good compliance to procedure. The "pressing a button" procedure might have felt as a new item on a list of many things that needed to be done before take off, and that might have led to the device being used.

The device being used by the crew can also relate to what Reason calls a flexible culture. The organization is able to handle change, in this case the introduction of a new device. The crew adjusted to the new procedure.

6.3 Situational Awareness

Situational awareness concerns how a person, and in turn a crew perceives and understand their environment. Both the need for an individual SA – how could what was pressed on the device affect a crewmembers performance. And, shared SA – how could what one crewmember pressed on the device affect the other crewmember and vice versa. SA is of importance in regards to fatigue, but also in the whole helicopter operation.

Could the device work as a continuous reminder without it becoming a habit? It was the aim of the implementation that the device would work as a reminder, but would it work in the long run? A suggestion is that the device can be for a certain period of time at the base, then to be removed for some time before it is returned again. The FRMS in that case needs another reminder for fatigue the time the device is gone. In that way the action of pressing the

button does not become a habit. For instance, the crew can have as a part of their start up procedure inside the helicopter to ask each other their felt level of fatigue at that moment. In that way, they have to make up their mind about their own level of fatigue, and be reminded and aware of fatigue issues. Then, when the device is returned to base, the procedure about asking each other is removed. In that way the habitual process is in some way changed. Other measures can also be implemented as a part of a rotating fatigue reminder program in a good FRMS. For the device to work as a reminder, it is important that the crew has the same perception and understanding of the objective of the device. The device can in some way be connected to situational awareness, not that pressing a button requires a lot of SA, but what the crew choose on the device might have an impact on SA. Level 1 SA could be noticing the presence of the device. Level 2 SA could be being aware of the impact of what the state of fatigue could have. Level 3 SA could be changing the behaviour or considering actions based on what level of fatigue was chosen on the device.

Bad weather and darkness was listed as the factors that the crew felt was the most fatiguing. These are conditions that are constant – there is nothing anyone can do to change these conditions – we just have to learn to deal with them. How to deal with these issues are however something that can be figured out. The manager of Lufttransport RW, explained that flying when it is dark was fatiguing due to the extra equipment like clothes and night vision goggles as tiresome. The crew mentioned bad weather and missions in the dark as fatiguing. These are factors that require attention and focus from the crew when operation in these conditions. SA is important in conditions like these, and the need for a good individual SA and a good shared SA in the crew are therefore needed to cope with these conditions. In wintertime, the weather could be good when the crew depart from the base, but can change towards the worse in a matter of short time.

6.4 FRMS and Defences in Depth

A suggestion for a tool to use when implementing FRMS is to use the error trajectory. The error trajectory for FRMS has 5 levels. Level one is explained with hazard assessment of enough sleep obtained. Control mechanisms to secure this is prescriptive HOS rules, prior sleep wake data and fatigue modelling. In the case of Lufttransport RW the first level of the trajectory would be the FTL-rules, the use of actiwatches and the data obtained from these to model fatigue. The hazard assessment would be obtaining adequate sleep quarters and making sure the crew obtain enough sleep and has no sleep debt. For instance, would the issues the respondents mentioned like; noise in the daytime due to people working on the base, noise

due to construction work, bad soundproofing and poorly ventilated bases, be something that the management should improve.

The second level in the trajectory identifies actual sleep obtained as a hazard assessment. Possible solutions are prior sleep wake data. This means that it needs to make sure that the crew obtains enough sleep. This is a step that is dependant on situations such as; no disturbing noise on the base, and that adequate sleeping quarters are ensured for the crew. To make sure of this - the use of actiwatches can be considered. In this way it is possible to check if enough sleep is obtained. The drawback to this is that it is not a proactive way of ensuring enough sleep. Regulation of how much sleep the crew should obtain is also an option, but the drawback is that everyone has different sleep needs. The use of prior sleep and wake data is also a way to go about this level. This means that the data needs to be collected before this step is implemented. Sleep diaries and actiwatches can be used in that data collection.

The third level is where the fatigue awareness device is relevant. Here the hazard assessment revolves around behavioural symptoms. Symptom checklists, self-reporting and physiological monitoring is described as control mechanisms to ensure the third level. The fatigue awareness device is a way of self-reporting, while at the same time making the crew check themselves for symptoms of fatigue. The third level is dependant on the two previous levels. If the crew does not obtain enough sleep, and has a high workload, it will not hinder fatigue – this will originate in undesired results in the self-reporting. If the two first layers are not successful in preventing fatigue, the self-reporting will hopefully show that the crew experiences fatigue. If that is an issue in the reports – the management needs to have a look at the two first levels, and figure out what is the cause of the fatigue. It could for example be shift rotation, work load or bad mattresses at the base.

The fourth level in the trajectory consists of creating systems that prevent fatigue related incidents and accidents. This could be achieved by trying to create a safety culture where closing off the base is considered acceptable if the crew is feeling effects of fatigue. The fatigue awareness device could be a part of this level considering one of the goals of the device – potentially stop missions that should not happen due to fatigue. If whatever the crew pushes on the device lead them to cancelling the missions due to fatigue, the device has worked as the fourth barrier in the trajectory – a system that detects a potential fatigue related incident.

The fifth level consists of making a system that investigates fatigue related incidents and accidents. The device could be a part of this, as well, as a reference to what level of fatigue the crew stated beforehand.

6.5 Attitude Change

The respondents perceived the device as user friendly. As the manager said, that was important since the point of the device was to make it an easy and effortless way of increasing awareness of fatigue. For the device to work as a reminder of fatigue it was important that the device was easy to use. There would be no point in placing something to increase awareness of fatigue, if the people using the device do not understand its meaning or how to operate it. Attitude change is related to behavioural change. Did the device lead to any? If we look at the three levels of attitude change; compliance, identification and internalization we could say some attitude change has occurred while the device was in place at the bases. Compliance could have occurred if the crew used the device in hopes of getting a positive reaction from the management, or in fear of getting reprimanded if the device was not used. Identification could have occurred if the crew saw the device as a possibility to get a closer relationship with the management. Internalization could be that the crew saw the intrinsic reward of using the device as a reminder of fatigue. For example with the reward being the device working as a reminder and enhancing safe operations in the crew. The most optimal outcome would of course be if internalization were the attitude change that occurred. Because, it the crew had internalized the attitude change they would perceive the use of the device as a reward for themselves, not the management.

If we connect the device to what Turner and Pidgeon (1978) wrote about warnings, even though warnings are a far stretch from the fatigue awareness device, but some of the issues they mention can be used in regards to the device. The device is in some ways the opposite of a warning, if we consider that the crew used it to state their own level of fatigue, and then evaluated what they answered on the device. The device works as a warning if – the crew take into account what they answered – and change their behaviour accordingly. It can either be by making other choices while on missions that they otherwise would not do, or cancel the mission due to the self reporting showing a high level of fatigue.

The respondents neither agreed nor disagreed with the statement concerning if they declined missions while feeling fatigue after the device was installed. The respondents disagreed with the statement “I have accepted missions while feeling fatigued after the device was installed”. What can be interpreted from this is that the crew has an opinion about

accepting missions while feeling fatigued – since they disagree with the statement they were presented. On the question asking if they had declined they did not have a strong opinion, they neither agreed nor disagreed. Accepting missions while feeling fatigued might be something they have stronger opinions about, and notice more. The crew might have declined missions – without relating that to fatigue. For example, by shutting down the base, or using arguments like "we've had four missions today, the next one presented we are going to decline". In a way – been proactive and therefore not happen to be in a situation where declining the mission has been necessary. It seems like it was easier to state their own level of agreement to if they had accepted missions while feeling fatigue than it was to form an opinion about if they had declined missions. But it might be that they have not had the chance to decline missions due to the base being shut off. This can be connected to SA and long-term memory. The memory of declining a mission might not have had an impact on their life in any way as was explained above. The higher level of disagreement to if the crew has accepted missions while feeling fatigued could be explained by the fact that the memory of that is stronger. If the device has changed their behaviour based on these two questions is impossible to answer, but it is interesting to see how it is easier to disagree with the statement about having done something than remembering if someone has not.

The respondents agreed with the statement that the device had led them to evaluate their actions while on missions, in respect to fatigue. The objective of this question was to see if the device had led to any behavioural change. If the device has made them evaluate their actions, their behaviour has therefore in some way been changed. We know little about what these changes are, or what they have evaluated, but something has happened. If a comparison to the stop and sleep project of the Norwegian Public Roads Administration was to be made, where the campaign resulted in an increase in drivers stopping to sleep, it is possible to say that constant reminders like the device can lead to behavioural change. Especially since the reminders have been more constant than the ones NPRA implemented (i.e. every time they went out on a mission).

Another way to check if there have been any behavioural changes is to see whether or not the willingness to report issues to the management has increased due to the device. According to the answers from the respondents, they neither agreed nor disagreed with this statement. The manager however had another opinion – they could report that for the first time they had received reports regarding fatigue – which they never had before. Looking at that data the willingness to report to management has improved – since fatigue never had been a topic in any reports before. Then after the device the management had received three

reports in three months. This can be connected to the implementation of FRMS – why else would suddenly three reports be made? Especially, since there have never been reports regarding fatigue before FRMS became a topic in Lufttransport RW.

If the device was to be used, it had to be placed somewhere the crew passed on their way to the helicopter. Remember, when the crew is called out to a mission, it is usually due to a critical medical situation. This leads us further to the question regarding the placement of the device. As explained earlier, the device used prior to missions was placed just in front of the entrance to the hangar. The device used after the missions were placed on the other side of the door of the other device. Meaning the crew had to pass the device to enter and exit the hangar. Noticing the device should work as a reminder, and it is understandable the device was used as much as it was, since the crew had to pass it. In theory, the crew could push the buttons while being on the move. Most of the respondents answered that they believed that the placement of the device was the best the way it was. Four respondents answered they believed the device should have been closer to the helicopter or inside the hangar. To get the right placement is difficult. The HEMS-bases has limited space, and the device needs to be placed where it is visible to work as a reminder. The same argument as in the paragraph above is applicable here – for the device to work as a reminder it needs to be visible and easily accessible. As mentioned in the theoretical framework – visibility is important. Approximately 80 % of what is perceived is perceived visually. This really underlines the importance of the placement. For a device to work as a reminder, and at the same time be noticed it has to be placed somewhere where it is impossible not to see the device when entering/exiting the hangar/helicopter.

Lines can be drawn to behavioural change. Something has changed, even when it is not clear in the data from the questionnaire – but facts from the management can prove it. Since the data from the questionnaire is not proving this, it might be the fatigue awareness campaign – with posters and general info about fatigue, which also has been a part of FRMS who has influenced this change. It cannot be proved that the change is due to the device. The fact that management has received reports can be related to increased awareness – as discussed earlier, the crew talks more about fatigue now than earlier. It might be that since it is easier to talk about fatigue among themselves and that reporting to management can be a barrier that has been easier to pass. Since fatigue has become a current issue – like one of the respondents answered – fatigue is on the agenda all the time – the behavioural change like increased willingness to report has not been noticed as much by the crew. Fatigue has become more of a normal topic than before – and that might have led to increased reporting. And

since it has become normalized ” the crew themselves might not have noticed the change. It could also be that it is just a small part of the population that reports, which can also explain the result from the questionnaire.

6.6 Awareness of fatigue

The fact that the device was perceived as user-friendly lead to the next issue of concern, would the device take away focus from the upcoming mission? Two of the intents of the device were to ask the crew about their level of fatigue in that moment and increase awareness of fatigue. The challenge being that when the device was used – the crew most likely was going out on an important mission. When the crew is called out on missions – most of the time it is as previously stated due to a medical emergency. It was important that the device did not take away focus from upcoming missions. When asked, most of the respondents answered that the device never took away focus and a few answered it rarely did. Which means that the device could serve its purpose without distracting the crew from the actual mission at hand. This can be connected to how the brain works concerning working memory. When the crew is called out to missions, they receive information about what the mission entails. At the same time, they might be thinking about how to go about doing the mission. The device could in theory take place in the working memory and remove some of the information stored there. Since the crew answered they did not feel like the device took away focus, the task of pressing the button could have been so easy it has not taken to great a part in the working memory. It might be that the crew is well trained in situations like that – it is their job to be ready at any time – and therefore the working memory is not full when they have pushed the buttons on the device. The routines of starting a new mission can also have happened so many times it has become a part of the crew long-term memory. The aim of the device was to have a reminder that did not take away focus and made them think about other issues before a mission. While at the same time, one of the goals of the devices was to potentially stop missions where crew felt too fatigued to perform safely. The objective was to force the crew to make their mind up about their felt level of fatigue and then continue their tasks. The important thing was therefore placement, user friendliness and an efficient way of reminding the crew about fatigue.

Data from the questionnaire verified that fatigue was discussed more after the device was introduced. The answers had a median increase of one – from occasionally to frequently. From that it can be concluded that the device in some way increased awareness of fatigue, especially if it is measured against how often the crew discussed fatigue. Culture is how a

common understanding takes form. Safety culture is about having a culture the focuses on risks. The crew discussing fatigue more often after the device was introduced might enhance the safety culture. There are no data about how the safety culture was before the device, but the increase in discussion can prove that there exists some sort of safety culture.

A question which can be asked about the increase in awareness / rate of how often fatigue is discussed, is if the increase is temporary. The device was placed on the base from June to October. The data collection for this thesis was done in February – three months after the device was removed from the bases. The device was somewhat fresh in mind – the crew still remembered the device and the fatigue posters still hung in common areas of the bases. Three months is some time, so the effect of the device is not short term. It might have increased awareness in a long-term perspective. One of the respondents answered that fatigue was on the agenda all the time. This can also serve as a reminder and explain why the device was still remembered, because of other reminders of fatigue that had stayed after the device was taken away.

In regards to awareness, the respondents were asked about the situation before and after the device was installed – at the same time. A more correct measurement might have been if the respondents had been asked how often they discussed fatigue before the device was placed at the bases. It can be discussed whether or not that was the correct methodological approach, unfortunately it was impossible to do a pre-test before the instalment. The important point to remember here is that the crew were asked about two points in time at the same time, and the increase in rate of discussion is still significant. That surely underlines the fact that awareness increased in terms of crew discussing fatigue while on shift. The manager had also noticed an increase in fatigue discussions on base. He had never heard the crew talk about fatigue before the device was installed, but he had noticed a massive increase in discussions between crewmembers about fatigue and the device after it was installed. Fatigue has been identified as a contributing factor in many accidents and incidents in aviation. The aim of a good safety culture is to be constantly aware of factors that can increase the risk of accidents. Being aware and working to implement reminders about fatigue is therefore of great importance to ensure a good safety culture. The increase form the questionnaire was one point up on the Likert scale, the manager identified a massive increase. The difference is interesting. The respondents reported an increase, yes, but not a statistic massive increase. The difference might be that it was difficult to vocalize the increase in the questionnaire. Or, the manager may have felt the increase as massive since they for the first time had received reports about fatigue.

To attain another aspect, the respondents were asked about how often they thought about fatigue, and if they thought more about fatigue than they did before the device was installed. When tested, there was not a significant increase in how often the respondents thought about fatigue. Still, when no deeper quantitative analysis was performed, it might seem that the respondents agree with the statement saying that they think more about fatigue now than before. The answers on the first question was centred around "frequently / one time per duty period". If the rate of how often the crew think about fatigue is correct, it means that crew had thought about fatigue rarely or never before. In that way it might be possible to say that awareness has increased. That is if the rate of how often fatigue is thought about is being used as measurement. This is not a significant find, the problem here is that the questionnaire was done after the device was removed. A more correct measure would have been to ask the respondents how often they thought about fatigue – before the device was placed at the bases. Then afterwards ask the respondents how often they thought about fatigue – and see whether or not there is an increase or decrease.

From a management point of view the awareness of fatigue among crewmembers has increased. They are receiving the reports from the HappyOrNot system, which the management group has to review. When management focuses on fatigue, this causes a chain reaction affecting the employees e.g. the crew. Renn describes how to implement risk management systems, which FRMS is, and the device a part of that. Such systems are implemented by the management, but effects the workday of the crew. It is therefore necessary that the crew was informed about the reason why and the point of the device. In that way, willingness to take part would increase. What management does reflects in what the employees do. Management inspires the crew. The fact that the whole management group was involved, potentially told the crew that fatigue is an area of interest and therefore makes fatigue a topic for the crew as well. Renn describes that monitoring and feedback is the last step in implementation of a risk management system. Monitoring would be that the management group reviewed the reports, but feedback would be communicating back to the crew *what* they did with the information received. This could for instance be reports about the information generated from the HappyOrNot systems or changes based on what the data told them – like the change in chapter 7.

7. Conclusion

The objective of this thesis was to bring attention to how FRMS could be implemented in an airline. The research question was *"How has the introduction of fatigue awareness devices as a part of Fatigue Risk Management System in an airline affected awareness of fatigue among crewmembers?"*

When collecting data to answer this thesis, three factors about the fatigue awareness device were taken into consideration: user friendliness, awareness of fatigue and behavioural change. User friendliness was incorporated since it was important to check if the device was perceived as user friendly. If it had not, it could have affected the results in the HappyOrNot system. Awareness of fatigue was because was what the research question directly asked about. Behaviour change was incorporated to check if the device had led to any changes and in turn affected awareness.

Summarizing, the findings in this thesis, indicated, that the device was user friendly – it was easy to use and understand, while at the same time did not take away focus from the mission. There has been somewhat change in crew behaviour, like reporting to management issues of fatigue and the evaluation of actions in regards to fatigue. If this change is connected to the device, or the implementation of FRMS in general is difficult to answer based on the data collected for this thesis. Awareness has in some way increased in the whole RW department. Management has it on the agenda more frequently, the rate of how often fatigue is discussed has increased, and the rate of how often the respondents think about fatigue has somewhat increased.

I would conclude that the use of the fatigue awareness device, as a reminder of reflecting on one's level of fatigue, could be a good part of a FRMS. Awareness of fatigue among crewmembers has increased due to the introduction of the device. To answer if the device could work as a reminder of fatigue in the long term is not possible to answer after just 3 months of the device being on the base.

7.1 Suggestions for further research

To check if the increase of awareness was temporary or not it could be possible to send out a survey to all of the bases establishing current view and perception of fatigue. Then, place the device back on one of the bases and send the same survey to the crew once again to see if there was an increase in awareness. The bases without the devise could be used to compare bases with and without the device. This was not possible due to time restrains and limitations regarding the scope of the master project.

A bigger study could also be performed with the devices, combined with other measures of fatigue. The fatigue awareness device, actiwatches and sleep diaries could together establish felt level of fatigue, and at the same time say something about activity level and amount of sleep obtained. In this way it could be studied how workload and sleep affects subjective measures of fatigue.

Another possibility of further studies is if there are differences in operations in the northern part of Norway versus in the southern part. This in regards to the circadian rhythm and melatonin levels. Effects of midnight sun and dark winters could be studied – for example: has the base in the north different levels of fatigue than the ones in the south?

7.2 Conclusive remarks

Fatigue represents a challenge because of its strong individual and subjective dependency. Given the same conditions, two persons might perceive their own level of fatigue differently. The issues and concerns surrounding fatigue are many. The research question of this master project focused on if and how awareness of fatigue increased as a consequence of the fatigue awareness device. This was due to the limitations of what is possible to do in a master project. What I have wanted to focus on is the importance of FRMS, trying to underline an easy and efficient way to manage fatigue. This was an experiment to make a collective solution for a subjective measure. It is difficult to implement a FRMS – management issues, the wellbeing of the crew and rules and regulations need to be carefully guided to establish a good working FRMS.

A FRMS also require the use of scientific data. This means that operative environments, like airlines and the academic world need to meet and cooperate in the developing, understanding and implementation of adequate fatigue risk management systems.

At last, I really appreciate the help and openness I have met in this process from Lufttransport. They have opened the doors to their organization and have encouraged this project from the beginning to the end. Thanks to the management for the possibility, help and information provided. Thanks to the HEMS-crewmembers and pilots who have taken the time to answer my questionnaire. Hopefully other airlines can learn from the openness and willingness Lufttransport has showed and open for further research on such an important topic.

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Appendixes

List of appendixes:

Appendix 1: Information letter to respondents

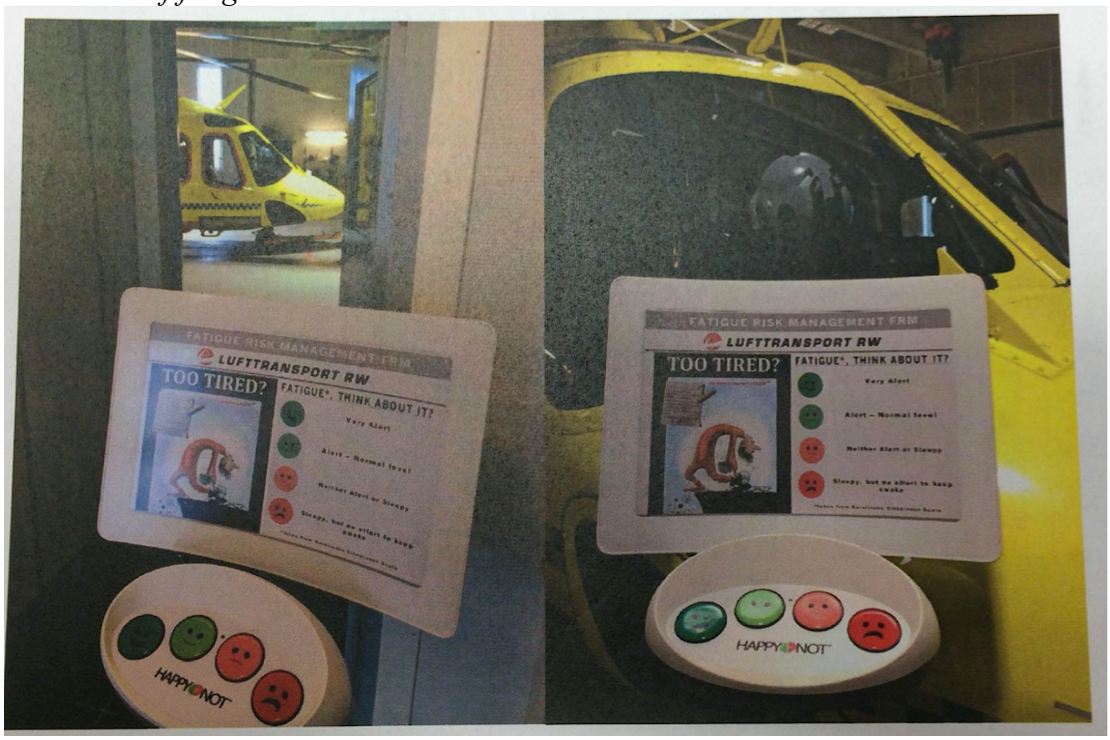
Informasjonsskriv vedrørende deltakelse i forskningsprosjekt

Awareness of fatigue in an operative setting

Bakgrunn og formål

Dette er en masteroppgave i Samfunnssikkerhet ved Institutt for ingeniørvitenskap og sikkerhet ved UIT Norges Arktiske Universitet.

Forskningsspørsmålet som masteroppgaven skal svare på er *"How has the introduction of fatigue awareness device as a part of Fatigue Risk Management System (FRMS) affected awareness of fatigue?"*



Med "fatigue awareness devices" mener jeg HappyOrNot-boksene som var plassert på basene fra juni 2015 til oktober 2015.

Jeg er interessert i å finne ut av hvordan dere opplevde brukervennligheten av boksen, skapte boksene økt bevissthet om fatigue og har det ført til eventuelle endringer hos dere?

Hva innebærer deltakelse i studien?

Studien gjennomføres ved hjelp av et spørreskjema. I spørreskjemaet er det 15 spørsmål som omhandler boksene. Deltakelsen tar ca. 10 minutter, og gjøres ved å svare på spørreskjemaet i linken som er lagt ved i denne eposten.

Hva skjer med informasjonen som samles inn?
Det vil ikke bli samlet inn personopplysninger og det skal ikke kunne identifiseres hvem som har trykket på knappen eller svart på spørreskjemaet. Alt som samles inn skal behandles konfidensielt og målet er å finne tendenser innenfor organisasjonen, ikke peke ut enkeltmennesker. Kun jeg (Hege) vil ha tilgang til svarene i spørreskjemaet. Informasjonen fra spørreskjema og boksene vil slettes når masteroppgaven er ferdigstilt våren 2016.

Frivillig deltakelse
Det er frivillig å delta i undersøkelsen. Du samtykker til deltakelse ved å svare på spørreskjemaet

Har du spørsmål angående prosjektet eller ønsker å bidra til prosjektet kan du kontakte Hege Weines på telefon 48038612 eller veileder Vegard Nergård på telefon 91575195.
Studiet er meldt til Personvernombudet for forskning, Norsk Samfunnsvitenskapelig datatjeneste AS.

Jeg setter stor pris på alle svarene jeg får og håper virkelig dere kan hjelpe meg med min masteroppgave!

Appendix 2: Questionnaire

Fatigue Awareness Device as a part of Fatigue Risk Management System

This questionnaire consists of 15 questions regarding the fatigue awareness device (happyornot) which was placed at the HEMS bases from June 2015 until October 2015. In this questionnaire you are being asked about the device that you used prior to the missions, but also the one you used after the missions.

This questionnaire has 4 categories: user friendliness, awareness, behavioral change and additional questions.

Please read the email where the link to this questionnaire was provided before answering. Thank you!

Questions regarding the user friendliness of the fatigue awareness device

1) * Did you use the device?

On every mission

On almost every mission

A few times per duty period

Not on every duty period

Never

2) * What did you think about the placement of the device, considering where it would be most effective?

It should have been placed just outside the hangar

It should have been placed inside the hangar

It should have been placed closer to the helicopter

It should have been placed closer to the sleeping quarters

The placement was the best where it were

Other:

3) * The device was user friendly?

I strongly agree

I agree

I neither agree nor disagree

I disagree

I strongly disagree

4) * The use of smiley faces on the device made it easy to report my level of fatigue?

I strongly agree

I agree

I neither agree nor disagree

I disagree

I strongly disagree

5) * Did the device take away any mission focus prior to the mission?

Very frequently (Daily while on duty)

Frequently (Every other day while on duty)

Occasionally (One time per duty period)

Rarely (Not on every duty period)

Never

Questions regarding awareness of fatigue

6) * Did you discuss fatigue as a crew before the device was introduced?

Very frequently (Daily while on duty)

Frequently (Every other day while on duty)

Occasionally (One time per duty period)

Rarely (Not on every duty period)

Never

7) * Did you discuss fatigue as a crew after the device was introduced?

Very frequently (Daily while on duty)

Frequently (Every other day while on duty)

Occasionally (One time per duty period)

Rarely (Not on every duty period)

Never

8) * How often do you think about fatigue while on duty?

Very frequently (Daily while on duty)

Frequently (Every other day while on duty)

Occasionally (One time per duty period)

Rarely (Not on every duty period)

Never

9) * I think more about fatigue now than I did before the device was introduced?

I strongly agree

I agree

I neither agree nor disagree

I disagree

I strongly disagree

Questions regarding behavioral change

10) * I have declined missions while experiencing fatigue after the device was installed?

I strongly agree

I agree

I neither disagree nor disagree

I disagree

I strongly disagree

11) * I have accepted missions while feeling fatigued after the device was installed?

I strongly agree

I agree

I neither neither agree nor disagree

I disagree

I strongly disagree

12) The device has made me evaluate my actions while on mission, in respect to fatigue?

I strongly agree

I agree

I neither agree nor disagree

I disagree

I strongly disagree

Questions falling into the category "other"

13) * The device has increased my willingness to report to the management issues regarding fatigue

I strongly agree

I disagree

I neither agree nor disagree

I disagree

I strongly disagree

14) * What are the factors that affects or increases fatigue in the different seasons (e.g weather, daylight, workload, conditions on the base etc.)

Open Question

15) * Are there other reminders or measures which can be implemented to make a successful FRMS?

Open question

Appendix 3: Interview guide with manager in Lufttransport

Interview guide with manager in Lufttransport

The participation in this interview is voluntary. The aim of this interview is to get the managements perspective on how the introduction of fatigue awareness devices has been. The interview will be recorded, so that I am sure that you are cited correctly. The recording and the transcribed interview will be deleted when the work with my thesis is done. You will be anonymised and referred to as a "manager in Lufttransport". You can at any time withdraw from this interview.

Do you have any questions or are anything unclear?

In general, how has the introduction of FRMS affected awareness of fatigue?

- Have you noticed any changes?

Can you spot any differences directly related to the device?

In the questionnaire, how often the crew discuss fatigue has increased – is that something you notice?

Why the Karolinska Sleepiness Scale?

What do you think makes crew fatigued?

- Clothes?
- Weather?
- Workload?
- Other?

What do you do with the reports from HappyOrNot?

How did you perceive the user friendliness of the devices?

Behavioural change - Have you noticed any?

What do you believe are the factors that increase fatigue in the different seasons?

Do you think there are other reminders, which can be implemented as reminders to make a more successful fatigue risk management?

Other things you want to discuss?

Appendix 4: Approval from NSD

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

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Vegard Nergård
Institutt for ingeniørvitenskap og sikkerhet UiT Norges arktiske universitet

9037 TROMSØ

Vår dato: 04.02.2016 Vår ref: 46543 / 3 / BGH Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 11.01.2016. Meldingen gjelder prosjektet:

46543	*Awareness of fatigue in an operational setting*
Behandlingsansvarlig	*UiT Norges arktiske universitet, ved institusjonens øverste leder*
Daglig ansvarlig	*Vegard Nergård*
Student	*Hege Weines*

Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger er meldepliktig i henhold til personopplysningsloven § 31. Behandlingen tilfredsstiller kravene i personopplysningsloven.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 01.06.2016, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Katrine Utaaker Segadal

Belinda Gloppen Helle

Kontaktperson: Belinda Gloppen Helle tlf: 55 58 28 74
Vedlegg: Prosjektvurdering

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Avdelingskontorer / *District Offices*:
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TROMSØ: NSD. SVF, Universitetet i Tromsø, 9037 Tromsø. Tel: +47-77 64 43 36. nsdmaa@sv.uit.no

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 46543

INFORMASJON OG SAMTYKKE

Utvalget informeres skriftlig om prosjektet og samtykker til deltakelse. Revidert informasjonsskriv mottatt 02.02.16 er godt utformet.

INFORMASJONSSIKERHET

Personvernombudet legger til grunn at forsker etterfølger UiT Norges arktiske universitet sine rutiner for datasikkerhet. Dersom personopplysninger skal lagres på mobile enheter, bør opplysningene krypteres tilstrekkelig.

Det var i utgangspunktet ikke krysset av for at det skal registereres personopplysninger ved hjelp av nettbasert spørreskjema, men etter epostuveksling mellom saksbehandler og student ble dette oppklart. Saksbehandler har derfor endret meldeskjema og lagt til at student skal benytte seg av Questback som databehandler.

Questback er databehandler for prosjektet. UiT Norges arktiske universitet skal inngå skriftlig avtale med Questback om hvordan personopplysninger skal behandles, jf. personopplysningsloven § 15. For råd om hva databehandleravtalen bør inneholde, se Datatilsynets veileder: http://www.datatilsynet.no/Sikkerhet-internkontroll/Databehandleravtale/.

PROSJEKTSLUTT OG ANONYMISERING

Forventet prosjektslutt er 01.06.2016. Ifølge prosjektmeldingen skal dere da anonymisere innsamlede opplysninger. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å slette direkte personopplysninger og slette eller omskrive indirekte personopplysninger.

Vi gjør oppmerksom på at også databehandler (Questback) må slette personopplysninger tilknyttet prosjektet i sine systemer. Dette inkluderer eventuelle logger og koblinger mellom IP-/epostadresser og besvarelser.