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Fatigue on the flight deck

Challenges & mitigations concerning fatigue in the Norwegian aviation sector

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Thematic description

The overall goal of this master's thesis is to explore to what extent pilots in Norway are affected by fatigue whilst working. Moreover, what stakeholders that are responsible for the current trends, and what measures can be implemented to shift these trends, are equally important themes in this thesis.

Main contents:

1. Motivation for subject.
2. Central important aspects & statistics.
3. An empirical study (Strategic interview of key individuals).
4. Discuss the results and give recommendations.

Preface

As the author of this thesis, I have a background from the aviation sector with a bachelor's degree in aviation completed in 2014, as well as some experience as a flight instructor.

This thesis marks the completion of a master's degree in health, security and environment (HSE) at the Norwegian University of Science and Technology (NTNU). With my background from the aviation sector, I have throughout the duration of the study at NTNU been interested in gaining more knowledge on aspects within commercial air transport, which in turn can be interrelated with HSE.

Whilst working with this thesis I have gained new knowledge and valuable insight on many new aspects and problems that are especially applicable to the aviation sector. At the same time, I have gained valuable insight in a business that has evolved rapidly during the last twenty years – in both positive and negative ways.

Firstly, I would like to direct a special thanks to my mentors Ivonne Herrera and Jo Bjørn Skatval. With your innovative directions, thorough feedback and former experiences you have been a great help for me in writing this thesis. The motivation and insight you have given me could not have been better. I really hope our paths will cross again in the future. Thank you!

Next, I would like to give a sincere thanks to my informants. Without your willingness to participate in my study, this thesis would never have been. Our interesting discussions on the subject of fatigue in the aviation sector gave me treasured new insights on both your personal experiences and on the industry as a whole. Thank you so much!

Lastly, I must say to both my family and girlfriend how much I appreciate your patience and support whilst completing my master's degree. Without you understanding how important this was to me, it would have been difficult to complete.

Asker, 11 June 2017

Nicholas Joel Tambala

Abstract

The main objective of this master's thesis is to explore to what extent pilots in Norway are affected by fatigue whilst working. To understand the environment pilots are working under, gathering information from different stakeholders in the Norwegian aviation sector, is another important objective. The same can be said for measures for preventing or coping with fatigue. Fatigue is a known challenge within the aviation industry, but is still an issue where there may be ambiguities surrounding the contributing factors or contexts. A study of the work environment for flying personnel by the Norwegian Civil Aviation Authority (NCAA), found that only 19% of pilots and 12% of cabin crew in large fixed-wing (FX) airlines respond that they get sufficient amounts of rest and relaxation between workdays. Additionally, 72% of pilots and 85% of cabin crew feel physically exhausted after the completion of a work period.

In this thesis, a qualitative approach based on gathering and reviewing secondary quantitative and qualitative data on fatigue is used as a method. These findings are used to design the qualitative study; performing strategic interviews of pilots and managers in SAS, NAS/NAI and Widerøe, in addition to representatives from the NCAA. The strategic interviews are used as innovation process for gaining new experience, and a total of 13 individuals participated. The interview questionnaire that is designed, can be applied on a regular basis in future studies.

Conclusively, Norwegian pilots are experiencing varying degrees of fatigue. Some state that they are so tired they even fall asleep on the flight deck. Stakeholders from the Norwegian aviation sector perceive fatigue as a challenge that needs to be continuously worked with. Fatigue is experienced highly individually. What is also apparent is that there is a current under-reporting of fatigue in Norway. Both the NCAA and the airlines need more fatigue-reports to mitigate the issues that arise, whilst the personnel in the sharp end are asking for changes.

This thesis presents several measures that can be implemented by pilots, managers and the NCAA to mitigate fatigue. Currently, many of the respondents state that an improvement and exploration of options is necessary. More work is needed in trying different systems and mechanisms instead of merely adhering to the prescribed flight time limitations (FTLs) and flight duty periods (FDPs). In a broader perspective, I would say there is a need for more research on fatigue in the aviation sector. There are several important themes that need to be discussed in more detail on all the levels that are mentioned. There is a need for studies which show more specific issues regarding fatigue. These scientific results should also be used to a larger degree when making fatigue-related decisions.

Sammendrag

Formålet med denne masteroppgaven er å undersøke i hvilken grad piloter i Norge blir rammet av fatigue mens de er på jobb. For å kunne forstå det miljøet piloter jobber under, vil innsamling av informasjon fra ulike interessenter i den norske luftfartssektoren være et viktig mål. Tiltak for å forebygge eller takle fatigue er like viktige tema å få kunnskap om. Fatigue er en kjent utfordring innen luftfartsindustrien, men er fortsatt et problem der det kan være tvetydigheter rundt de bidragende faktorene og sammenhengene. En studie av arbeidsmiljøet for flygende personell utført av Luftfartstilsynet, fant at bare 19% av pilotene og 12% av kabinpersonalet i store fixed-wing flyselskaper, svarer at de får tilstrekkelige mengder hvile og avslapning mellom arbeidsdagene. I tillegg svarer 72% av piloter og 85% av kabinpersonalet at de føler seg fysisk utmattet etter at en arbeidsperiode er fullført.

I denne oppgaven er det valgt å bruke en kvalitativ tilnærming basert på innsamling og gjennomgang av sekundære kvantitative og kvalitative data om fatigue som metode. Disse funnene brukes så for å designe den kvalitative studien; å utføre strategiske intervjuer av piloter og ledere i SAS, NAS/NAI og Widerøe, i tillegg til representanter fra Luftfartstilsynet. De strategiske intervjuene brukes som innovasjonsprosess for å etablere nye erfaringer, og 13 personer deltok. Intervjuguiden som er utformet, kan brukes regelmessig i fremtidige studier.

For å konkludere, opplever norske piloter varierende grad av fatigue. Noen sier at de er så trette at de til og med sovner i cockpit. Interessentene fra den norske luftfartssektoren oppfatter fatigue som en utfordring som må kontinuerlig jobbes med. Fatigue oppleves svært individuelt. Det er også tydelig at det er en nåværende underrapportering av fatigue i Norge. Både Luftfartstilsynet og flyselskapene trenger mer fatiguerapporter for å begrense problemene som oppstår, mens personellet i den skarpe enden ber om endringer.

Denne oppgaven presenterer flere tiltak som kan implementeres av piloter, ledere og Luftfartstilsynet for å redusere fatigue. Mange av respondentene oppgir at en forbedring og utforsking av alternativer er nødvendig. Mer arbeid er nødvendig for å prøve forskjellige systemer og mekanismer i stedet for bare å overholde de foreskrevne flygetidsbegrensningene og arbeidstidsbestemmelsene. I et bredere perspektiv vil jeg si at det er behov for mye mer forskning på fatigue i luftfartssektoren. Det er flere viktige temaer som må diskuteres mer detaljert på alle nivåer som er nevnt. Det er behov for studier som viser flere spesifikke problemer med fatigue. Disse vitenskapelige resultatene bør også brukes i større grad når det skal tas fatigue-relaterte beslutninger.

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Glossary

Acclimatised	A state in which a *crew member's* circadian phase is synchronised to the time zone where the crew member is.	(CAA UK, 2015)
Airline (operator)	An *organisation* offering regular transportation of passengers and/or goods.	(Caldwell and Caldwell, 2016)
Augmented flight crew	A flight crew which consists of more *crew members* than what is required to operate an aircraft; which in turn allows each flight *crew member* to be able to leave his/her post for in-flight rest, and to be replaced by another qualified flight *crew member*.	(CAA UK, 2015)
Bio-mathematical model	A computer programme designed to predict aspects of a schedule that might generate an increased fatigue risk for the average person, based on scientific understanding of the factors contributing to fatigue. Biomathematical models are an optional tool for predictive fatigue hazard identification within an FRMS. All biomathematical models have limitations that need to be understood for their appropriate use.	(ICAO et al., 2015)
Company	See *organisation*.	
Consequence	Outcome of an event affecting *performance*.	(ISO 31000:2009)
Continual improvement	Recurring activity to enhance *performance*.	(ISO 27000:2016)
Countermeasure	Action that is intended to modify *risk* positively.	(ISO 31000:2009)
Crew member	A person assigned by an *airline* to duty on an aircraft during a flight duty period.	(ICAO et al., 2015)
Effectiveness	Extent to which planned activities are realised and planned results achieved.	(ISO 27000:2016)
Fatigue	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 et al., 2015)
Fatigue Risk Management System (FRMS)	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 et al., 2015)
Fatigue Safety Action Group (FSAG)	A group comprised of representatives of all *stakeholder* groups (e.g. management, scheduling, operational personnel) together with any additional specialist experts (i.e. scientists, data analysts, and medical professionals), which are responsible for	(ICAO et al., 2015)

	coordinating all fatigue management activities in the *airline*.	
"Fit for flight"	Being physiologically and mentally prepared and capable of performing assigned duties at the highest degree of *safety*; i.e. being adequately rested and not anticipating being too *fatigued* to fly an assigned leg. Same meaning as "fit for duty".	(ICAO et al., 2015)
Flight duty period (FDP)	A period which commences when a crew member is required to report for duty that includes a flight or series of flights. The period finishes when he/she leaves the workplace after the end of the last flight.	(Modified from; ICAO et al., 2015)
Flight time limitation (FTL)	An accumulated flight time for several flights over a given time period (day, week, year, etc.). Flight time is to be understood as the total time from the moment an aeroplane first moves for the purpose of taking off until the moment it finally comes to rest at the end of the flight.	(Modified from; ICAO et al., 2015)
High reliability organisation	See subchapter 3.5.4: High reliability organisations	
Just culture	A culture in which front line operators and others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but where gross negligence, wilful violations and destructive acts are not tolerated.	(Dekker, 2012)
Management system	Set of interrelated or interacting elements of an *organisation* to establish policies and *objectives*, and *processes* to achieve those objectives.	(ISO 27000:2016)
Measure	See *countermeasure*.	
Mitigation	Intervention designed to reduce a specific identified fatigue risk.	(ICAO et al., 2015)
Objectives	Result to be achieved.	(ISO 27000:2016)
Organisation	Person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its *objectives*.	(ISO 27000:2016)
Performance	Measurable result.	(ISO 27000:2016)
Process	Set of interrelated or interacting activities which transforms inputs into outputs.	(ISO 27000:2016)
Regulator	Person or governmental organisation governing or directing according to rule.	(Caldwell and Caldwell, 2016)
Reliability	Property of consistent intended behaviour and results.	(ISO 27000:2016)
Requirement	Need or expectation that is stated generally implied or obligatory.	(ISO 27000:2016)
Resilience	See subchapter 3.5.5: Adaptation & flexibility: Resilience engineering	

Risk	Effect of uncertainty on *objectives*.	(ISO 31000:2009)
Robustness	The ability of an object to resist the impact of an unwanted event and to restore it to its original state or function following the event.	(Rausand, 2011)
Roster	(noun) a list of planned shifts or work periods within a defined period of time; (verb) assignment of individuals to a schedule/roster or pattern of work. Synonymous with *schedule*.	(ICAO et al., 2015)
Safety	The state in which *risks* associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.	(ICAO et al., 2015)
Safety management	All activities carried out in more or less coordinated shapes of an organisation to control hazards.	(Hale, 2003)
Safety Management System (SMS)	Systematic activities to achieve and maintain a level of *safety* in accordance with the objectives and demands the *organisation* has set itself.	(Luftfartstilsynet, 2016b)
Schedule	See *roster*.	
Stakeholder	Person or *organisation* that can affect, be affected by, or perceive themselves to be affected by a decision or activity.	(ISO 31000:2009)
Sleep	A reversible state in which conscious control of the brain is absent and processing of sensory information from the environment is minimal. The brain goes "off-line" to sort and store the day's experiences and replenish essential systems depleted by waking activities.	(ICAO et al., 2015)
State Safety Program (SSP)	An integrated set of rules and activities whose purpose is to improve the aviation *safety* in a country.	(Luftfartstilsynet, 2016b)
Suitable accommodation	An individual room for each flight *crew member* which is situated in a silent, ventilated environment with possibilities for regulating temperature and light brightness, as well as a bed and access to drink and food.	(CAA UK, 2015)
Threat	Potential cause of an unwanted incident, which may result in harm to a system or *organisation*.	(ISO 27000:2016)
Top management	Person or group of people who directs and controls an *organisation*.	(ISO 27000:2016)
Unaugmented flight crew	A flight crew that has exactly the minimum number of *crew members* required by the airplane type-certificate to operate the aircraft.	(CAA UK, 2015)

Abbreviations

AIBN	Accident Investigation Board Norway
AR	Accident Rate
ATO	Approved Training Organisation
ATSB	Australian Transport Safety Bureau
CAA (UK)	Civil Aviation Authority (United Kingdom)
CASA	Civil Aviation Safety Authority
CAT	Commercial Air Transport
CRM	Crew Resource Management (previously: Cockpit Resource Management)
EASA	European Aviation Safety Agency
ECA	European Cockpit Association
EEA	European Economic Area
EU	European Union
FAA	Federal Aviation Authority
FAR	Fatal Accident Rate
FDP	Flight Duty Period
FRMS	Fatigue Risk Management System
FSAG	Fatigue Safety Action Group
FTL	Flight Time Limitation
FX	Fixed-wing
HRO	High Reliability Organisation(s)
HSE	Health, Safety and Environmental management
IATA	the International Air Transport Association
ICAO	the International Civil Aviation Organization
IFALPA	the International Federation of AirLine Pilots' Associations
JAA	Joint Aviation Authorities
JPDO	Joint Planning and Development Office
NAS/NAI	Norwegian Air Shuttle/Norwegian Air International
NCAA	Norwegian Civil Aviation Authority
NGO	Non-Governmental Organisation
NSD	Norwegian centre for research data (NO: Norsk senter for forskningsdata)
NTSB	National Transportation Safety Board
SAG	Safety Action Group
SARPs	Standards and Recommended Practices
SMS	Safety Management System
SSP	State Safety Program
UN	United Nations
WOCL	Window of circadian low

1 Introduction

This master's thesis is a continuation of the term paper *Fatigue in Aviation: A literature review* by Tambala and Bolås (2016). *Fatigue* (further defined in subchapter 1.1) is something that can be associated with tiredness and/or exhaustion. Fatigue has become a challenge within the aviation industry because of a change in the way airline companies operate over the last 20 years. This change has largely affected the people who work in aviation and their work environment. From being an industry previously dominated by national regulation and state ownership, there is a current increase in competition and requirements for profitability and efficiency (Luftfartstilsynet, 2016a).

Then again, not all the changes that have happened in the aviation industry are negative. It is much safer to fly today than it was 20 years ago (EASA, 2016b). Nevertheless, fatigue is still an issue where there are ambiguities surrounding the contributing factors and contexts. There is room for improvement when it comes to the regulatory frameworks personnel must follow – and the fact that governmental regulators need to make more decisions based on scientific results when applying limitations in working and flying hours for flight crew. To be able to implement measures to cope with fatigue, the future approach within aviation organisations should be to move away from the current proceedings (Tambala and Bolås, 2016). Naturally, this is easier said than done, and a further study of this subject therefore seems fit.

1.1 Defining fatigue

The three aviation organisations, the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA) and the International Federation of AirLine Pilots' Associations (IFALPA), mention in their common article; *Fatigue Management System Guide for Airline Operators* (2015, ch. 2, p. 6), that crewmember fatigue can be defined 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."*

There are many more definitions on fatigue, as well as several ways to understand the concept, but all have roughly the same meaning. Åkerstedt (2000) says that fatigue is synonymous with drowsiness, sleepiness and tiredness. Another states that fatigue involves a diminished capacity for work and possible decrements in attention, perception, decision-making and skilled performance (Flin et al., 2008). Caldwell and Caldwell (2016) defines fatigue as a state of tiredness that is associated with long working-days, longer periods of sleep-deprivation and/or requirements to work during hours where the body is used to being asleep, like during night time operations or flying across several time zones.

Avers and Johnson (2011) describes that fatigue has been a challenge already from the early years of aviation. Charles Lindbergh – known for being the first aviator to cross the Atlantic – has described how he felt the effects of what we today describe as fatigue:

> *"My mind clicks on and off. I try letting one eyelid close at a time when I prop the other open with my will. But the effort is too much. Sleep is winning. My whole body argues dully that nothing, nothing life can attain is quite so desirable as sleep. My mind is losing resolution and control."* (Lindbergh, 1954, in Avers and Johnson, 2011)

As we can see, the challenges associated with fatigue are not new. Although the effects of fatigue are hard to grasp and fully understand – even today – there is a need to explore this area further to achieve continuous means of improvement in a high-risk industry like the aviation sector. We are in possession of much more information and knowledge now than when Lindbergh flew over the Atlantic in 1927.

1.2 Objectives

The entity of the aviation sector is an extremely complex system. This must be considered when elaborating further on the objectives of this thesis. The main objective of this thesis is to explore to what extent pilots in Norway are affected by fatigue whilst working. Naturally, pilots are not considered the *only* stakeholders responsible for successful operations in the aviation industry (ref. Figure 1), but are those who are traditionally considered having a large responsibility and blame potential, other than e.g. air traffic controllers and mechanics.

To better understand the environment pilots are working under, gathering information from stakeholders in the *blunt end* that directly influence the workers in the *sharp end* of the organisation, is considered an important objective in this thesis. Representatives from the Norwegian Civil Aviation Authority (NCAA) and managers in different airlines are also considered important stakeholders to explore further. When it comes to these three groups of stakeholders it can be interesting to explore how they see the challenges associated with fatigue in Norway. Additionally, there are several countermeasures implemented to manage fatigue; How are these viewed by these three groups? Do they want to do things differently?

Figure 1 shows different stakeholders and actors that can affect an airline. Conflicting objectives (ref. subchapter 3.5.1) are to be understood as being present in all parts of this figure, and can be related to Rasmussen (1997) and his *socio-technical system* (see subchapter 3.5.2).

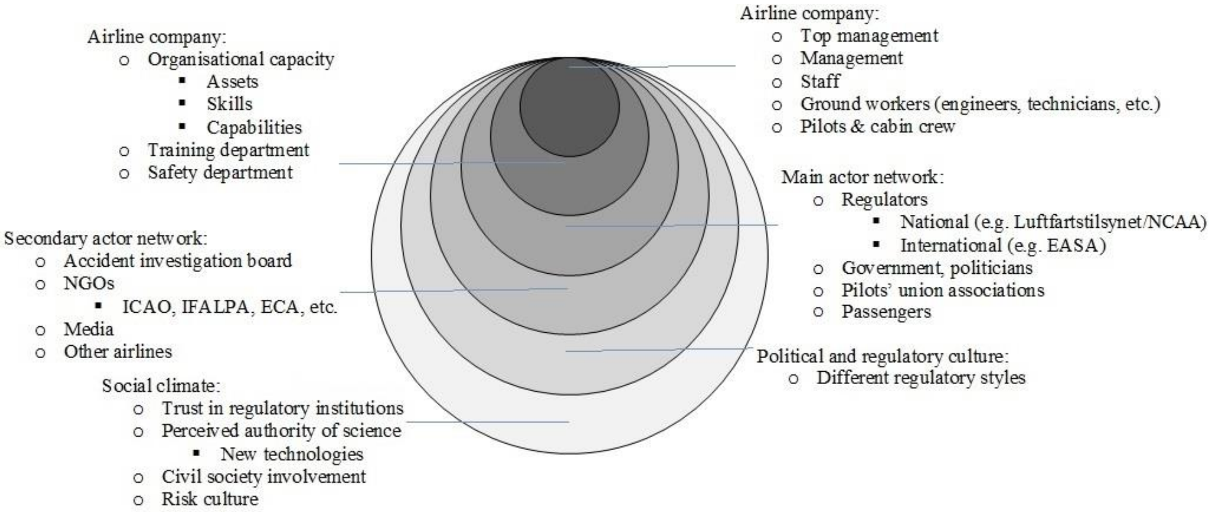


Figure 1 - Stakeholders and aspects affecting an airline. Modified from IRGC (2008).

1.3 Research questions

In 2016 the NCAA released a study of the work environment in commercial civilian aviation in Norway in 2015 (Luftfartstilsynet, 2016a). The study is based on an annual survey on living conditions in Norway, and is the first ever to be performed at this scale by the NCAA. Furthermore, it is the intention that the results from the survey are to be seen in conjunction with other professions in Norway (e.g. farmers, doctors, store employees, etc.), where this is possible (see subchapter 2.4). Criticism has arisen regarding the fact that this study should have given a more detailed account of proposed measures to be implemented following the results of this study. For example; only 19% of the pilots and 12% of the cabin crew that responded to the survey, stated that they get sufficient amounts of rest and relaxation between workdays. In comparison, the national average among all employees in Norway is as high as 71% saying that they get enough rest. What could be done to improve these numbers? This is one of the questions I will try to answer in this thesis.

The research questions are formulated to analyse if there is either a direct need or certain possibilities for improvement in everything from legislation to informal practises. There is a particular interest in improving both the wellbeing and overall safety of crew, passengers and other relevant stakeholders in the aviation industry. Consequently, the purpose of this master's thesis will be to answer the following research questions:

1. *How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?*
2. *Which measures can be used to mitigate fatigue among pilots who work in large aviation companies in Norway?*
3. *Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?*

1.4 Limitations

The aim of this thesis is to answer the research questions formulated in the previous subchapter. Moreover, the thesis will mainly focus on flight crew members involved in commercial airline operations in Norway; which lies within the area of responsibility of the European Aviation Safety Agency (EASA). Personnel with direct knowledge and/or experience on the effects of fatigue will be used as sources for information, to better portray the matter at hand. A limitation in this case is the availability and honesty of the resources. This will be discussed in more detail in chapter 4; Method. Another limitation that is worth mentioning is the time available to conduct the study and finish the thesis. There was about five months available for completion.

1.5 Structure

This thesis is structured as described in Figure 2. The chapter that has currently been presented is the introduction. Chapter 2 will give more background information surrounding the subject of fatigue, such as the current aviation safety levels in Europe, explanations of important aspects and statistics on fatigue levels. In chapter 3, different theoretical aspects concerning the science of sleep, fatigue prevention, current legislation, Fatigue Risk Management System (FRMS) and different theoretical aspects related to safety management are explained. Next, there will be given an outline of the method that has been chosen along with the reason for this selection in chapter 4. This is followed by chapter 5 which will show the results from the gathered empirical data based on the method chosen. In chapter 6, these data are to be discussed. This chapter also includes recommendations for further work within this field of study, as well as a review of the chosen methodological approach. Lastly, chapter 7 will give a conclusion to this master's thesis. Chapter 8 contains the references used.

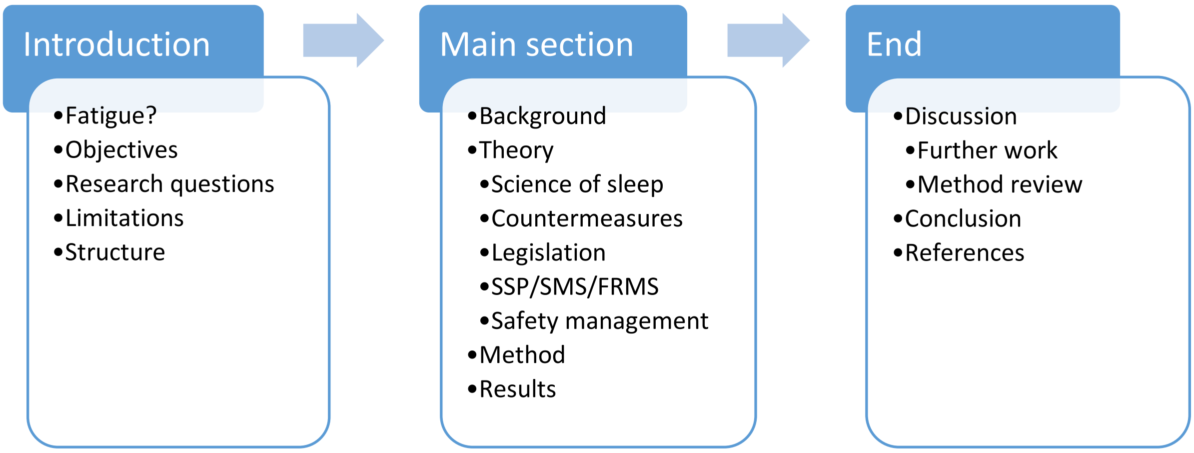


Figure 2 - Structure of the master's thesis

2 Background on fatigue in an aviation context

In this chapter I will take a closer look on important aspects related to fatigue in an aviation context. The definition of fatigue was given in subchapter 1.1 by Caldwell and Caldwell (2016) as; a state of tiredness that is associated with long working-days, longer periods of sleep-deprivation and/or requirements to work during hours where the body is used to being asleep. The definition given by ICAO et al. (2015, ch. 2, p. 6), further sums up a similar definition of fatigue:

"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."

To give a better understanding of the underlying assumptions related to fatigue in aviation, this chapter will start with an overview of literature on significant aspects related to fatigue. This will be followed by looking at the current state of aviation safety in Europe and Norway, before motivating further as to why fatigue is a problem for flight crews, and showing some relevant statistics. Most of the information shown in this chapter is taken from Tambala and Bolås (2016).

2.1 Overview of literature with aspects related to fatigue

Initially, a presentation of the more significant aspects, challenges and statistics related to fatigue will be given. For information regarding the state of aviation safety in Europe and Norway, the following reports have been placed most emphasis on:

- *Annual Safety Review*, by EASA (2016b).
- *Norges flysikkerhetsprogram (utkast)*, by Luftfartstilsynet (2016b).

Further, there are seven sources that are used as the main sources of information regarding aspects and challenges concerning fatigue in aviation. The list below shows these sources:

- *Paper prepared for the ETSC*, by Åkerstedt et al. (2003).
- *Safety at the sharp end: a guide to non-technical skills*, by Flin et al. (2008).
- *Fatigue risk management: Organizational factors at the regulatory and industry/company level*, by Gander et al. (2011).
- *A Review of Federal Aviation Administration Fatigue Research: Transitioning Scientific Results to the Aviation Industry*, by Avers and Johnson (2011).
- *Fatigue Management Guide for Airline Operations*, by ICAO et al. (2015).
- *Atypical Forms of Employment in the Aviation Sector*, by Jorens et al. (2015).

- *Fatigue in aviation: a guide to staying awake at the stick*, by Caldwell and Caldwell (2016).

In addition to this, when it comes to sources containing statistical data portrayed in this chapter, there are mainly three papers that are used to show the current trends concerning fatigue levels in Europe and Norway:

- *Barometer on pilot fatigue*, by ECA (2012).
- *European pilots' perceptions of safety culture in European Aviation*, by Reader et al. (2016).
- *Luftfartstilsynets undersøkelse av arbeidsmiljøet i sivil luftfart 2015*, by Luftfartstilsynet (2016a).

2.2 The European & Norwegian aviation sector

In this subchapter, a brief introduction as to how the current state of safety in the aviation sector in Europe and Norway with respect to fatigue, will be emphasised. Established in 2002, EASA is now the European Unions (EU) authority for aviation safety, after taking over the functionality from the previous Joint Aviation Authorities (JAA) in 2008. EASA's main responsibilities are to do analyses and research on safety in civilian aviation. Additionally, the organisation is an advising organ that implements and monitors safety rules along with related inspections in the member states. The organisation is also responsible for certifications such as airworthiness and environmental declarations, as well as determining the flight and duty time limitations (FTLs and FDPs) for flight crew, which in turn is closely related in the efforts to prevent fatigue (EASA, 2016a) (see also subchapter 3.3: EASA, the Norwegian CAA and current legislation).

EASA issues an annual report of the previous year's trends in accidents and incidents. The following figures are taken from their report for 2015 issued in 2016. Figure 3 shows the fatal accident rate (FAR) per million departures in commercial air transport (CAT), from 2005 to 2015 (EASA, 2016b). There is a clear decline in worldwide FAR, while the FAR within EASA is fairly constant (below 0.5 since 2006).

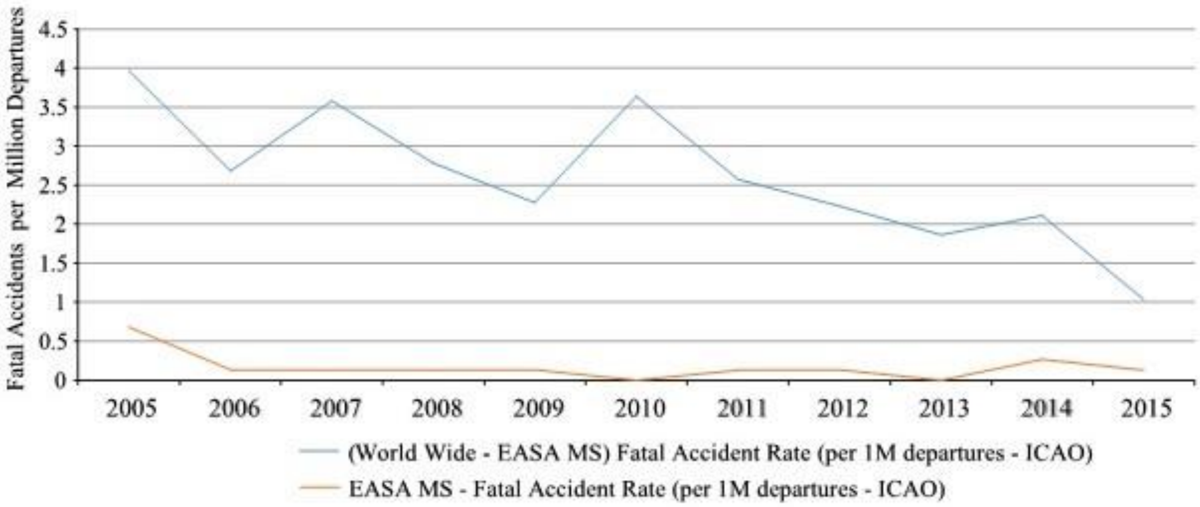


Figure 3 - FAR per million departures (2005-2015) for CAT (EASA, 2016b)

The accident rates (AR) (Figure 4) show us a similar trend as in Figure 3. There is an overall worldwide decline in the number of accidents per million departures (EASA, 2016b). However, the trend is not exactly like that of the FAR. As we can see, a peak in worldwide AR in 2010 was followed by a declining rate until 2014. The rate in 2015 shows an increasing AR. Within EASA the AR seems to be similar to the FAR, but with a minimal increasing trend since 2010.

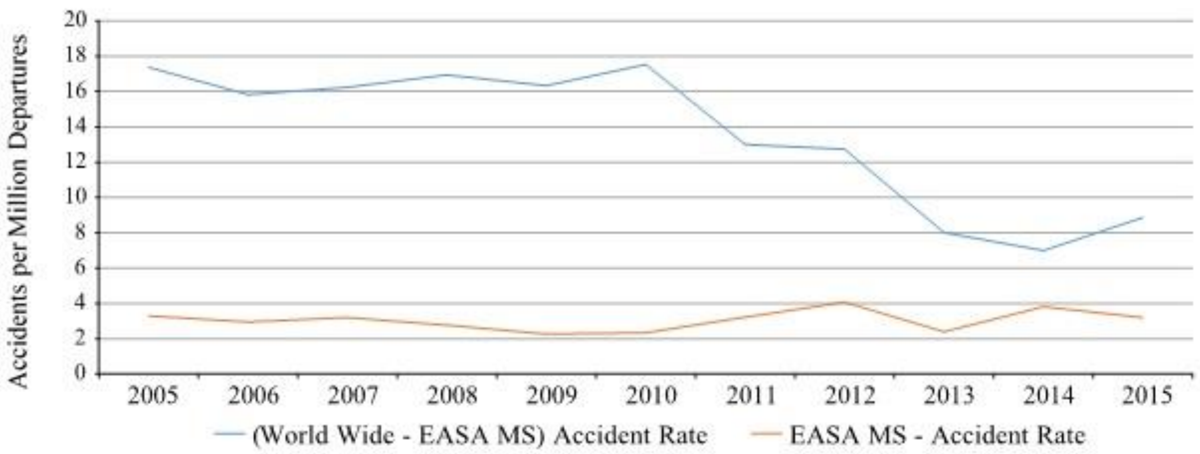


Figure 4 - AR per million departures (2005-2015) in CAT (EASA, 2016b)

Figure 3 and Figure 4 gives us an *indication* of the trends of accidents and fatal accidents both worldwide and in Europe. Although we can see an improving trend of these indicators over the last ten years, we cannot thereby say that the aviation sector is "safe enough". There should be a constant mind-set of continuous improvement to see a further decrease in the trends that are provided, as stated by e.g. ICAO et al. (2015).

EASA (2016b) reports that 64% of the fatal accidents that happened in CAT over the last ten years were due to loss of control in flight; 45% of the accidents were due to aircraft system failure; 27% happened due to ground collisions and ground handling. There are several areas having a significant representation of fatal accidents. Consequently, we can ask the following rhetorical questions: How can one be expected to cope with these situations if influenced by fatigue? Additionally, how can we be sure that fatigue did not contribute to several of these situations?

In Norway, the Norwegian Civil Aviation Authority (NCAA) has set a goal for both the FAR and AR in its proposal for a State Safety Program (SSP). The NCAA is authorised by the Norwegian Ministry of Transport to adopt and adapt national and international regulations. The agency's main task is to contribute to increased safety in all parts of Norwegian civil aviation (see also subchapter 3.3). This also implies a need to supervise that all stakeholders follow valid laws, rules and regulations. Figure 5 shows the historical development of the FAR-value from 1984 onwards, as well as the proposed goal for the next decade in Norwegian CAT (Luftfartstilsynet, 2016b). Like the development in the entire world, and within EASA (Figure 3), there is a declining trend of fatal accidents in Norwegian CAT.

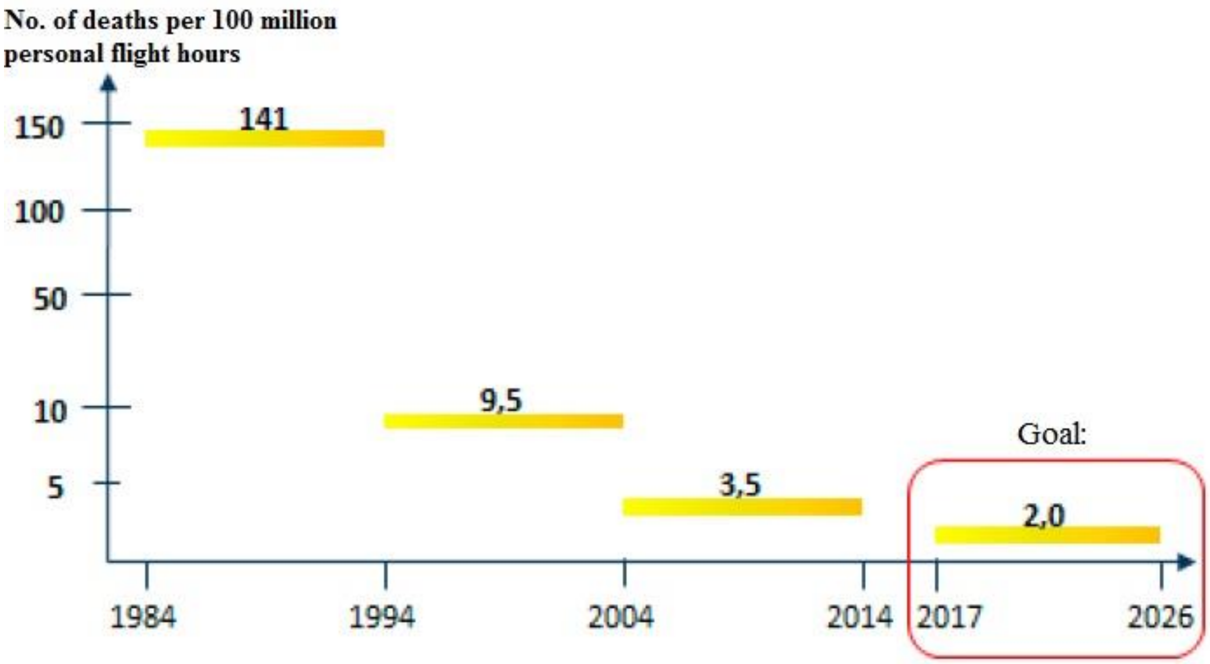


Figure 5 - Development and goal concerning the FAR in Norwegian CAT (Luftfartstilsynet, 2016b)

Similar to Figure 5, Figure 6 shows the historical values of the AR from 1994 onwards, and the proposed goals for the next five-year period in Norwegian CAT for heavy aircraft. Also, here there is a declining trend in the AR per 100.000 landings, like that shown in Figure 4.

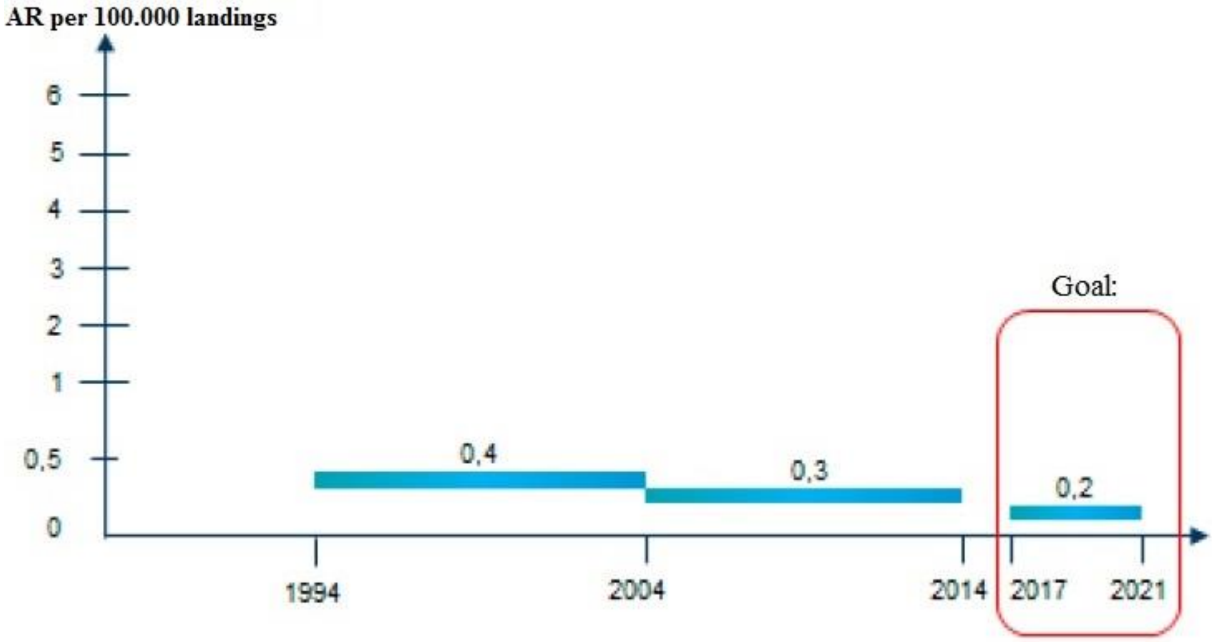


Figure 6 - Development and goal concerning the AR in Norwegian CAT (Luftfartstilsynet, 2016b)

The proposed implementation of a Norwegian SSP should primarily lead to improved coordination and strengthening of the already existing processes that are in place, with the addition of a risk based element to form a comprehensive framework for controlling the flight safety. As a regulator, the NCAA may historically be defined as an event-based and deviation based authority. This implies a system that is based on what has already happened (reactive) and the managerial focus is on unwanted events and deviations. The NCAA has an ambition to make a gradual transition to make decisions on a proactive level – which is much more based on predicted risks like those shown in Figure 5 and Figure 6 (Luftfartstilsynet, 2016b, Skatval, 2015). Further, it is stated by Dawson et al. (2017) that the aviation industry and its regulatory bodies increasingly move towards performance-based approaches to safety management of fatigue. Over the next decade, it is estimated that this will gradually become the standard.

Figure 5 and Figure 6 also gives an *indication* of the trends of accidents and fatal accidents in Norway. It is shown that there is an improving trend of these indicators over the last ten years, but neither here can it be said that the aviation sector has reached a level of safety that is to be maintained. The goals outlined by Luftfartstilsynet (2016b) shows that the NCAA has a mindset of trying to achieve continuous improvement, to realise a further decrease in the FAR and AR.

Other than EASA and NCAA, there are three major NGOs (Non-Governmental Organisations) who affect the level of safety within the aviation sector worldwide. ICAO (The International Civil Aviation Organization), IATA (The International Air Transport Association) and IFALPA (The International Federation of AirLine Pilots' Associations) are organisations that work towards achieving a higher level of safety worldwide. ICAO, IATA and IFALPA are important stakeholders in how the level of safety in Europe is affected as well. These organisations are strongly committed to improve aviation safety in terms of development of recommendation, sharing practices and strategies. EASA legislation is greatly affected by the recommendations and practices given by these NGOs. Moreover, much of the foundation for this thesis is based on literature that involves these organisations – a brief description of the three is therefore given in the following paragraphs.

ICAO is a UN (United Nations) specialized agency that works with its 191 member states to reach consensus on civil aviation Standards And Recommended Practices (SARPs) and policies (ICAO, 2016). The intention is to promote and support a safe, efficient, economically sustainable and environmentally friendly civil aviation sector that conforms to standards set by the organisation.

IATA is the trade organisation for airlines around the world, currently representing 83% of the worldwide airlines. It is an organisation that mostly represent their member airlines in cases that regard them specifically - as well as working with formulating industry policies on critical issues within the aviation sector (IATA, 2016a).

IFALPA is an organisation formed with the intention of representing pilot's opinions in critical matters. Today, their main objective is guiding ICAO in the forming of SARPs and policies, in order to give the perspective of pilots where these opinions seem fit (IFALPA, 2016).

2.3 Is fatigue a challenge?

In this subchapter, I shall further motivate as to why fatigue has been chosen as the main emphasis in this thesis, and how it can be an important contributing factor for the development of aviation accidents.

If we look at the statistics for the FAR in the aviation industry for the past decade (Figure 3), we can see that there has been a decreasing order in accidents. It seems like it is safer than ever to use airplanes as transportation – especially in Europe. This may partly be explained by an advancement in technology during recent years. There is also a strong focus on training and continuous development of pilots and other workers in the sharp end – as well as an increasing degree of knowledge (Caldwell and Caldwell, 2016).

Global societal and economic factors have made it possible for more people to travel. According to Caldwell and Caldwell (2016), the aviation industry responded to a greater demand in air traffic at the beginning of this century, by designing larger aircraft with longer endurance. Thus, we now have several non-stop routes that operate 17 hours from departure to arrival. During the last four years, there has been an increase in demand of approximately 5% each year. Thus, there is a demand for passengers being able to travel at convenient times suiting them – in return creating a 24-hour operation that needs to be operated by pilots and cabin crew in the sharp end.

In my opinion, the different airlines in the aviation industry is experiencing a greater pressure than ever before to operate as cost-effectively and punctual as possible; which in turn reflects the growing trend of travellers worldwide (Avers and Johnson, 2011, Caldwell and Caldwell, 2016). With higher pressure to operate based on the companies' requirements and preferences, and customers' expectations, it could at worst affect the airline's ability to operate in a safe and secure manner (ref. subchapter 3.5.1: Different decision settings: Conflicting objectives). This is where fatigue can be an important factor, and there rests an enormous responsibility on the pilots in an airline to be physically and mentally prepared in order to perform their tasks in a safe manner; e.g. preventing loss of control in flight, as was the predominant cause of fatal accidents (ref. 64%, EASA (2016b)).

According to the report *Atypical Forms of Employment in the Aviation Sector*, by Jorens et al. (2015), the liberalisation of the European aviation market and the emergence of new business models (i.e. low-cost airlines) has given rise to numerous trends in employment relations towards pilots and cabin crew members. On the one hand, this evolution has significantly increased and facilitated the competitive nature of the aviation industry to the benefit of many consumers in what concerns both price and accessibility of flights. On the other hand, however, atypical forms of employment (form of employment other than an unrestricted employment contract) are increasingly widespread within the aviation industry. Resultantly, there is an increase in self-employment, fixed-term work, work via temporary work agencies, as well as zero-hour contracts and pay-to-fly schemes among flight crew members. From a legal perspective, atypical forms of employment may not necessarily be problematic. However, there is a rising concern that the application and usage of these types of employment may be subject to potential abuse, to the detriment of the pilots and cabin crew members concerned. Indeed, cost-efficient techniques such as the use of atypical employment are a result of heightened competition and the occurrence of new business models that emerged in a more liberalised competitive aviation market. Unfortunately, some of these techniques have proven harmful to both fair competition and workers' rights. Moreover, these forms of employment also stimulate a higher occurrence of fatigue among flight crew members, and can ultimately have negative effects on safety within the airlines that use these practises.

"Human fatigue is acknowledged to be a significant safety concern in high-risk industries", as stated by Flin et al. (2008, p. 191) derived from Rosekind et al. (1995). Typically, accidents and incidents result from interactions between organisational processes (i.e. workplace conditions that lead crewmembers to commit active failures), and latent conditions that can penetrate current defences and have adverse effects on safety (ICAO et al., 2015).

On 25 January 2010, Ethiopian flight 409 from Beirut to Addis Ababa crashed in the Mediterranean Sea shortly after take-off, killing all the 90 people on board. The investigation board could not conclude with the final cause of the accident, but one of the contributing factors to the accident was mentioned to be fatigue. Having had a heavy meal that did not allow the captain – who was the pilot flying on this flight – proper sleep before his work day, combined with emotional stress, tiredness and blood chemistry imbalances, fatigue and stress were concluded being some of the contributing factors to why this accident happened (Directorate General of Civil Aviation, 2011).

The captain had also accumulated more than 188 hours of flying on a new type of aircraft in the last 51 days – often flying at different hours of the day. While that number of hours was still within the legal limits, it certainly could have generated some successive periods of acute fatigue due to the combination of mental activity required to fly a new aircraft and the excessive physical activity associated with the tight schedule. All of these were also factors that affected the captain's performance on this day (Directorate General of Civil Aviation, 2011).

Caldwell (2005, p. 86) says that an NTSB (National Transportation Safety Board) study concluded that: *"...crews comprising captains and first officers whose time since awakening was above the median for their crew position, made more procedural and tactical decision errors*." It was estimated in 1996 that 4-7% of all civil aviation mishaps (non-military) in the US were due to the influence of fatigue (Caldwell, 2005, Caldwell and Caldwell, 2016). It seems logical that crews will make a greater number of mistakes, the longer they have been awake. This needs to be considered from all the stakeholders involved in aviation. An NTSB study from 1999 estimated that fatigue was a contributing factor in everything from 3.8 to 21% of the accidents in aviation during the 1990s (NTSB, 1999). Gander et al. (2011) explain that this extent in percentage is because of the relation between human performance and accidents is less clear, and thereby more difficult to measure. In these complex systems, fatigue is only one of several contributing factors. Multiple layers of defences such as automation, team work, and checklists, reduce the probability of having an accident.

Furthermore, a paper by Åkerstedt et al. (2003) claims that the NTSB has estimated the overall contribution by fatigue to transport accidents (i.e. air, road, rail, sea) to be between 20 and 30%. Moreover, it is also assumed that approximately 15-20% of the accidents happening in aviation are partly due to the fact that the crew are influenced by fatigue. It seems like newer research shows that flight crews are more influenced by fatigue than what was originally estimated (ref. 4-7% in 1996, as stated by Caldwell (2005)).

In more recent times, a tool known as a Fatigue Risk Management System (FRMS) has been introduced by several airlines around the world – more lately in Norway. This is an example of a system that can be implemented by management to reduce the impact of fatigue on the personnel working in *the sharp end* of an organisation; e.g. pilots or other flight crew members. For example; the implementation of an FRMS in Air New Zealand almost halved the percentage of personnel reporting fatigue "at least once a week" over the course of 13 years, according to ICAO et al. (2015). Today, an FRMS is not legally required to be implemented by airline operators in Europe – yet certain circumstances do require this implementation by a governmental regulator; e.g.: in the case of a specific flight constantly exceeding the flight crew's duty period or flight time limit (more in subchapter 3.4.2: Fatigue Risk Management System).

Caldwell (2005) states that there have been few changes to crew scheduling methods and legislated flight-time limitations (FTLs) since these systems were first introduced. Additionally, the science behind our understanding of fatigue, how we sleep, shift work and circadian phases, has improved significantly during the same period. Still few changes have been made. This can be said to be a further problem that needs to be addressed in the *blunt end*, i.e. by legislators and management.

2.4 Statistics on fatigue in the European & Norwegian aviation sector

The European Cockpit Association (ECA) is an organisation which represents 38.000 European pilots' interests. In a study by ECA (2012), 6.000 pilots from different countries in Europe were asked to assess the way fatigue influenced their normal work day. Some of the findings are summarised below:

- More than 50% of the participants stated that fatigue affected their ability to perform well while flying.
- About 80% of the flight crew members had to cope with fatigue while in the cockpit, according to polls carried out in Austria, Norway, Sweden, Germany and Denmark.

- It is shown that fatigued pilots are prone to fall asleep or experience episodes of micro-sleep while in the cockpit. About 50% of the participants state that this has happened to them on one or more occasions.

In the study named *European pilots' perceptions of safety culture in European Aviation*, by Reader et al. (2016, p. 5-6), the following results are summarised:

"A total of 7,239 (14% of the population) commercial pilots in Europe completed the survey. The results show that perceptions of safety culture are generally positive amongst pilots in Europe. However, the survey also reveals significant differences in pilot' assessments of safety culture depending factors such as the type of airlines they work for, or the type of contracts they work to. Pilots working on atypical contracts, and those working for low cost and cargo airlines, have more negative perceptions of safety culture than their colleagues working under more secure forms of employment and for network carrier airlines. Perceptions of management commitment to safety, staffing and equipment, fatigue and perceived organisational support were not especially positive across the whole sample. For example, over half of the sample of pilots (50.05%) felt that fatigue was not taken seriously within their organisation (while 28.83% neither agreed nor disagreed) and less than 20% agreed that their company cares about their well-being. On the positive side, almost all pilots (93.49%) agreed that their colleagues are committed to safety, 88.45% agreed that they read reports of incidents or occurrences relevant to their work, and the large majority (79.08%) felt prepared to speak to their direct manager if an unsafe situation develops."

Based on these statistics, it is fair to say that fatigue is definitely a challenge for flight crew members in Europe. About 50% of the pilots that participated in the study stated that they feel their organisation not taking fatigue seriously in the organisation they are working in – less than 20% agree that their organisation do take it seriously.

What about fatigue among flight crews in Norway? As mentioned in subchapter 1.3, in November, 2016, the Norwegian Civil Aviation Authority (NCAA) published a study conducted to survey the work environment in the Norwegian aviation sector (Luftfartstilsynet, 2016a). All airlines with a base in Norway and more than ten employees were invited to answer this survey-based study. Out of 35 invited companies, 25 distributed the survey to their employees. 2578 out of 5138 people completed the survey, which gives a response rate of around 50%. The findings in the group "large fixed-wing (FX)" are most relevant to this thesis. The airlines this classification involves are SAS, Widerøe and Norwegian Air Shuttle/Norwegian Air International (NAS/NAI).

The study was conducted in order to compare the responses from the aviation industry in Norway to answers gathered from the rest of the workforce (ref. - Levekårsundersøkelsen om arbeidsmiljø; Vrålstad and Revold, 2014). Below are some of the findings from the survey by Luftfartstilsynet (2016a):

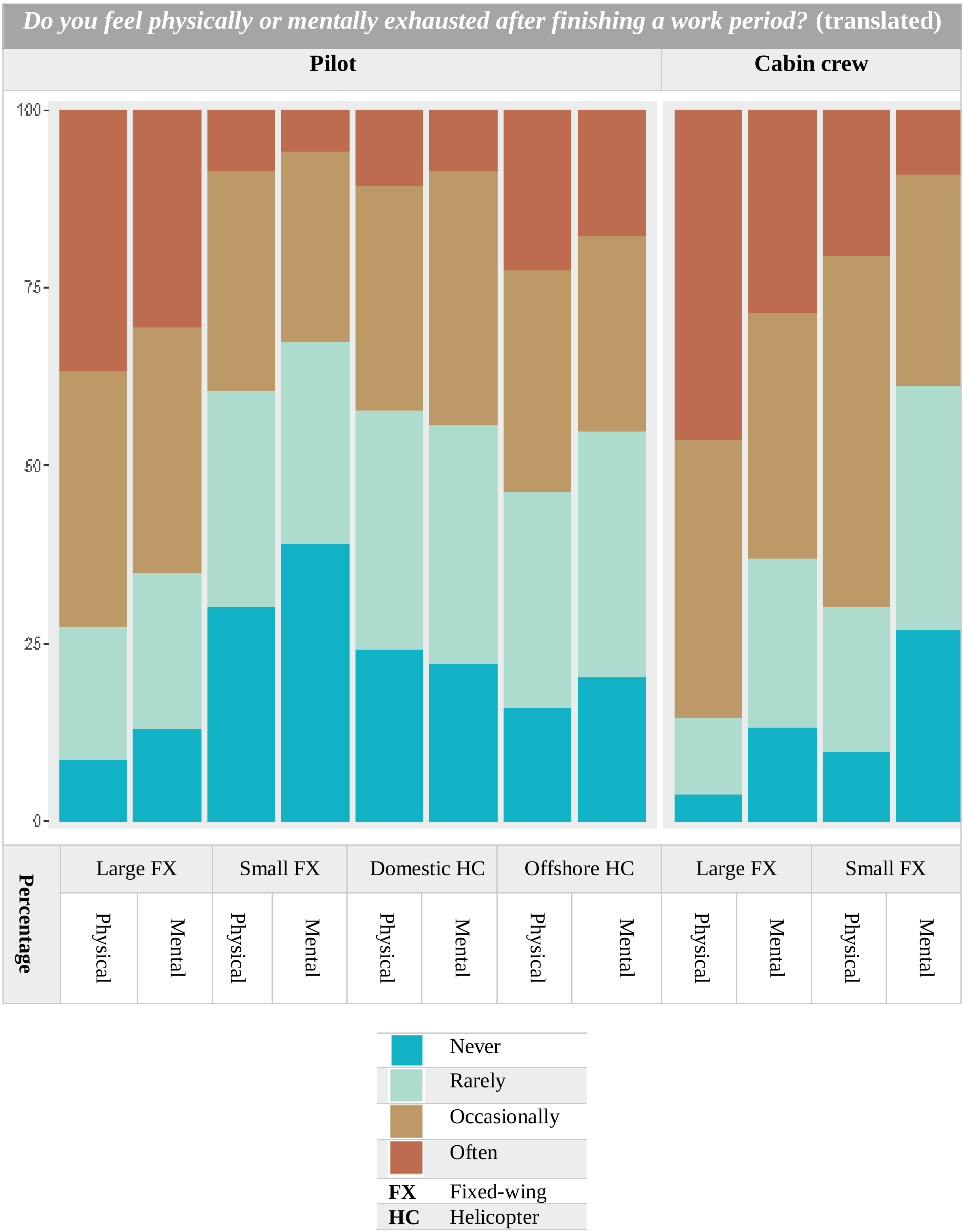
Only 19% of pilots and 12% of cabin crew in large FX airlines, responded that they get sufficient amounts of rest and relaxation between workdays (Table 1). This is similar to cabin crew in small FX, where only 13% state the same. In comparison, the national average in the Norwegian workforce is 71% stating that they get enough rest. Pilots in small FX, as well as pilots in domestic and offshore helicopter (HC) show quite similar numbers as the national average in Norway.

Table 1 - Sufficient amounts of rest between workdays, excluding sleep (Luftfartstilsynet, 2016a)

	Large FX		Small FX		Domestic HC	Offshore HC	Norway
	Pilot	Cabin crew	Pilot	Cabin crew	Pilot	Pilot	All professions
Rare or never	10%	15%	1%	5%	3%	2%	8%
A couple of times per month	20%	245	5%	24%	5%	25	4%
Approx. once per week	37%	36%	11%	40%	26%	25%	5%
A couple of times per week	15%	12%	7%	18%	6%	5%	13%
Daily	**19%**	**12%**	75%	**13%**	59%	66%	**71%**

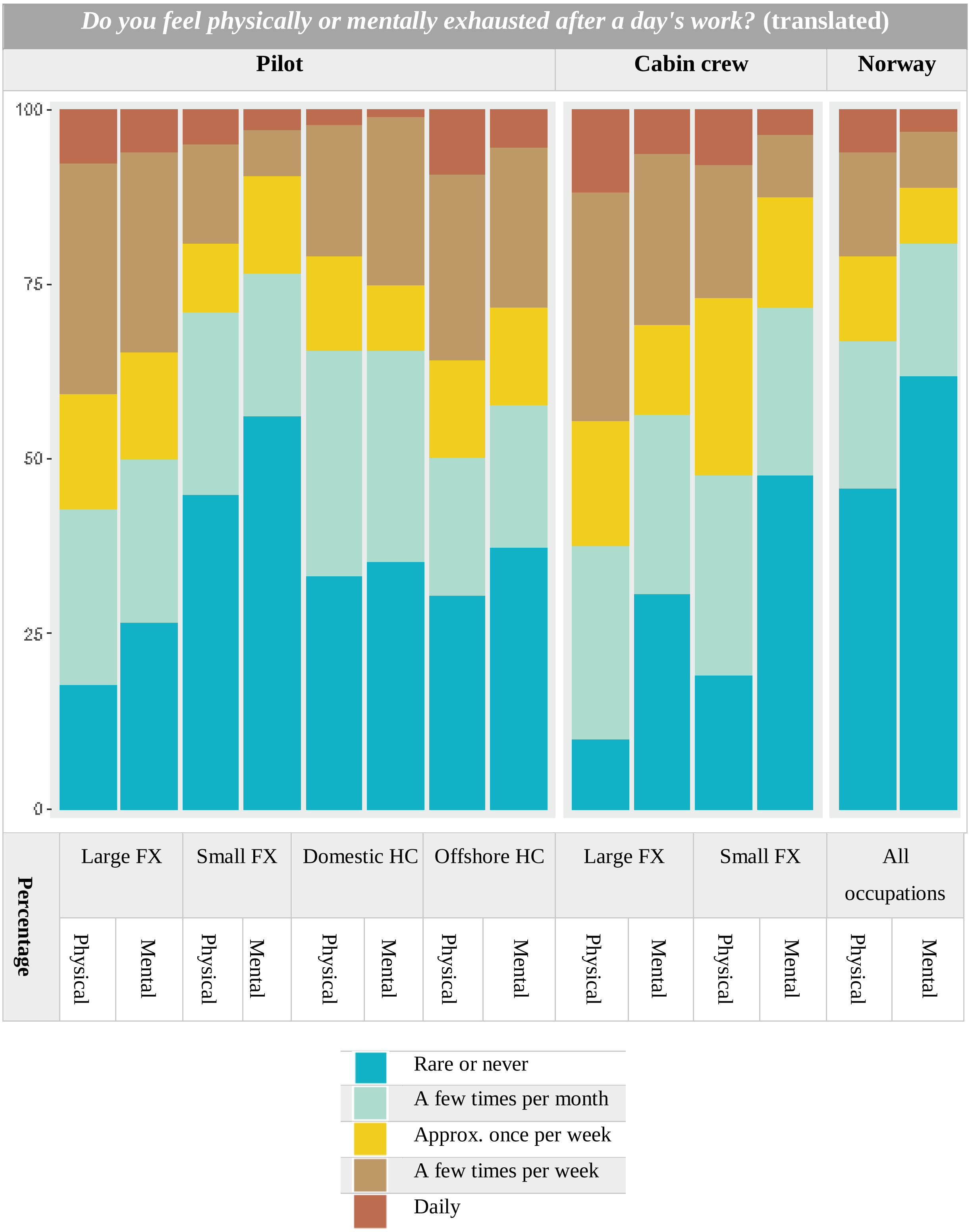
72% of pilots and 85% of cabin crew in large FX, feel physically exhausted after the completion of a work period (Table 2).

Table 2 - Physical/mental exhaustion after a work period (Luftfartstilsynet, 2016a)



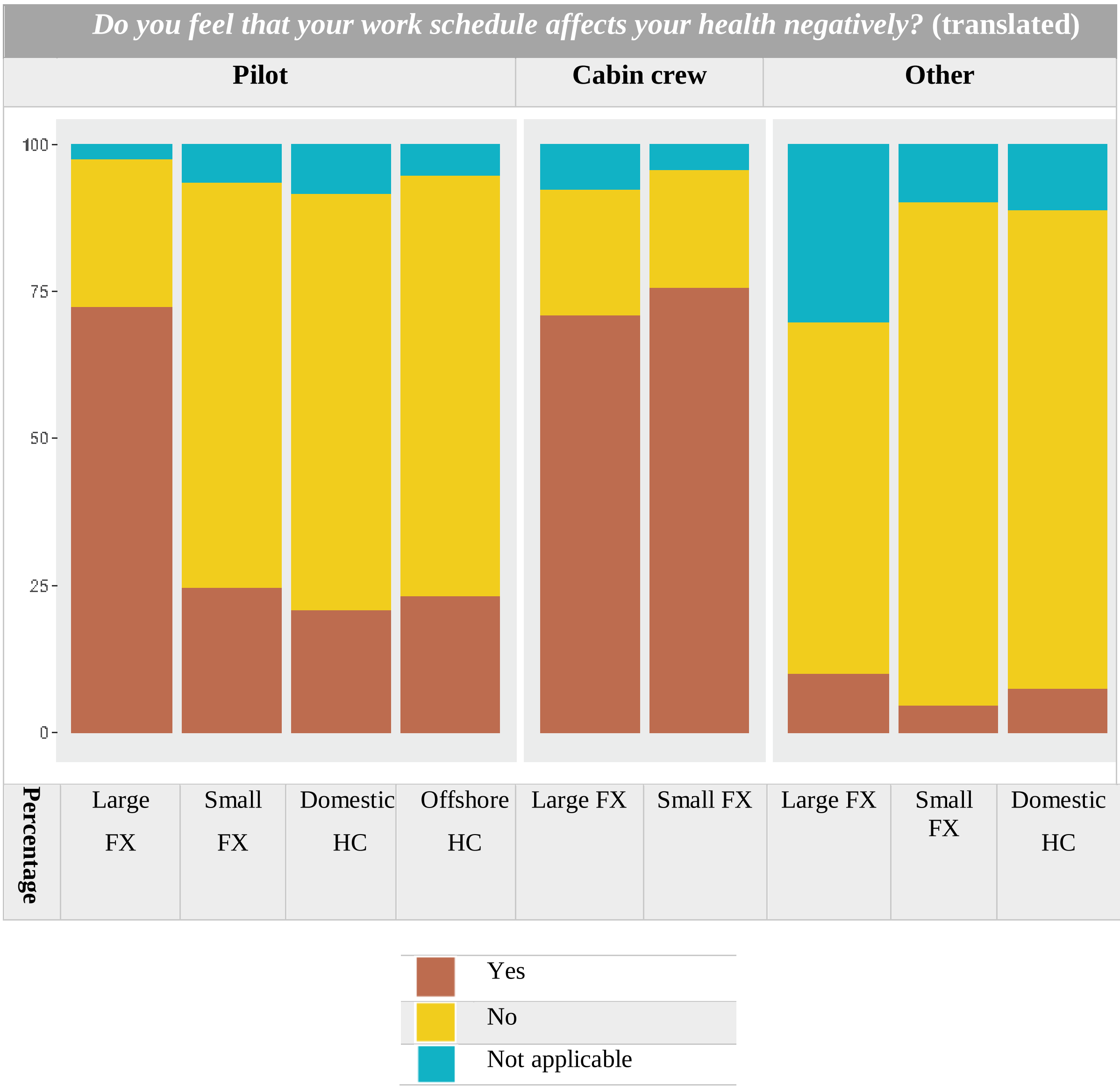
According to Table 3, 7% of pilots and 12% of cabin crew in large FX, feel physically exhausted after *each* work day. Table 3 also compares the physical and mental exhaustion in the aviation industry to the rest of the work force in Norway.

Table 3 - Physical/mental exhaustion after a day's work (Luftfartstilsynet, 2016a)



Among pilots and cabin crew in large FX airlines, nearly 75% state that their work schedule has a negative impact on their health (Table 4). The survey does not specify in more detail as to what types of negative effects this might be or what the respondents describe as negative health effects.

Table 4 - Experiences of the work schedule in relation to health (Luftfartstilsynet, 2016a)

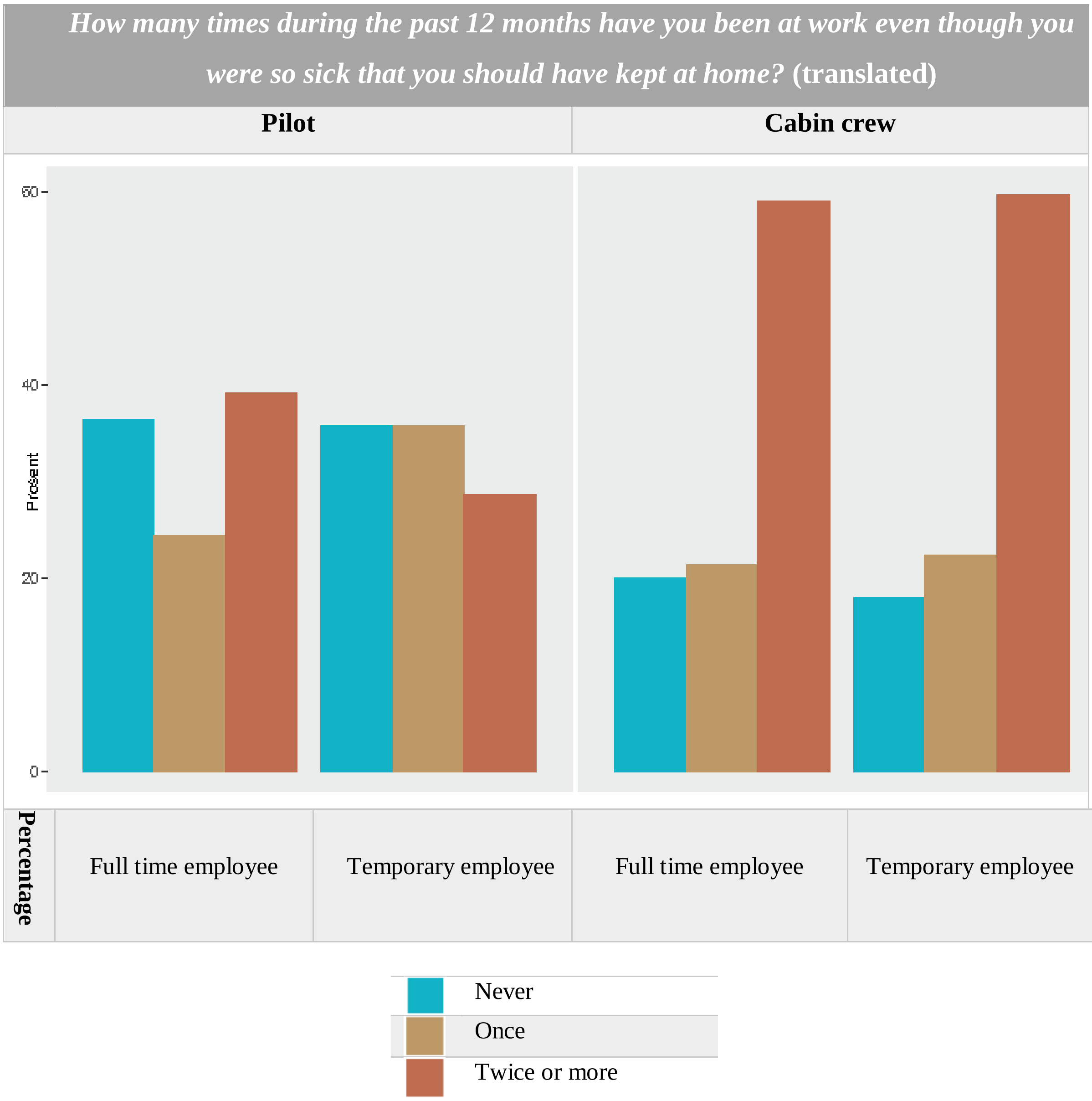


Physical health issues are experienced among pilots and cabin crew, and the most prominent is having sleeping disorders. 20% of pilots and 24% of cabin crew respond that they are fairly afflicted by this, while respectively 7% and 15% are severely afflicted. This can be a problem due to several factors such as shift work and irregular working hours within a work period. Moreover, crossing of time zones can give sleeping disorders to the individuals who operate such routes.

Crew members are obligated to report as unfit for flight in the cases where they are aware of being in a condition where their health reduced in such a way that deems them unsuitable for safe execution of normal tasks. However, Table 5 shows that there is a high reporting that both pilots and cabin crew went to work when they were so ill that they should have stayed at home.

As shown, more than 60% of pilots, and nearly 80% of cabin crew have gone to work once or more during the last 12 months, even though they should not. The survey did not issue follow-up questions explaining further what the background for these numbers are.

Table 5 - Incidence of going to work while sick (Luftfartstilsynet, 2016a)



15% of pilots respond that they to a small extent have time to perform work in a safe manner put in context to work-environment. Although this cannot be proven to be directly connected to fatigue, it gives an indication of the current trends regarding aviation safety in Norway. Conclusively, it is fair to state that fatigue is an issue that is definitely worth addressing. The importance of a flight crew being able to execute their job in a safe manner, while ensuring their own physical and psychological health is safeguarded, should not be questioned. The question is what can be done to improve or change the current conditions?

2.5 Summary

In this chapter, to give a better understanding of the underlying assumptions related to fatigue in aviation, significant aspects related to fatigue and important literature on the subject have been portrayed. Additionally, the current state of aviation safety in Europe, through looking at the FAR and AR from the *Annual Safety Review* by EASA (2016b), was shown and commented on. It was shown that the safety associated with flying has only become better both worldwide and in Europe during the last ten years. 64% of fatal accidents that happened in CAT during the last ten years were due to loss of control in flight; 45% of accidents were due to aircraft system failure; 27% happened because of ground collisions and ground handling. Consequently, the following rhetorical questions were asked: How can one be expected to cope with these situations if influenced by fatigue? Additionally, how can we be sure that fatigue did not contribute to several of these situations? These are some of the questions that are relevant while researching further on this subject.

Moreover, fatigue has become a growing concern for flight crews in Europe and Norway, as shown in the studies by ECA (2012), Reader et al. (2016) and Luftfartstilsynet (2016a). In Norway, only 19% of pilots and 12% of cabin crew in large FX airlines, responded that they get sufficient amounts of rest and relaxation between workdays. 7% of pilots and 12% of cabin crew in large FX airlines, feel physically exhausted after each work day, and 72% of pilots and 85% of cabin crew in large, feel physically exhausted after the completion of a work period. Nearly 75% state that their work schedule has a negative impact on their health. Further, physical health issues are also experienced among pilots and cabin crew; the most prominent is being affected by sleeping disorders: 20% of pilots and 24% of cabin crew respond that they are fairly afflicted by this type of disorder, while respectively 7% and 15% are severely afflicted. More than 60% of pilots, and nearly 80% of cabin crew have gone to work once or more during the last 12 months, even though they should not have done so because of their unfitness for duty (i.e. sickness, fatigue, etc.). These statistics will be interesting to get a deeper understanding of when performing the study outlined in the subsequent chapters. Why is the situation like this? As is also included in this thesis' research questions; What can be done to manage, or even prevent, the challenges associated with fatigue in Norwegian airline operators?

3 Theory

As mentioned in part 1.3, the following research questions are to be answered in this thesis:

1. *How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?*
2. *Which measures can be used to mitigate fatigue among pilots who work in large aviation companies in Norway?*
3. *Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?*

This chapter is mainly divided into four applicable parts. The first part will show relevant theory on the science of sleep, which includes the effects of fatigue and how to counter it on an individual level. The second part will give an overview of the legislators in Europe/Norway, and the current legislations that are in effect regarding flight and duty time limitations within this area of responsibility. Next, the third part shall introduce Fatigue Risk Management System (FRMS) and its implementation. This can be said to be a fatigue-countermeasure on both a company- and governmental level. The fourth part will review appropriate theory associated to safety management. Finally, main implications for the study are highlighted.

3.1 Overview of theory related to fatigue in aviation

Initially, a presentation of the more significant literature used in the first three parts of this chapter will be presented. Most of the information shown in these parts is taken from Tambala and Bolås (2016). The last part will introduce the literature used later in the chapter (subchapter 3.5).

There have been found numerous sources of information, but there are four that are used as the main source of information regarding aspects concerning the science of sleep in an aviation context in this thesis:

- *Safety at the sharp end: a guide to non-technical skills*, by Flin et al. (2008).
- *Human Performance & Limitations*, by Nordian (2010).
- *Fatigue Management Guide for Airline Operations*, by ICAO et al. (2015).
- *Fatigue in aviation: a guide to staying awake at the stick*, by Caldwell and Caldwell (2016).

Some of these sources have given origin to the discovery of new literature and information. The newer the source of information, the more relevant and reliable the information portrayed is believed to be. This is because a lot changes have happened in the aviation sector over the last years, thus newer information shows a more current state of the existing trends. If we look at the concentration of sources the last ten years, approximately 15 articles and books were found. However, many of these refer to information given in several sources which are more than ten years of age, but still contain acknowledgeable material. I.e. these sources have proven themselves as solid foundations for explaining fatigue, and helped in further development of the topic.

Generally, the sources contain the same information with regards to theory on fatigue – as is the case with specific theory on fatigue in aviation. It seems like most of the literature have a unanimous opinion of what the recognised facts are. A general representation of the salient aspect themes across different literature is shown in Table 6; as is also the literature used in the second part (subchapter 3.3) and the third part (subchapter 3.4) of this chapter.

Table 6 - Salient aspects under selected chapters with corresponding sources

Chapter	Salient aspect(s)	Sources
3.2 The science of sleep in an aviation context	Basic theory concerning sleep-science.	• Kleitman (1963) • Caldwell and Caldwell (2016) • Nordian (2010) • ICAO et al. (2015) • Van Someren (2011)
3.2.1 The stages of sleep	Stages of sleep, physiological and psychological effects of sleep.	• Flin et al. (2008) • ICAO et al. (2015) • Nordian (2010) • Caldwell and Caldwell (2016)
3.2.2 Shift work and jet lag: What are the effects of fatigue in the aviation sector?	Effects of shift work and jet lag, fatigue effects, design of work schedule.	• Flin et al. (2008) • Caldwell and Caldwell (2016) • Samel et al. (1995) • Nordian (2010) • Avers and Johnson (2011) • ICAO et al. (2015) • Petrilli et al. (2006) • Knauth and Hornberger (2003)
3.2.3 Fatigue countermeasures for flying personnel	Countermeasures to fatigue, rest breaks, napping, sleep inertia, diet.	• Caldwell and Caldwell (2016) • Anund et al. (2015) • Flin et al. (2008) • Hartzler (2014) • Naval Strike and Air Warfare Center (2000) • Nordian (2010)
3.3 EASA, the Norwegian CAA and current legislation	Information about EASA and the NCAA. Current regulations concerning flight and duty time limitations within EASA & Norway.	• Luftfartstilsynet (2017a) • Luftfartstilsynet (2017b) • EASA (2017) • CAA UK (2015) • Official Journal of the European Union (2014)
3.4 Managerial framework regarding fatigue	What is SMS, SSP and FRMS and how can it be implemented?	• ICAO et al. (2015) • Caldwell and Caldwell (2016) • Skatval (2015)

3.2 The science of sleep in an aviation context

This subchapter will present scientific results on fatigue that are relevant for understanding the basic underlying assumptions regarding the subject. What sleep is, why we become fatigued and how fatigue affects the human body, are examples of questions that will be answered here. Additionally, a presentation of scientific fatigue countermeasures will be given.

"Sleep is commonly looked upon as a periodic temporary cessation, or interruption, of the waking state, which is the prevalent mode of existence for the healthy human adult"

(Kleitman, 1963, p. 3)

The aspects behind sleep have been subject for research and experimental trials for several centuries. One of the most known and famous scientists on this area was Dr Nathaniel Kleitman, also known as the "father of modern sleep research". He was a psychologist and researcher, and made history of his research on human *circadian phases*, explained in the next paragraph. He also made the discovery of rapid eye movement (REM) sleep, which will be mentioned in the next subchapter (Wepman, 2000, *Kleitman, father of sleep research*, 1999).

Caldwell and Caldwell (2016) use a lot of Kleitman´s work in their book *Fatigue in Aviation*, where they mention the term, *circadian phases*. This can be defined as a process over a 24-hour day that naturally varies due to a human's internal mechanisms. This is also known as the biological or internal clock – which in turn affects the biological and psychological processes in our body like e.g.: alertness, hormone secretions, body temperature, amongst many other processes (Nordian, 2010).

For us humans – in order to generally feel good – these processes need to be synchronised, and there are several so called *(environmental) time cues* within the environment that help us with this. These time cues keep the phase of the normal human circadian clock aligned with the world around us, and provide our 24-hour day with a stabilised circadian phase, as well as the ability to feel good. The light-dark cycle is the most important environmental time cue. The light we get from the sun is the primary time cue, which in turn keeps the rhythms consistent and in synchrony with one another. Other time cues such as societal factors (e.g.: food, drink, activity at work, etc.) also help stabilise these internal processes (Van Someren, 2011, Caldwell and Caldwell, 2016). According to Nordian (2010) – as adults, we normally require 8 hours of sleep every 24 hours.

3.2.1 The stages of sleep

Flin et al. (2008), and ICAO et al. (2015) argue that during one typical night the cycles through an extended period of sleep, can be divided into five stages of different kinds of sleep, as shown in Figure 7. The first stage is the *transitional sleep* stage (between Wake and Stage 1 in Figure 7) which can last for five to ten minutes. Here we are in the transition between being awake and falling asleep, and we can also have some degree of awareness to the surroundings in our immediate environment. Light hallucinations and images can occur in this state of sleep, while we drift to and from consciousness. This is called *hypnogogia*. Moreover, this stage can sometimes be referred to as *micro-sleep*, which is like falling asleep for just a few seconds, and then waking up again.

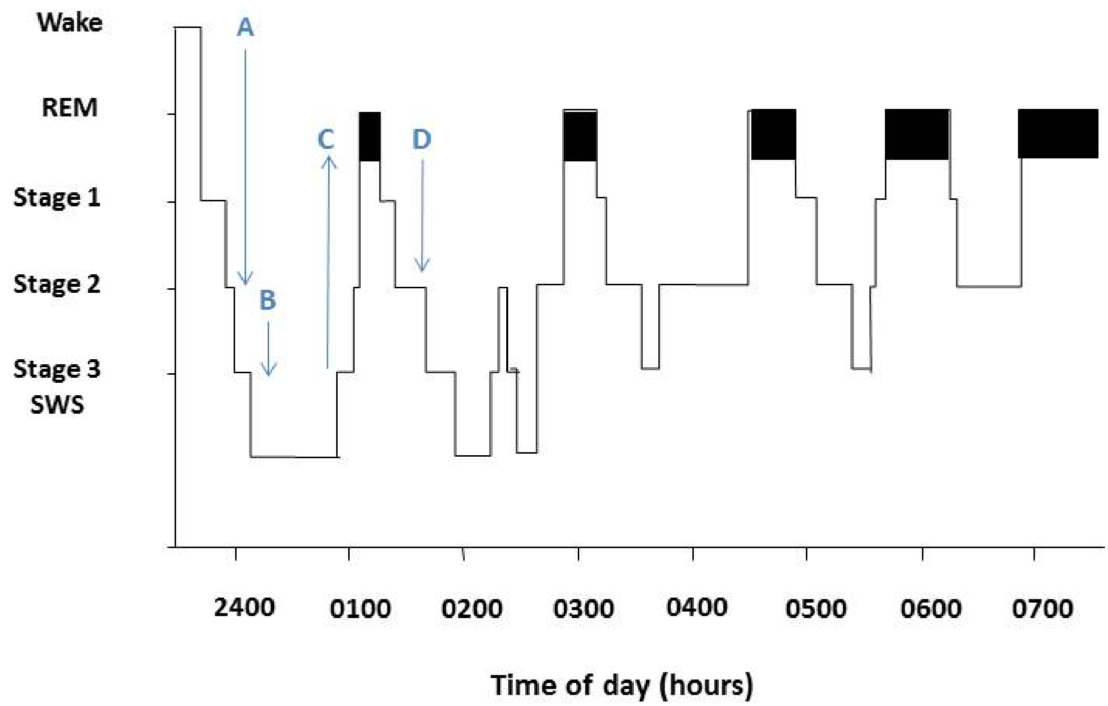


Figure 7 - Normal sleep cycle (ICAO et al., 2015)

In the second stage of sleep (Stage 2 in Figure 7), we get a small decrease body temperature combined with slower heart-rate and breathing – the brain waves also become slower. This stage is the state of *light sleep*, and lasts for about ten to twenty minutes. Stage three and four are the states where we are in *deep sleep*. They last for about thirty minutes, and cause restricted activity in the muscles of the body – additionally the brain generates slow delta waves. Furthermore, it would be difficult to wake up and get ready for work or other activities from these stages. It could take several minutes to be able to function properly after waking up from stage three and four. Nevertheless, some suggest that in case of any immediate emergency, the adrenaline produced in the body can be able to prevail over the negative effects of this so-called *sleep inertia* (Flin et al., 2008, Nordian, 2010, ICAO et al., 2015).

The last stage of sleep is where the muscles relax, the brainwaves speed up, so does the heart rate and breathing becomes more fast and shallow. This stage is called *rapid eye movement (REM) sleep,* and is characterised by rapid eye movements behind the closed eyelids (REM in Figure 7), as we start dreaming. There are various periods of this REM sleep during a night of normal sleep. The first period is quite short (five to ten minutes), but the periods become longer in duration as sleep continues (Flin et al., 2008, Nordian, 2010, ICAO et al., 2015).

We humans have generally been programmed to sleep at night when it is dark, and be awake when it is light outside. This is by far the most common way to describe our natural 24-hour cycle. Briefly explained, this happens physiologically because the light perceived via the retina in the eyes is transmitted to the brain's biological clock. The brain receives the light stimulation through optic nerves to regions in the brain that control behaviour. If we violate this rhythm in our internal clock by, for example, eating unhealthier food, drinking alcohol or staying awake during the night and sleeping more during the day, we will generally struggle to function normally or be able to feel good (Nordian, 2010, Caldwell and Caldwell, 2016).

The human body’s internal temperature varies with the circadian phase, as shown by the red line in Figure 8. During a typical day, our body will have its lowest temperature between around 02:00-06:00 and highest temperature between 18:00-22:00 – all local times to where a person is situated. As we can see, there is a steady increase in REM propensity (green dotted line) right before and after the temperature low point. Additionally, the *evening wake maintenance zone* is a period during which a person will feel most awake during the day. This is where our bodies have the highest core temperature. Thus, sleeping in this period of time will be quite difficult (Nordian, 2010, ICAO et al., 2015, Caldwell and Caldwell, 2016).

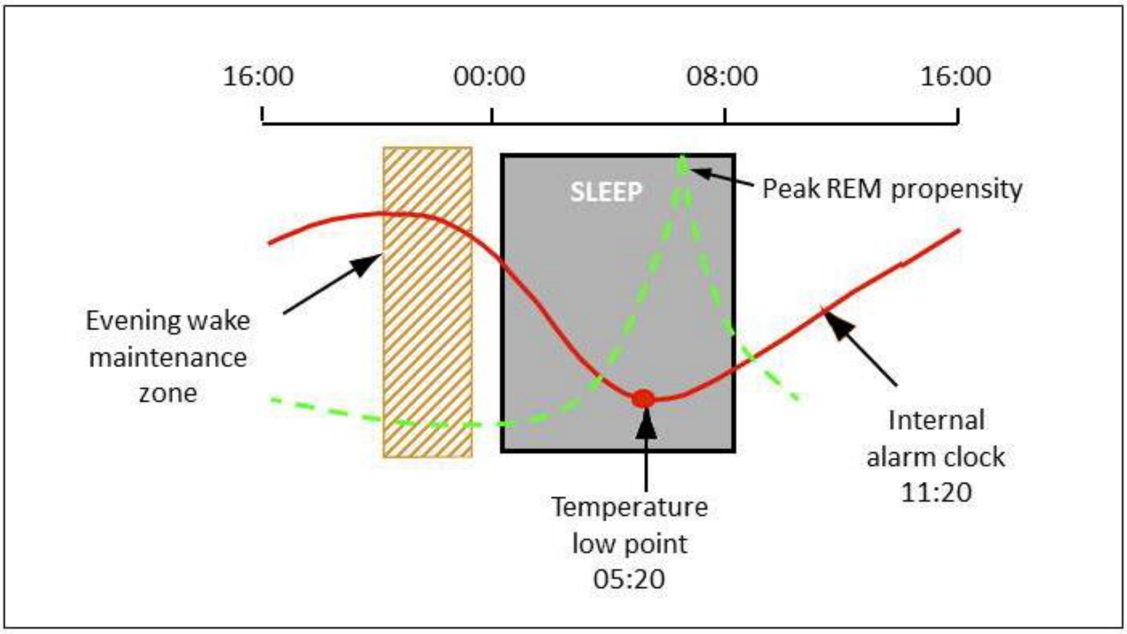


Figure 8 - Normal sleep cycle and the circadian body clock (ICAO et al., 2015)

The time in the circadian body clock cycle when fatigue and sleepiness are greatest and people are least able to do mental or physical work, is known as *the window of circadian low* (WOCL). The WOCL occurs around the time of the daily low point in core body temperature – as mentioned, usually around 02:00-06:00 when a person is fully adapted to the local time zone. However, there is individual variability in the exact timing of the WOCL (ICAO et al., 2015).

According to Caldwell and Caldwell (2016), disruption of the circadian phase, also called *circadian desynchronises*, has many different symptoms; sleepiness, confusion, lack of motivation, insomnia, digestive disorders and fatigue, to mention some of them. These symptoms occur because of the disagreement between what the body is told to do by the environment, and what the body is programmed to do genetically. Nowadays such disagreement can occur because of travel or because of shift work.

3.2.2 Shift work and jet lag: What are the effects of fatigue in the aviation sector?

The ability of people to cope with and adapt to shift work consists of individual differences. The same prevails for the individual's circadian phase. Some of us are naturally morning persons, and some are the opposite. Some will therefore be more suited than others to work night shifts and vice versa (Flin et al., 2008).

Shift work is part of the normal life in the aviation industry, and circadian disruptions is something that pilots encounter frequently. One of the ways this can be encountered, is according to Caldwell and Caldwell (2016), through crossing of multiple time zones. When this happens, the rhythms of the body and the time cues supplied from the environment becomes out of synchronisation – and the condition of *jet lag* becomes apparent. Technically this condition appears when the environmental time cues are at least three hours dissimilar from the circadian biological clock (Samel et al., 1995). For example, flying from London to Moscow involves a time difference of three hours in terms of when the sun rises, when the food is served, and when other activities are planned. Even if you set the watch for the new time zone, your body still believes you are on London time, even though the environmental time cues are telling you that everything is on Moscow time.

For long-haul pilots with transatlantic flights this can be a problem. Although the internal clock has the ability to readjust to the new time zone quite rapidly, the problem is that most pilots nowadays do not stay at their destination long enough to readjust, before flying to a new destination or back to the origin. Caldwell and Caldwell (2016) say that as a rule of thumb, the internal clock needs approximately 24 hours for each time zone travelled to readjust. This is also stated by Flin et al. (2008), Nordian (2010), Avers and Johnson (2011) and ICAO et al. (2015). In other words, there is a wide consensus on most of the theory related to shift work and jet lag, but also on other matters related to fatigue. Transatlantic flights can contribute to acute fatigue among the flight crew, and the abilities to stay awake and to maintain a high level of alertness in the cockpit, can be greatly reduced. It does not help that the physical activity among the pilots is quite restricted for the whole period of the flight. Furthermore, there are not many things that stimulates the body or mind in a positive manner, with regards to the automation systems in the cockpit.

Factors such as stress, lack of sleep, noisy environment from the cockpit and long hours of work are some of the clear causes of fatigue. You are also more likely to be fatigued if the task you are dealing with is boring. According to Flin et al. (2008) and Caldwell et al. (2009), there are also several effects of fatigue; including lack of cognitive skills such as flexible decision-making, being less able to take new information into consideration, and reduced ability to cope with unpredicted rapid changes. Other effects can be poorer coordination and manual flying skills, difficulties in communication, as well as becoming more introverted and more prone to being irritable and distracted. Nordian (2010) similarly states that symptoms of fatigue can include tiredness, slow reactions, diminished motor skills and vision, short-term memory problems and channelled concentration. Furthermore, these symptoms can lead to effects such as reduced awareness, easier distraction, increased mistakes, abnormal mood swings and a general poorer ability to fly an aircraft.

A study by Petrilli et al. (2006) was performed on long-haul flight crews´ capability to perform decision-making tasks after a transatlantic flight, compared with rested crews. They found that fatigued crews were more probable to avoid risky options than rested crews, and that those who were fatigued made more conservative decisions and wanted to stay more in their "comfort zone" e.g. by diverting to another destination rather than continuing to a risky one. The results from this study also concluded that the time to make decisions took 34-42% longer with fatigued crews compared with rested crews.

"From an operational perspective, taking longer to make decisions may compromise flight safety as it can lead to greater time pressures at later stages of flight, particularly during the high-workload stages of descent, approach, and landing." (Petrilli et al., 2006, p. 7)

Working shift can therefore be a huge challenge for pilots. Whether it's for short haul-, long haul-, or night operations, the duration and the type of operation plays a role in potentially causing fatigue for the pilots. As does the time off between the shifts, and the amount and quality of sleep before starting the next shift. Knauth and Hornberger (2003) state that it is better to start as late as practicable on the morning shift, to get the as much sleep as possible – even if it is just for an extra hour. The evening shift should end as early as possible, and even earlier in the weekends to get more social contact and togetherness with family etc. This also maximises the amount of sleep. Further, the night shift should also end as early as possible, so that the opportunity for sleeping during some hours of the night is possible.

ICAO et al. (2015, p. xii) state the following about the circadian body clock, shift work and jet lag:

"The circadian body clock is a neural pacemaker in the brain that monitors the day/night cycle (via a special light input pathway from the eyes) and determines our preference for sleeping at night. Shift work is problematic because it requires a shift in the sleep/wake pattern that is resisted by the circadian body clock, which remains 'locked on' to the day/night cycle. Jet lag is problematic because it involves a sudden shift in the day/night cycle to which the circadian body clock will eventually adapt, given enough time in the new time zone."

Knauth and Hornberger (2003) say that timing shifts is difficult, and that there is no best way of doing it. Whether one shift period gets optimised, it will always affect other shifts negatively. One important aspect regarding shift planning and the design of the best possible arrangement, is to find a compromise between the company's goals and the pilot's desire. Every large organisational change may give rise to scepticism, doubts, fear or even resistance in everyone concerned, i.e. the workers, workers' representatives and management. Therefore, the implementation strategy of a new shift system is as important for its acceptance as the new model itself.

3.2.3 Fatigue countermeasures for flying personnel

"Extended duty times (work shifts that exceed eight hours) are already common in aviation, and increased demands on both civilian and military pilots will no doubt require additional work hours in the future." (Caldwell and Caldwell, 2016, p. 8)

There are many techniques from scientific research which can help both individuals and entire organisations to cope with fatigue. Like e.g. introducing a *bio-mathematical model*. This is an example of a system designed to predict aspects of a schedule that might generate an increased fatigue risk for the average person, based on scientific research (ICAO et al., 2015, Dawson et al., 2017).

Most of the recommendations given below are personal countermeasures, i.e. performed by a pilot or cabin crew. Some of these may be obvious and self-explanatory, but they can still be useful tools that are important coping in the daily life. *Education* is one of the most important countermeasures (Anund et al., 2015). Flin et al. (2008) states the importance of the managers and leadership in the blunt end of an organisation educating themselves on how fatigue can be a result of shift work. It can be difficult for the people working in the blunt end – who often have little experience with shift work - having a good understanding of the consequences associated with this type of work. Especially regarding shift work causing poorer performance, sleep deprivation, disruptions in the circadian phase and lack of concentration and alertness.

Further, Flin et al. (2008) mention *sleep hygiene* as an important fatigue countermeasure to improve both sleep length and quality. It is also important to be aware of the significance of going to bed without consuming caffeine, alcohol and heavy meals, as well as avoiding too heavy exercise. One should instead try to relax a bit before going to sleep and keep the bedroom dark, cool and quiet during the hours whilst sleeping.

Rest breaks is also one of the countermeasures. Even if it is a 10-minute break, it can give positive effects in terms of less influence of fatigue – at least if you can move around talking with other colleagues instead of sitting. It is not just an effective instrument for reducing the effects of fatigue, but also an instrument to counteract boredom, which in turn can be a contributing factor to fatigue itself (Flin et al., 2008).

The recommendation of a 10-minute rest break, also applies for 10 minutes of *napping*. Short naps can improve performance significantly, and is a well discussed countermeasure for preventing fatigue. Samel et al. (1995), Driskell and Mullen (2005), Hartzler (2014) and Caldwell and Caldwell (2016) are some who are in agreement on this. Moreover, Naval Strike and Air Warfare Center (2000, p. 4) states that:

> *"(…) naps of 10 minutes or more will help maintain alertness and job performance. There is some risk from "sleep inertia" lasting about 5 minutes after awakening characterized by confusion, sluggishness and incoordination."*

According to Caldwell and Caldwell (2016), sleep inertia should be taken into account, especially by pilots working in the sharp end. They emphasise the importance of not performing any safety-critical tasks right away upon waking up from a nap, and underline that 10 minutes of napping is *better than nothing*. However, they mainly recommend that the naps should be as long as possible; between a period of 40 minutes up to two hours.

A balanced *diet* is also recommended as a countermeasure in fatigue management. People who are working shift in general should avoid heavy meals and alcohol before going to bed. Alcohol can make you feel more relaxed and leads to tiredness, but the chances of being dehydrated and getting a headache the next morning are present – which in itself can lead to fatigue. Regarding the meals, it is important to be aware that the digestion is at its lowest at night. The use of caffeine can be advantageous as a fatigue countermeasure, but the ones who are best equipped to exploit this advantage, are those who do not normally consume caffeine daily (Flin et al., 2008).

Nordian (2010) suggest the following strategies for delaying or preventing fatigue by flight crew members:

- Establishing habits for a daily routine.
- Staying fit by exercising regularly.
- Eating regular healthy meals.
- Avoiding frequent use of alcohol.
- Ensuring control of emotional and psychological life.

- Warranting preparedness for flights by planning properly.
- Ensuring comfort in the flight deck by, e.g.; sitting properly, having access to water, restricting noise, etc.

Exposure to *bright light* can also be a fatigue countermeasure. In this case, it is probably most important for those working night shifts. They should avoid bright light in the morning for better adaptation to their circadian phase after a night shift, and can expose themselves to artificial bright light before starting a shift. The body will be better synchronised to the night shift by doing this. Moreover, the opposite is true for those going from night shift to day shift. Then, it is important to be exposed to bright light in the morning, and to avoid light exposure at night (Flin et al., 2008).

In a study by Anund et al. (2015), a workshop in Stockholm with a total of 23 participants were asked to identify promising measures for coping with fatigue. Here are the results based on their proposals (not in order):

- Influence on the schedule.
- Sleep opportunity.
- *Just culture*.
- Education.
- Napping.
- Caffeine.
- Team monitoring.
- FRMS.

There are a lot of similarities to the previously stated measures, but these are mainly directed towards the individual interacting with the airline he/she is working for. According to Dekker (2012), just culture can be said to be a culture in which front line operators and others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but where gross negligence, wilful violations and destructive acts are not tolerated.

3.3 EASA, the Norwegian CAA and current legislation

The European Aviation Safety Agency (EASA) is an EU agency established in October 2002, located in Cologne, Germany. EASA has overall supervision and responsibility of the European Union (EU) and the European Economic Area (EEA) when it comes to matters concerning aviation legislation. Some of the tasks performed by EASA are e.g.: regulatory development, supervision of member states, certifications and flight safety analyses. The EU's aim with EASA is to ensure a high, uniform level of aviation safety in Europe. EASA shall also contribute to equal competitive conditions and economic savings for the aviation industry

(Luftfartstilsynet, 2017a). Figure 9 shows the organisational structure of EASA. There are several departments that can be highlighted when it comes to working with fatigue, but the Strategy & Safety Management Directorate and Flight Standards directorate – under Air Operations and Aircrew & Medical – are worth mentioning.

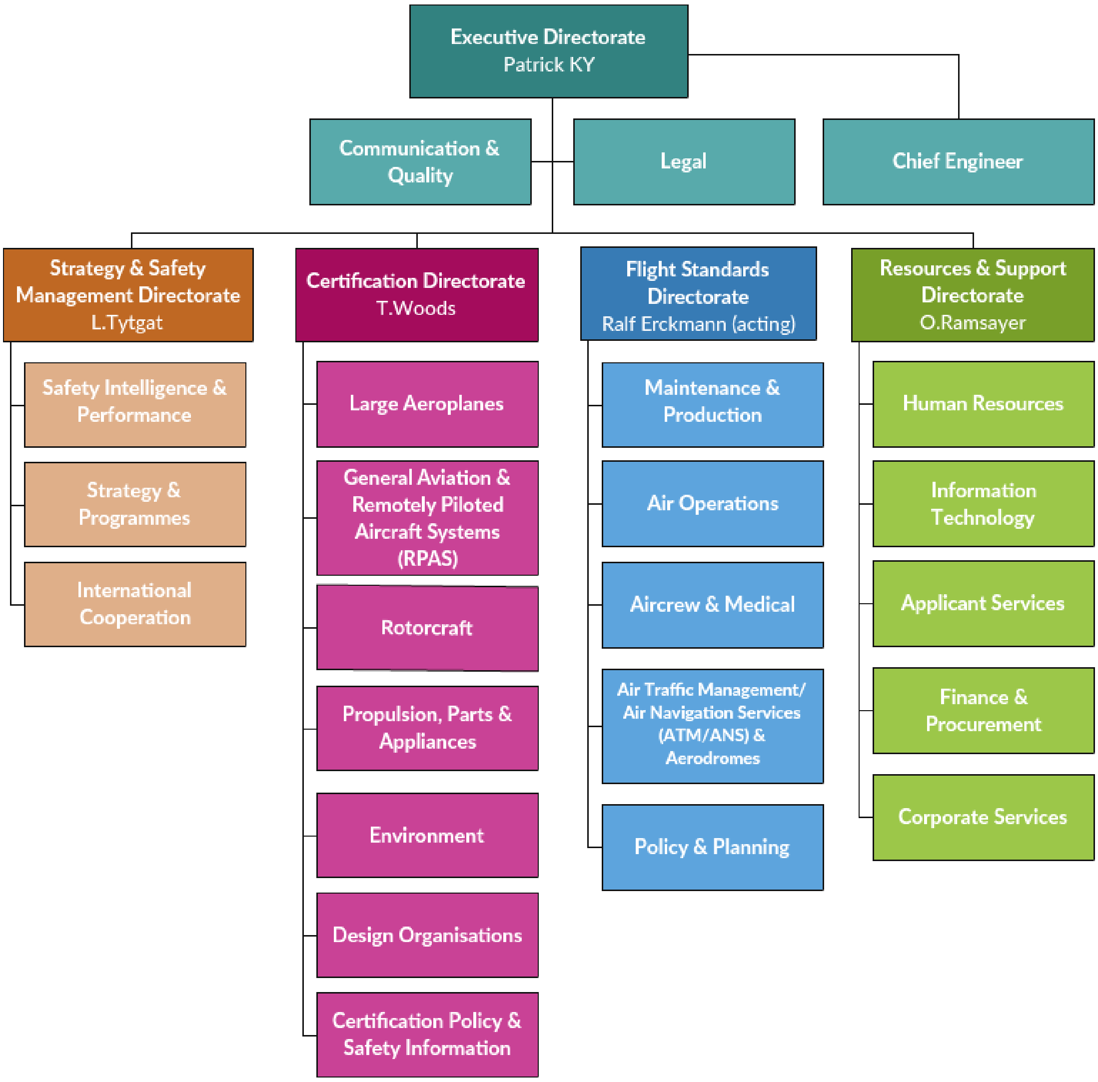


Figure 9 - EASA's organisational structure (EASA, 2017)

The EU's European Commission executes the EASA regulations and take these into legislation. Norway has been a member since 1 June, 2005 and is committed through the EEA to introduce and apply regulations to continuously replace corresponding Provisions for Civil Aviation (so-called BSL's). Membership implies that the Norwegian authorities (i.e. the Ministry of Transport and the Civil Aviation Authority) participates in meetings of the EASA committee, and has the right to speak, but not to vote. Thus, the Norwegian Civil Aviation Authority (NCAA) is no longer free to preapprove rules established by EASA. EASA has also received the right to impose fines on Norwegian citizens and businesses, and are given greater responsibility in certain fields (Luftfartstilsynet, 2017a, Skatval, 2015).

The NCAA is an independent government agency with headquarters in Bodø, Norway, authorised by the Norwegian Ministry of Transport to adopt and adapt national and international regulations. The agency's main task is to contribute to increased safety in all Norwegian civil aviation. This also implies a need to supervise that all stakeholders follow valid laws, rules and regulations. Here, stakeholders mean e.g. airlines, pilots, maintenance staff and airports. The NCAA is divided into different sections (see Figure 10). Both notified and unannounced audits/inspections are carried out by inspectors from these sections. Also, here there are several departments working with fatigue, but the Strategy department – under Safety Management and Human Factors – and the Professional Competence department – under Human Performance and Training and Flight Operations – are the ones who can be highlighted when it comes to this work.

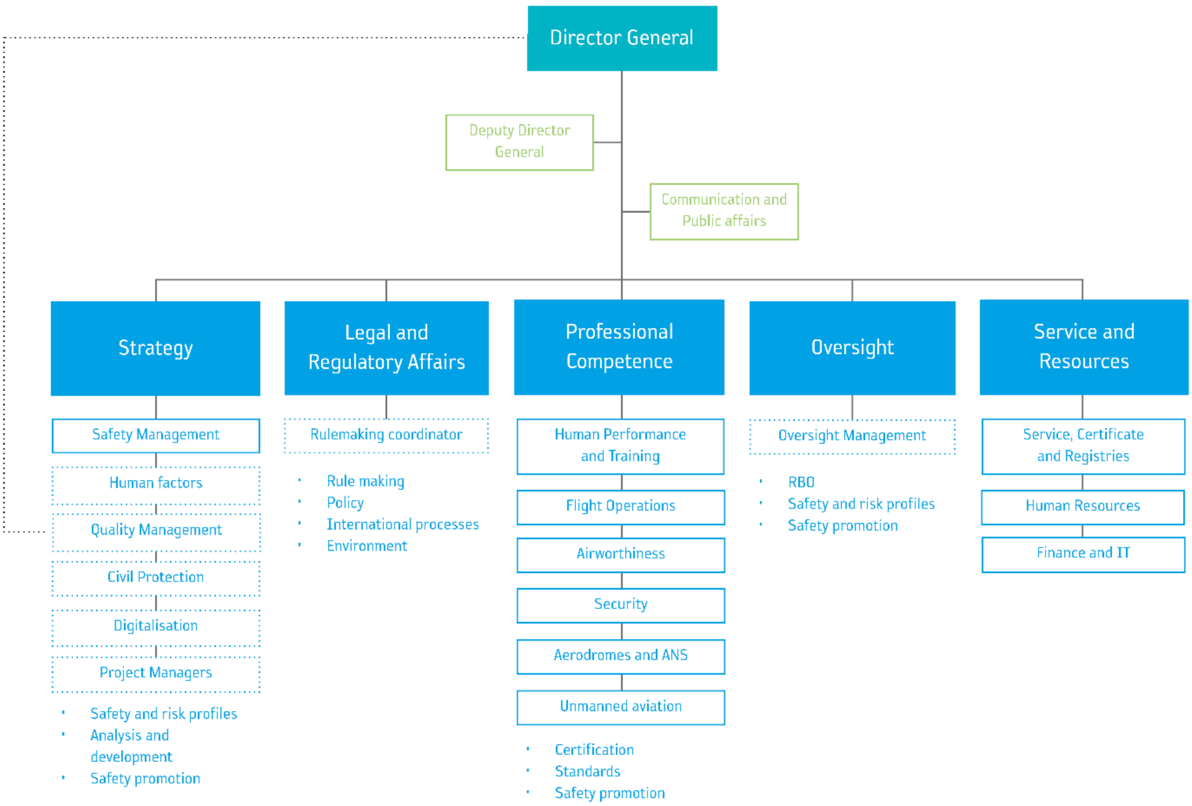


Figure 10 - Organisational structure of the NCAA (Luftfartstilsynet, 2017b)

3.3.1 EASA regulations

The following subchapter will give an overview of legislation within EASA – enforced by the NCAA in Norway and the Civil Aviation Authority in the United Kingdom (CAA UK) regarding flight and duty time limitations. To limit the amount and complexity of the legislation, not all information provided from the different sources is included. The idea is that key information described in the regulations should be summarised. CAA UK is included because it's text is easier to interpret. Resultantly, the following sources have been used here:

- *Commission Regulation (EU) No 83/2014*, published by Official Journal of the European Union (2014).
- *EASA FTL Regulations – Combined Document*, published by CAA UK (2015).

The legislation portrayed here is applicable to commercial air transport by aeroplanes for scheduled and charter operations, thereby excluding emergency medical service (EMS), air taxi (aeroplanes of 19 seats or less), helicopter operations and single pilot operations. It can also be mentioned that the legislation can be different in an individual company – seeing as they can establish their own operational regulations, as long as they are equal to or better than the legislated requirements (ref. subchapter 3.4.2: Fatigue Risk Management System)

The official EASA regulation published in Official Journal of the European Union (2014), state that there are a number of duty and flight time limitations (FTL) that need to be adhered to over the course of everything from a single day up to an entire year. The total *flight duty period* (FDP) to which a crew member may be assigned shall not exceed:

1. 60 duty hours in any 7 consecutive days;
2. 110 duty hours in any 14 consecutive days; and
3. 190 duty hours in any 28 consecutive days,

The duty periods shall also be spread as evenly as practicable throughout that period. A duty period is to be understood as a period which starts when a crew member is required by an operator to report for or to commence a duty, and ends when that person is free of all duties. Post-flight duty shall also count as duty period. The airline operator (e.g. SAS, NAS/NAI, Widerøe) shall specify in its operations manual the minimum time period for post-flight duties (Official Journal of the European Union, 2014).

The total *flight time limitation* (FTL) of the sectors on which an individual crew member is assigned as an operating crew member shall not exceed:

1. 100 hours of flight time in any 28 consecutive days;
2. 900 hours of flight time in any calendar year; and
3. 1 000 hours of flight time in any 12 consecutive calendar months.

Next, it is important to define the term *acclimatised*. This is described by the Civil Aviation Authority in the United Kingdom (CAA UK, 2015, Official Journal of the European Union, 2014) as a state in which a crew member's circadian phase is synchronised to the time zone where the crew member is. A crew member is considered to be acclimatised to a 2-hour wide time zone surrounding the local time at the point of departure. When the local time at the place where a duty commences differs by more than 2 hours from the local time at the place where the next duty starts, the crew member, for the calculation of the maximum daily flight duty period, is considered to be acclimatised in accordance with the values in Table 7 .

Table 7 - Acclimatisation table (CAA UK, 2015)

Time difference (h) between reference time and local time where a crew member starts the next duty	**Time elapsed since reporting at reference time**				
	< 48	***48 – 71:59***	***72 – 95:59***	***96 – 119:59***	***≥ 120***
< 4	B	D	D	D	D
≥ 4 and ≤ 6	B	X	D	D	D
> 6 and ≤ 9	B	X	X	D	D
> 9 and ≤ 12	B	X	X	X	D

In Table 7, "B" means acclimatised to the local time of the departure time zone, "D" means acclimatised to the local time where the crew member starts his/her next duty, and "X" means that a crew member is in an unknown state of acclimatisation. The degree of acclimatisation has a significant impact on the maximum allowable FDP for flight crew members. As shown in Table 8, the start of the FDP also has an impact; as well as how many sectors the individual is scheduled to fly that specific day. Additionally, Table 8 shows the maximum daily allowable FDP without any extensions in duty period factored in.

Table 8 - Maximum daily FDP (CAA UK, 2015)

Start of FDP	**1-2 Sectors**	**3 Sectors**	**4 Sectors**	**5 Sectors**	**6 Sectors**	**7 Sectors**	**8 Sectors**	**9 Sectors**	**10 Sectors**
0600–1329	13:00	12:30	12:00	11:30	11:00	10:30	10:00	09:30	09:00
1330–1359	12:45	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00
1400–1429	12:30	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00
1430–1459	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00	09:00
1500–1529	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00	09:00
1530–1559	11:45	11:15	10:45	10:15	09:45	09:15	09:00	09:00	09:00
1600–1629	11:30	11:00	10:30	10:00	09:30	09:00	09:00	09:00	09:00
1630–1659	11:15	10:45	10:15	09:45	09:15	09:00	09:00	09:00	09:00
1700–0459	11:00	10:30	10:00	09:30	09:00	09:00	09:00	09:00	09:00
0500–0514	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00	09:00
0515–0529	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00	09:00
0530–0544	12:30	12:00	11:30	11:00	10:30	10:00	09:30	09:00	09:00
0545–0559	12:45	12:15	11:45	11:15	10:45	10:15	09:45	09:15	09:00

The maximum FDP is lower the more sectors a crew member is scheduled to fly. Moreover, the duty periods are shorter if you are required to start a shift later in the day; i.e. at night versus early in the morning.

In the event where a crew member is in an unknown state of acclimatisation as given by Table 7, the maximum daily FDP is limited to what is shown in Table 9.

Table 9 - Maximum FDP with unknown state of acclimatisation (CAA UK, 2015)

Maximum daily FDP according to sectors						
1–2	***3***	***4***	***5***	***6***	***7***	***8***
11:00	10:30	10:00	09:30	09:00	09:00	09:00

CAA UK (2015) state that the maximum daily FDP can be extended if there are some in-flight rest opportunities available. This must, however, take into account the individual crew members' minimum assigned in-flight rest, the actual type of in-flight rest facilities, the number of sectors flown (given in Table 8 and Table 9), as well as the augmentation of the basic flight crew.

The term *augmented flight crew* is defined as a flight crew which consists of more crew members than what is required to operate the aircraft, which in turn allows each flight crew member to be able to leave his/her post for in-flight rest, and to be replaced by another qualified flight crew member. Further, *unaugmented flight crew* means a flight crew that has exactly the minimum number of crew members required by the airplane type-certificate to operate the aircraft (CAA UK, 2015).

In case of any unforeseen circumstances in flight operations, the rule of the commander's (captain/pilot in command) discretion applies. The commander can modify the FDP and/or rest period, but must comply with the basic maximum daily FDP as shown in Table 8, and the extension of the FDP due to in-flight rest opportunities, as mentioned above. Nevertheless, this extension of FDP cannot be increased by more than 2 hours. However, if the flight crew has been augmented, it can be increased by a maximum of 3 hours. With regards to the rest period, it can be reduced. But it cannot be less than 10 hours due to unforeseen circumstances. These rules also specify that the commander shall consult the crew members on their level of alertness before making the decision to exceed the FDP. This also applies if the unforeseen circumstances could lead to severe fatigue, where the commander should reduce the FDP and/or increase the period of rest to counteract the adverse effects on flight safety. If the commander has decided to reduce the FDP and/or increase the rest period, the commander shall correspondingly send a report to the operator. If the legislated duty or flight period is exceeded by more than 1 hour, the operator shall additionally send a copy of the report to the competent authority within 28 days after the occurrence (CAA UK, 2015).

With regards to minimum rest periods, CAA UK (2015) state that when a crew is operating from their home base, the crew shall have a minimum rest period equal to the length of the previous FDP, or 12 hours, whichever is greater. Therefore, a duty period of 14 hours will require a subsequent rest period of 14 hours. When crews are away from their home base, and the operator can provide *suitable accommodation*, the crew shall have a minimum of the same time period as the previous FDP, or 10 hours, whichever is greater – 8 hours shall be devoted to the sleep period itself. Thus, more than 10 hours of duty will require an extended rest period. Suitable accommodation is defined as an individual room for each flight crew member which is situated in a silent, ventilated environment with possibilities for regulating temperature and light brightness, as well as a bed and access to drink and food.

CAA UK (2015, p. 47) state the following regarding recurrent extended recovery rest periods:

"Flight time specification schemes shall specify recurrent extended recovery rest periods to compensate for cumulative fatigue. The minimum recurrent extended recovery rest period shall be 36 hours, including 2 local nights, and in any case the time between the end of one recurrent extended recovery rest period and the start of the next extended recovery rest period shall not be more than 168 hours. The recurrent extended recovery rest period shall be increased to 2 local days twice every month."

3.4 Managerial framework regarding fatigue

Many of the sources included in this subchapter state that a new era of fatigue prevention in the aviation sector is the way forward. The point is that the regulators within the aviation industry need to change to meet the fast pace of changes happening at both a company/management-level, as well as in the sharp end at the bottom of the company. Gander et al. (2011) are among those who mean that the Fatigue Risk Management System (FRMS) approach is the way forward. Figure 11 shows the advantages for all stakeholders involved in implementing this approach. It starts with what is the current situation; "Full compliance with HoS limits", where HoS limits is to be understood as limits in prescribed working hours, such as the FDPs and FTLs. The next stage is developing a "template FRMS toolkit" in a collaboration between regulator and the airline industry. Over time each airline company should have their own system which is suitable, unique and flexible to their specific operations.

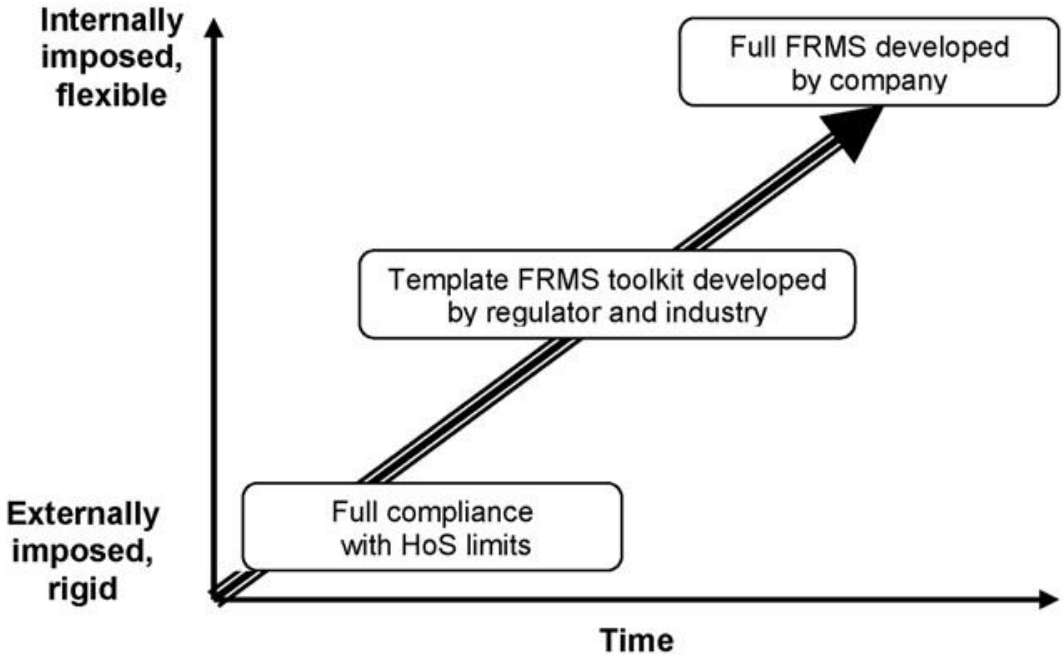


Figure 11 - A hybrid regulatory model for an FRMS (Gander et al., 2011)

Here are some which state that incorporation of FRMS as a tool is the way forward: Caldwell and Caldwell (2016), Avers and Johnson (2011), Signal et al. (2006), Ingre et al. (2014), Anund et al. (2015), etc. Additionally, several non-governmental organisations like e.g.; ICAO, IATA, IFALPA and ECA also believe that an FRMS should be the approach to counteract fatigue among flight crew in the future. Consequently, three aviation regulators: in Europe, the U.S. and Australia, respectively EASA (European Aviation Safety Agency), FAA (Federal Aviation Authority) and CASA (Civil Aviation Safety Authority), have already begun implementing regulations regarding applying an FRMS in an airline company. Companies must adhere to these rules to get their FRMS approved by the relevant authority in their country of origin.

3.4.1 Safety management system and State Safety Program

Before elaborating in more detail on FRMS, the aspects of a Safety Management System (SMS), needs to be explained. SMS is a concept that has become a standard in the aviation sector all over the world. The SMS is acknowledged by the Joint Planning and Development Office (JPDO), Civil Aviation Authorities in the United Kingdom (CAA UK), ICAO, and other service providers as an important aspect in the development of aviation safety. Working with a Safety Management System is an organised way of managing safety – taking into consideration organisational structures, responsibilities, procedures and policies. All service providers such as the approved training organisations (ATO), the pilots in each airline and other stakeholders, are responsible for establishing this system as per ICAO requirements, and should also be accepted and supervised by their respective country (FAA, 2016, IATA, 2016b).

The main intention of the SMS is that the service providers work with this framework through audits – among other things – to identify safety hazards. This is to ensure that remedial actions necessary to maintain an acceptable level of safety is implemented, and aim to make continuous improvement to the overall level of safety (IATA, 2016b). An example of an SMS can be seen in subchapter 3.5.3: Safety management as a control problem (cf. Figure 16).

The NCAA is in the process of establishing a Norwegian aviation safety program – a program involving several structural elements. With some similarities to the SMS, a State Safety Program (SSP) is defined as an integrated system of rules and measures aimed at improving aviation safety in a country. It includes specific safety measures that must be implemented by each country's authorities; as well as regulations and directives promulgated by state authorities in order to support and complete its responsibilities in connection with a safe and effective delivery of aviation activities in that country. It is important to implement a SSP in conjunction with the introduction of a SMS in the aviation industry (Luftfartstilsynet, 2016b, Skatval, 2015).

3.4.2 Fatigue Risk Management System

A Fatigue Risk Management System has been introduced in the aviation industry for the past years, and is still evolving. ICAO et al. (2015, p. 47) define an 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."

The concept of an "*effective safety reporting culture*" is something that both the SMS and the FRMS are relying on. The meaning of this is that all personnel in the airline have been trained in reporting and are encouraged to report incidents and hazards when they are noticed in the operating surroundings – for whatever the type of event (i.e. just culture). To be able to encourage for reporting of hazards linked to fatigue, and to involve all personnel in an FRMS, an airline must with clarity differentiate between unintentional human errors, and intentional violations of rules and procedures – so-called "gross negligence" (ICAO et al., 2015).

Furthermore, ICAO et al. (2015) describe that fatigue management has to be a shared responsibility between the three stakeholders in this setting – regulators, the airline and crew members. The regulator must provide a framework and to ensure that the airlines can manage the risks related to fatigue – for the purpose of achieving a level of safety that is within the limits of acceptance. The airlines have the responsibility to give education within fatigue management, provide rosters which optimize the opportunity for each crew member to perform safely and to implement procedures to manage hazards related to fatigue. The crew members, on the other hand, have the responsibility to be “fit for flight” when on duty; which includes making appropriate use of rest periods by combining sleep and other time-off duties, as well as reporting any hazards or incidents related to fatigue. This is also expected in an airline without FRMS.

ICAO et al. (2015) also state that with regards to the shared responsibility, it is important to be aware that the FRMS can only be effective if all the stakeholders are aware of their concrete duties and responsibilities, and that they each have the obligations, resources and expertise to meet them.

An FRMS makes use of defensive strategies in multiple layers to manage risk related to fatigue, independently of the source. As per the ICAO definition mentioned above, it is a data-driven and ongoing process for managing fatigue and identifying hazards, as well as implementing and evaluating strategies for control and measures. It is a system that uses both the SMS procedures and processes from the service providers to manage and identify crew member fatigue. Within an FRMS, the actual risk related to fatigue in operations is relevant, compared to *prescriptive limits* (i.e. to FDPs and FTLs), where predicted risk applies. Where no regulations within the FRMS are established, an airline can only manage their respective fatigue risks using the SMS processes that already exists, and within the restrictions of the limits that are prescribed. However, when an airline operations regulator has established FRMS regulations, the airline has three different possibilities for implementing these two approaches to fatigue management (ICAO et al., 2015):

1. The airline may throughout all their respective operations – comply with prescriptive limitation regulations, or;
2. The airline may throughout all their respective operations – implement an FRMS that has been accepted for use, or;
3. The airline may use a combination of these two approaches, for example implementing an FRMS in some part of their operations, and in other parts comply with the prescriptive FDPs and FTLs.

Generally, this means that where no FRMS is implemented, it is the responsibility of the airlines to manage risks related to fatigue – through their safety management processes that already exists. However, for operations that keep inside the flight time limitations, and where the risk related to fatigue generally is at a low level, the complexity and the cost of an FRMS may not be expedient to these kind of operations (ICAO et al., 2015).

A study called *Fatigue Management in the New Zealand Aviation Industry* by Signal et al. (2006) – in collaboration with the Australian Transport Safety Bureau (ATSB) – was performed to determine how aviation organisations in New Zealand managed fatigue. This was done by administering questionnaires for several airline operators, and dividing the respondents into three groups; the pilots, the management and those making the rosters. The study showed that some organisations used fatigue management strategies to a greater extent than others. Some of the strategies were to monitor the workload of the pilots, as well as the flight and duty times. Other strategies were to educate those making the rosters or reviewing the processes of the company, thus considering the management of fatigue.

"Comparisons between organisations that complied with the prescriptive limits and those that indicated their company had a Fatigue Management Scheme (FMS) or other accredited scheme, showed no differences in ratings of how well fatigue was managed, the number of fatigue management strategies in place, and their frequency of use." (Signal et al., 2006, p. 5)

Another finding in the study by Signal et al. (2006) was that pilots and the management in the same organisation had different views of how the fatigue management strategies were implemented. A significantly higher number of the management staff considered that their company educated their pilots and other management staff well enough, compared with the opinion of the pilots. The study stated that some of the aviation organisations had well implemented strategies and procedures for managing fatigue. Still, there were many organisations that had a lack of understanding of fatigue and poor management of countermeasures. Conclusively, the study wanted to raise the awareness and understanding of the causes and consequences of fatigue in the whole aviation industry. The different opinions of the workers in the sharp end versus the blunt end, as well as lack of understanding of fatigue and poor management of countermeasures shows the need for either implementing an FRMS, or utilising elements from the system in the organisation.

3.4.3 Implementation of an FRMS in an airline

Before an airline can implement an FRMS, a dialogue with the governmental legislator must be established. There needs to be an interaction and cooperation between these two – also including employees on different levels – to find out how implementation of the FRMS should be created, developed, and how it should be adapted to the airline. Namely, there are several aspects related to the establishment, including size, scope and complexity, in addition to what degree the risk of fatigue is actually present. In addition, the stakeholders also need to ensure that the new system will lead to at least an equivalence or improvement on the level of safety compared to what it currently is. The way the implementation can be done, varies between countries. However, the main essence will be approximately equal. It is done through different phases, where the regulator needs to approve each phase before going to the next (ICAO et al., 2015).

Table 10 shows how the implementation can be done, and the relationship between the airline and the regulator during this process. First is the *preparation* phase, and according to ICAO et al. (2015), this is the phase where the plan of the overall implementation should be established and approved by the regulator. The airline operator needs to specify the functionality of the FRMS, as well as how it can be integrated in other parts of the organisation. This phase should also describe who will oversee both the system itself and the establishment process within the company.

Table 10 - The different phases for implementing an FRMS (ICAO et al., 2015)

		Airline Operator	Regulator
Approval process	Phase 1. Preparation	Developing FRMS capability	Assessment of feasibility
	Phase 2. Trial	Validating their FRMS capability	Assessment of FRMS capability
	Phase 3. Launch	Getting approval	Approval of FRMS
Continued oversight	Phase 4. Continuous Improvement	Embedding FRMS into normal operations	Embedding FRMS into normal regulatory oversight

The regulator also needs proof that the airline can manage fatigue related risks through their existing SMS procedures before the FRMS can be implemented. This is because the regulator needs to know that the airline has the skills and capability to implement a new and complex system in their operations. Other aspects the regulator need to consider are; whether and how the airline handles risk assessment, how they use their systems to identify hazards and how they implement mitigations. All these are safety aspects that the airline must demonstrate for the regulator to decide and give the permission to proceed with the preparation. Further, in the planning phase of the preparation, the airline needs to provide a gap analysis, where elements of the FRMS already existing in the present systems and procedures should be identified. The airline also needs to identify existing systems that can be modified, to avoid that some elements from the FRMS comes as an addition to the existing systems. Moreover, identifying areas where new procedures and systems are required for the FRMS, also need to be identified. The reason for this gap analysis is to have something to build further on by establishing a foundation for how the airline should progress through the next phases – as well as describing how to proceed with the implementation of the processes and components that are required for the FRMS. To enable this implementation, the airline has to describe their financial and human resources, identify who will be the accountable executive, and identify the Fatigue Safety Action Group (FSAG) or similar.

The FSAG is defined as a group of representatives from several groups within an airline, such as the operational personnel (i.e. pilots and cabin crew), scheduling group and management. Collaboration with other experts and specialists like medical experts, scientists, analysts etc., is also considered an advantage. Together they have the responsibility to coordinate all the management activities in the organisation related to fatigue (ICAO et al., 2015).

ICAO et al. (2015) state that to be able to continue towards the next phase of the implementation, the airline needs to provide several documentation plans. This includes the mentioned gap analysis, an FRMS policy statement, distribution of the human and financial resources, an FRMS implementation, documentation and communication plan, as well as a training programme for all the personnel who will be related with the second phase – the FRMS *trial*.

In the second trial phase, the airline operator need to prepare a trial plan with respect to duration, scope and mitigations. The airline is also required to give details in the trial plan about; the specific operations where the trial will take place, details about the different sources of information that will be used for calculating fatigue related risk, details for the monitoring to track the actual risk and mitigation strategies with accompanying timelines for specifics and duration. The airline is also responsible for the personnel being adequately trained in being able to tackle their roles in the FRMS. This includes the rostering staff, flight crew members, management staff and personnel in the FSAG. After this is done, the airline can propose their FRMS trial plan to the regulator – which in turn needs to be approved before the trial can commence. During the actual conduct of the trial, the regulator will closely monitor the progress, and the airline may be required to send regular updates and reports. The regulator may also come for audits and inspections during the process, thus being able to evaluate the airline's process and to confirm that the airline's FRMS is on track to meet the required safety goals. The trial can be modified during the process if the regulator or the airline identifies the need for any possible improvements. In turn, this may delay the whole process, but is an additional safety aspect to ensure that the system actually meets the requirements, as well as the desired outcomes of implementing it (ICAO et al., 2015).

When the regulator is satisfied, and sure that the airline operator's FRMS is functioning per the requirements, the FRMS gets approved. This means that the third phase can begin, the *launch* of the system. The main difference between phase 2 and 3, is the degree of monitoring from the regulator and the updates being sent from the airline, which depends on the complexity and degree of the fatigue-related risks in the specific operations. In the launch-phase the system itself has been activated to the operations described in the FRMS. However, the airline may need to continue reporting to the regulator, and the regulator needs to have a certain degree of oversight to still be sure that the FRMS is functioning as required and intended in the applied operations. The airline can in this phase still implement FRMS in other operations than specified from the first trial, but then the new components may need to go through a new trial-phase and new approvals.

ICAO et al. (2015) state that in the fourth phase of the implementation, if any extensions of the scope of the FRMS are submitted – or new components – it may have to go through a new trial (phase 2). Nevertheless, the degree of oversight and monitoring from the regulator will at this phase be at a routine level. A keyword for this phase is *continuous improvement*, and it is expected that the airline is more or less independent in the future work with the FRMS. Yet, the regulator can still review the airline's procedures, carry out audits, and make adjustments to the system. All this work with continuous improvement is attained through the safety assurance processes of the FRMS. ICAO et al. (2015, p. 76) states that:

"the primary responsibility for the FRMS safety assurance processes is assigned to a Quality Assurance person or team that is accountable to the Executive Safety Team, and maintains close communication with the FSAG."

An example of how this can be done is to use safety performance indicators like a software in the rostering system, which detects and notifies; for example, when flight crew members are approaching the monthly flight time limitations. This to ensure that nobody goes over the prescribed limits, as well as being able to plan better ahead to give the airline better flexibility and margins. It can be that a flight crew needs to exceed the flight time limits due to unforeseen circumstances in flight operations (e.g.: technical/mechanical failure during flight, sick passenger, diversion due to weather, etc.). This is, among many other examples, a way of implementing and embedding the FRMS into normal operations (ICAO et al., 2015).

The mentioned example above also underpins the statement by Caldwell and Caldwell (2016) that an FRMS should be data-driven, and that decisions are based on collection and objective analysis of data – not on opinions. Caldwell and Caldwell (2016) also point out the same essential element as ICAO et al. (2015); that FRMS and the general managing of fatigue should be an exhaustive part of the organisation´s procedures, supported by the management and the staff, who are also aware that managing fatigue-related issues is a shared responsibility. The use of mathematical fatigue models to predict crew fatigue levels in order to reduce it, is another element of FRMS that is emphasised by several stakeholders; namely, ICAO et al. (2015), Yildiz et al. (2017) and Hursh et al. (2004) – amongst others. After the implementation of FRMS, the system needs to be continuously improved and evaluated based on collection of data and investigations from incidents and accidents related to fatigue.

"In a good FRMS, key defences against fatigue are integrated into an overall program that ensures employees are getting sufficient sleep, that they are free from fatigue-related issues due to factors such as sleep disorders, that controls are in place to minimize the impact of any fatigue-related errors that do in fact occur, and that the controls are periodically assessed to ensure their effectiveness." (Caldwell and Caldwell, 2016, p. 150)

3.5 Overview of theoretical safety management aspects

Safety is a problematic concept that has many different interpretations and meanings. A good definition of safety is given by DoD (2012, p. 7): *Freedom from conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment*. However, in this thesis, the following definition of safety given by ICAO et al. (2015, p. xiv) is used: *The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.*

Similar to the safety concept, *risk* has many different interpretations. According to ISO (ISO 31000:2009) *risk* is to be understood as; *effect of uncertainty on objectives*. Further, risk is often characterised by reference to potential events and consequences, or a combination of these, and is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

When it comes to *safety management*, Hale (2003) defines the notion as follows: *All activities carried out in more or less coordinated shapes of an organisation to control hazards*. From this we can understand that to avoid accidents and incidents, it is necessary to understand both the responsibilities of an organisation, as well as *how* it can avoid incidents. It is equally important to reduce the consequences of an accident/incident in the case where it does occur. Subchapter 3.5.3, will further elaborate on safety management – viewing it as a control problem.

The following subchapter will an overview of different theoretical aspects that will be used to enlighten different characteristics concerning fatigue and fatigue prevention in later chapters. The most important pieces of literature used to in this chapter are:

- *A contingency model of decision-making involving risk of accidental loss*, by Rosness (2009).
- *Organisational Accidents and Resilient Organisations: Six Perspectives*, by Rosness et al. (2010).
- *Managing the risks of organizational accidents*, by Reason (1997).
- *Risk management in a dynamic society: a modelling problem*, by Rasmussen (1997).
- *Prevention of accidents through experience feedback*, by Kjellén (2000).
- *Working in practice but not in theory: Theoretical challenges of "High-Reliability Organizations"*, by LaPorte and Consolini (1991).
- *Resilience engineering in practice: A guidebook*, by Hollnagel (2013).
- *Safety-I and safety–II: the past and future of safety management*, by Hollnagel (2014).
- *Working to rule or working safely? Part 2: The management of safety rules and procedures*, by Hale and Borys (2013a).
- *Working to rule, or working safely? Part 1: A state of the art review*, by Hale and Borys (2013b).

3.5.1 Different decision settings: Conflicting objectives

According to Rosness (2009), decision-making involving risk of accidental loss (material or immaterial) occurs in a variety of settings. The limitations of the decision settings will have an impact on the decision-making. Different decision settings may therefore call for different approaches to decision support, which is based on the two dimensions, (a) proximity to hazard and (b) level of authority. Decision-making is limited and affected by former choices, and these choices may interact in the way they affect the risk of accidental loss.

There are five types of decision settings, as shown in Figure 12: operations, business management, administrative and technical support functions, political arenas, and crisis handling. However, which decision settings that mainly lie in the blunt end versus the sharp end, is the most interesting feature to pay attention to. Many of the decisions made in the blunt end will affect what occurs in the sharp end of a specific organisation.

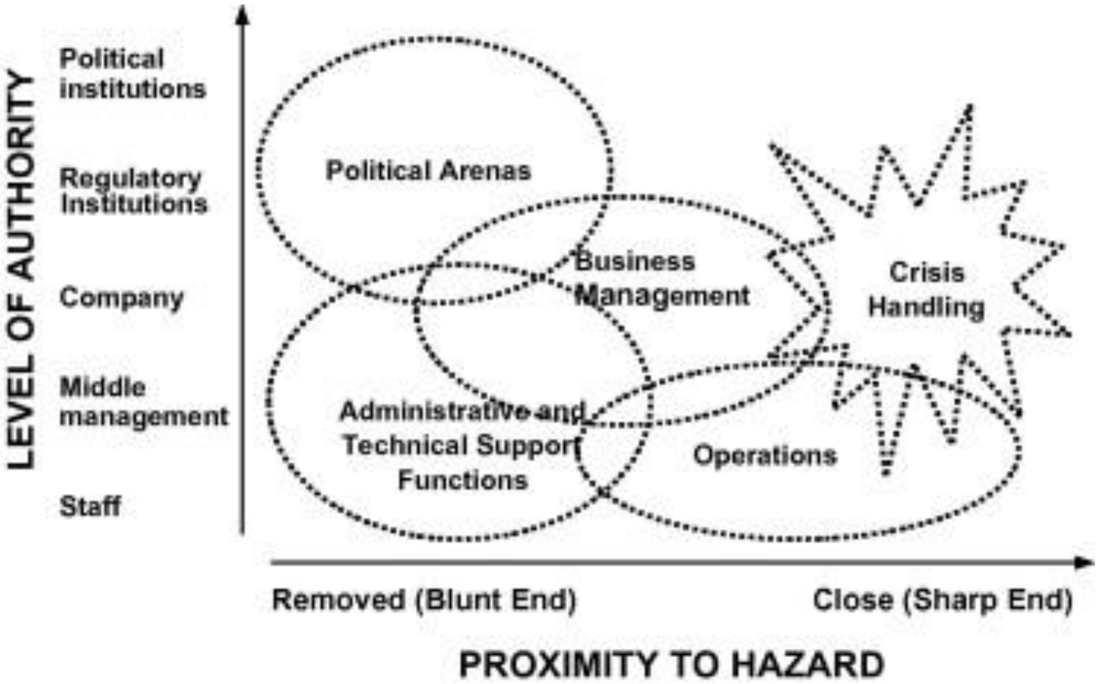


Figure 12 - Different decision settings (Rosness, 2009)

The different decision settings can be related to the way the aviation hierarchy is built up in Norway. As mentioned in chapter 1, the staff in sharp end are considered being pilots (and cabin crew), while the regulatory institutions in the political arena, i.e. EASA and the Norwegian Civil Aviation Authority (NCAA), are removed from the hazards, and are in the blunt end of this figure. The decisions they make in the blunt end, are not always appropriate in the way they affect the other stakeholders. Most of the power lies with the regulatory institutions, seeing as they can directly affect how operations are conducted.

Rosness et al. (2010) and Rasmussen (1997), state that individuals, groups, organisations and institutions deal with conflicting objectives all the time. Since there exists an open market economy in most areas of the world, competition between companies will be present. Whoever manages to produce goods or services at a lower cost than its competition, will have an advantage in the market they operate in.

Accidents are often the product of several choices made independently by different stakeholders. Some accidents result from a pattern of distributed decisions where the actors do not know how the actions of other stakeholders affect the consequences of their own actions, while very few accidents result from deliberate risk-taking by workers (i.e. pilots) in the sharp end.

Conflicting objectives are often set through gradual adaptation of wanted or unwanted behaviour. Safety in an organisation requires money, time and competent workers. This may be a challenge to establish well enough for some organisations. In other words, there will be an ever-lasting conflict between safety, economy and efficiency, as shown in Figure 13.

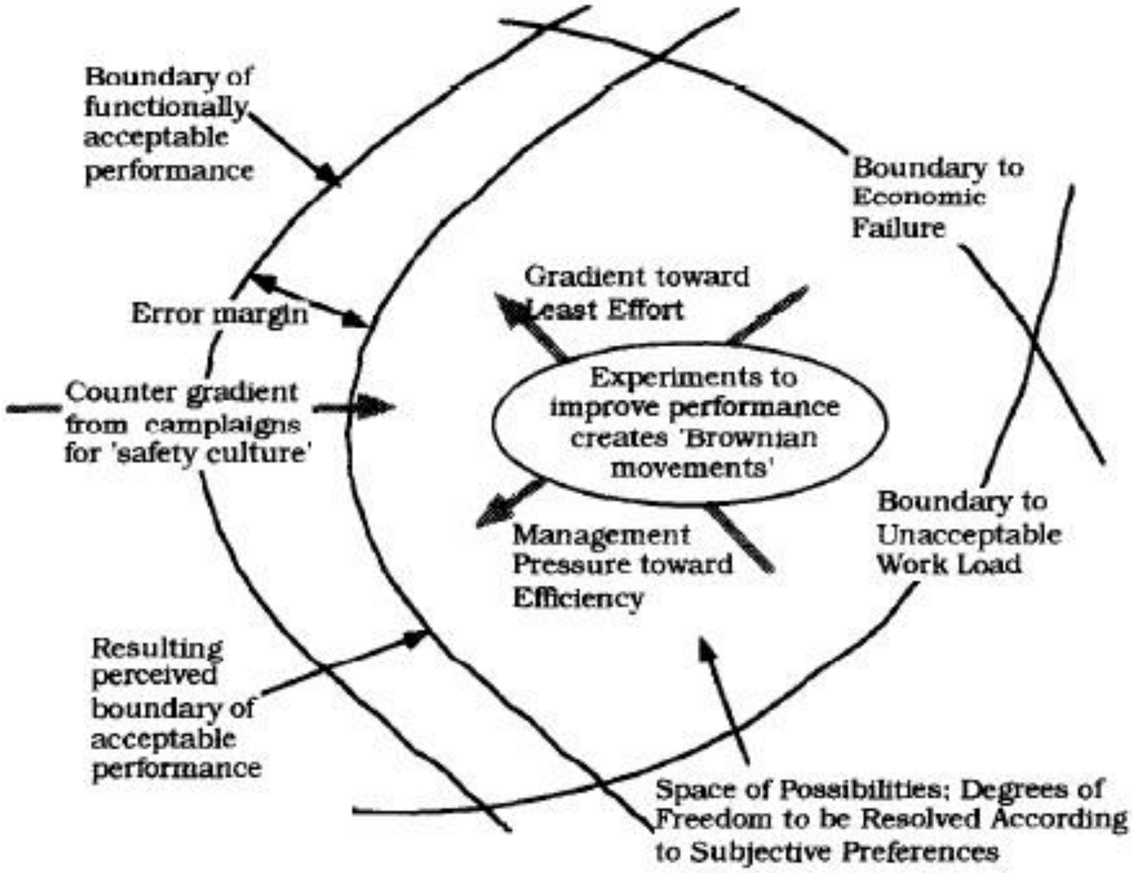


Figure 13 - Mitigation of risk (Rasmussen, 1997)

What is mentioned in the preceding paragraphs regarding conflicting objectives can be related to Reason (1997). It is stated that all organisations "produce something". Almost every day, managers, supervisors and workers should decide on cutting safety corners to meet operational demands in the "production". In an ideal world, all the "defences" (i.e. barriers) would be intact, allowing no penetration by possible trajectories of accidents. It is argued that protection requires resources; both people and other assets. An organisation too careful will be at risk of ending up in bankruptcy; while organisations who act carelessly and neglect protection, will operate under high risk of catastrophic accidents, as seen in Figure 14. This can be closely related to how airlines must manage the challenges associated with fatigue, while maintaining as close to the parity zone as possible. During an aviation organisation's lifecycle, there will be several encountered elements affecting the ability to stay within the limits. Individual events, as well as external influencers such as e.g. the NCAA or even the Accident Investigation Board Norway (AIBN), should help the organisation decide whether to change course or not.

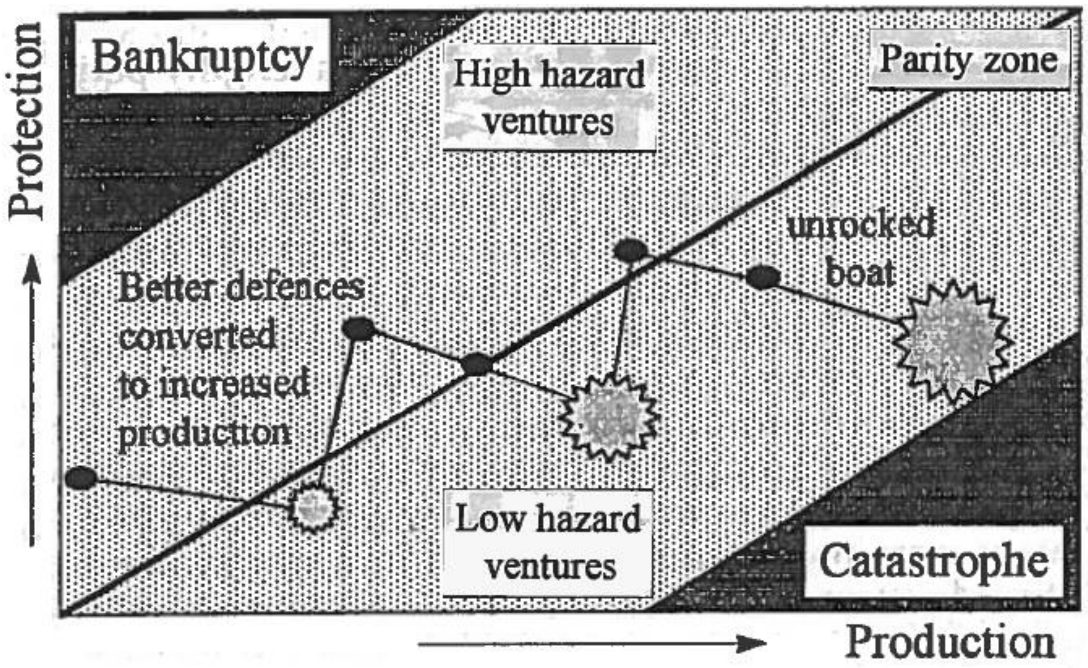


Figure 14 - The lifespan of a hypothetical organisation through the production-protection space (Reason, 1997)

It is argued in subchapter 2.3, that the aviation sector in Norway has become a good example of an industry where different decision setting has led to conflicting objectives. This is, however, not only unique to the aviation industry as a whole. The need to produce more and become more efficient has induced the problem of fatigue among pilots, and the boundaries in the figure (Figure 14) have become much closer than what they were only a few years ago. This is just another way of looking at the threat that fatigue poses to successful operations. The next subchapter can be seen in close relation to the different decision settings and conflicting objectives in a given organisation, by looking at the *socio-technical system*.

3.5.2 The socio-technical system

The socio-technical system includes several stages ranging from legislators, managers and work planners, to system operators in the sharp end (Figure 15). The system is presently strained by a fast pace of technological change, by an increasingly competitive environment, and by altering regulatory practices, as well as public pressure. Conventionally, each level of this system is studied separately by a specific academic discipline. Modelling is done by generalising across systems and their particular sources for hazards. It is argued by Rasmussen (1997) that management of risk must be modelled by cross-disciplinary studies – considering this type of management to be a control problem, where one should be involving all levels of society for each particular hazard category.

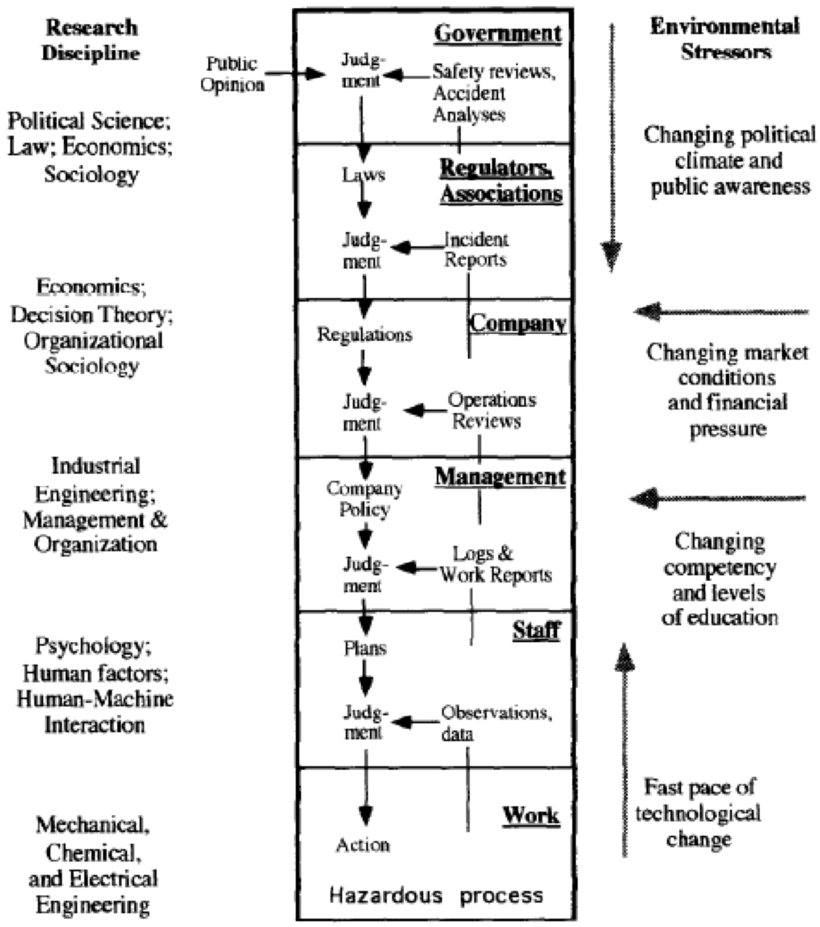


Figure 15 - The socio-technical system (Rasmussen, 1997)

Every part of the socio-technical system affect one another in some way. The fast pace technological change, changing market conditions and financial pressures are very comparable to the aviation industry in Norway, but also Europe in general. The lower part of the figure (the sharp end) has moved in an entirely different way than the top (the blunt end) – arguably due to the regulators not being able to keep up with the level of change (Tambala and Bolås, 2016). Thus, fatigue has become a challenge the blunt end now must find a way for the sharp end to cope with.

3.5.3 Safety management as a control problem

According to Kjellén (2000), an organisation learns in three ways; individual learning through experience, through knowledge sharing and via externalisation of the organisational memory. This is considered a continuous process. Figure 16 shows a typical view of how information should move in an organisation, and how this information should be utilised as a resource in a continuous loop (i.e. seeking continuous improvement). Positive effects on safety are only achieved when the loop is closed, i.e. when the outcomes of the decisions are implemented in a way that affects the organisation positively now or in the future. Thus, inadequate distribution of information breaks up the loop, and can lead to incidents and/or accidents. We can relate this to *single*- and *double-loop learning*.

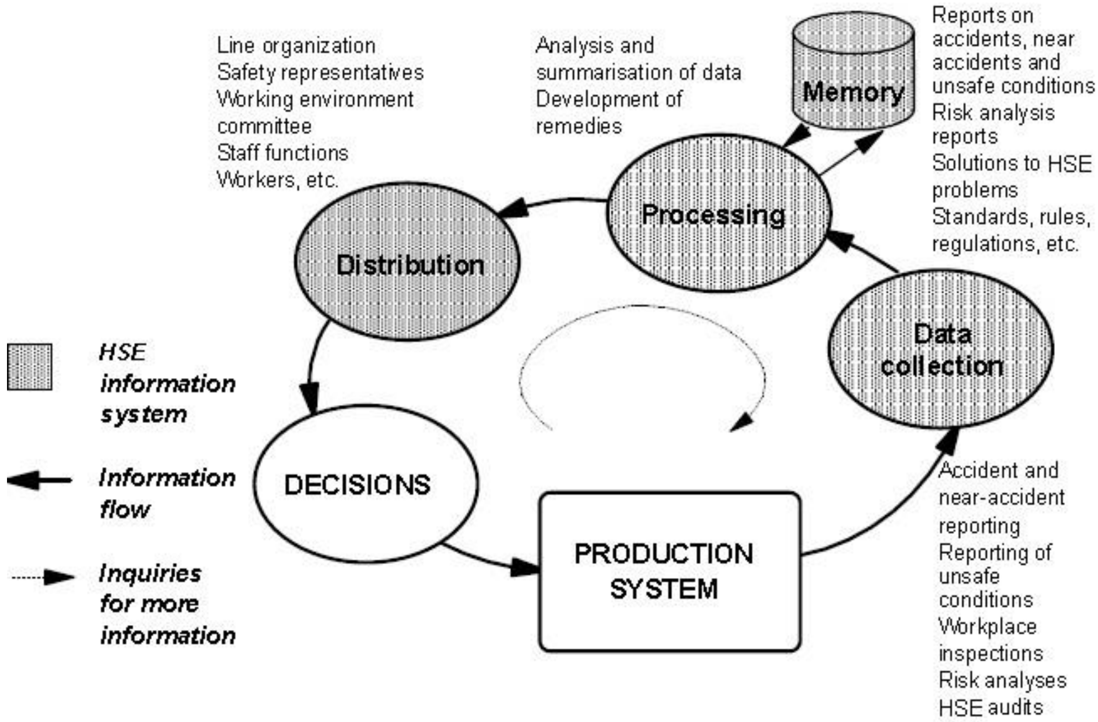


Figure 16 - Flow of information in an HSE information system (Kjellén, 2000)

Argyris (1992), explains that single-loop learning aims at solving the increasing changes and the problems that have risen because of this. However, this form of learning ignores the need to find the real cause of the problem. Double-loop learning will go more deeply into the cause of the problem, and feedback is used to look at the governing variables (Figure 17). Questions are asked to find the *real* cause of the problem, e.g.: What were the considerations of the managers and the employees to implement certain procedures? What went well and what should be enhanced? This naturally affects the level of safety in an organisation.

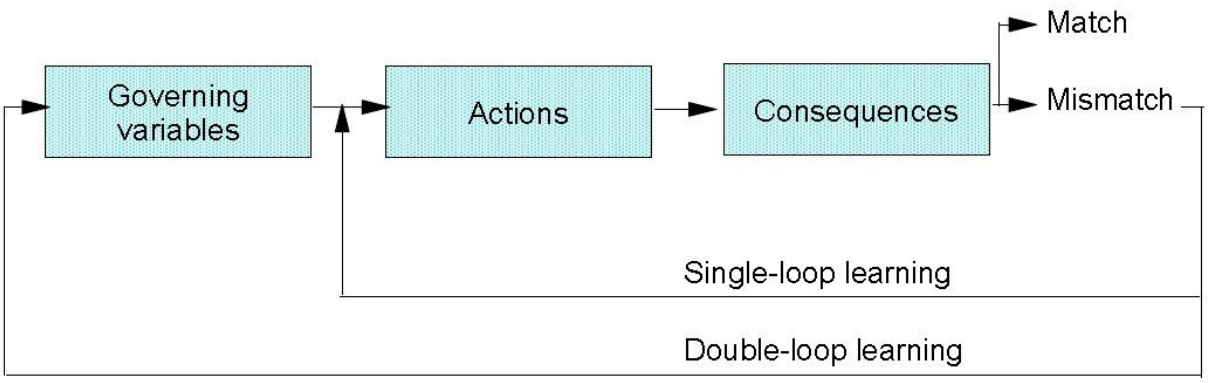


Figure 17 - Single and double loop learning (Argyris, 1992)

Based on the above mentioned, it is necessary to include the terms of feedback and feedforward mechanisms. In a closed system like the one shown in Figure 16, feedback is a persistent and continuous process, where a part of the output is fed back as new input to modify and improve the subsequent output. Figure 18 illustrates this by showing how information travels as an output through sensors, affected by norms, set in effect by actuators, before affecting the process as new input. Feedforward is information for control of a process that is obtained from other sources than those giving the output. It can be said to be an anticipation of future behaviour of the input variables.

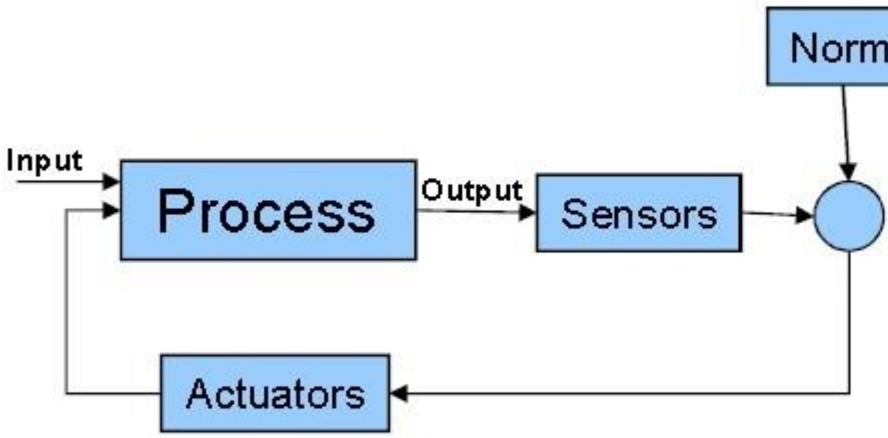


Figure 18 - Closed loop system (modified from Kjellén, 2000)

To sum up, we can relate the aspects of safety management being a control problem, to the systems incorporated in the aviation sector to cope with fatigue. The SMS, and more importantly, the FRMS in an airline, need to take into consideration the brief aspects featured in this subchapter. The need for an SMS/FRMS which has a closed loop, seeking continuous improvement of safety levels through both single- and double-loop learning as well as using a combination of a feedback and feedforward mechanisms, should be the set standard. Naturally, this is can pose as quite a challenge. Safety management is most definitely a control problem.

3.5.4 High reliability organisations

Charles Perrow (1984) claimed in his book *Normal accidents: living with high-risk technologies*, that organisations who are characterised by being highly complex and utilising tightly coupled technologies, are vulnerable to experience systemic accidents (see Table 11). The nuclear accident in Chernobyl is an example of such an accident. Yet, the theory presented by Perrow (1984) was widely criticised. Among other things, it is impossible to design an organisation which is sufficiently centralised to handle the tight coupling. Thus, group of researchers who studied so-called High Reliability Organisations (HROs) challenged the theory of *Normal accidents*.

Table 11 - Interactions and couplings related to the theory of "Normal accidents" (Rosness et al., 2010)

		Interactions	
		Linear	**Complex**
Coupling	**Tight**	Train transport	Nuclear power plants Chemical plants
	Loose	Mail services	Universities & research facilities

LaPorte and Consolini (1991) argued that certain systems such as aircraft carriers, air traffic control, nuclear submarines and nuclear power plants only are a benefit to society if they can operate as close to failure-free as possible. Moreover, these types of operations utilise complex and demanding technologies used in situations which can be extremely demanding. A quote taken from Rochlin et al. (1987, p. 78) gives a good description of what operating in a HRO can be like:

"So you want to understand an aircraft carrier? Well, just imagine that it's a busy day, and you shrink San Francisco Airport to only one short runway and one ramp and gate. Make planes take off and land at the same time, at half the present time interval, rock the runway from side to side, and require that everyone who leaves in the morning returns that same day. Make sure the equipment is so close to the edge of the envelope that it's fragile. Then turn off the radar to avoid detection, impose strict controls on radios, fuel the aircraft in place with their engines running, put an enemy in the air, and scatter live bombs and rockets around. Now wet the whole thing down with salt water and oil, and man it with 20-yearolds, half of whom have never seen an airplane close-up. Oh, and by the way, try not to kill anyone."

According to LaPorte and Consolini (1991), there are three reasons why HROs are so successful:

1. Organisational redundancy.
2. Spontaneous reconfiguration.
3. The organisation is characterised by mindfulness.

Firstly, when it comes to organisational redundancy, this is achieved through overlap in the structural and cultural dimension of the organisation itself. In the structural dimension, there can be similar competencies among personnel and overlapping areas of responsibility. Additionally, the personnel working together may be in close proximity to each other, allowing direct observation and conversation; even body language can be used in communication. In the cultural dimension, emphasis is placed on the ability and will to exchange information with other people. There should be an environment that allows scrutinising both one's own and others' decisions. Moreover, everyone taking responsibility for rectifying wrongful acts, is also an important quality. Importantly, one of the significant aspects in the cultural dimension is the ability to readjust the hierarchy of the organisations in situations when this is necessary (e.g. going from normal operation to handling an emergency). Here, the placement in the hierarchy is "reset" as to be able to handle the situation in a more efficient manner. The person that has most knowledge or experience in handling the situation at hand, is the one who becomes the "leader". Table 12 shows what characterise different types of organisations. As explained, an organisation that excels in both dimensions, can be described as a HRO.

Table 12 - Two dimensions of organisational redundancy (Rosness et al., 2010, Kongsvik, 2013)

		Structural dimension	
		Poor	**Excellent**
Cultural dimension	**Excellent**	Structural vulnerability	High reliability organisations
	Poor	"Low reliability organisations"	Cultural vulnerability

Secondly, LaPorte and Consolini (1991) found that spontaneous reconfiguration is an important quality that exemplify HROs. They found that during crises and difficult situations, rank became unimportant; authority was granted based on your experiences and abilities, as described in the previous paragraph. If the situation demands it, the interactions between personnel was more informal and loose to ease communication and understanding. It can be deduced that HROs switch between mechanical and organic organisation as occasion demands it, shown in Figure 19.

Figure 19 - Spontaneous reconfiguration in HROs (Kongsvik, 2013)

Lastly, when it comes to mindfulness, Weick and Sutcliffe (2011) defines the term as "*…being attentively present*". Additionally, they also state that HROs accept the fact that failures occur, and that there is no perfection of zero errors. An organisation needs to develop skills to detect and contain errors at early stages. Mindfulness concerns anticipation and awareness of the unexpected, as well as containment of unexpected events that could appear everywhere in the organisation. Weick and Sutcliffe (2011) identify five elements in mindfulness that are of key importance in HROs:

Anticipation and awareness of the unexpected

1. Preoccupation with failure; emphasis on learning from mistakes.
2. Reluctance to simplify interpretations; attention to nuances, critical questions are rewarded.
3. Sensitivity to operations; the main focus is on the sharp end – where things go wrong.

Contain the unexpected

4. Commitment to resilience; handles unexpected events and manages to come back to a normal state of operation.
5. Defence to expertise; diversity is cultivated and encouraged.

Some limitations associated to HROs should also be mentioned. The qualities described can be found in mainly large, military or military-like organisations. Therefore, it is difficult to see whether the theory surrounding HROs is valid in other types of organisations or types of operations. Furthermore, the cost associated with operating with a vast organisational redundancy is very high compared to what many businesses are comfortable with today. On the other hand, one can argue that a large accident in the organisations would be much more expensive.

The aviation sector is arguably made up of several HROs. The theory concerning HROs is not directly transferable to the aviation industry in Norway, but gives an indication of how an ideal organisation copes with errors and failures – especially when it comes to communication, cooperation and Crew Resource Management (CRM). Fatigue can most definitely influence airlines to an extent where unwanted occurrences happen. What can be utilised from this theory to cope with or avoid fatigue, or even incidents/accidents related to fatigue? The principles surrounding the HRO-theory is interesting to combine with the coping of fatigue in an aviation context.

3.5.5 Adaptation & flexibility: Resilience engineering

Hollnagel (2013) defines resilience in the following way: *The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.* Following a negative unforeseen event, the philosophy behind the resilience strategy means it will be necessary to come back to normal function as soon as possible; while seeking to contain the adverse effects of the event itself.

The perspective of resilience engineering is relatively new, and continuously evolving. One can say that it is a synthesis of several other aspects and theory like e.g. the Swiss cheese model, HRO, Man-made disasters, etc. The reason for the development of resilience engineering is due to the evolvement of technology, and as such, the overall complexity of systems. Furthermore, we are experiencing a higher degree of automation and connection of different systems which *can* lead to hitherto unknown adverse effects. Learning from past accidents provides a limited base to prevent new incidents from happening in the future. Thus, there is a need for combining this learning with a proactive approach, where one seeks to facilitate the development of distinct, positive organisational abilities: How can we create systems to prevent accidents from happening in the first place? What are the principles we can use to avoid accidents from happening; that also helps us quickly return to a normal state when accidents first happen? These are central question that are illustrated in this perspective (Rosness et al., 2010). Consequently, there are four hallmarks in resilient organisations:

1. An ability to avoid accidents; e.g. through design.
2. An ability to anticipate what might go wrong and improvise if necessary; e.g. improvisation in the case of Apollo 13.
3. An ability to handle problems when they occur; e.g. in an emergency room in a hospital.
4. An ability to recover from damage or accident.

Hollnagel (2013) sums up the qualities of resilience as shown in Figure 20.

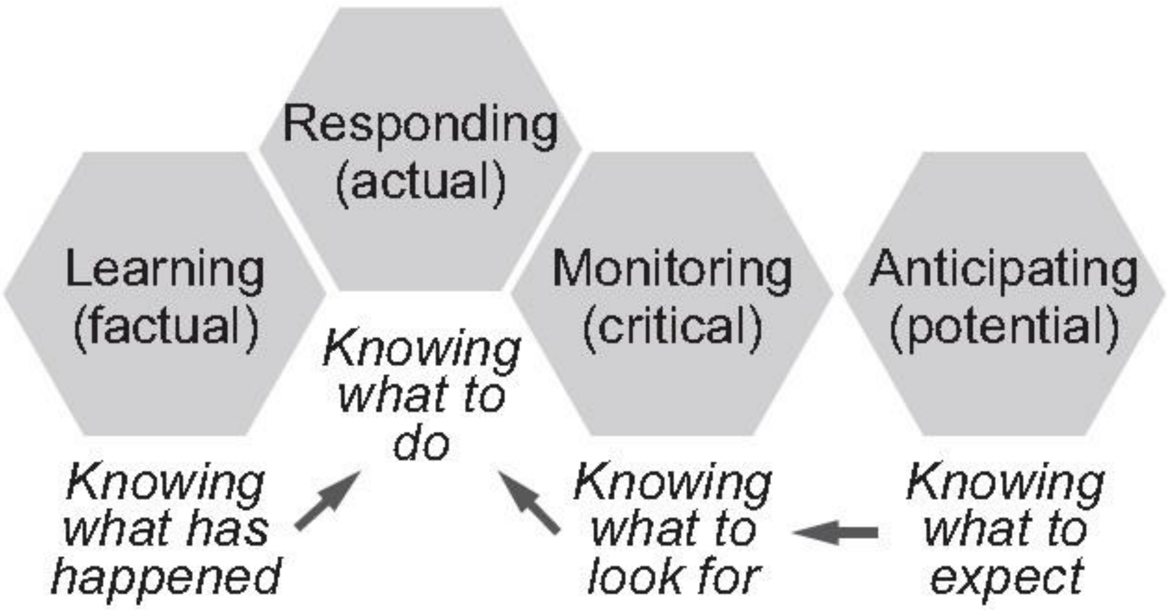


Figure 20 - The four cornerstones in resilience engineering (Hollnagel, 2013)

Further, there are two safety understandings highlighted from the resilience engineering perspective. The first one is called safety I, which involves facilitating in such a way that as few things as possible go wrong. This can be called the traditional and reactive method used to achieve safety, and is mainly addressed by risk management. The second approach, called safety II, is all about exploiting the potential from both what goes well and what goes wrong; particularly from everyday successful operations (addressing potential to monitor, anticipate, respond and learn). This is illustrated in Figure 21, where we can see numbers associated with performance, as well as the focus of safety I and II (Hollnagel, 2014, Hollnagel et al., 2013).

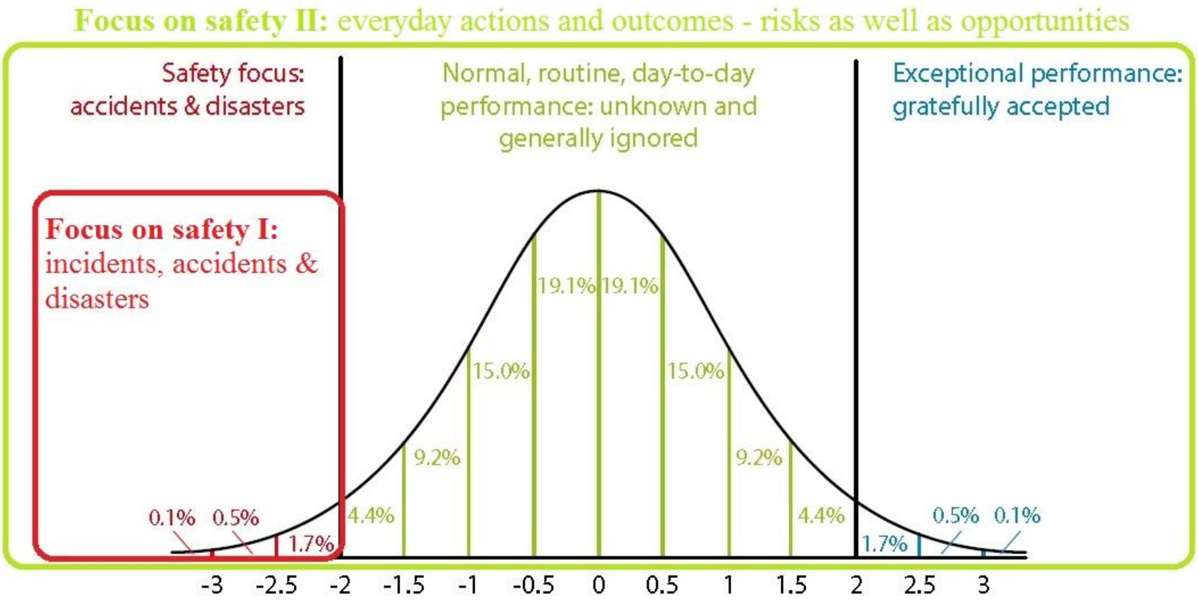


Figure 21 - Event probability seen in relation with safety focus (Hollnagel et al., 2013)

The most important, different aspects concerning safety I and II, are best illustrated using a summarising table (Table 13):

Table 13 - Safety I versus safety II (Hollnagel, 2014, Kongsvik, 2013)

	Safety I	Safety II
Understanding of safety	As few things as possible go wrong.	As many things as possible go right.
Principle for safety management	Reactive: learn from the accidents that have happened already; prevent, eliminate and constraint.	Proactive: predict trends and incidents; create, maintain and compensate.
Explanation of accidents	Accidents happen due to errors and faults. The purpose of an investigation is to identify causes and contributing factors.	Things basically happen in the same way regardless of the outcome. The purpose of an investigation is to understand how things usually go right as a basis for explaining how things occasionally go wrong.
View of 'the human factor'	A negative load ("to err is human").	An important resource (necessary for system flexibility and resilience).
Role of performance variability	Harmful; should be avoided as far as possible.	Inevitable and useful. Should be monitored and managed.

As mentioned in subchapter 1.2, the entity of the aviation sector is an extremely complex system, and therefore needs complex solutions. The aviation sector is trying to become more resilient. The theory concerning resilience shows that learning from successful operations (safety II) should be the way forward in this industry. The same can be said for the challenges concerning fatigue. There have been some accidents related to fatigue in the aviation sector that we can learn from, but what about the normal, day-to-day operations that go well? There is a potential to learn a lot from this, and use this information to cope with fatigue in Norwegian airline companies.

3.5.6 Compliance of rules and procedures: Two paradigms

Hale and Borys (2013b) establishes two paradigms concerning compliance of rules and procedures. In short, paradigm 1 is about the fact that *following rules* is essential – complying with these rules results in accident avoidance. Some advantages of this paradigm are; there is an available set of regulations to refer to where the rules should be clearly defined, and that there is a logical and rational approach to the regulations. Disadvantages can be; too large and comprehensive set of regulations, increasing bureaucratisation, encouragement of a "scapegoat-culture", a negative outlook on procedural violations, and that it can be difficult to handle exceptions to the rules (Hale and Borys, 2013b).

Paradigm 2 defines the rules as being underspecified and never adequate for real-world situations. Here, *adaptations and improvisations* are quintessential to avoid accidents, or cope with an accident when it does occur, which can be related to the previous subchapter on resilience. The paradigm recognises the workers in the sharp end as the important individuals in rule configuration, as well as this being a continuous and dynamic activity. The successful landing of US Airways flight 1549 on the Hudson River in 2009 is an example of an accident that was avoided due to the crew adapting and improvising (NTSB, 2010). Some of the drawbacks to paradigm 2 are; it can be difficult to verify whether the rules are good and adequate enough, it may underestimate the need for clear controlling of regulations, there are greater demands for experience in the type of work that is done, different interpretations of situations, and lastly, differences in skills provide valuable experiences to some individuals – which in turn become unavailable to others (Hale and Borys, 2013b).

As mentioned, both paradigm 1 and 2 have advantages and drawbacks, but they may be joined together within a framework, describing necessary steps in the management of rules and procedures (Figure 22). This framework has a circular structure for continuous improvement, whose purpose is to develop, inform, use, monitor, change, and enforce rules and procedures within an organisation (Hale and Borys, 2013a).

According to the framework by Hale and Borys (2013a), you either have new tasks that need rules for the first time, or you have existing tasks with applicable rules. For the first mentioned; one needs to define both tasks, risk scenarios and barriers - based on analysis of practice – define which rules to apply and who are the users. Then one must develop and formulate rules, try them out and approve them, before saving them in the organisational memory (ref. Figure 16). Afterwards you convey and train in the use and adaptation of rules, use the rules and handle exceptions, before monitoring how rules are applied and give feedback to this. In the end, you need to evaluate the rules and violations, and either enforce use of good rules for implementation, or revise or discard bad or inadequate rules. Then start the process all over again with "defining the tasks" in box number 6, as shown in Figure 22. If you are going to handle rules with existing tasks, you start with box number 1 for monitoring the use of rules and to give feedback, then evaluate (box no. 2) for either to redesign (box no. 5) or enforce (box no. 3) the use of good rules.

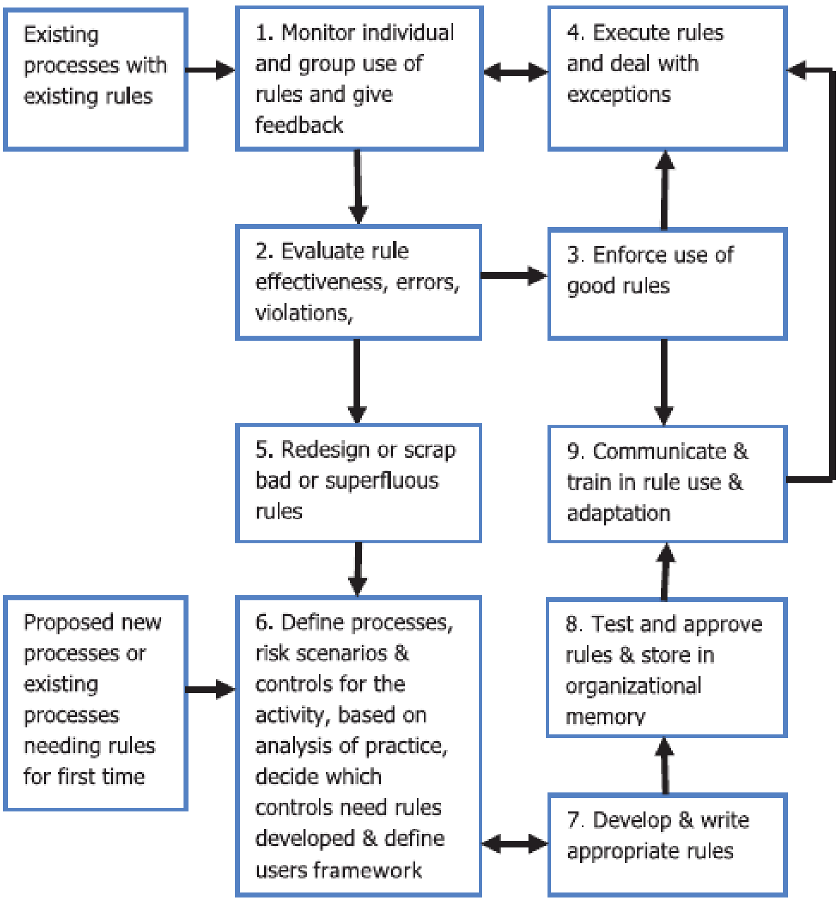


Figure 22 - Framework for establishing rules (Hale and Borys, 2013a)

The regulatory frameworks established by e.g. EASA and the NCAA, or even an airline's own rules and regulations (cf. SMS), can be revised using the framework (Figure 22), to make it easier for personnel to cope with or avoid fatigue. A simple and understandable set of rules make it easier for pilots to understand what rules must be followed and adhered to concerning fatigue. Consequently, their opinions should also be considered when establishing new rules, or revising old ones; e.g. in an SMS or FRMS. After all, the workers in the sharp end are the ones most directly affected by these types of rules, and should therefore cooperate in their establishment and/or review.

3.6 Summary: Implications for the study

This chapter was divided into four interrelated parts to show:

- Relevant theory on the science of sleep, effects of fatigue and how to counter it on an individual level.
- An overview of the legislators in Europe and Norway, and the current legislations that are in effect regarding flight and duty time limitations within these areas of responsibility.
- What a SMS, SSP and FRMS is. With focus on the implementation of an FRMS, which can be said to be a fatigue-countermeasure on both a company- and governmental level.
- What safety, safety management and risk is. And lastly, relevant theory associated with safety management, and its connection to fatigue in the aviation sector has been presented.

The matters presented in the first three parts accounts for specific concepts and theories that are relevant for understanding the challenges associated with fatigue. The last part presented relevant theories in safety management – most of which are to be used in chapter 6: Discussion.

4 Method

This chapter will present the methodological approach that has been chosen to use in this thesis. Additionally, it will present the research design that has been chosen to answer the research questions formulated in subchapter 1.3:

1. *How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?*
2. *Which measures can be used to mitigate fatigue among pilots who work in large aviation companies in Norway?*
3. *Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?*

4.1 Existing approaches

As described in subchapter 1.2, the objective of this thesis is to explore to what extent pilots in Norway are affected by fatigue whilst working, hence being in close relation to the formulated research questions. So far, the introductory goal, background on fatigue and theoretical basis for this thesis have been presented in previous chapters. This chapter will show the projected way to go from theory to empirical data, by presenting the methods that are used for production of data. There will be an explanation of how the problem was investigated and why the appropriate steps were chosen. Moreover, there will be a description of the type of data and data collection methods that have been used in the study, followed by a description of the type of analysis that is used and why this is appropriate. Finally, this chapter will conclude saying something about the study quality (strengths and weaknesses).

4.1.1 Available methods

According to Bryman (2012) there are generally two types of research styles available when conducting a social study – either a quantitative or qualitative method. Table 14 shows the main features associated with each of these methods. As shown, a quantitative method is a more structured method, that relies on reliable quantifiable data to prove or test a theoretical hypothesis. The researcher's point of view is the base from which the study evolves. A qualitative method relies more on going through a process within the theme that is chosen to study. Most of these studies are done at a much smaller level than with a quantitative method and goes much deeper into the subject that is analysed. It does not necessarily rely on previous theory, but can seek to establish new hypotheses', thus being "theory emergent". Here, the base lies from the point of view of the participants. The study progresses from their answers and feedback.

Table 14 - Contrasts between quantitative and qualitative research (Bryman, 2012)

Quantitative	Qualitative
Numbers	Words
Point of view of researcher	Point of view of participants
Researcher distant	Researcher close
Theory testing	Theory emergent
Static	Process
Structured	Unstructured
Generalisation	Contextual understanding
Hard, reliable data	Rich, deep data
Macro	Micro
Behaviour	Meaning
Artificial settings	Natural settings

To begin with, simply using a quantitative research design is considered impractical because the research questions in this thesis cannot necessarily be quantified only by using numbers. Moreover, due to my current knowledge on using quantitative methods within the given time-frame for this thesis, as well as the quite new quantitative studies performed by Reader et al. (2016) and Luftfartstilsynet (2016a), further supports the impracticalness of using only this design. I am more interested in gathering data that is rich and deep from the point of view of relevant stakeholders.

Moving on, cross-sectional design, which for example collects data through questionnaires and/or structured interviews, could be a feasible quantitative method to use. It would have given a “snapshot” of how the regulations works in practice for workers in the sharp end, at this specific point in time. There may be a problem with regards to the privacy of the individuals participating in the survey. The same can be said for conducting a qualitative study where privacy may be a challenge. I am aware that different airlines may look negatively on participation in surveys as this may be perceived as damaging the company's reputation. It would therefore be useful to ensure that the company does not have anything against their employees participating in such a study, and/or ensuring the anonymity the participants. The purpose by performing this research is, after all, to help improve safety in a high-risk industry (Bryman, 2012).

Due to the above mentioned, it can therefore be deduced that simply using a qualitative method is not what I consider being most advantageous in this thesis. It is possible to expand the study of fatigue within the aviation industry longitudinally – which may prove necessary in connection with further work on this topic (more on this in subchapter 6.4: Further work). However, due to the time constraint on this thesis, this is not considered a practicable option.

The qualitative approach may have some weaknesses. It is not easy to draw firm conclusions because of an unrepresentative selection. It is rarely possible to generalise results that have come forward, since the selection can be small and crooked. In the case where semi-structured interviews are used, the interviewees may not get the anonymity that ethical guidelines require, and may not respond honestly; either because of leading questions or because the interviewee comes with what he/she considers as a strategically correct answer. Additionally, it is often very time and resource consuming to collect data and analyse them (Bryman, 2012).

According to Bryman (2012), a benefit of using a qualitative approach is that it can give the interviewee the opportunity to deepen their opinions. It also provides opportunities for follow-up questions from both the interviewer and the interviewees. In the quantitative approach using secondary data, it may be difficult to assess the quality of the data. It can also be difficult to interpret the data correct. This may cause misrepresentation of the survey and entail the wrong conclusions.

Quantitative surveys may leave issues to be addressed more thoroughly in e.g. a qualitative interview. Using quantitative and qualitative methods in parallel, the qualitative data shed light on the numerical results, while the figures may indicate something about the prevalence of the findings of the qualitative parts of the survey. One can use qualitative interviews as a complementary method to answer the research question or see it from a different point of view (Bryman, 2012). The qualitative interview will provide additional answers to questions about action – e.g. what is happening in aviation within the subject of fatigue.

Based on the approach and argumentation regarding the choice of method, in this thesis it has been chosen to use a qualitative approach based on the gathering and review of secondary quantitative and qualitative data on the subject of fatigue, largely based on the study by Luftfartstilsynet (2016a) and Tambala and Bolås (2016). The findings from this will be used to design a qualitative study based on *strategic interviews* of relevant stakeholders that are either affected, or can affect the current fatigue levels amongst pilots in Norway. By using these designs, I intend to limit the disadvantages from each of the research methods, as well as strengthening the advantages. According to Bryman (2012), this can be seen as a form of triangulation of methods. Using only a quantitative approach can create unclear or results that are difficult to understand. Further developing the study by designing a new qualitative study based on the quantitative one, may elaborate and complement the previous results to give more reliable and understandable findings, as shown in Figure 23. This is not the exact method I will be using in this thesis, but I believe the findings from reviewing already existing results can qualify as a sound basis for conducting the strategic interviews, thereby strengthening the findings.

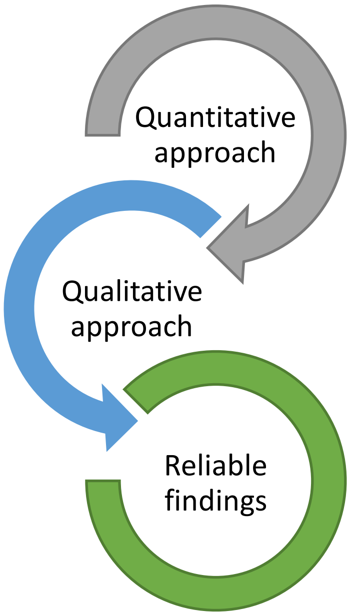


Figure 23 - Triangulation of methods

4.2 Selected research design

In the previous subchapter, it was decided that a qualitative research design using strategic interviews is what will be used in this thesis. These interviews are to be semi-structured, following an interview guide that can be found in Appendix D: Intervjuguide. When conducting a strategic interview, it should be understood that the recruitment of individuals is based on their relevance to the research questions. Thus, we cannot generalise the findings to a normal population, but it might be possible to generalise among the population the interviewees are from. In this case, the participants will be chosen from the aviation industry in Norway.

4.2.1 Previous research design

In the term paper by Tambala and Bolås (2016), a literature review was the chosen method for performing the study. This was accomplished using different sources of information like e.g. legislation, standards & recommendations, books, scientific articles, reports and news articles.

The literature was found searching databases as shown in Table 15, as well a few number of free searches on the internet. The searches were mainly focused on literature published within the last ten years. However, some older sources were included due to their significance on the subject of fatigue within the aviation sector.

Table 15 - Literature search

Database	Search words
Oria Scopus ScienceDirect Journal of Sleep Science ProQuest Wiley Google Scholar	*Fatigue in aviation* *Sleep deprivation* *Sleep loss* *Aviation fatigue* *Sleep aviation*
ICAO IATA EASA Luftfartstilsynet	*Fatigue* *Safety report*
Lovdata CAA UK FAA NTSB CASA	*Luftfartsloven* *Fatigue* *FTL, FDT, Flight time limitations*

In this thesis, much of the experience gathered from the work by Tambala and Bolås (2016) is used and elaborated on. The results of the former literature search have been used to perform further searches due to the findings of new search words, new concepts and insight in new information.

Kitchenham and Charters (2007) explains that a literature review is performed to identify, evaluate and interpret all available research relevant to e.g. a specific area, problem or question. The most common reasons for performing a literature review are either to summarise the existing information on a certain subject, identifying gaps in current research to develop improvements, or to provide an outline for new research activities. Additionally, it is also possible to perform a literature review to find out if empirical evidence supports or contradicts a specific hypothesis. Further, this can even help in establishing a new hypothesis. Similarly, Bryman (2012) states that a literature review is a critical examination of existing research relating to the phenomena of interest and of relevant theoretical ideas.

4.2.2 Interview as an innovation process

Figure 24, shows the development of an interview guide, according to Bryman (2012). Before conducting the interview itself, it is important that both the questions and the purpose of asking these are clearly defined. Many questions can easily be misinterpreted or misunderstood if they are not thought through properly and reviewed thoroughly. The process of developing an interview guide can be long and difficult, but is necessary to create good, clear and unequivocal questions. As we can see from the figure, in the process of reviewing and revising interview questions it might prove necessary to review the interview topic itself. A constant reconsideration of the questions should be in focus – especially in the start-up phase of designing the survey.

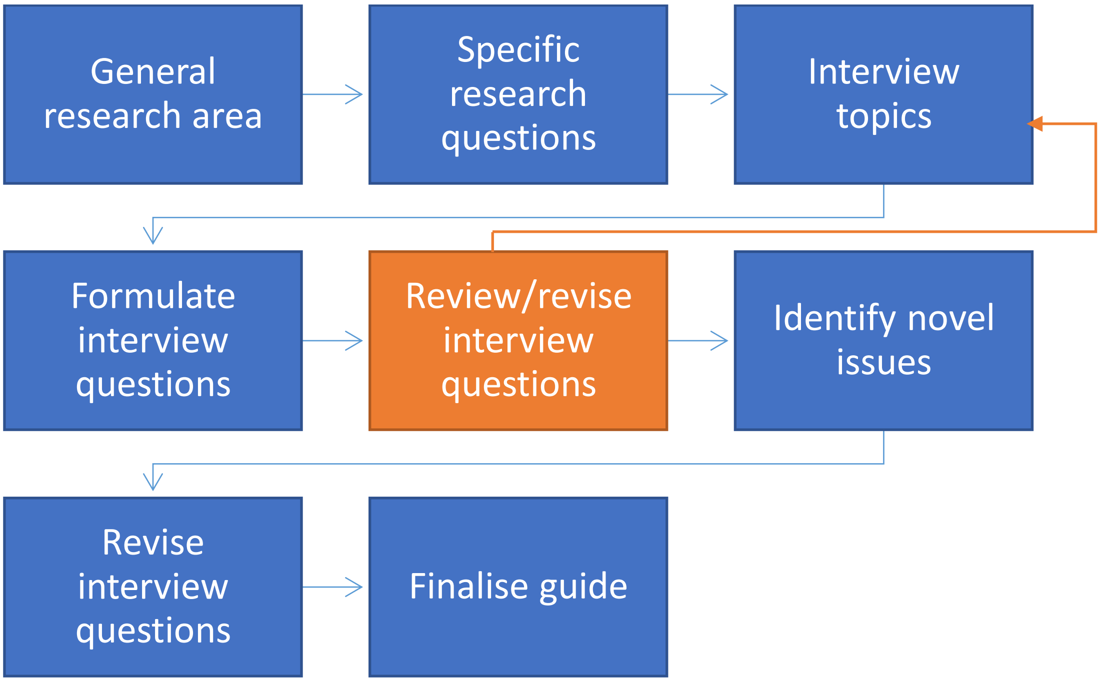


Figure 24 - Development of an interview guide (adapted from; Bryman, 2012, p. 476)

In this thesis, the interview will be used as innovation process for gaining new experience – sort of as an experiment for further development on the subject of fatigue in the Norwegian aviation sector. Before conducting the interviews on actual participants, I have chosen to perform an interview mock-up rapid prototyping based on minimum viable product that is iterated and improved continuously (Patton, 2015). Here, mainly the mentors of this thesis have been used as interview-participants. The process can be related to the de:cycle by Roesler et al. (2005) (Figure 25), where the three roles in design and their respective interests and expertise, are in a cycle of analysis and synthesis. The figure alternates between counter-clockwise rotation, which moves design towards object creation, and clockwise rotation which captures design intent whilst stimulating broadening in the search for what will prove useful.

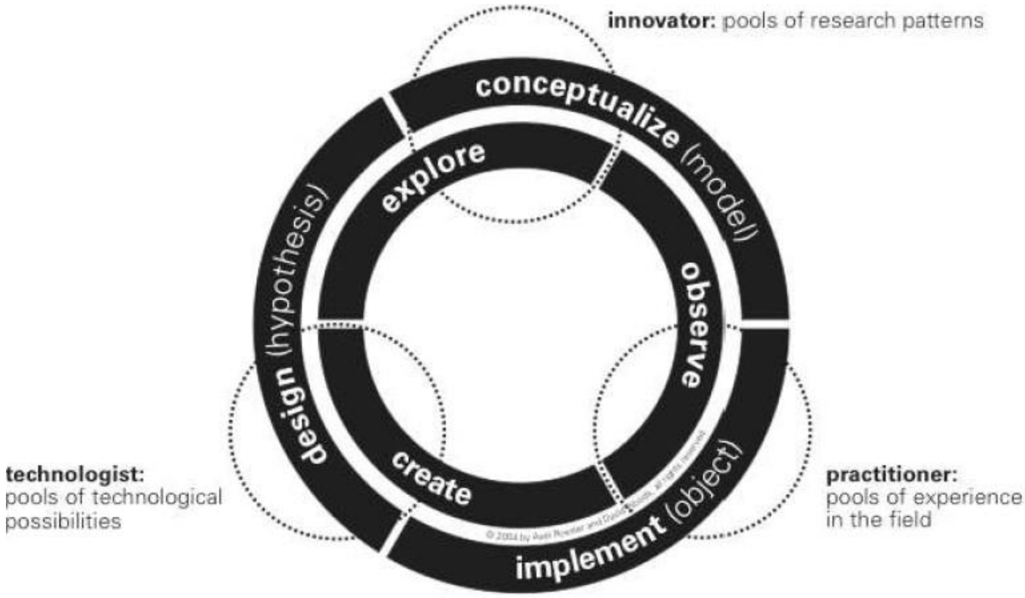


Figure 25 - The de:cycle (Roesler et al., 2005)

By performing the process as intended, it can be seen (Figure 26) that one moves from what is considered most abstract, to most concrete. Thus, the developing concepts – in this case the interview questions – can be deployed into the field. The point located across from the point at which the designed product is deployed into the field, is known as “The Northwest Passage” – it also known as the mysterious area in which ideas are born (Roesler et al., 2005). The model is based on the fact that continuous development should be the basis for performing a good study. However, in this thesis this process cannot go on forever due to time constraints.

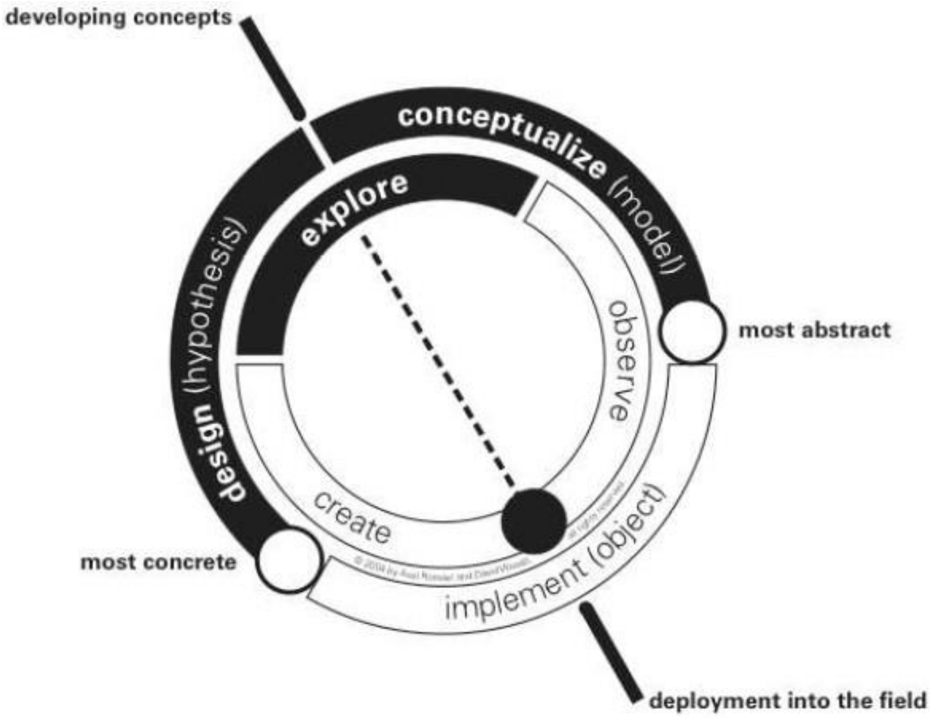


Figure 26 - "The Northwest Passage" in the de:cycle (Roesler et al., 2005)

The end product of the process mentioned above, resulted in an interview guide used continuously when conducting interviews of the various participants (see Appendix D: Intervjuguide). What was considered most abstract in the beginning of the process, now has evolved into something more concrete and substantial. I would say the de:cycle was gone through three times, before deciding to stick with the questions that were developed. Inspiration for the initial (abstract) questions were gathered from the study by Luftfartstilsynet (2016a).

4.2.3 Recruitment of informants

Initially, it should be mentioned that permission from the Norwegian centre for research data (NSD) was requested, seeing as the project will process person-identifying data. The application is included in Appendix A: Meldeskjema til NSD, while the recommendation is included in Appendix B: Anbefaling fra NSD.

The participants in the strategic interviews are recruited through the mentors of this thesis' own professional network. Naturally, the primary criteria for recruitment is that the individual is a part of the aviation industry in Norway; and can either be affected by fatigue or affect the level of fatigue in the industry to some extent. Moreover, it is interesting to find participants who are of different age and possess varying levels of experience.

It is forwarded to each contributor that participation in the interviews is voluntary – everyone has the right to withdraw their participation at any time, without any consequences. Furthermore, a description is also given to the participants of the objectives, methods, implication of the research and the nature of participation. Procedures for the collection and archiving of data will be explained to each participant before each interview, as well as a description of how the data will be anonymised (see Appendix C: Informasjonsskriv for utføring av intervju).

4.2.4 Data collection

When it comes to conducting the interviews, there are several aspects and varieties one need to consider. Different varieties can yield different results. Kvale (1996) proposes ten criteria that characterise a successful interviewer:

- *Knowledgeable*: thoroughly familiar with the focus of the interview.
- *Structuring*: gives purpose to the interview, asks for questions, rounds it off.
- *Clear*: asks simple, easy and short questions.
- *Gentle*: lets people finish, gives pauses and time for the interviewee to think.
- *Sensitive*: listens attentively to what is said, and how it is said.
- *Open*: responds to what is important to the interviewee and provides flexibility.
- *Steering*: knows what he/she wants to find out.
- *Critical*: is prepared to challenge what is said (e.g. if there are inconsistencies).

- *Remembering*: relates what is said to what is previously said.
- *Interpreting*: clarifies and extends meanings of interviewees' statements without imposing meaning on these.

Other than these proposed characterisations, Bryman (2012) also adds the following two criteria for a successful interviewer:

- *Balanced*: does not talk too much or too little.
- *Ethically sensitive*: sensitive to the ethical dimension of interviewing, ensuring the interviewee appreciates what the research is about, its purposes and that his/her answers are treated with confidentiality.

Trying to follow these recommended criteria while interviewing all participants, should ensure an equal result gathered from the interviewees. It also makes the interview run more smoothly and effectively. However, due to practical considerations, there may be a need to conduct the interviews under different settings. This will be elaborated on in the next paragraphs, explaining the actual data collection.

Bryman (2012) lays down certain principles for conducting the interview. An interview can take place face to face, over the phone or via the Internet (e.g. via email, Skype or similar). Essentially, an interview face to face gives greater relevance and reliability. Furthermore, the time before the interview is conducted makes it easier to achieve personal contact and make the situation more relaxed, thus improving the chances of obtaining information which can be considered being more sensitive or difficult to talk about. Meanwhile, the respondent's body language could further help gather information; where hesitation and uncertainty can provide an opportunity to request more detailed or more concrete answers. Skype, or similar means of communication, can partially exploit this effect, and is a desirable option to keep costs down compared to conducting an interview in person. Further, Skype and telephone may be desirable options to preserve confidentiality as high as possible. Conducting an interview by telephone or via Skype gives the interviewee a greater sense of anonymity. It may be easier to avoid questions and speaking falsely when using these types of communication – especially over the telephone. At the same time, respondents may be less affected by the presence of the interviewer, seeing as this setting can get respondents to behave abnormally (Bryman, 2012, Skatval, 2015).

Before conducting the interviews surrounding this thesis, the following assessments were performed:

- Information about the study and the guarantee of anonymity was given in a text distributed to the participants (see Appendix C: Informasjonsskriv for utføring av intervju).

- What was to happen with the information that was given, was also explained in this same text.
- Respondents got to choose location or means (telephone, Skype) for the conduction of the interviews, to make them feel more comfortable of the interview-setting.

Most of the participants wanted to perform the interview over the phone, while the some found it most expedient to use Skype. Only a couple of individuals were interviewed in person. Recordings of the personal interviews, Skype calls and telephone conversations were executed only after consent was given by the respondents.

The respondents consisted of representatives from three different levels of the Norwegian aviation sector – pilots, managers and the NCAA. Thus, different questions were developed, by following the method explained in the previous subchapter. These questions are included in Appendix D: Intervjuguide.

4.2.5 Data analysis

The interviews were recorded with a recording device while conducting them – and later transcribed before being translated from Norwegian to English. This text was then *coded* using computer assisted software for qualitative analysis. The software that was used is called Nvivo 11. From the analysis method presented below, the results are to be presented in chapter 5, before being discussed in chapter 6.

Put simply, a code is a label attached to a section of text to index it as relating to a theme or issue in the data which the researcher has identified as important to his or her interpretation (Cassell and Symon, 2004). In this thesis, I decided to use *template analysis* as the way of analysing the collected data. King (2004, p. 256) describes it to be; *"The term 'template analysis' does not describe a single, clearly delineated method; it refers rather to a varied but related group of techniques for thematically organizing and analysing textual data"*. The following list presents some principles which describe the process of template analysis:

- The process of organising and analysing text data by theme, reduces large amounts of unstructured text to what is relevant and manageable.
- Emphasizes hierarchical coding. Thus, broad themes turn into gradually narrower, more specific themes.
- Starts with a priori codes in an initial template which are modified as coding continues. Consequently, developing a final template which is the basis for interpretation.

According to King (2004) template analysis is a more flexible technique with fewer specified procedures, permitting researchers to tailor it to match their own requirements. It works particularly well when the aim is to compare the perspectives of different groups of staff within a specific context – as is the intention in this thesis.

Figure 27 shows the a priori coding sections (nodes) that were used in Nvivo 11 to categorise the data from the strategic interviews. Text that suited the different nodes were placed there for later review – thus reducing the amount of data significantly. Pilots, managers and the NCAA were coded separately, but in the same type of coding sections as shown in the figure. Furthermore, the different nodes were continuously reviewed as the analysis process continued (the final coding sections can be seen in subchapter 5.3).

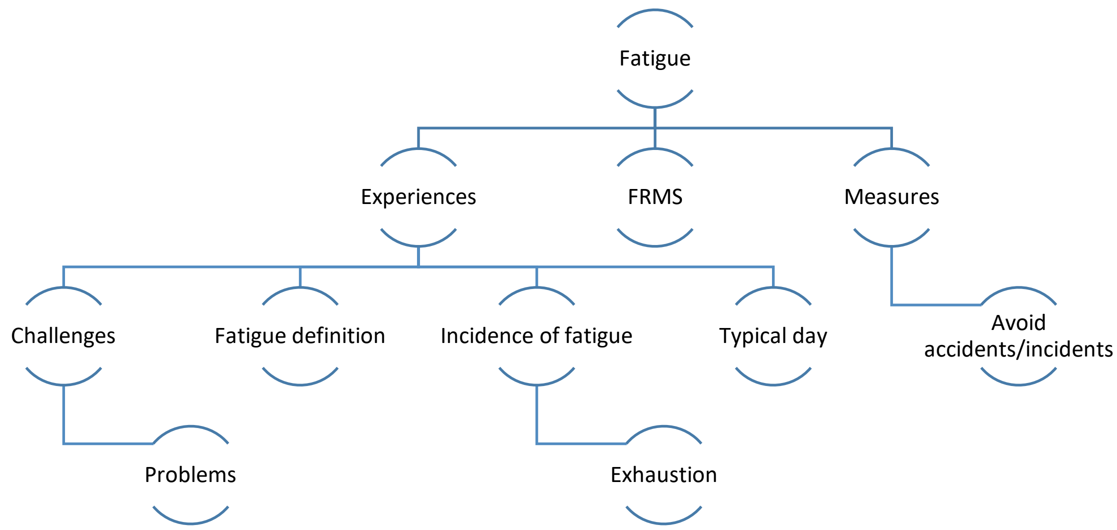


Figure 27 - The coding sections (nodes) chosen to categorise data in

4.3 Authenticity and relevance

The authenticity and relevance of this thesis will be judged by validity (the extent to which you measure what you seek to measure) and reliability (the accuracy/trustworthiness of the data) (Bryman, 2012). The validity of this thesis is thereby strengthened by giving an explanation to how data is gathered.

4.3.1 Ethical considerations

Ethics has many connotations as well as challenges revolving around it – particularly so when conducting interviews with participants that can be affected by it in some way. Bryman (2012, p.130) asks: *How should we treat the people on whom we conduct research? Are there activities in which we should or should not engage in our relations with them?*

In this thesis, the anonymity of the participants is of key importance for both the participants and the survey itself. Answers given during the interviews that could be disadvantageous for both own position and company, as well as other organisations, explains why anonymity is so important. Nobody should be able to be faced with consequences from answering questions in a study whose purpose is to help improve safety levels by finding better ways to manage fatigue. This is a contemplation I have constantly taken into consideration while performing the interviews, as well as writing this thesis.

4.4 Summary

This chapter has shown that there are several approaches available when researching the subject of fatigue in the aviation sector. It has been chosen to use a qualitative approach based on the gathering and review of secondary quantitative and qualitative data on the subject of fatigue, largely based on the study by Luftfartstilsynet (2016a) and Tambala and Bolås (2016). These findings will be used to design the qualitative study, using *strategic interviews* of relevant stakeholders that are either affected, or can affect the current fatigue levels amongst pilots in Norway. By using these designs, the intention is to limit the disadvantages from each of the research methods, as well as strengthening the advantages. According to Bryman (2012), this can be seen as a form of triangulation of methods.

The strategic interviews will be used as innovation process for gaining new experience – sort of as an experiment for further development on the subject of fatigue in the Norwegian aviation sector. Before conducting the interviews on actual participants, it was chosen to perform an interview mock-up rapid prototyping based on minimum viable product that was iterated and improved continuously (Patton, 2015). Here, mainly the mentors of this thesis were used as interview-participants. This process is related to the de:cycle, where the three roles in design and their respective interests and expertise, are in a cycle of analysis and synthesis. One moves from what is considered "most abstract", to "most concrete". Thus, the developing concepts can be deployed into the field. The point identified as "The Northwest Passage", it also known as the mysterious area in which ideas are born (Roesler et al., 2005).

It is intended that the participants in the strategic interviews are recruited through the mentors of this thesis' own professional network. It is decided to forward to each contributor that participation is voluntary – everyone has the right to withdraw their participation at any time. A description of the objectives, methods, implication of the research and the nature of participation is included in Appendix C: Informasjonsskriv for utføring av intervju. Procedures for the collection and archiving of data will be explained to each participant before each interview, as well as a description of how the data will be anonymised. This is also included in the same appendix.

Respondents got to choose location or means (telephone, Skype, etc.) for the conduction of the interviews. They have consisted of representatives from three different levels of the Norwegian aviation sector – pilots, managers and regulator (i.e. the NCAA). Different questions were developed to each of the different levels, and are included in Appendix D: Intervjuguide. The interviews were recorded, transcribed, and lastly coded using Nvivo 11. Template analysis was chosen as the method for analysing the collected data. Finally, the results are presented in chapter 5, and discussed in chapter 6.

4.4.1 Lessons learnt and implications

Given challenges associated with replicability of this thesis, it cannot be omitted that other researchers may draw different conclusions related to the issue at hand. This can for example be due to different individual perceptions, having a hidden agenda with the research results, or other factors. Still, it can just as likely be that conclusions correspond with each other, bearing in mind that previous and current research should have good validity and reliability.

The authenticity and relevance of this thesis will be judged by validity (the extent to which you measure what you seek to measure) and reliability (the accuracy/trustworthiness of the data) (Bryman, 2012). This will be discussed further in subchapter 6.5: Methodology.

4.4.2 Strengths & weaknesses

According to Kitchenham and Charters (2007) the strengths of systematic literature reviews are as follows:

- A clearly defined methodology indicates it being less probable that the literature gathered is biased – thereby increasing the probability that the results of the review are impartial.
- Literature reviews can provide information about the properties of some occurrences on a vast area of situations and empirical methods. If studies give dependable results, systematic reviews suggest that the phenomenon is robust and reproducible. If the studies give variable results, the origin of variation can be studied.

The weakness is described to be:

- A systematic literature review requires noticeably more effort than a normal literature review.

As stated by Bryman (2012), the systematic review approach contains some elements that cannot easily be utilised in a student research project because of time limitations and available resources. Therefore, I have not performed a complete systematic review in this thesis as described by Kitchenham and Charters (2007). This will naturally cause more possible sources for error.

According to Bryman (2012), there are several benefits of using a strategic interviews as the qualitative approach; some of which are listed below:

- It can give the interviewee the opportunity to explain their opinions in vast detail.
- The participants are of significance to the subject that is studied, and therefore sit on experiences that are mostly relevant.
- The interview provides opportunities for follow-up questions from both the interviewer and the interviewees. Thus, removing any doubts either may experience from questions or answers.

When it comes to weaknesses surrounding the strategic interviews, several issues should be taken into account, according to Bryman (2012):

- The interviewees may not get the anonymity that ethical guidelines require.
- They may choose to not respond honestly; either because of leading questions or because the interviewee comes with what he/she considers as a strategically correct answer.
- Additionally, it is often very time and resource consuming to collect data and analyse it.

5 Results and findings

In this chapter the results from the qualitative study are to be presented. 32 people were asked to participate in the study, and subsequently 13 ended up partaking. As mentioned in subchapter 1.2, the main objective of this thesis is to explore to what extent pilots in Norway are affected by fatigue whilst working. To better understand the environment pilots are working under, gathering information from stakeholders in the *blunt end* that directly influence the workers in the *sharp end* of the organisation (ref. subchapter 3.5.1), is also considered an important objective in this thesis. The NCAA, as well as management the airlines, are important stakeholders which have been included in the study, alongside pilots. Figure 28 underlines the applicable stakeholders that have been included in this study.

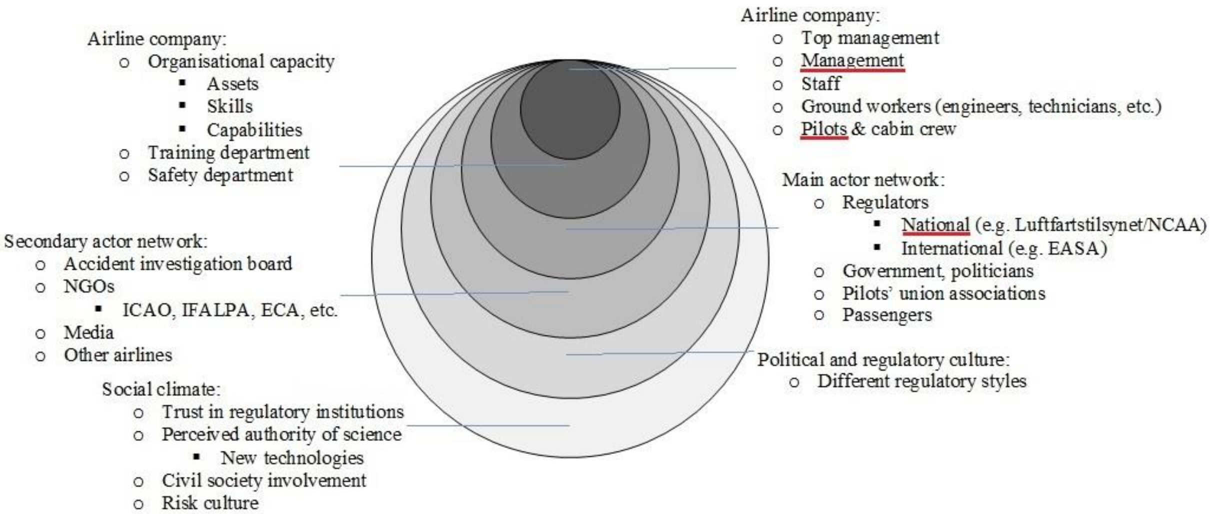


Figure 28 - Underlined applicable stakeholders, seen in relation to Figure 1. Modified from IRGC (2008)

5.1 Introduction

While writing this thesis, eleven individuals from what is considered being the three largest airlines in Norway – SAS, NAS/NAI and Widerøe – were interviewed. The individuals consisted of seven pilots and four from management. Moreover, two people from the NCAA were also interviewed. It should be mentioned that all the management-personnel in the different airlines are either currently employed as pilots in the same company, or have previous experience from working as pilots. In total, four of the interviewees were from SAS, four were from NAS/NAI and three from Widerøe. In the list below, more of the characteristics regarding the interview subjects are summarised:

- Two of the thirteen participants were women.
- The ages and seniority varied among those who participated. The ages spanned from 27 to 58; with everything from 5 years, to about 30 years of experience from the aviation sector.

- Four people are presently employed as first officers in their company.
- Five are currently employed as captains, while two were working as captains earlier in their careers. These numbers include individuals who now have both operational and managerial responsibility.
- The interviewees from the NCAA had varying experiences from operational work in the Norwegian aviation sector; currently involved in supervision and audits of the largest airlines in Norway.

Other than the above mentioned, some of the individuals had experience from working in pilot unions or similar organisations. Additionally, some were currently or previously involved in taking more education or courses – not necessarily related to the aviation sector.

5.2 The strategic interview

As mentioned in subchapter 4.2.4, information about the study and the guarantee of anonymity was given in a text distributed to the participants. This can be found in Appendix C: Informasjonsskriv for utføring av intervju. What was to happen with the information that was given, was also explained in this same text. It was also explained that the respondents got to choose location or means (in person, telephone or Skype) for the conduction of the interviews.

Most of the participants wanted to perform the interview over the phone, while the some found it easiest to use Skype. Only a couple of individuals were interviewed in person. All the participants were asked the same questions – formulated differently based on the level they were employed (i.e. pilot, manager or regulator). The contributors were all Norwegian, thus the questions were recorded in this language, transcribed and later translated to English. The questions that were asked can be seen in Appendix D: Intervjuguide, but are translated and listed below as well.

All the interviews started with a short introduction on the interviewee before the audio recordings were started. These are the elements that were focused on here:

A. Name (was not written down or recorded with audio recorder)
B. Age
C. Position
D. Seniority (countries, type of industry, etc.)

Next, the participants were given more information on the researcher and the study itself, before starting the audio recording:

E. About me: background, age, interest of study.
F. Purpose of the interview: master's thesis for HSE-study at NTNU
G. Background: NCAA working environment survey
H. Inform about recording and consent. Everything is <u>anonymous</u>.
I. Questions?
J. Start recording

From this point, the interviewees knowledge concerning fatigue and the nature of a typical workday for pilots in Norway were explored. Not all of these questions were asked in exactly the manner as shown below. Furthermore, several of the questions were omitted if it was considered that the interviewee already had answered what the question asked of. On the other hand, questions not included in the interview guide were asked where it was pertinent; like if elaborations were needed on a certain subject. Additionally, several of the questions are closely related to each other in case the interviewee needed a rephrase or elaboration of what was asked:

1. Do you have some idea what fatigue is?
    a. What does fatigue mean to you?
    b. How do you characterize fatigue?
    c. Describe your associations with three words.
2. Give a description of a typical workday for a pilot in a Norwegian airline?
3. How do you see that you/he/she would prefer to work?
    a. Type of shift, time of day, etc.?
4. Anything you/they want to change with the current work arrangement?
5. What kind of experiences do you have with fatigue?
6. Can you give examples of situations where you/a pilot have/has been affected by fatigue?
    a. What caused fatigue in those situations you're describing?
    b. Do you see any similarities?

After this part, the intention with the interview was to focus on more specific themes that were considered applicable:

7. How often would you say that a pilot in Norway is affected by fatigue?
    a. Occurrence in other employees?
8. Have you worked you if you feel exhausted/Do pilots in Norway work if they feel exhausted?
    a. Occurrence in other employees?
9. Do you feel that fatigue is a problem in the aviation industry in Norway?
    a. Why/why not?
10. Is fatigue a problem in other parts of the world?
11. Do you/the employees/management/the NCAA speak about fatigue?
    a. Others?
12. Describe how you would like fatigue to be handled and/or spoken about in an airline.
    a. How can we handle/cope with fatigue?
13. Do you see any trend in how the working hours have evolved in the industry?
14. Is there a pressure for pilots in Norway to work more than they feel comfortable with?
    a. Where do you think the main problem lies?
15. Why does not fatigue in this industry create more accidents?
    a. What is done correctly to prevent incidents/accidents?
    b. Who/what is it that makes sure it goes well?
    c. What are you doing?
16. What do you think can be done individually, on a company level and at the governmental level in order to mitigate fatigue?
    a. What steps do you consider appropriate?

b. Are there mitigations that have worked poorly?

17. Are you familiar with the aspect Fatigue Risk Management System (FRMS)?
    a. What can you tell me about this?
    b. Do you have any specific opinions about FRMS?
    c. Do you see advantages/disadvantages?

5.3 Result overview

This subchapter will summarise some of the more relevant findings from the strategic interviews. As mentioned in subchapter 4.2.5, the collected data was coded in different sections (nodes) judged by what the interviewee answered to the question at hand. It was decided to separate the coding sections into three separate but similar sections in order to compare answers from pilots, management and the NCAA. To give a general impression, Figure 29 shows a word cloud of the 1000 most used words by the interviewees in the different sections. This word cloud was made using Nvivo to perform a query on word frequency in all the coded nodes.

Figure 29 - Word cloud from the coded nodes

Based on the method for data analysis described in subchapter 4.2.5, template analysis was used to categorise the data from the strategic interviews. Text that suited the different nodes were placed there for later review in order to reduce the vast amounts of data. Furthermore, the different nodes were continuously reviewed as the analysis process continued. Figure 30 shows the final coding sections that were used in Nvivo to categorise the answers.

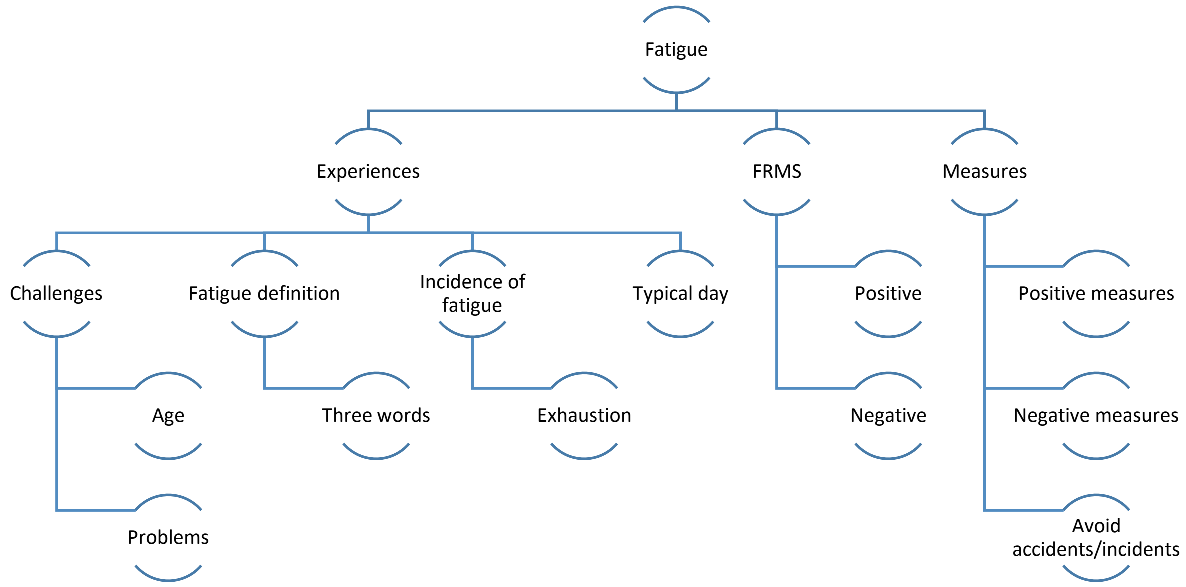


Figure 30 - Final coding section template

In relation to the final coding sections template shown in Figure 30, Table 16 shows how many individuals that gave answers which were coded in the different sections. Additionally, the total number of codes that were included in each node is also shown. As mentioned earlier in this chapter; 7 pilots, 4 from management and 2 from the NCAA participated in the study.

Table 16 - Number of individuals' responses seen in relation to the total codes in a node

Number of individuals with responses in specific nodes (total coded in node)			
	Pilots	**Management**	**NCAA**
• Experiences	3 (6)	4 (8)	2 (7)
○ Challenges	7 (29)	4 (16)	2 (13)
▪ Age	2 (2)	1 (1)	2 (3)
▪ Problems	7 (25)	4 (10)	2 (5)
○ Fatigue definition	6 (7)	4 (6)	2 (5)
▪ Three words	7 (9)	3 (3)	1 (1)
○ Incidence of fatigue	6 (12)	4 (8)	2 (2)
▪ Exhaustion	3 (4)	4 (6)	2 (2)
○ Typical day	7 (11)	4 (6)	2 (2)
• FRMS	-	-	-
○ Positive	1 (1)	3 (8)	2 (2)
○ Negative	4 (7)	-	-

• Measures	6 (30)	4 (15)	2 (8)
○ Positive measures	5 (20)	4 (16)	2 (15)
○ Negative measures	6 (21)	3 (3)	2 (6)
○ Avoid accidents/incidents	7 (17)	4 (9)	2 (4)

5.4 Raw data overview

Taking into consideration the research questions formulated in subchapter 1.3, I will now present some possible answers to questions at hand taken directly from the different interviewees' responses. These responses will be included in the subsequent three subchapters, directly referring to the research questions.

5.4.1 Research question 1

In the paragraphs below, some relevant answers to research question 1 are included, ending in a final comment before the next subchapter.

1. ***How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?***

Pilots:

"I would say that everyone experiences fatigue regularly. You definitely do. In different degrees. But like... In more serious cases, I've experienced being so fatigued that I've fallen asleep involuntarily or noticing that my concentration and capacity were completely bottomed out. I have done that. What is more likely is that you notice things like not working just as well as you normally do, but coping enough so that no incidents happen."

"I think that with fatigue it is very individual. I sleep well, wherever; Whether it's at hotels or at home or at others. I do not have these problems with sleep. And never really had trouble being tired. But, I know that sometimes, if I struggle to sleep, it may be difficult to get up at five in the morning."

"I would say that the number of fatigue-related accidents has increased significantly. But it's in a way they do not see this because... total... so, the total number of accidents, goes down [indicating downward]"

"I think many pilots feel that they do not nearly have the same support now they had before ... from, from operational management... that's what I want to say... and

I think, as I said again, I do not think it's badly meant, really, but they are only affected by the huge commercial pressure coming from above ... I'm experiencing it."

"So, on paper it can look very nice to work for ten hours ... but ... I think it depends on what time of day it is ... and ... what climate you work in. Do you fly in ... I Northern Norway in a hurricane, or; Do you fly to central-Europe; where there are long, dry runways - so ... I think there are many things that come into play here."

Management:

"I think that all parties involved in this work generally must deal with fatigue for what it is - as a question of aviation safety. If you do, you have come very far. And so, we try to comment on it as it is, a question of aviation safety. That's what we treat it like (in this company)."

"Fatigue is a part of commercial aviation. This is known. And there is a shared responsibility between the (airline) operator and crew. And since ... This is really my main ideas around this, that's what I'm building up my day around when I'm working with fatigue, statistics and mitigations. So that... It's a shared responsibility"

"(…) but it's important to say that in this context; That fatigue is extremely individual. Thus, the only way you can do this is to take one single person and schedule him just the way he/she wants it, but there's a long time before we get *there*."

"Yes, (fatigue) it's a challenge - it absolutely is. And that's what airlines need to work with continuously. And always be careful with, and plan with. To fight fatigue. It's a quite common opinion in the departments you're talking to now - the operational department - we're the ones who notice it and see the consequences of it. So that's something we have to face in other departments - among other things - help schedule the pilots."

"(…) you want to achieve profitability; Then you will try to use the European flight time provisions (FTL) fully. And then it's not always that this sees the whole picture ... It sets limits, it sets a max frame, but it is not said that the max frames are appropriate when it comes to fatigue. It does not look at what you're *really* doing - it just says how long you fly. So, there are many other factors that matter to a pilot then."

The NCAA:

"This again is very individual. Obviously, if you had been able to go to work eight o'clock in the morning and finish four to five o'clock in the afternoon, as many other professions have, then it's ideal. But the world of aviation is not like that."

"Yes, I would probably say it is. Once I've said that, of course, there are those measures that I mentioned a little earlier. You have both a duty and the right to call in to say that; "You know what? Today I am so fatigued that I don't belong in a cockpit" And that's what the employer will have to respect of course. And I THINK... in general, at least both SAS and Widerøe and NAS/NAI and so on, are respected. But, something like that is not something you call in with every week. Then you have to figure out what's going on."

"It's a challenge, yes. Not necessarily a big problem, but it is a challenge that we must definitely take seriously and which we must keep in mind. And to the extent that we have the opportunity to go in and do something about it, we have to take care of it all the time .. yes ... That's a very important factor that will be addressed. But again it is not a big challenge, because Norwegian companies are really very good. They are ... "

"But in reality, we're not living in a big risk zone here - it's not like that in any way. It is closely monitored - things are taken care of and things are being done. But if it's always optimal, and whether crews are satisfied on 100 percent of the solutions that are put in place - they are necessarily not - but it's not the same as operating at risk to safety in any way ..."

"There may be other things that bother you in life which make you fatigued to a degree so that you may not sleep as well as usual - you may not eat as well as you have done before and so on. Fatigue is extremely individual... "

As deduced by some of the responses, both how fatigue is experienced and how it is perceived, is *highly* individual. That is probably one of the most important findings from conducting the study; *How individually fatigue is perceived among the different stakeholders*. Some indicate that fatigue is problem, others call it a challenge – mostly pilots say it is a problem, while managers and the NCAA indicate it being a challenge one must work further with. Some pilots have seen other studies on the subject of fatigue, and are sure that a major accident is waiting to happen – in fact, some state that there probably already have been several. But they claim that Norway is safer than other countries in the world. This is supported by the statistics from EASA (2016b) and Luftfartstilsynet (2016b) shown in subchapter 2.2: The European & Norwegian aviation sector.

Based on the responses one can say that there has been a lot of changes in the companies themselves over the last ten years. The pilots that were interviewed feel like they are no longer appreciated to the extent they have been before; some indicate that lower-/mid-level management should work differently to counteract fatigue. As of now, they do not fully see/understand the mitigations that are put in place by management or the NCAA – "IF ANY AT ALL", as some respondents' state. On the other hand, the NCAA claim that we are not living in a risk to safety when it comes to fatigue. These two polarities show how different fatigue is perceived among the stakeholders.

5.4.2 Research question 2

Below, some relevant answers to research question 2 are encompassed, ending in some remarks before the succeeding subchapter.

2. *Which measures can be used to mitigate fatigue among pilots who work in large aviation companies in Norway?*

Pilots:

"(…) THAT YOU TAKE A CONTROLLED NAP ... IT'S TECHNIQUE THAT WORKS FOR ME, THE FEW TIMES I DO IT. IT IS BASICALLY TO SLEEP FOR TEN MINUTES, MAXIMUM FIFTEEN MINUTES ... JUST, WELL, JUST ... "WAKE ME UP IN ABOUT A QUARTER", THEN MAYBE I SLEEP SEVEN TO EIGHT MINUTES OF THE FIFTEEN ... IT MAKES YOU GET ONE... A... SORT OF A, *RESTART*... WHERE... IF YOU SLEEP LONGER THAN THAT - AT LEAST FOR ME – IF I SLEEP *LONGER* THAN HALF AN HOUR... THEN IT JUST BECOMES WORSE... BECAUSE THEN I'VE ENTERED DEEP SLEEP."

"ON THE LAST LEG OF A... A DAY, MAYBE, WE'LL INCLUDE IT WITH... IN SUCH A TEM BRIEFING - A THREAT AND ERROR MANAGEMENT BRIEF. WHILE WE ARE TAXIING FOR TAKE-OFF OR BEFORE STARTING WE SAY SOMETHING LIKE; "YES, THE LAST LEG OF A LONG WORK DAY. NOW WE MUST... TAKE CARE TO... TAKE IT A LITTLE… WE'LL TAKE IT A BIT SLOWER NOW, SO WE'LL GET EVERYTHING DONE RIGHT."

"I SEE THAT SOME COLLEAGUES HAVE STARTED TO WORK OUT TO GET IN BETTER SHAPE, AND THUS WITHSTAND A HIGHER WORKLOAD."

"Yes, surely we work more than we used to do. The days are longer. But, there are opportunities to have a little more creative planning than it was before, perhaps."

"Then I feel that the first thing we should do – It's that everyone must pull themselves together and start writing fatigue reports."

Management:

"As a leader, I can contribute... What I can now contribute to is to make sure that we use enough resources to make most of the best possible measures."

"In the cockpit you can take a five-minute nap, but of course you must brief all the others - including the cabin crew."

"(…) we have just decided to buy an electronic surveillance system of the working days or rosters of the pilots. Over time, it looks at workload and load - and then it calculates how much fatigue this produces. And it's an appliance, no, it's a program we've bought. It is voluntary to buy such a system, but we do it for a better overview of fatigue; and having a system that is objective, and not necessarily having a person who believes *something*. It is, thus, a tool developed by professionals with empirical research."

"When you get to work you have to be fit for flight. It is every individual's responsibility. If you're not, you should not fly. And at the same time, when you're out working, we have… We have a lot of information to crew about how to handle fatigue, how to proceed to avoid it; it's about sleeping patterns, it's about exercise, it's about how to eat, how to sleep and so on. And it is the responsibility of the individual/our crew to follow it, or do their best to avoid fatigue."

"From the airline's side it's the most... What we can do is try to design rosters that are as gentle as possible. Remove these changes that switches from early flights to late flights, and so on. If you have a roster over several days where you start early in the morning, you shouldn't suddenly turn it around and fly in the evening - it is obvious that this causes tiredness or fatigue. So, it is the company's responsibility to make as good rosters as possible."

The NCAA:

"There are also many pilots who feel when they get a bit older that this is too heavy, and so they work 80 percent instead of 100. It is also a measure you can do

YOURSELF. ONCE YOU HAVE COME UP IN THE 50S, YOU'RE FINISHED PAYING OFF THE BIGGEST DEBTS. AND YOU MAY NOT NEED THE HIGHEST SALARY ANY MORE, BUT YOUR BODY NEEDS A LITTLE MORE REST. SO, THAT'S ALSO A MEASURE YOU HAVE."

"BUT I THINK IF YOU HAVE THE POSSIBILITY TO HAVE COMPLETELY REGULAR... LET'S SAY YOU HAVE SOME FIXED EARLY-STARTS, OR SOME FIXED LATE-STARTS - THEN YOU HAVE A PREDICTABILITY IN THIS; THAT'S PROBABLY ONE OF THE MOST IMPORTANT THINGS WE SEE."

"THAT AIRCRAFT AND CREW FOLLOW EACH OTHER OVER A PERIOD OF TIME IF YOU UNDERSTAND WHAT I MEAN, SO YOU DON'T HAVE TO LEAVE A FLIGHT AND CAN GET NEW CREW ALL THE TIME. YOU DO NOT HAVE TO CHANGE THE CABIN SEVERAL TIMES, OR THAT YOU DON'T HAVE TO CHANGE 2P, CO-PILOT OR CAPTAIN - THAT YOU HAVE A STEADINESS IN WHAT YOU DO."

"I SEE THAT THE COMPANIES HAVE BECOME VERY CONSCIOUS OF LOOKING AT EVERYONE - SHOULD I SAY - WHERE ONE IS IN LIFE. ABOUT THIS WITH LIFE STAGES. THIS IS TO ARRANGE A LITTLE FOR - FOR EXAMPLE - PEOPLE WHO ARE IN A FAMILY SITUATION WITH LITTLE CHILDREN AND SUCH THINGS. CAN THE COMPANY OFFER MORE FLEXIBILITY AND SO ON… FOR EXAMPLE, IF THEY WANT TO FLY FOUR MORNING TRIPS BECAUSE THEY ARE UP IN THE MORNING ANYWAYS OR SOMETHING LIKE THAT - I SEE THAT THEY ARE HELPING THE EMPLOYEE MAKE IT HAPPEN. THEY MAKE SEVERAL FLIGHT-TIME SYSTEMS THAT ALLOW YOU TO CHOOSE YOUR OWN SCHEDULE, SO TO SPEAK. SOME DO NOT WANT TO HAVE FREE DURING WEEKENDS, SOME WANT TO. SO THEY... YOU CAN BID ON IT; INTO DIFFERENT OPTIONS. I CONSIDER IT A VERY GOOD MEASURE. IT ALSO GIVES THEM THE OPPORTUNITY TO HAVE SO-CALLED BOARDING STATIONS, SO THEY DO NOT HAVE TO SHOW UP AT THEIR HOME BASE BUT CAN COME OUT OF THEIR HOME AND START WORKING, INSTEAD OF COMMUTING."

Mitigations that can be done on the three levels the interviewees consisted of is included here; everything from the sharp end to the blunt end. Most of the answers considering measures that can be done on an individual level (by pilots) were based on, or similar to, what is mentioned under the subchapters in 3.2: The science of sleep in an aviation context. This is some of what the airlines educate their employees on today, and is mentioned repeatedly as measures by stakeholders on all levels – especially the measures listed in subchapter 3.2.3. Other than this, working 80% instead if 100% is a mentioned possible measure. Using Threat and Error Management-briefing (TEM-briefing) is also listed. This is something that is also suggested by Dawson et al. (2015) as an informal strategy to use for reducing fatigue related risks.

When it comes to mitigations on a company level; SMS, FRMS, a Safety Action Group (SAG) or Fatigue Safety Action Group (FSAG) are stated as possible effective measures to cope/counteract fatigue by several of the respondents. Some of these are presented earlier in this thesis (subchapter 3.4: Managerial framework regarding fatigue). One of things I would like to emphasise is the use of more creativity in the way crew are rostered as a possible measure. Several of the respondents stated that more flexibility was a factor that is valued highly for flying personnel; e.g. an airline's use of a rostering system where you can design your own schedule to some extent. This was also found in the study by Anund et al. (2015) concerning *influence on the schedule* mentioned in subchapter 3.2.3. There are several measures which are mentioned – most of these are quite innovative and effective, according to some of the respondents.

On a governmental level, mostly pilots mention proposed measures that they see fit. They mention wanting a tightening of the prescribed FTLs and FDPs. Many of the operations that are conducted in Norway (e.g. during winter operations or poor weather) need to be considered especially as these are considered being more fatiguing than flying in a more stable environment without these challenges (i.e. than operations with a lower workload). In general, they want a larger involvement of the NCAA and/or EASA in mitigating the issues at hand. However, the NCAA, as well as representatives from management and some pilots, state that there is a need for more fatigue-reports to mitigate specific issues that arise. Today, this reporting is far too low when comparing to the answers given in studies like the ones mentioned in subchapter 2.4: Statistics on fatigue in the European & Norwegian aviation sector. This is a challenge that will be discussed further in the next chapter.

There is a vast number of measures that can be implemented to mitigate fatigue. Currently, many of the respondents' state that an improvement and exploration of options is necessary. More work is needed in trying different systems and mechanisms instead of merely adhering to the prescribed FTLs and FDPs, according to several of the interviewed objects.

Table 17 shows some of the proposed measures given by several of the different stakeholders. They are each put in the category of which they are applicable – pilots, airline and government – to see what measures they are suggested to undergo.

Table 17 – Measures proposed by the different stakeholders to mitigate fatigue

Measures		
Pilots	**Airline (managers)**	**Government (NCAA/EASA)**
Producing more fatigue-reports. Increasing one's own will to report fatigue. Working less (80% instead of 100%). Going to bed at decent hours. Good sleep hygiene. Napping on the flight deck. Eating healthy and exercising regularly. Using TEM-briefing.	Emphasising the need for more fatigue-reports. Ensuring that reports are handled without any form of consequences to the one who reports. Having a flight time system that enables design of workdays from employees. Utilising elements from an FRMS without necessarily implementing the system. Educating employees on all levels; e.g. those responsible for scheduling crew, managers, pilots, etc. Communicating the airline's trends and visions. Employing enough personnel, which in turn enables higher flexibility.	"Pushing" the companies to produce more fatigue-reports. Being more proactive instead of reactive. Being more involved. Ensuring that special regulations apply for operations under different conditions (e.g. operations in Northern Norway, winter operations, etc.) Redefining the current FTLs and FDPs, producing a more restrictive regulation.

5.4.3 Research question 3

Lastly, some relevant answers to research question 3 are included, resulting in some comments before a summary of this chapter is presented – including a subchapter on relevant themes to discuss further.

3. ***Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?***

Pilots:

"I feel I do not get enough rest to recover fully... Bringing fatigue from the previous work period to the next round again"

"They (the airline) request reports. They ask... ask us to report when appropriate... But, as said, the will to write a report isn't there... Because one hears of someone... someone who has done it – maybe he or she gets the stamp of being a complainer. So, the willingness to spend energy writing a report may not be present because of this."

“*My* perception is that it is very focused on what sort of systems we have, which will in a way, catch things or do something like that. But, according to what I notice; I do not see any changes. And therefore, one question I ask sometimes is: "Do we have the systems because it is legally required and it looks good from the outside that we work with safety? Or do we have them because we actually want to use it and that it is actually used to reduce things?" It remains to be seen, but I feel like we have improvements to do on that side.”

“It's a matter of how long you are at work and how long you are in the position you are doing. And with the new regulations that came after the Germanwings accident, where we are not allowed to go out of the cockpit unless someone else enters, it ends up with the fact that you do not stretch your legs anyway either, you are sitting very much physically calm and that is not good. All research says to avoid, or reduce... to reduce the possibility of being fatigued, it's important with long walks where you actually move. And get yourself a little away from the tasks.”

“And to sit on the ground and say that; "Now I'm... On the next leg, I'll be fatigued", we also have no room for doing because we're not allowed to use it preventively. You'll get off when you're fatigued and you're rarely fatigued when you're on the ground. It comes when you are up in the air somewhere; And what are you going to do then?”

Management:

“The times they report fatigue, then it's real fatigue reports. And it gives the me an indication, at least, that the communication around it is good enough - that people actually report their real cases.”

“For a very long time we had something called "split schedule". This means that you are at work in the morning, and then you have a long break and then you have work again in the evening. We have, for all practical purposes, now almost completely moved away from this practise. And I have a clear impression that the staff, both pilots and cabin crew, are quite happy without this type of scheduling.”

“It's really quite incomprehensible that EASA has set these limits. And it's almost impossible to sweep away. But there is a lot of research suggesting that it's not

SMART TO SET THESE LIMITS. IT'S AFTER THE 14 HOURS YOU'RE GOING TO DO THE HARDEST TASKS - LAND, RIGHT? BUT THERE'S A LOT OF POLITICS INVOLVED HERE."

The NCAA:

"(…) YOU HAVE SOMETHING CALLED AMC; ACCEPTABLE MEANS OF COMPLIANCE - THAT IS, IT IS A KIND OF GUIDANCE LIST ON HOW TO COMPLY WITH THE LEGISLATION. IF YOU DO NOT, YOU CAN CREATE AN ALTERNATIVE MEANS OF COMPLIANCE; WHAT IS CALLED ALTMOC. BUT THEN YOU MUST PROVE TO YOUR AUTHORITIES THAT THE WAY WE DO IT HERE HAS THE SAME LEVEL OF SECURITY AS THE INTENTION OF THE RULE. THIS IS DONE BY USING THESE RISK ANALYSES. SO, YOU CAN SAY THAT THE COMPANIES HAVE A MUCH BIGGER ROOM AND FREEDOM OF ACTION THAN IT HAD BEFORE. AND IT'S GOOD AND BAD. AND SOMETIMES, THEY ALSO HAVE A GREATER LEVEL OF SECURITY THAN THE REGULATORY FRAMEWORK IS BASED ON. I THINK IT'S OKAY AS LONG AS THEY HAVE PEOPLE WHO UNDERSTAND THE RULES AND REGULATIONS, THAT THEY SUBMIT THESE ANALYSES, THAT THEY ARE GOOD AT MAKING THESE ANALYSES AND THAT THE MEASURES ARE IMPLEMENTED - SOMETHING WE OF COURSE CHECK - AND IT IS FOLLOWED UP THROUGH THEIR QUALITY SYSTEM THAT; "WAS IT EFFECTIVE ENOUGH? DO THEY WORK? IS THERE SOMETHING TO CHANGE? ", AND SO ON. SO, YOU'RE ALWAYS SAFE. IT'S REALLY MUCH BETTER THAN HAVING A HARD SET OF RULES THAT YOU'VE IMPLEMENTED ONCE AND DO NOTHING MORE WITH BEFORE SOMETHING HAS HAPPENED ... SO, WITH THAT IN MIND, I'LL SAY THAT I REALLY THINK THAT THE PERFORMANCE-BASED REGULATORY FRAMEWORK - AS IT'S CALLED - MIGHT WORK BETTER THAN IT DID BEFORE. BECAUSE THEN YOU ONLY LEARNED FROM YOUR MISTAKES."

"(…) AND THERE I SEE THAT VERY FEW OF THESE REPORTS ARE CONCERNING CREW BEING... THIS WITH FATIGUE, IT IS A TWO-SIDED THING. ONE IS THAT THE COMPANY HAS A RESPONSIBILITY FOR CREW NOT GETTING FATIGUED, BUT IT'S ALSO AN INDIVIDUAL, THAT IS, AN INDIVIDUAL'S RESPONSIBILITY. AND I SEE THAT THERE ARE VERY, VERY FEW - WELL BELOW 10 PERCENT OF THE REPORTS WE RECEIVE - WHO REPORT THAT THEY THEMSELVES MAY BE THOSE WHO HAVE CAUSED THEIR OWN FATIGUE. IT MAY BE THAT YOU HAVE COMMUTED, HAVEN'T GONE TO BED ON TIME, THE KIDS HAVE BEEN AWAKE ALL NIGHT, YOU'VE BEEN SICK OR EXHAUSTED OR ANYTHING OF THE SORT. BEEN IN AN ARGUMENT... SO THOSE THINGS WHICH CAUSE YOU TO NOT FEELING IN SHAPE - LIKE BEING TIRED OR FEELING TIRED... THAT'S - THAT'S SOMETHING I SEE HERE ... SO I THINK IT'S AN INCREASED AWARENESS ON THIS AMONGST CREWS THAT NEEDS IMPROVEMENT."

When it comes to the beliefs the interview subjects have concerning the last research question, there are different opinions. Some feel that a lot of improvement is needed, while others are satisfied with the current systems. Moreover, there is a wide consensus on achieving working continuously with fatigue-related matters. It is not necessarily something you can implement a measure to “fix” – it is something that needs to be monitored and worked on in a constant cycle. These challenges associated with this are closely related to the theory presented in subchapter 3.5.3: Safety management as a control problem.

Presently, there is a consensus among the respondents that there is a need for further improvements on all levels (sharp end to blunt end). Many pilots stated that they feel that the systems they have in their airline are put in place because they are required or look good – not actually to cope with fatigue-related issues. Managers do not share this opinion. This can be compared to what was mentioned in subchapter 3.4.2: Fatigue Risk Management System, where Signal et al. (2006) found that that pilots and management in the same organisation had different views of how the fatigue management strategies were implemented. A significantly higher number of the management staff considered that their company educated their pilots and other management staff well enough, compared with the opinion of the pilots. Conclusively, the different opinions of the workers in the sharp end versus the blunt end, as well as lack of understanding of fatigue and poor management of countermeasures shows the need for either implementing an FRMS, or utilising elements from the system in the airline

5.5 Summary

In this chapter the results from the strategic interviews have been presented. 13 people with different backgrounds participated in the study that has been presented. To better understand the environment pilots (the sharp end) are working under, gathering information from stakeholders in the blunt end is explained being an important objective in this thesis. The NCAA, representatives from management and pilots with different experience are important stakeholders which have been included in the study.

The interviews were conducted by asking the same questions, but in different settings (i.e. Skype, telephone and in person). All the interviews were recorded and transcribed, before categorising and reducing the amounts of data using template analysis. Information that suited the different node categories were placed there for later review. Next, the different nodes were continuously reviewed as the analysis process continued, before ending up with a final coding section template. An outline of how the stakeholders have responded was presented as well.

Lastly, taking into consideration the research questions, possible answers to the questions at hand were taken directly from the different interviewees' responses. There are certain themes that became apparent when reviewing the data set and corresponding nodes.

5.5.1 Themes for further discussion

From the themes that became apparent from interviewing the different individuals, I have selected two that I consider being both important and interesting to discuss further in the next chapter. These themes are seen as being in closest relation to the research questions, as well as being mentioned by several stakeholders on different levels. Furthermore, several other findings are less possible to discuss, like e.g. finding that fatigue is considered being a problem by pilots in the Norwegian aviation sector.

Firstly, as mentioned in subchapter 5.4.2 above, there is a challenge associated with the different views in the sharp and blunt end. In the sharp end, they want a larger involvement of the NCAA and/or EASA in mitigating the issues at hand. Yet, there is a paradox that both the NCAA and the airlines have a need for more fatigue-reports to mitigate the specific issues that arise. Today, the reporting from personnel in the sharp end is far too low when comparing to the results from the studies by e.g. Luftfartstilsynet (2016a), Reader et al. (2016) and ECA (2012). This is the first theme that is to be discussed – seen in connection with background and theory presented in chapters 2 and 3.

Finally, the last theme that is to be elaborated on is the use of more creative ways to cope with fatigue on a small (individual) and large scale (airline/regulator) will be discussed further. Some of the questions that were given to the interviewees were on how successful operations are ensured even though fatigue is present among workers in the organisation. Additionally, they were asked if they can see any possible measures to shift the current trends (ref. questions 15 a-c and 16 a-b). For instance, all companies currently have a policy where they encourage their employees to report not fit for flight on occasions where this may be necessary – e.g. sickness, fatigue, etc. Yet, the study by Luftfartstilsynet (2016a) shows that more than 60% of pilots, and nearly 80% of cabin crew have gone to work once or more during the last 12 months, even though they felt that they should not have done so (ref. subchapter 2.4). This is just one of the challenges that need mitigations or possible solutions, and will be interesting to see in relation to some of the background and theory presented in chapters 2 and 3.

6 Discussion of the results

In this chapter a discussion around the research questions formulated in subchapter 1.3 is the main focus. The research questions will be seen in relation to the themes established in chapter 5, and compared to what has been portrayed in previous chapters regarding background on fatigue, theory concerning fatigue and applicable safety management aspects. Additionally, there will be a review of the methodological approach that was chosen to answer the research questions.

6.1 Research questions in relation to selected themes

Here, the research questions for this thesis are presented again:

1. *How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?*
2. *Which measures can be used to mitigate fatigue among pilots who work in large aviation companies in Norway?*
3. *Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?*

As mentioned in subchapter 5.4.2, there is a challenge associated with the different views in the sharp and blunt end regarding the management of fatigue. In the sharp end, they wish for a larger involvement of the NCAA and/or EASA in mitigating the issues at hand. The paradox is that both the NCAA and the airlines have a need for more fatigue-reports to mitigate the specific issues that arise. Other than; *how individually fatigue is perceived among the different stakeholders*, this paradox is possibly one of the biggest challenges that was found during the interviews. This is to be understood as mainly a discussion of research question 1 and 3.

Next, what are considered more creative ways to cope with fatigue on an individual and large (i.e. airline and government/regulator) scale? Each of the stakeholders that were interviewed had some ideas regarding the current and possible future measures on how successful operations are ensured even though fatigue is present in the sharp end of the airline. This is to be understood as mainly a discussion of research question 2 – and to some extent research question 3.

The following subchapters will discuss the selected themes related to the research questions, including background information on fatigue (chapter 2) and selected theory (chapter 3).

6.1.1 Safety management of fatigue

As mentioned in subchapter 2.3: Is fatigue a challenge?, there has been a decreasing order of accidents in the aviation sector. It seems like it is safer than ever to use airplanes as transportation – especially in Europe. This may partly be explained by an advancement in technology during recent years. There is also a strong focus on training and continuous development of pilots and other workers in the sharp end – as well as an increasing degree of knowledge (Caldwell and Caldwell, 2016).

Furthermore, it was mentioned that the different airlines are experiencing a greater pressure to operate as cost-effectively and punctual as possible, which in turn reflects the growing trend of travellers worldwide (Avers and Johnson, 2011, Caldwell and Caldwell, 2016). With higher pressure to operate based on the companies' requirements and preferences, and customers' expectations, it could arguably affect an airline's ability to operate in a safe and secure manner when seen in relation to subchapter 3.5.1: Different decision settings: Conflicting objectives. Many of the decisions made in the blunt end will affect what occurs in the sharp end of a specific organisation. It can be said that these decisions are not always appropriate in the way they affect the other stakeholders. Most of the power lies with the regulatory institutions, seeing as they can directly affect how operations in an airline are conducted (Tambala and Bolås, 2016).

Rosness et al. (2010) and Rasmussen (1997), state that individuals, groups, organisations and institutions deal with conflicting objectives all the time. Since there exists an open market economy in Europe, competition between airlines is heavily present. Whoever manages to produce travel from A to B at a lower cost than its competition, will have an advantage in the market they operate in. As was mentioned in subchapter 3.5.2: The socio-technical system, the fast pace technological change, changing market conditions and financial pressures are very comparable to the aviation industry in Norway today. The sharp end has moved in an entirely different way than the blunt end – arguably due to the regulatory institutions not being able to keep up with the level of change (Tambala and Bolås, 2016). Thus, fatigue has become a challenge the blunt end now must find a way to cope with in an airline.

Conflicting objectives are often set through gradual adaptation of wanted or unwanted behaviour. Safety in an organisation requires money, time and competent workers. This may be a challenge to establish well enough for some airlines. In other words, there will be an ever-lasting conflict between safety, economy and efficiency. This is where fatigue can be a great challenge. There rests an enormous responsibility on the pilots in an airline to be physically and mentally prepared in order to perform their tasks in a safe manner; e.g. preventing loss of control in flight, which was the predominant cause of fatal accidents in 2015 (cf. 64% of the accidents, EASA (2016b)). On the other hand, management are experiencing a large commercial pressure to reduce costs and save money due to the current economic environment that they operate under. This commercial pressure is sustained in lower parts of the company according to several of the interviewed stakeholders. Debatably, this is a factor that affects the reporting of fatigue – among several other things like e.g. work environment, work culture, stress, etc.

Today, one major challenge arguably concerns the fact that the reporting from personnel in the sharp end is far too low when comparing to the results from the studies by e.g. ECA (2012), Reader et al. (2016) and Luftfartstilsynet (2016a). This was confirmed by several of the stakeholders who were interviewed in the qualitative study. There are simply not enough submitted reports which can be used to act on. An interviewee from the NCAA explains the issue when asked if there is anything pilots would want to change with their current work arrangement (question 4, subchapter 5.2): "(…) I PICTURE THAT WITH MORE STEADY REPORTING – AND GOOD REPORTING – THESE ARE THINGS WE WILL GET IDEAS ON, BUT TODAY WE HAVEN'T GOT A LARGE AMOUNT OF MATERIAL IN ORDER FOR ME TO GIVE A CONCRETE VIEW OF THAT." When asked what kind of experiences or examples of situations the interviewee had concerning fatigue, this was part of the answer (question 5 and 6, subchapter 5.2): "THEY JUST STARTED REPORTING TO US. SO, I CANNOT SAY THAT WE HAVE ANY BIG AND GOOD PICTURE OF THIS YET. WE DO NOT SEE TYPICAL TRENDS. (…)"

Furthermore, it shows that using reporting as a measure to manage fatigue in the Norwegian aviation sector possibly does not work as fully intended, seeing as the airlines can have a different impression of the level of fatigue in the company than what it *actually* is among workers in the sharp end. From performing the interviews, it was found that almost all the pilots experienced fatigue regularly. They also considered it being an extensive challenge, similar to the findings in the studies mentioned above. This can be related to what was presented in subchapter 3.5.3: Safety management as a control problem.

According to Kjellén (2000), an organisation learns in three ways: individual learning through experience, through knowledge sharing and via externalisation of the organisational memory. This is considered a continuous process. In this case, mainly learning through knowledge sharing, is the lacking part of the continuous loop in the HSE information system – seeking continuous improvements to an airline. Positive effects on safety are only achieved when the loop is closed, i.e. when the outcomes of the decisions are implemented in a way that affects the organisation positively now or in the future. Thus, missing flow of information breaks up the loop (Figure 31), and can eventually lead to incidents and/or accidents. Lacking amounts of fatigue-reports from the production system (i.e. data collection), not only affects the organisational memory, but the entire process. The airlines are not able to generalise the findings in the fatigue-reports on a larger level, ensuring that making decisions in the end of the process becomes quite difficult. As one interviewee from management stated when asked what kind of experiences or examples of situations concerning fatigue – or where employees had been affected by fatigue (question 5 and 6, subchapter 5.2): "(…) WE GET REPORTS MONTHLY. FROM LOYAL EMPLOYEES WHO REPORT *COMPLETELY* REAL CASES OF THEM BEING FATIGUED. WHAT IS THE GENERAL PATTERN OF THOSE REPORTS IS OF COURSE THAT THEY ARE RELATIVELY FEW – THEREFORE THEY ARE HARD TO FIND PATTERNS IN."

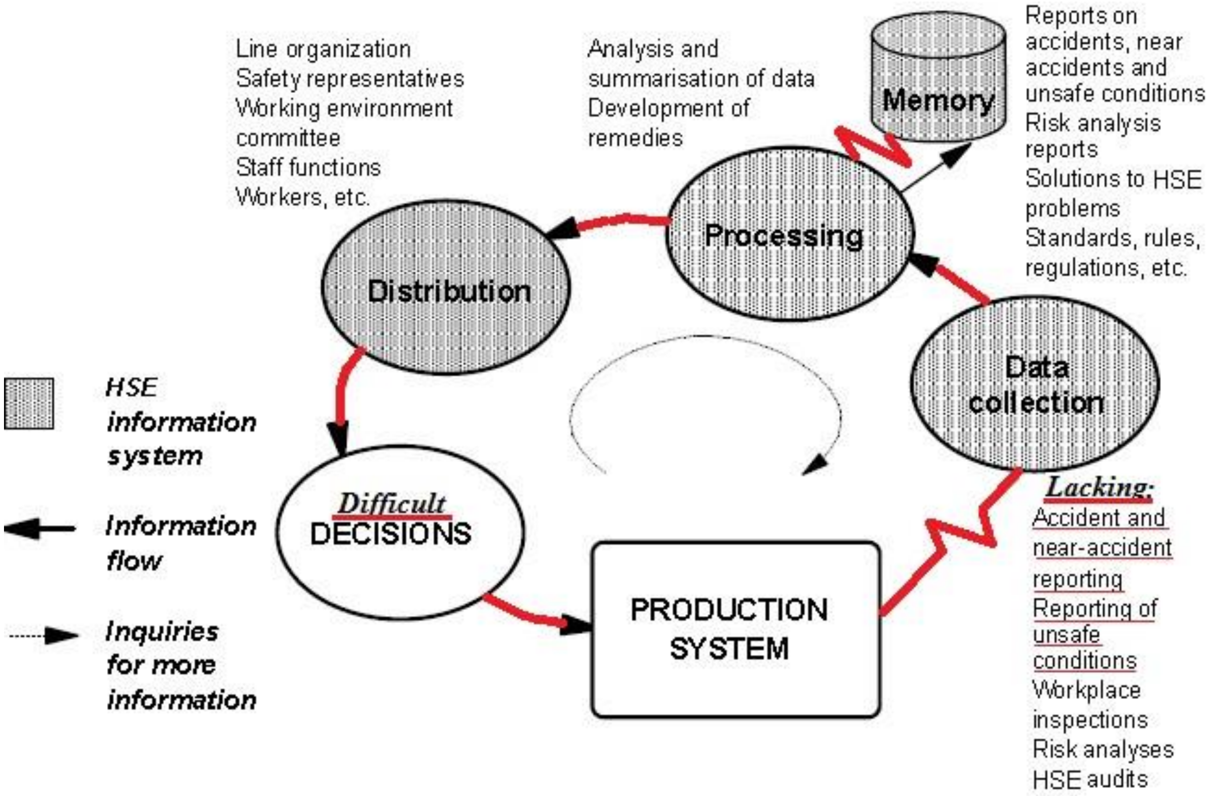


Figure 31 – Missing flow of information in the HSE information system. Modified from Kjellén (2000)

We can relate the aspects of safety management being a control problem to the systems incorporated in the aviation sector to cope with fatigue. Namely, the SMS and the FRMS in an airline (explained in subchapter 3.4: Managerial framework regarding fatigue), that need to take into consideration the flow of information in the designed system. The need for an SMS/FRMS which has a closed loop, seeking continuous improvement of safety levels through both single- and double-loop learning as well as using a combination of a feedback and feedforward mechanisms, should be the set standard. Naturally, this is can pose quite a challenge. If there are too few reports to make decisions from, seeking continuous improvements regarding fatigue in the Norwegian aviation sector is difficult.

As explained in subchapter 3.5.33.5.1 and related to what was mentioned in the previous paragraph, Argyris (1992), states that single-loop learning aims at solving the increasing changes and the problems that have arisen as a reaction. This form of learning ignores the need to find the real cause of the problem. Double-loop learning will go more deeply into the cause of the problem, and feedback is used to look at the governing variables. Questions are asked to find the *real* cause of the problem, e.g.: What were the considerations of the managers and the employees to implement certain procedures? What went well and what should be enhanced? Some of the interviewees explained that they do not submit reports because of several reasons. Some feel that their reports cannot change anything. Others are afraid of reprisals or being labelled as a complainer. This is a challenge that should be worked on in each individual airline in order to enable double-loop learning – finding the real cause of the problems. One can argue that the current practice only enables single-loop learning in most cases. The underlying causes to why fatigue is considered such a challenge on a general level in the sharp end of an airline are not found. Naturally, this would pose quite a challenge in itself, seeing as fatigue is experienced so differently. However, based on the results from the qualitative study – what is important now is for all personnel to start submitting more fatigue-reports, as well as the airline ensuring that they are taken seriously. It should not matter how many reports are submitted, as long as they are relevant in mitigating real issues concerning fatigue in the company.

Additionally, it is necessary to include the terms of feedback and feedforward mechanisms, also presented in subchapter 3.5.1. In a closed system, feedback is a persistent and continuous process, where a part of the output is fed back as new input to modify and improve the subsequent output. Information travels as an output through sensors, affected by norms, set in effect by actuators, before affecting the process as new input. Feedforward is information for control of a process that is obtained from other sources than those giving the output. It can be said to be an anticipation of future behaviour of the input variables. For instance, where an airline decides to mitigate fatigue based on information from other sources (e.g. research from universities, new legislation, etc.).

It cannot be said that all the major companies in the Norwegian sector experience the challenges mentioned in the previous paragraphs – at least not to the same extent. The system works on some areas, as is explained by one member of the NCAA:

"WHAT I SEE IS THAT THERE ARE SOME COMPANIES WHO ARE VERY ACTIVE... WITH CREWS WHO ARE VERY ACTIVE AT REPORTING. WHILE OTHER COMPANIES HAVE VERY LOW REPORTING, SO IT MEANS THAT; EITHER THEY HAVE NOT UNDERSTOOD HOW IMPORTANT IT IS, OR THE COMPANY HAS NOT BEEN ACTIVE ENOUGH TO MAKE THEM REPORT AS MUCH AS POSSIBLE. THAT'S WHERE WE HAVE A TASK TO DO WHEN IT COMES TO PUSH THEM TO PRODUCE MORE REPORTS. AND THE one company that we start to get a good picture of at the moment; There we see that there are a number of regularities on, for example, destinations that some get tired of. We see that there are regularities on, for example, hotels that are difficult to stay in. We see this early start/late start problematisation on the composition of routes and activity. So, we can go in and see that here are the very specific things that make… If the company makes some mitigations concerning these, then they will sort of manage to fix it."

Thus, the idea that using fatigue-reports as a tool to manage fatigue in the Norwegian aviation sector do not work as fully intended, is not fully generalizable. It clearly works to some extent. Nevertheless, there is most definitely a need for more reporting to be able to see if the fatigue levels are at a level of what is portrayed in the studies by ECA (2012), Reader et al. (2016) and Luftfartstilsynet (2016a). It is likely that there are a lot of figures which are not shown because of the low levels of fatigue-reports, as is also shown by an interviewee from management's answer to how often a pilot in Norway is affected by fatigue:

"And so, we know – based on everything from, of course, the NCAA's work environment survey (ref. Luftfartstilsynet, 2016a), to things done down in Europe. We see that there is a general picture that fatigue is a relatively under-reported event. So we... In our thinking, we expect that this or that happens… That this is an underreported field of expertise, to put it that way. And thus, we know that the actual amount of fatigue out there is higher than our reporting system indicates."

6.1.2 Coping measures regarding fatigue

As was shown in subchapter 2.3, global societal and economic factors have made it possible for more people to travel. For the last three years, there has been an increase in demand of approximately 5% each year. Additionally, we now have several non-stop routes that operate 17 hours from departure to arrival, and there is a demand for passengers being able to travel at convenient times suiting them – in return creating a 24-hour operation that needs to be operated by pilots and cabin crew. Consequently, it is claimed by Åkerstedt et al. (2003) that the NTSB has estimated that approximately 15-20% of the accidents happening in aviation are partly due to the operating crew being influenced by fatigue.

There are several challenges that need to be addressed as well. As mentioned, all companies currently have a policy where they encourage their employees to report not fit for flight on occasions where this may be necessary – e.g. sickness, fatigue, etc. Yet, the study by Luftfartstilsynet (2016a) shows that more than 60% of pilots, and nearly 80% of cabin crew have gone to work once or more during the last 12 months, even though they felt that they should not have done so (ref. subchapter 2.4). This is just one of the challenges that need mitigated or new solutions.

Caldwell (2005) states that there have been few changes to crew scheduling methods and legislated FTLs since these measures were first introduced. Additionally, the science behind our understanding of fatigue, how we sleep, shift work and circadian phases, has improved significantly during the same period. Still few changes have been made. However, in more recent times, FRMS has been introduced by several airlines around the world – more lately in Norway. Today, Widerøe is the only company which have implemented a full FRMS, according to several interview subjects – some employed in the airline itself. This is an example of a system that can be implemented by management to reduce the impact of fatigue on the personnel working in the sharp end of an organisation, while monitoring closely and implementing suiting measures when necessary. Such a system is mentioned by several of the stakeholders as a measure to mitigate fatigue in the Norwegian aviation sector. However, not everyone is positive to a FRMS. Many pilots feel that it is a system which can be implemented just because it looks good – not because it will help cope with fatigue. As a pilot mentions when asked whether he/she has any specific opinions about FRMS (question 17b): "THE FIRST THING THAT STRIKES ME IS THAT IT'S A TOOL THAT THE OPERATOR USES TO PROTECT THEMSELVES… AGAINST BEING ACCUSED FOR SOMETHING LATER."

What can be further discussed are the positive and negative sides related to having a FRMS. According to Tambala and Bolås (2016), not all aspects of applying an FRMS are positive. The greatest disadvantage can be said to be the amount of time and resources that are required in the first stages of incorporating the system. It cannot be expected that all operators have the resources to carry out the implementation to a degree that is required. Moreover, the financial cost can also be the most difficult to see benefit from. FRMS is a relatively new concept that may not work in the type of operations that a specific company undertakes. In general, one can ask whether FRMS is positive in all types of operations? Do we know that it will succeed? There are no clear answers to these questions because we have barely begun to see the effects of implementing an FRMS.

On the other hand, the adaptation of an FRMS makes it possible to create a custom system that quite likely functions most efficiently to the airline's own operations. The financial cost associated with the implementation of the system might be high, but as it becomes a part of the normal operations in a company, it might prove less costly over time (Caldwell and Caldwell, 2016, Yildiz et al., 2017). Furthermore, the NCAA and EASA can get a lighter workload – due to more cases being handled internally in a company. Naturally, the regulators will still have chief authority, but seeing as more responsibility lies within the company, one can expect a reduction in the number of interactions between regulator and company.

An important aspect to emphasise, is whether the introduction of an FRMS can lead to a company becoming too bureaucratic. The sheer number and wording of current rules and regulations can make the implementation of an FRMS superficial and more difficult to work with for the personnel in the sharp end.

Lastly, the greatest strength that can be associated with the implementation of an FRMS, are the results that are seen from companies that have already implemented the system. A study by Gander et al. (2011) includes a figure (Figure 32) which indicates the amount, and how often fatigue is experienced by flight crew members after the implementation of an FRMS in Air New Zealand. Over a period of 13 years, fewer and fewer flight crew members experience fatigue after the implementation of the system. This trend proves that some companies will benefit largely when it comes to the reduced effect of fatigue in the sharp end. Thus, we can assume that these employees gained a higher level of job satisfaction – and more importantly – a safer operating space for all stakeholders involved.

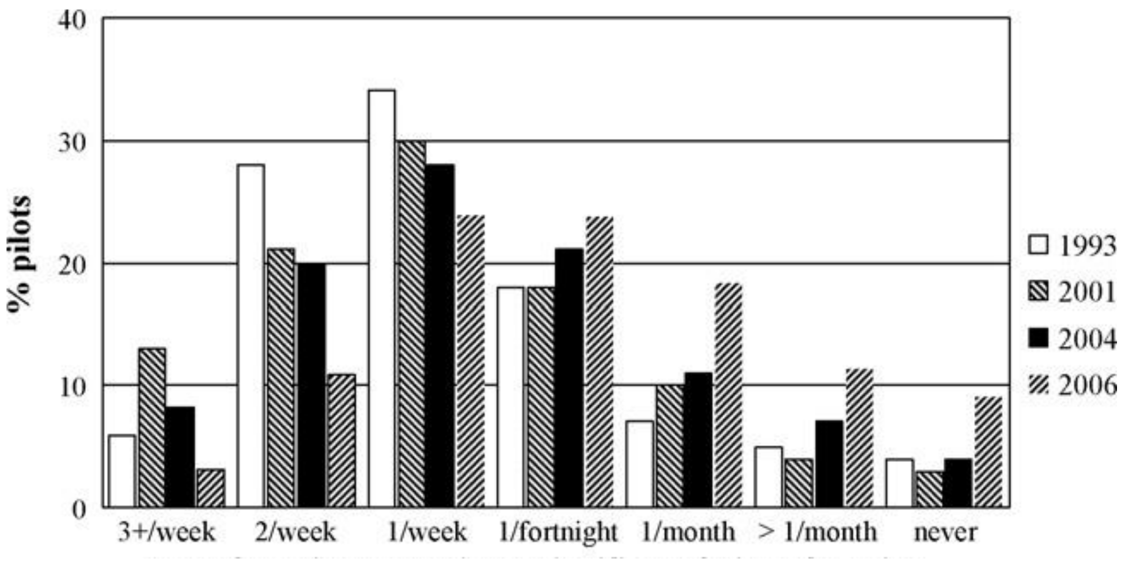


Figure 32 - Evolution of pilots' experience of fatigue (Gander et al., 2011)

There are many techniques from scientific research which can help both individuals and entire organisations to cope with fatigue. Some may be obvious and self-explanatory, but they can still be useful tools that are important coping in the daily life. Education is one of the most important countermeasures – also mentioned in subchapter 3.2.3: Fatigue countermeasures for flying personnel. It is my impression that not all the stakeholders I have interviewed know exactly what an FRMS is, but are still negative towards it. It cannot thereby be said that implementing an FRMS solves all the problems associated with fatigue. The airline needs to constantly work on it. Education of personnel in all levels of the organisation is of key importance. If the person who schedules pilots does not know what fatigue is, how can we expect to cope with it? Flin et al. (2008) states the importance of the blunt end of an organisation educating themselves on how fatigue can be a result of shift work. It can be difficult for the people working in the blunt end – who often have little experience with shift work – to have a good understanding of the consequences associated with this type of work. Especially regarding shift work causing poorer performance, sleep deprivation, disruptions in the circadian phase and lack of concentration and alertness. This can be said to be a measure that is not necessarily unique to airlines with an FRMS – all airlines should educate their staff on specific challenges like that of fatigue. Naturally, it is time consuming and costly, but it would probably save time and money when looking at a longer time frame.

On a more individual level, Flin et al. (2008) mention sleep hygiene as an important fatigue countermeasure to improve both sleep length and quality. It is also important to be aware of the significance of going to bed without consuming caffeine, alcohol and heavy meals, as well as avoiding too heavy exercise. One should instead try to relax a bit before going to sleep, and keep the bedroom dark, cool and quiet during the hours whilst sleeping. This is widely known by most of the interview subjects from the strategic interviews. However, it is easier said than done. Many of the pilots with children state that establishing a good sleep hygiene can be a huge challenge, as is understandable. There is a vast difference between theory and practise in this case. Many state that they sleep better when they are away from home, i.e. have a night stop in another city than where they live.

Taking rest breaks is another mentioned countermeasure. Even if it is a 10-minute break, it can give positive effects in terms of less influence of fatigue. It is not just an effective instrument for reducing the effects of fatigue, but also an instrument to counteract boredom, which in turn can be a contributing factor to fatigue itself (Flin et al., 2008). This is a measure mentioned by several of the interviewees. Some also mention that it can be difficult to perform this in practise. Flying short legs, in areas where communications are difficult (i.e. high workload), etc., makes taking a rest break quite difficult. It is, however, appreciated largely when possible. This also applies for napping on the flight deck. Short naps can improve performance significantly according to Hartzler (2014) and Caldwell and Caldwell (2016). Pilots that were interviewed state that they use this measure more often than before, with varying levels of success. Sometimes it works well; sometimes not.

Eating regular healthy meals is also recommended as a countermeasure to cope with fatigue. Naturally, consuming alcohol can make you feel more relaxed and leads to tiredness, but the chances of being dehydrated and getting a headache the next morning are present – which itself can lead to fatigue. The use of caffeine can be advantageous as a fatigue countermeasure, but the ones who are best equipped to exploit this advantage are those who do not normally consume caffeine daily. Moreover, staying fit by exercising regularly is a stated measure (Flin et al., 2008). Several of the interviewed stakeholders also state the measures mentioned in this paragraph. The stakeholders also mention several measures, as shown in Table 17 in subchapter 5.4.2.

As mentioned in subchapter 3.5.4: High reliability organisations, the aviation sector is arguably made up of several HROs. The theory concerning HROs is not necessarily directly transferable to the aviation industry in Norway, but gives an indication of how an ideal organisation copes with errors and failures using organisational redundancy, spontaneous reconfiguration and by the organisation being characterised by mindfulness. The principles surrounding the HRO-theory is interesting to combine with the coping of fatigue in an aviation context. Specifically, what can be utilised from this theory to cope with or avoid fatigue? Are there elements which are already incorporated?

When it comes to organisational redundancy, this is achieved through overlap in the structural and cultural dimension of the organisation itself. In the structural dimension, there can be similar competencies among personnel and overlapping areas of responsibility. Additionally, the personnel working together may be in close proximity to each other, allowing direct observation and conversation; even body language can be used in communication. All of which can be compared to the two pilots working together in a flight deck. This is already a part of today's commercial aviation, and is especially transferable to CRM. Furthermore, In the cultural dimension, emphasis is placed on the ability and will to exchange information with other people. There should be an environment that allows scrutinising both one's own and others' decisions. Several pilots mention this as measures they already use to a varying degree when it comes to speaking about fatigue with their co-worker. During the strategic interviews, several stated that they discuss being fatigued or other possible challenges with their colleagues almost every day, to help maintain understanding of each other's' state of mind.

HROs accept the fact that failures occur, and that there is not a desire for maintaining zero errors. An organisation needs to develop skills to detect and contain errors at early stages. Mindfulness concerns anticipation and awareness of the unexpected, as well as containment of unexpected events that could appear everywhere in the organisation. This is highly relatable to the safety management of fatigue using both the SMS and/or FRMS in an airline.

Some limitations associated with HROs should also be mentioned. The qualities surrounding HROs can mainly be found in large, military or military-like organisations. Therefore, it is difficult to see whether the theory surrounding HROs is valid or usable in other types of organisations; like in the Norwegian aviation sector. Furthermore, the cost associated with operating with a vast degree of organisational redundancy is very high compared to what many airlines are comfortable with today. Then again, one can argue that a large accident concerning a Norwegian airline would be much more expensive.

Thus, we can say that there are some elements from the theory concerning HROs which is already incorporated. The ability to integrate all the elements that define a successful HRO seems impractical and unnecessary. The next subchapter will take a closer look at suggested improvements regarding fatigue in the Norwegian aviation sector.

6.2 What can be improved?

Other than what has already been discussed, I would like to include some of the theory presented in subchapter 3.5.5: Adaptation & flexibility: Resilience engineering. It can be argued that today's aviation sector is highly robust, but not quite resilient. Nevertheless, the entire aviation industry is trying to become more resilient by navigating towards the limits of its competence and design envelope, through adaptions in the organisation's continuing operations. Traditionally, the aviation sector has mainly learned from previous accidents and incidents (safety I). However, the theory concerning resilience shows that both safety I *and* safety II – learning from successful operations – should be the way forward. The same can be said for the challenges concerning fatigue. There have been some accidents related to fatigue in the aviation sector that we can learn from; but what about the normal, day-to-day operations that are successful? There is a potential to learn a lot from what goes well, and use this information to cope with fatigue in Norwegian airline companies. "The human factor" is an important resource which is necessary for system flexibility and resilience (Hollnagel, 2014). This can be compared to Hale and Borys (2013b) who say in their second paradigm that *adaptations and improvisations* are quintessential to avoid accidents. The paradigm recognises the workers in the sharp end as the important individuals in rule configuration. Using what in this case can be seen as performance variability; should be monitored and managed according to Hollnagel (2014). This is also my opinion.

As is mentioned in Tambala and Bolås (2016), I think that another important aspect to improve regarding fatigue management is to focus on improving the needs of those mostly affected by fatigue, or those who are most vulnerable to it with regard to the type of operations. Thus, focusing on those with the greatest challenges relating to working hours, type of work and those with the most complex operations. This should partly be up to the authorities to focus on, but also a responsibility that each operator should undertake while being aware of their own challenges and limitations; e.g. in the case of operations in Northern-Norway. However, people are individuals; with individual perceptions and limitations of the term fatigue. Because of this, it can be challenging for regulators to make more decisions based on scientific results, seeing as they will be interpreted quite differently by a large span of different companies. As was discussed in subchapter 6.1.1 above, what is important now is for all personnel to start submitting more fatigue-reports, as well as the airline ensuring that they take the reports seriously. Having a *just culture* as explained by Dekker (2012) (subchapter 3.2.3) is considered important in this case.

The regulatory frameworks established by e.g. EASA and the NCAA – or even an airline's own rules and regulations – can be revised using the framework presented in subchapter 3.5.6: Compliance of rules and procedures: Two paradigms, to make it easier for personnel to cope with or avoid fatigue. If we look at the framework established by Hale and Borys (2013a), this model combines and takes into account Hales two paradigms concerning compliance with rules and procedures (Figure 22, subchapter 3.5.6). The main goal with this framework is to get into the circular movement in the model of continuous improvement, where one conveys and train in the use and adaptation of rules, the actual practical applications of the rules, and lastly, on monitoring and evaluation of their use – either to proceed in a circular motion, or to reject or revise and start over with new definitions and analyses. A simple and understandable set of rules makes it easier for pilots to understand what rules must be followed and adhered to, when it comes to fatigue. Consequently, their opinions should also be considered when establishing new rules, or revising old ones like in an SMS or FRMS. After all, the workers in the sharp end are the ones most directly affected by these types of rules, and should therefore cooperate in the frameworks' establishment and/or review.

I believe that by introducing FRMS in an organisation, it is advantageous if the implementation is carried out in such a motion as described in the framework by Hale and Borys (2013a).

Precisely to assure the quality of use of a new system and regulations through testing and trials, training, communication and feedback, and through continuous monitoring, evaluations and audits – for optimal implementation and compliance.

Lastly, I would like to emphasise the importance of establishing creative solutions to help cope with fatigue in a Norwegian airline. It is through working together on all levels, and communicating possible measures together, new and improved solutions can be established.

6.3 Summary

In this chapter a discussion concerning the research questions formulated in subchapter 1.3 has been the main focus. The research questions were seen in relation to the themes established in chapter 5, and compared to what has been portrayed in previous chapters regarding background on fatigue, theory concerning fatigue and applicable safety management aspects.

Presently, there is a challenge associated with the different views in the sharp and blunt end regarding the management of fatigue in the Norwegian aviation sector. In the sharp end, they wish for a larger involvement of the NCAA and/or EASA in mitigating the issues at hand. The paradox is that both the NCAA and each of the different airlines have a need for more fatigue-reports to mitigate the specific issues that arise. The fact is that the reporting from personnel in the sharp end is far too low when comparing to the results from the studies by e.g. ECA (2012), Reader et al. (2016) and Luftfartstilsynet (2016a). This was confirmed by several of the stakeholders who were interviewed in the qualitative study. Thus, the need for more reporting of fatigue, and an emphasis of no consequences for those who report, is presented as important to help mitigate fatigue.

Furthermore, each of the stakeholders that were interviewed had some ideas regarding the current and possible future measures on how successful operations are ensured even though fatigue is present in the sharp end of the airline. The study by Luftfartstilsynet (2016a) shows that more than 60% of pilots, and nearly 80% of cabin crew have gone to work once or more during the last 12 months, even though they felt that they should not have done so. The implementation of an FRMS is a possible solution, but has several limitations and interpretations associated to it. Additionally, there are many techniques from scientific research which can help both individuals and entire organisations coping with fatigue. Some may be obvious and self-explanatory, but they can still be useful tools that are important for coping with daily life. Education of personnel is regarded as one of the most important countermeasures.

The theory concerning HROs is not directly transferable to the aviation industry in Norway, but gives an indication of how an ideal organisation copes with errors and failures using organisational redundancy, spontaneous reconfiguration and by the organisation being characterised by mindfulness. We can say that there are some elements from the theory concerning HROs which is already incorporated on different levels in today's aviation sector in Norway. The ability to integrate all the elements that define a successful HRO seems impractical and unnecessary – as well as quite expensive.

What is proposed is that the Norwegian aviation sector should try to become more resilient concerning challenges associated with fatigue. It can be argued that today's aviation sector is highly robust, but not quite as resilient. The entire aviation industry is trying to become more resilient by navigating towards the limits of its competence and design envelope, through adaptions in the organisation's continuing operations. Traditionally, the aviation sector has mainly learned from previous accidents and incidents. However, both safety I *and* safety II should be the way forward. There is a potential to learn from what goes well, and use this information to cope with fatigue in Norwegian airline companies. "The human factor" is mentioned as an important resource which is necessary for system flexibility and resilience. Comparingly, *adaptations and improvisations* are quintessential to avoid accidents and incidents. Therefore, the workers in the sharp end are the important individuals in rule configuration. Performance variability should be monitored and managed.

People are individuals; with individual perceptions and limitations of the term fatigue. Because of this, it can be challenging for regulators to make more decisions based on scientific results, seeing as they will be interpreted quite differently by a large span of different companies. What is important now is for all personnel to start submitting more fatigue-reports, as well as the airline ensuring that they take the reports seriously. Having a just culture is considered being very important.

When looking at the framework established by Hale and Borys (2013a), the main goal with this framework is to get into the circular movement in the model of continuous improvement, where one conveys and train in the use and adaptation of rules, the actual practical applications of the rules, and lastly, on monitoring and evaluation of their use – either to proceed in a circular motion, or to reject or revise and start over with new definitions and analyses. A simple and understandable set of rules makes it easier for pilots to understand what rules must be followed and adhered to, when it comes to fatigue. Consequently, their opinions should also be considered when establishing new rules, or revising old ones like in an SMS or FRMS.

Lastly, the importance of establishing creative solutions to help cope with fatigue in a Norwegian airline was mentioned. It is through working together on all levels of the airline – and communicating possible measures together – new and better solutions can be established. This was shown throughout the examples given in some of the paragraphs in this chapter. Numerous good ideas have emerged, and should be discussed further on a company-level.

6.4 Further work

When it comes to proposals for further work from the foundation of this thesis, one can adopt a variety of research methods to expand the study. Several studies on the fatigue have already been performed in Norway; e.g. Aarhus et al. (2013), as well as Luftfartstilsynet (2016a), but there is definitely a need for more research. Another Swedish study that also performs interviews of flying personnel can also be mentioned. It is the study by Hjort and Taipale (2009).

A strictly quantitative analysis to answer the research questions was not used to help answer the research questions in this thesis. However, this may be used as a method in a subsequent study on a larger scale. It should be mentioned that the lessons learned in this thesis or future assignments can be relevant to other safety critical domains within land/rail/sea transport, nuclear power-plants and petroleum industries. A study can even be based on comparing fatigue within these different industries.

One can – for example – compare fatigue in different airlines by using both a survey and/or interviewing pilots to map their vision and perception of fatigue as a problem. Even their views on how to create improvements. The questions can be formulated using common aspects on fatigue and regulations succeeding an extensive literature review. By using that method, it can be possible to get a better understanding of how airline personnel perceive fatigue as a problem. Further, these results can be used to compare between typical low-cost carriers and "normal" network companies – possibly finding correlations between different types of employment conditions, and if and how this can affect the degree of fatigue and/or aviation safety.

Another example of further research might be to use a survey to chart the current situation on aspects regarding fatigue in a specific airline in Norway. This can be done to find out how pilots are experiencing fatigue as a problem in their own company, and how these findings can be used to propose further measures to combat fatigue.

It could also be interesting to further study airline companies (or a single company) with different types of rosters (e.g. 7 days on. 7 days off; versus; 5 days on, 4 days off), to investigate if one alternative is more beneficial than the other. This could for example be done by performing a comparative case-study, where surveys or interviews with the same questions could have been given to two groups, each with its individual roster, to see whether there are differences in how the operators are experiencing fatigue.

A survey can also be used to see if there are differences in fatigue-levels between companies using FRMS and those who are not. Studies such as the one performed by Signal et al. (2006) motivates for the need to be able to compare statistics over a longer period of time. How do the fatigue-levels evolve over time? A longitudinal case study of a specific company in Norway after implementing FRMS would definitely be interesting to perform.

Moreover, another interesting area one could researched further on, is whether there is any correlation between perceived fatigue and experience level. One might examine whether more experienced pilots use less capacity in the cockpit than those who are inexperienced, thus making them less prone to fatigue? Or if the role as a captain requires much more of the available capacity, so that it is the reverse case? This could unquestionably have been an interesting area to examine further. It could even be possible to make an experiment to compare level of fatigue between captains and first officers. This may indeed be a challenging experiment to achieve in practice in terms of time, money and other resources, but also getting valid findings, seeing as all operators are individuals; with individual constraints and capacity. Nevertheless, I believe it would be an interesting research area, and perhaps it could have been possible to find some correlations – not only causal contexts.

Next, it is proposed to perform an organisational analysis of the results from this study which combines storytelling and other expertise. For example, by using experts such as anthropologists and/or sociologists in an interdisciplinary analysis to get an entirely different perspective of the challenges associated with fatigue in the Norwegian or European aviation sector.

6.5 Methodology

In this subchapter, I will review the methodological approach that was chosen to answer the research questions in this thesis. As described in subchapter 1.2, the objective of this thesis was to explore to what extent pilots in Norway are affected by fatigue whilst working – thus being in close relation to the formulated research questions.

6.5.1 Validity and reliability

As mentioned in subchapter 4.4.1: Lessons learnt and implications, it cannot be omitted that other researchers may draw different conclusions related to the issues described in thesis. This can for example be due to having a different perception of the subject than myself, having a hidden agenda with the research, or other factors. Still, it can just as likely be that conclusions correspond with each other, bearing in mind that previous and current research should have good validity and reliability.

The authenticity and relevance of this thesis will be judged by validity (the extent to which you measure what you seek to measure) and reliability (the accuracy/trustworthiness of the data) (Bryman, 2012). My opinion is that I have achieved a good authenticity and relevance in this thesis.

Firstly, I have learnt to remain neutral both in the literature chosen to include, but also during the conduction of interviews; so that the interviewees are the least amount affected by my choice of words or reflections. Secondly, due to the assurance of anonymity, the interviewees felt less obligated to hide or omit the facts they provided. The anonymity of the participants was explained as being of key importance for the survey itself. Answers given during the interviews that could be disadvantageous for both own position and company, explains why anonymity is so important. Because of this, the interviewees probably felt less obligated to hide or omit some of the facts they provided.

The inputs and feedback given by the interviewees was processed as thoroughly and unbiased as possible, before being evaluated in the template analysis. It became clear that I had to remain as impartial as possible trying not to let any of the interviewee's opinions affect the results. I do believe that I have measured what I sought to measure, and that the data is both accurate and trustworthy.

6.5.2 Strengths & weaknesses: What could have been done differently?

Parts of the method that was chosen in this thesis can be viewed as a bit experimental, seeing as the strategic interview was used as innovation process for gaining new experience. Like an experiment for further development of knowledge surrounding fatigue in the Norwegian aviation sector. Before conducting the interviews on actual participants, I chose to perform an interview mock-up rapid prototyping based on minimum viable product that was iterated and improved continuously. This process can be related to the de:cycle, where the three roles in design and their respective interests and expertise, are in a cycle of analysis and synthesis.

A triangulation was performed through utilising a qualitative approach based on the gathering and review of secondary quantitative and qualitative data on the subject of fatigue, and thereby using the aforementioned findings to design the qualitative study. By using these designs, the intention is to limit the disadvantages from each of the research methods, as well as strengthening the advantages.

I believe that the information that was gathered during the strategic interviews gives a picture of how the aviation industry in Norway is perceived by those who work in it. There is definitely a strength that stakeholders from different levels of the Norwegian aviation industry are included in the study.

A possible weakness that I can see, is the number of stakeholders that were included in the study. For the results to be even more reliable, several more participants would have had to be included; consequently making it an even larger study. Due to time constraints, this was considered being impractical and difficult for one person to do. Still, I do believe that the outcomes – for the most part – are generalizable to the aviation sector in Norway.

Additionally, my proximity to the aviation industry may make me more biased to the workers in the sharp end of the operations. This is something I have tried to stay well aware of while writing this thesis. Thus, my relation may have helped strengthening the validity through insight and experience.

One thing I would have done differently is to limit the amount of questions given in the interviews. While performing the interviews, I felt that a great deal of information was given to me, without the opportunity to include all of it in the results and discussion due to the sheer number of different themes. It was indeed quite time-consuming to collect data and analyse it, due to the amount of raw data. If I were to do this over again, it would be easier to focus on questions within a specific theme or area, seeing as this would be less time-consuming to work with. However, it would have been hard to present the results that I have found, without all the interview questions that were used in this study. Thus, it is difficult to say which ones to exclude if I were to do it again. Still, if I would *have* to change something, I would have omitted asking question 1-7 given in subchapter 5.2: The strategic interview. These questions are less direct, but can also give important information.

7 Conclusion

This final chapter will summarise the master's thesis and review the answers to the research question presented in subchapter 1.3. Lastly, some recommendations will be given based on some of the findings from the qualitative study.

7.1 Introduction

This master's thesis has been a continuation of the term paper *Fatigue in Aviation: A literature review* by Tambala and Bolås (2016). Fatigue has become an increasing challenge within the aviation industry because of a change in the way airline companies operate during the last 20 years. From being an industry previously governed by national regulation and state ownership, there is a current increase in competition and requirements for profitability and efficiency (Luftfartstilsynet, 2016a). Then again, not all the changes that have happened in the aviation industry are negative; it is much safer to fly today than it was 20 years ago (EASA, 2016b).

The main objective of this thesis has been to explore to what extent pilots in Norway are affected by fatigue whilst working. Most of the effort has been placed on conducting strategic interviews of personnel on three levels – pilots, management and the NCAA – in the Norwegian aviation sector. The study included a total of 13 individuals, where 11 were employees in SAS, NAS/NAI and Widerøe, in addition to two from the NCAA. Of the interviewees from the three airlines, there were seven pilots and four from management.

Further, different measures in preventing and coping with fatigue in all levels of an airline have been important to show and discuss. Research from several eras and parts of the world have been used to gain understanding on different aspects and challenges concerning fatigue.

It should also be mentioned that the lessons learned in this thesis can be relevant to other safety critical domains, e.g. within land/rail/sea transport, nuclear power-plants and petroleum industries.

7.2 Research questions

Fatigue is not a new phenomenon - even Charles Lindbergh struggled with the challenges associated with fatigue while crossing the Atlantic in 1927. Still, the knowledge we possess today should help counteract the negative effects of fatigue. In 2016 the NCAA released a study of the work environment performed in commercial civilian aviation in Norway in 2015 (Luftfartstilsynet, 2016a). Only 19% of the pilots and 12% of the cabin crew said that they get sufficient amounts of rest and relaxation between workdays. 72% of pilots and 85% of cabin crew feel physically exhausted after the completion of a work period. Because of this, the research questions were formulated to see if there is either a direct need or certain possibilities for improvement in everything from legislation to informal practises when it comes to shifting these trends regarding fatigue. There is an interest in improving both the wellbeing and overall safety of crew, passengers and other relevant stakeholders in the aviation industry. Therefore, the following research questions were established:

1. *How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?*
2. *Which measures can be used to mitigate fatigue among pilots who work in large aviation companies in Norway?*
3. *Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?*

In general, it has been found that the selected members of the Norwegian aviation sector perceive fatigue as a challenge that needs to be continuously worked with. Both how fatigue is experienced and how it is perceived, is highly individual. That is probably one of the clearest results from the study. Most of the interviewed pilots say fatigue is an extensive challenge. It was also found that almost all the pilots experienced varying degrees of fatigue quite regularly.

Managers in the airlines and the NCAA tend to indicate fatigue being a challenge that needs further work. Some pilots are sure that a major accident is waiting to happen – in fact, some state that there most likely already have been several accidents with fatigue being a contributing factor. Still, they claim that Norway is safer than other countries in the world. This is supported by statistics from EASA (2016b) and Luftfartstilsynet (2016b). On the other hand, the NCAA claim that we are not living in a risk to safety when it comes to fatigue. These two polarities show how different fatigue is perceived among the different levels of stakeholders.

There is a vast number of measures that can be implemented to mitigate fatigue. Currently, many of the respondents' state that an improvement and exploration of options is necessary. More work is needed in trying different systems and mechanisms instead of merely adhering to the prescribed FTLs and FDPs. Most of the answers considered measures that can be done in the sharp end (i.e. by pilots): e.g. sleep hygiene, eating healthy and regularly, avoiding alcohol, etc. When it comes to mitigations on a company level; SMS, FRMS, a SAG or FSAG are stated as possible effective measures to help cope with or counteract fatigue. Even using elements from FRMS without implementation of the entire system, is mentioned. Emphasis is placed on the use of more creativity in the way crews are rostered as a possible measure. Several of the respondents stated that more flexibility was a factor that is valued highly for flying personnel; e.g. an airline's use of a rostering system where you can design your own schedule to some extent. There are several measures which are mentioned – most of these are quite innovative and effective, according to some of the respondents. On a governmental level, wanting a tightening of the prescribed FTLs and FDPs is mentioned frequently by several stakeholders. Many of the operations that are conducted in Norway during winter operations or similar need to be considered especially as these are considered being more fatiguing than operations with a lower workload. In general, personnel in the sharp end want a larger involvement of the NCAA and/or EASA in mitigating the issues. However, the NCAA, as well as representatives from management and some pilots, state that there is a need for more fatigue-reports to mitigate specific issues that arise. Today, this reporting is far too low when comparing to the answers given in several studies.

When it comes to the beliefs the interviewees have concerning the last research question, there are several different opinions. Some feel that a lot of improvement is needed, while others are satisfied with the current practices. Also, there is a wide consensus on achieving working continuously with fatigue-related matters. It is not necessarily something you can implement a measure to "fix" – it is something that needs to be monitored and worked on in a constant cycle. Presently, there is a consensus among the respondents that there is a need for further improvements on all levels. Everything from the sharp end to the blunt end. Many pilots stated that they feel that the systems they have in their airline are put in place because they are required by law, or because they "look good" – not actually to help cope with fatigue-related issues.

7.3 Recommendations

What has become apparent is that there is a current under-reporting of fatigue in the Norwegian aviation sector. In the sharp end, they want a larger involvement of the NCAA and EASA in mitigating the issues related to fatigue in the industry. However, it is a paradox that both the NCAA and the airlines need more fatigue-reports to mitigate the specific issues that arise. Without enough reports on the issues, it is difficult to make decisions on what measures are to be implemented. Therefore, there lies a responsibility with the pilots to submit more reports. The airlines must also provide pilots the opportunity to do this without the risk of being faced with consequences for reporting. They might need to handle the reports differently and work on implementing a more *just culture*. Moreover, the NCAA must guide the companies by demanding more reports. The way forward is establishing a successful SMS relying on the flow of information in a HSE information system shown by Kjellén (2000) (Figure 16).

Other than what has been presented above, Table 18 shows some more of the proposed measures given by several of the different stakeholders, also shown in subchapter 5.4.2. They are each put in the category of which they are applicable – pilots, airline and government – to see what measures they each are suggested to undergo. This is something that each of the stakeholders should emphasise on working towards in the future.

Table 18 – Measures proposed by the different stakeholders to mitigate fatigue (repeated)

Measures		
Pilots	**Airline (managers)**	**Government (NCAA/EASA)**
Producing more fatigue-reports. Increasing one's own will to report fatigue. Working less (80% instead of 100%). Going to bed at decent hours. Good sleep hygiene. Napping on the flight deck. Eating healthy and exercising regularly. Using TEM-briefing.	Emphasising the need for more fatigue-reports. Ensuring that reports are handled without any form of consequences to the one who reports. Having a flight time system that enables design of workdays from employees. Utilising elements from an FRMS without necessarily implementing the system. Educating employees on all levels; e.g. those responsible for scheduling crew, managers, pilots, etc. Communicating the airline's trends and visions. Employing enough personnel, which in turn enables higher flexibility.	"Pushing" the companies to produce more fatigue-reports. Being more proactive instead of reactive. Being more involved. Ensuring that special regulations apply for operations under different conditions (e.g. operations in Northern Norway, winter operations, etc.) Redefining the current FTLs and FDPs, producing a more restrictive regulation.

It is argued that today's aviation sector is highly robust, but not quite resilient. Traditionally, the aviation sector has mainly learned from previous accidents and incidents (safety I). However, the theory concerning resilience shows that both safety I *and* safety II – learning from successful operations – should be the way forward. There is a vast potential to learn a lot from what goes well, and use this information to cope with fatigue in Norwegian airline companies. Using what in this case can be seen as performance variability; should be monitored and managed according to Hollnagel (2014).

Another important aspect to improve regarding fatigue management is to focus on those with the greatest challenges relating to working hours, type of work and those with the most complex operations. This should partly be up to the authorities to focus on, but also a responsibility that each operator should undertake while being aware of their own challenges and limitations. Because of individual perceptions of fatigue, it can be challenging for regulators to make more decisions based on scientific results, seeing as they will be interpreted quite differently by a large span of different airlines.

The regulatory frameworks established by e.g. EASA and the NCAA – or even an airline's own rules and regulations – can be revised using the framework established by Hale and Borys (2013a). A simple and understandable set of rules make it easier for pilots to understand what rules must be followed and adhered to, when it comes to fatigue. Additionally, their opinions should also be considered when establishing new rules, or revising old ones. Pilots are the ones most directly affected by these types of rules, and should therefore cooperate in the frameworks' establishment and/or review.

The importance of establishing creative solutions to help cope with fatigue in a Norwegian airline should be mentioned. It is through working together on all levels of the airline – and communicating possible measures together – new and improved solutions can be established. This is something that some interviewees mentioned during the interviews.

To put this thesis in a broader perspective it can be said that there is a need for much more research and exploration on fatigue in the aviation sector. My proposals for further research was shown in subchapter 6.4: Further work. The contribution this thesis can give to the industry in Norway is small when looking on the entirety. However, there are several important themes that need to be discussed in more detail on all the levels that are mentioned. All the way from pilots to the NCAA; even in the government. It is clear that Norwegian pilots are experiencing varying degrees of fatigue whilst working. Some interviewees reveal that they are so tired, they even fall asleep on the flight deck. There is a need for more studies which show specific issues regarding fatigue. These scientific results should also be used to a larger degree when making fatigue-related decisions.

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Appendix A: Meldeskjema til NSD

NSD

MELDESKJEMA

Meldeskjema (versjon 1.4) for forsknings- og studentprosjekt som medfører meldeplikt eller konsesjonsplikt (jf. personopplysningsloven og helseregisterloven med forskrifter).

1. Intro		
Samles det inn direkte personidentifiserende opplysninger?	Ja ● Nei ○	En person vil være direkte identifiserbar via navn, personnummer, eller andre personentydige kjennetegn. Les mer om hva personopplysninger. NB! Selv om opplysningene skal anonymiseres i oppgave/rapport, må det krysses av dersom det skal innhentes/registreres personidentifiserende opplysninger i forbindelse med prosjektet.
Hvis ja, hvilke?	■ Navn □ 11-sifret fødselsnummer □ Adresse ■ E-post ■ Telefonnummer □ Annet	
Annet, spesifiser hvilke		
Skal direkte personidentifiserende opplysninger kobles til datamaterialet (koblingsnøkkel)?	Ja ○ Nei ●	Merk at meldeplikten utløses selv om du ikke får tilgang til koblingsnøkkel, slik fremgangsmåten ofte er når man benytter en databehandler
Samles det inn bakgrunnsopplysninger som kan identifisere enkeltpersoner (indirekte personidentifiserende opplysninger)?	Ja ● Nei ○	En person vil være indirekte identifiserbar dersom det er mulig å identifisere vedkommende gjennom bakgrunnsopplysninger som for eksempel bostedskommune eller arbeidsplass/skole kombinert med opplysninger som alder, kjønn, yrke, diagnose, etc. NB! For at stemme skal regnes som personidentifiserende, må denne bli registrert i kombinasjon med andre opplysninger, slik at personer kan gjenkjennes.
Hvis ja, hvilke	Arbeidsplass kombinert med alder, kjønn og yrke	
Skal det registreres personopplysninger (direkte/indirekte/via IP-/epost adresse, etc) ved hjelp av nettbaserte spørreskjema?	Ja ○ Nei ●	Les mer om nettbaserte spørreskjema.
Blir det registrert personopplysninger på digitale bilde- eller videoopptak?	Ja ○ Nei ●	Bilde/videoopptak av ansikter vil regnes som personidentifiserende.
Søkes det vurdering fra REK om hvorvidt prosjektet er omfattet av helseforskningsloven?	Ja ○ Nei ●	NB! Dersom REK (Regional Komité for medisinsk og helsefaglig forskningsetikk) har vurdert prosjektet som helseforskning, er det ikke nødvendig å sende inn meldeskjema til personvernombudet (NB! Gjelder ikke prosjekter som skal benytte data fra pseudonyme helseregistre). Dersom tilbakemelding fra REK ikke foreligger, anbefaler vi at du avventer videre utfylling til svar fra REK foreligger.
2. Prosjekttittel		
Prosjektittel	Fatigue in the flight deck: How can we manage it?	Oppgi prosjektets tittel. NB! Dette kan ikke være «Masteroppgave» eller liknende, navnet må beskrive prosjektets innhold.
3. Behandlingsansvarlig institusjon		
Institusjon	NTNU	Velg den institusjonen du er tilknyttet. Alle nivå må oppgis. Ved studentprosjekt er det studentens tilknytning som er avgjørende. Dersom institusjonen ikke finnes på listen, har den ikke avtale med NSD som personvernombud. Vennligst ta kontakt med institusjonen.
Avdeling/Fakultet	Fakultet for økonomi (ØK)	
Institutt	Institutt for industriell økonomi og teknologiledelse	
4. Daglig ansvarlig (forsker, veileder, stipendiat)		

Fornavn	Ivonne Andrade	Før opp navnet på den som har det daglige ansvaret for prosjektet. Veileder er vanligvis daglig ansvarlig ved studentprosjekt. Daglig ansvarlig og student må i utgangspunktet være tilknyttet samme institusjon. Dersom studenten har ekstern veileder, kanbiveileder eller fagansvarlig ved studiestedet stå som daglig ansvarlig. Arbeidssted må være tilknyttet behandlingsansvarlig institusjon, f.eks. underavdeling, institutt etc. NB! Det er viktig at du oppgir en e-postadresse som brukes aktivt. Vennligst gi oss beskjed dersom den endres.
Etternavn	Herrera	
Stilling	Førsteammanneunsis/Seniorforsker	
Telefon		
Mobil	90680634	
E-post	ivonne.a.herrera@ntnu.no	
Alternativ e-post	jbskatv@gmail.com	
Arbeidssted	NTNU / SINTEF Digital	
Adresse (arb.)	Strindveien 4	
Postnr./sted (arb.sted)	7034 Trondheim	
5. Student (master, bachelor)		
Studentprosjekt	Ja ● Nei ○	Dersom det er flere studenter som samarbeider om et prosjekt, skal det velges en kontaktperson som føres opp her. Øvrige studenter kan føres opp under pkt 10.
Fornavn	Nicholas	
Etternavn	Tambala	
Telefon		
Mobil	93213383	
E-post	nictamb@msn.com	
Alternativ e-post	nicholastambala@gmail.com	
Privatadresse	Korpåsen 75b	
Postnr./sted (privatadr.)	1386 Asker	
Type oppgave	● Masteroppgave ○ Bacheloroppgave ○ Semesteroppgave ○ Annet	
6. Formålet med prosjektet		
Formål	The main objective of this thesis is to investigate the impact fatigue has on personnel working in the aviation industry in Norway. Focus will be put on pilots, as they are the operators who ultimately make the final decisions that can result in major accidents. 1.How do individual members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting? 2.Which measures can be used to manage fatigue among pilots who work in large aviation companies in Norway? 3.How can we implement measures to manage pilots' influence of fatigue?	Redegjør kort for prosjektets formål, problemstilling, forskningsspørsmål e.l.
7. Hvilke personer skal det innhentes personopplysninger om (utvalg)?		
Kryss av for utvalg	□ Barnehagebarn □ Skoleelever □ Pasienter ■ Brukere/klienter/kunder ■ Ansatte □ Barnevernsbarn □ Lærere □ Helsepersonell □ Asylsøkere □ Andre	

Beskriv utvalg/deltakere	Utvalget vil bestå av interessenter på tre nivåer direkte tilknyttet ulike luftfartsselskap. Piloter, (mellom-)ledere og representanter i Luftfartstilsynet. Hensikten er å utføre strategiske intervjuer av personer på disse ulike nivåene, for å kunne bidra til å svare på forskningsspørsmålene.	Med utvalg menes dem som deltar i undersøkelsen eller dem det innhentes opplysninger om.
Rekruttering/trekking	Utvalget vil rekrutteres gjennom veiledernes egne nettverk på denne studentoppgaven. Her vil det legges vekt på å få deltakere som er i ulik alder og innehar ulik erfaring. Deltakelse på intervjuene er frivillig og alle har rett til å trekke sin deltakelse på hvilket som helst tidspunkt, uten noen konsekvenser. Det vil på forhånd gis en beskrivelse til deltakerne av mål, metoder og implikasjon av forskningen og arten av deltakelse. Prosedyrer for innsamling og arkivering av data vil bli forklart til hver deltaker. Videre vil det også beskrives hvordan data vil anonymiserte.	Beskriv hvordan utvalget trekkes eller rekrutteres og oppgi hvem som foretar den. Et utvalg kan trekkes fra registre som f.eks. Folkeregisteret, SSB-registre, pasientregistre, eller det kan rekrutteres gjennom f.eks. en bedrift, skole, idrettsmiljø eller eget nettverk.
Førstegangskontakt	Studenten vil hovedsakelig kontakte deltakerne via e-post/telefon som er aktuelle for å delta. I noen tilfeller vil veilederne opprette førstegangskontakt.	Beskriv hvordan kontakt med utvalget blir opprettet og av hvem. Les mer om dette på temasidene.
Alder på utvalget	□ Barn (0-15 år) □ Ungdom (16-17 år) ■ Voksne (over 18 år)	Les om forskning som involverer barn på våre nettsider.
Omtrentlig antall personer som inngår i utvalget	10-20	
Samles det inn sensitive personopplysninger?	Ja ○ Nei ●	Les mer om sensitive opplysninger.
Hvis ja, hvilke?	□ Rasemessig eller etnisk bakgrunn, eller politisk, filosofisk eller religiøs oppfatning □ At en person har vært mistenkt, siktet, tiltalt eller dømt for en straffbar handling □ Helseforhold □ Seksuelle forhold □ Medlemskap i fagforeninger	
Inkluderes det myndige personer med redusert eller manglende samtykkekompetanse?	Ja ○ Nei ●	Les mer om pasienter, brukere og personer med redusert eller manglende samtykkekompetanse.
Samles det inn personopplysninger om personer som selv ikke deltar (tredjepersoner)?	Ja ○ Nei ●	Med opplysninger om tredjeperson menes opplysninger som kan spores tilbake til personer som ikke inngår i utvalget. Eksempler på tredjeperson er kollega, elev, klient, familiemedlem.

8. Metode for innsamling av personopplysninger

Kryss av for hvilke datainnsamlingsmetoder og datakilder som vil benyttes	□ Papirbasert spørreskjema □ Elektronisk spørreskjema ■ Personlig intervju ■ Gruppeintervju □ Observasjon □ Deltakende observasjon □ Blogg/sosiale medier/internett □ Psykologiske/pedagogiske tester □ Medisinske undersøkelser/tester □ Journaldata (medisinske journaler)	Personopplysninger kan innhentes direkte fra den registrerte f.eks. gjennom spørreskjema,intervju, tester, og/eller ulike journaler (f.eks. elevmapper, NAV, PPT, sykehus) og/eller registre (f.eks.Statistisk sentralbyrå, sentrale helseregistre). NB! Dersom personopplysninger innhentes fra forskjellige personer (utvalg) og med forskjellige metoder, må dette spesifiseres i kommentar-boksen. Husk også å legge ved relevante vedlegg til alle utvalgs-gruppene og metodene som skal benyttes. Les mer om registerstudier her. Dersom du skal anvende registerdata, må variabelliste lastes opp under pkt. 15
	□ Registerdata	
	□ Annen innsamlingsmetode	
Tilleggsopplysninger		

9. Informasjon og samtykke

Oppgi hvordan utvalget/deltakerne informeres	■ Skriftlig □ Muntlig □ Informeres ikke	Dersom utvalget ikke skal informeres om behandlingen av personopplysninger må det begrunnes. Les mer her. Vennligst send inn mal for skriftlig eller muntlig informasjon til deltakerne sammen med meldeskjema. Last ned en veiledende mal her. NB! Vedlegg lastes opp til sist i meldeskjemaet, se punkt 15 Vedlegg.
Samtykker utvalget til deltakelse?	● Ja ○ Nei ○ Flere utvalg, ikke samtykke fra alle	For at et samtykke til deltakelse i forskning skal være gyldig, må det være frivillig, uttrykkelig og informert. Samtykke kan gis skriftlig, muntlig eller gjennom en aktiv handling. For eksempel vil et besvart spørreskjema være å regne som et aktivt samtykke. Dersom det ikke skal innhentes samtykke, må det begrunnes.
10. Informasjonssikkerhet		
Spesifiser	Personidentifiserende opplysninger oppbevares separat fra datamaterialet, og kan heller ikke knyttes til dette.	NB! Som hovedregel bør ikke direkte personidentifiserende opplysninger registreres sammen med det øvrige datamaterialet.
Hvordan registreres og oppbevares personopplysningene?	■ På server i virksomhetens nettverk □ Fysisk isolert PC tilhørende virksomheten (dvs. ingen tilknytning til andre datamaskiner eller nettverk, interne eller eksterne) ■ Datamaskin i nettverkssystem tilknyttet Internett tilhørende virksomheten □ Privat datamaskin □ Videoopptak/fotografi ■ Lydopptak ■ Notater/papir ■ Mobile lagringsenheter (bærbar datamaskin, minnepenn, minnekort, cd, ekstern harddisk, mobiltelefon) □ Annen registreringsmetode	Merk av for hvilke hjelpemidler som benyttes for registrering og analyse av opplysninger. Sett flere kryss dersom opplysningene registreres på flere måter. Med «virksomhet» menes her behandlingsansvarlig institusjon. NB! Som hovedregel bør data som inneholder personopplysninger lagres på behandlingsansvarlig sin forskningsserver. Lagring på andre medier - som privat pc, mobiltelefon, minnepinne, server på annet arbeidssted - er mindre sikkert, og må derfor begrunnes. Slik lagring må avklares med behandlingsansvarlig institusjon, og personopplysningene bør krypteres.
Annen registreringsmetode beskriv		
Hvordan er datamaterialet beskyttet mot at uvedkommende får innsyn?	Studenten har tilgang til fysisk avgrenset rom med adgangskontroll. Datamaskinene der tilhører NTNU, og har individuelt brukernavn og passord. Gjennom pålogging har man tilgang til server og internett som er sikret av virksomheten. Lydopptak og notater vil oppbevares separat, i låst skap. Mobile lagringsenheter vil også bli brukt, men ikke til behandling av personidentifiserende data.	Er f.eks. datamaskintilgangen beskyttet med brukernavn og passord, står datamaskinen i et låsbart rom, og hvordan sikres bærbare enheter, utskrifter og opptak?
Samles opplysningene inn/behandles av en databehandler (ekstern aktør)?	Ja ○ Nei ●	Dersom det benyttes eksterne til helt eller delvis å behandle personopplysninger, f.eks. Questback, transkriberingsassistent eller tolk, er dette å betrakte som en databehandler. Slike oppdrag må kontraktsreguleres.
Hvis ja, hvilken		
Overføres personopplysninger ved hjelp av e-post/Internett?	Ja ○ Nei ●	F.eks. ved overføring av data til samarbeidspartner, databehandler mm. Dersom personopplysninger skal sendes via internett, bør de krypteres tilstrekkelig. Vi anbefaler for ikke lagring av personopplysninger på nettskytjenester. Dersom nettskytjeneste benyttes, skal det inngås skriftlig databehandleravtale med leverandøren av tjenesten.
Hvis ja, beskriv?		
Skal andre personer enn daglig ansvarlig/student ha tilgang til datamaterialet med personopplysninger?	Ja ○ Nei ●	
Hvis ja, hvem (oppgi navn og arbeidssted)?		
Utleveres/deles personopplysninger med andre institusjoner eller land?	● Nei ○ Andre institusjoner ○ Institusjoner i andre land	F.eks. ved nasjonale samarbeidsprosjekter der personopplysninger utveksles eller ved internasjonale samarbeidsprosjekter der personopplysninger utveksles.
11. Vurdering/godkjenning fra andre instanser		

D

Søkes det om dispensasjon fra taushetsplikten for å få tilgang til data?	Ja ○ Nei ●	For å få tilgang til taushetsbelagte opplysninger fra f.eks. NAV, PPT, sykehus, må det søkes om dispensasjon fra taushetsplikten. Dispensasjon søkes vanligvis fra aktuelt departement.
Hvis ja, hvilke		
Søkes det godkjenning fra andre instanser?	Ja ○ Nei ●	F.eks. søke registereier om tilgang til data, en ledelse om tilgang til forskning i virksomhet, skole.
Hvis ja, hvilken		
12. Periode for behandling av personopplysninger		
Prosjektstart Planlagt dato for prosjektslutt	15.01.2017 30.06.2017	Prosjektstart Vennligst oppgi tidspunktet for når kontakt med utvalget skal gjøres/datainnsamlingen starter. Prosjektslutt: Vennligst oppgi tidspunktet for når datamaterialet enten skalanonymiseres/slettes, eller arkiveres i påvente av oppfølgingsstudier eller annet.
Skal personopplysninger publiseres (direkte eller indirekte)?	□ Ja, direkte (navn e.l.) □ Ja, indirekte (bakgrunnsopplysninger) ■ Nei, publiseres anonymt	NB! Dersom personopplysninger skal publiseres, må det vanligvis innhentes eksplisitt samtykke til dette fra den enkelte, og deltakere bør gis anledning til å lese gjennom og godkjenne sitater.
Hva skal skje med datamaterialet ved prosjektslutt?	■ Datamaterialet anonymiseres □ Datamaterialet oppbevares med personidentifikasjon	NB! Her menes datamaterialet, ikke publikasjon. Selv om data publiseres med personidentifikasjon skal som regel øvrig data anonymiseres.Med anonymisering menes at datamaterialet bearbeides slik at det ikke lenger er mulig å føre opplysningene tilbake til enkeltpersoner. Les mer om anonymisering.
13. Finansiering		
Hvordan finansieres prosjektet?		
14. Tilleggsopplysninger		
Tilleggsopplysninger		

E

Appendix B: Anbefaling fra NSD

Ivonne Herrera
Institutt for industriell økonomi og teknologiledelse NTNU

7491 TRONDHEIM

Kopi: Nicholas Tambala nictamb@msn.com

Vår dato: 31.03.2017 Vår ref: 53044 / 3 / BGH Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 15.02.2017. Meldingen gjelder prosjektet:

53044	*Fatigue in the flight deck: How can we manage it?*
Behandlingsansvarlig	*NTNU, ved institusjonens øverste leder*
Daglig ansvarlig	*Ivonne Herrera*
Student	*Nicholas Tambala*

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/personvernombud/meld_prosjekt/meld_endringer.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, 30.06.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Kjersti Haugstvedt

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.

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 53044

FORMÅL
Prosjektets formål er å undersøke påvirkningen fatigue har på personell som arbeider i norsk luftfart.

INFORMASJON OG SAMTYKKE
Utvalget informeres skriftlig om prosjektet og samtykker til deltakelse. Informasjonsskrivet er godt utformet.

SENSITIVE OPPLYSNINGER OM INFORMANTENE
Vi vurderer at det vil kunne komme frem helserelaterte opplysninger om informantene.

INFORMASJONSSIKKERHET
Personvernombudet legger til grunn at forsker etterfølger NTNU sine interne rutiner for datasikkerhet. Dersom personopplysninger skal lagres på mobile enheter, bør opplysningene krypteres tilstrekkelig.

PROSJEKTSLUTT OG ANONYMISERING
Forventet prosjektslutt er 30.06.2017. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:
- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)
- slette digitale lydopptak

Appendix C: Informasjonsskriv for utføring av intervju

Forespørsel om deltakelse i forskningsprosjektet:

"Fatigue in the flight deck: How can we manage it?"

Bakgrunn og formål
Dette prosjektet er en del av en avsluttende masteroppgave i Helse, miljø og sikkerhet ved NTNU. Studenten som skriver oppgaven har selv en bakgrunn innenfor luftfart, og er interessert i å fordype seg i et tema relatert til dette. Følgende problemstillinger skal svares på i oppgaven:

1. *How do selected members of the aviation industry in Norway perceive the challenges of fatigue in a high-risk setting?*
2. *Which measures can be used to manage fatigue among pilots who work in large aviation companies in Norway?*
3. *Do the implemented measures to manage fatigue in the Norwegian aviation sector work as intended?*

Da oppgaven tar for seg en meget bransjespesifikk problemstilling, er det naturlig å innhente synspunkter fra personer som kan påvirke fatigue i luftfartsbransjen - nærmere bestemt piloter, ledere i selskaper og representanter fra tilsynsorgan.

Hva innebærer deltakelse i studien?
Deltakelse i denne studien innebærer å delta i et intervju på maks 60 minutter. Spørsmålene vil i all hovedsak omhandle fatigue i luftfartsbransjen, og hvordan man kan begrense/hindre effektene av dette. Spørsmålene vil ta for seg litt generelle bakgrunnsopplysninger (alder, stilling og ansiennitet), kunnskap om fatigue, opplevelse av emnet og hva man kan gjøre for å begrense/hindre dette. Alle svar på disse spørsmålene vil registreres gjennom lydopptak og notater.

Hva skjer med informasjonen om deg?
Alle personopplysninger vil bli behandlet konfidensielt. Det er kun student og veiledere som har tilgang til personopplysningene som blir gitt. Ingen personopplysninger vil bli knyttet til svar som blir gitt på spørsmål i intervjuet. Datamaterialet skal bearbeides slik at det ikke lenger er mulig å føre opplysningene tilbake til enkeltpersoner. Det vil derfor ikke være mulig å innhente direkte informasjon om nøyaktig *hvem* som har svart hva.

Studenten har tilgang til fysisk avgrenset rom med adgangskontroll. Datamaskinene der tilhører NTNU, og har individuelt brukernavn og passord. Gjennom pålogging har man tilgang til server og internett som er sikret av denne virksomheten, og det er her mesteparten av datamaterialet vil lagres. Lydopptak og notater vil oppbevares separat, i låst skap. Mobile lagringsenheter vil også bli brukt, men ikke til behandling av personidentifiserende data.

Deltakerne vil ikke kunne gjenkjennes i den endelige masteroppgaven. Oppgaven skal etter planen leveres 11.06.2017. Alle personopplysninger og opptak slettes før dette.

Frivillig deltakelse
Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker deg, vil alle opplysninger om deg bli anonymisert.

Dersom du ønsker å delta eller har spørsmål til studien, ta kontakt med:

Student: Nicholas Tambala 93213383 / nictamb@msn.com
Veileder: Ivonne Andrade Herrera 90680634 / ivonne.a.herrera@sintef.no
Veileder: Jo Bjørn Skatval 92637028 / jbskatv@gmail.com

Studien er meldt til Personvernombudet for forskning, NSD - Norsk senter for forskningsdata AS.

Samtykke til deltakelse i studien

Jeg har mottatt informasjon om studien, og er villig til å delta

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(Signert av prosjektdeltaker, dato)

Appendix D: Intervjuguide

Introduksjon

1. Navn (skal ikke skrives ned eller tas opp med lydopptaker)
2. Alder
3. Stilling
4. Ansiennitet (land, bransje, etc.)

Informasjon

5. Litt om meg: bakgrunn, alder, interesse av studien.
6. Formålet med intervjuet: masteroppgave for HMS-studiet ved NTNU
7. Bakgrunn: Luftfartstilsynets arbeidsmiljøundersøkelse
8. Informer om opptak og samtykke til dette. Alt er anonymt.
9. Evt. spørsmål?
10. Start opptak

Erfaringer

Piloter	Managers	Tilsynsmyndighet
1. Noen formening om hva fatigue er? a. Hva betyr fatigue for deg? b. Hva mener du kjennetegner fatigue? i. Beskriv assosiasjonene dine med tre ord. 2. Kan du gi en beskrivelse av en typisk arbeidsdag? a. Hvordan ser du for deg at du helst vil jobbe? i. Skift, tid på dagen, etc.? ii. Noe du ville endret ved nåværende arbeidsordning? 3. Hva slags erfaringer har du med fatigue? a. Kan du gi eksempler på situasjoner hvor du har vært påvirket av fatigue? i. Hva forårsaket fatigue i de situasjonene du beskriver? ii. Ser du noen fellestrekk?	1. Noen formening om hva fatigue er? a. Hva betyr fatigue for deg? b. Hva mener du kjennetegner fatigue? i. Beskriv assosiasjonene dine med tre ord. 2. Kan du gi en beskrivelse av en typisk arbeidsdag for pilotene i selskapet? 3. Noen formening om hvordan de helst vil jobbe? a. Skift, tid på dagen, etc.? b. Noe spesifikt de vil endret ved nåværende arbeidsordning? 4. Hva slags erfaringer har du med fatigue? a. Kan du gi eksempler på situasjoner hvor du vet noen av dine ansatte har vært påvirket av fatigue? i. Hva forårsaket fatigue i de situasjonene du beskriver? ii. Ser du noen fellestrekk?	1. Noen formening om hva fatigue er? a. Hva betyr fatigue for deg? b. Hva mener du kjennetegner fatigue? i. Beskriv assosiasjonene dine med tre ord. 2. Har du noen formening om hva en typisk arbeidsdag er for piloter i norske selskaper? a. Noen formening om hvordan de helst vil jobbe? i. Skift, tid på dagen, etc.? ii. Noe du kan tenke deg de ville endret ved nåværende arbeidsordning? 3. Hva slags erfaringer har du med fatigue? a. Kan du gi eksempler på situasjoner? i. Hva forårsaket fatigue i de situasjonene du beskriver? ii. Ser du noen fellestrekk?

Fokusering

Piloter	Managers	Tilsynsmyndighet
1. Hvor ofte vil du si at du er påvirket av fatigue? a. Og evt. forekomst hos andre ansatte? 2. Har du jobbet/jobber du om du føler deg utmattet? a. Og evt. forekomst hos andre ansatte? 3. Føler du at fatigue er et problem i luftfartsbransjen i Norge? a. Hvorfor/hvorfor ikke? b. Problem i andre deler av verden? 4. Prates det om fatigue blant ansatte? a. Av ledelsen? b. Andre? 5. Beskriv hvordan du vil at fatigue helst skal håndteres og/eller snakkes om i selskapet. 6. Ser du noen tendens i hvordan arbeidstidene har utviklet seg i bransjen? a. Presses du til å til å jobbe mer enn du føler deg komfortabel med? b. Hvor mener du hovedproblemet ligger? 7. Hvorfor fører ikke fatigue i denne bransjen til flere ulykker? a. Hva er det som gjøres riktig for å hindre hendelser/ulykker? b. Hvem/hva er det som sørger for at det går bra? c. Hva gjør du? 8. Hva mener du kan gjøres både personlig, fra selskapet sin side og på myndighetsnivå, for å håndtere fatigue? a. Hva slags tiltak ser du for deg er hensiktsmessige? b. Hva har evt. fungert dårlig?	1. Hvor ofte vil du si at pilotene i selskapet er påvirket av fatigue? a. Og evt. forekomst hos andre ansatte? 2. Vet du om pilotene jobber om de føler seg utmattet? a. Og evt. forekomst hos andre ansatte? 3. Føler du at fatigue er et problem i luftfartsbransjen i Norge? a. Hvorfor/hvorfor ikke? b. Problem i andre deler av verden? 4. Prates det om fatigue blant ledelsen? a. Hos de ansatte? b. Andre? 5. Beskriv hvordan du vil at fatigue helst skal håndteres og/eller snakkes om i selskapet. 6. Ser du noen tendens i hvordan arbeidstidene har utviklet seg i bransjen? a. Presses pilotene til å til å jobbe mer enn de føler seg komfortabel med? b. Hvor mener du hovedproblemet ligger? 7. Hvorfor fører ikke fatigue i denne bransjen til flere ulykker? a. Hva er det som gjøres riktig for å hindre hendelser/ulykker? b. Hvem/hva er det som sørger for at det går bra? c. Hva gjør du? 8. Hva mener du kan gjøres både personlig, fra selskapet sin side og på myndighetsnivå, for å håndtere fatigue? a. Hva slags tiltak ser du for deg er hensiktsmessige? b. Hva har evt. fungert dårlig?	1. Hvor ofte vil du si at norske piloter er påvirket av fatigue? a. Og evt. forekomst hos andre ansatte? 2. Føler du at fatigue er et problem i luftfartsbransjen i Norge? a. Hvorfor/hvorfor ikke? b. Problem i andre deler av verden? 3. Prates det om fatigue blant ansatte hos Luftfartstilsynet? a. Anerkjent problem? b. Evt. annet? 4. Beskriv hvordan du vil at fatigue helst skal håndteres og/eller snakkes om i norske selskap. a. Hvordan kan vi håndtere problemet? 5. Ser du noen tendens i hvordan arbeidstidene har utviklet seg i bransjen? a. Presses norske piloter til å til å jobbe mer enn de føler seg komfortable med? b. Hvor mener du hovedproblemet ligger? 6. Hvorfor fører ikke fatigue i denne bransjen til flere ulykker? a. Hva er det som gjøres riktig for å hindre hendelser/ulykker? b. Hvem/hva er det som sørger for at det går bra? c. Hva gjør Luftfartstilsynet? 7. Hva mener Luftfartstilsynet kan gjøres både av piloter, fra flyselskapene sin side og på myndighetsnivå, for å håndtere fatigue? a. Hva slags tiltak ser Luftfartstilsynet for seg er hensiktsmessige? b. Tiltak som evt. har fungert dårlig?

9. Kjenner du til aspektet Fatigue Risk Management System (FRMS)? a. Hva kan du fortelle meg om dette? b. Har du noen spesifikke meninger rundt FRMS? i. Ser du fordeler/ulemper?	9. Kjenner du til aspektet Fatigue Risk Management System (FRMS)? a. Hva kan du fortelle meg om dette? b. Har du noen spesifikke meninger rundt FRMS? i. Ser du fordeler/ulemper?	8. Kjenner du til aspektet Fatigue Risk Management System (FRMS)? a. Hva kan du fortelle meg om dette? b. Har du noen spesifikke meninger rundt FRMS? Ser du fordeler/ulemper?

Oppsummering

10. Oppsummere intervjuet
11. Eventuelle tilleggsspørsmål
    a. Har jeg forstått deg riktig…?
12. Har du noen kommentarer eller noe du vil legge til?
13. Forsikre om anonymitet
14. Takke for deltakelse!