Fatigue Reporting Behaviour Within a Regional Airline

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Abstract

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Fatigue is widely understood to be a safety threat in modern aviation as long working hours, shift work, and most significantly insufficient sleep disrupt crew from achieving adequate rest. Fatigue causes the decline of individuals performance to complete safety-related tasks, and negatively impacts crew's long-term health and wellbeing. Furthermore, crew under-reporting fatigue is a known issue which may give operator's the illusion of fatigue being inconsequential within their operations. Not only does fatigue have detrimental effects to flight safety, but it also incurs additional expenses to businesses through added health care expenditures, missed days of work, and lower workplace productivity.

This thesis was commissioned by a regional airline to investigate whether fatigue was a common occurrence, what the crew's attitudes and behaviors were on fatigue reporting, and whether the operator's fatigue mitigating procedures were effective. The theoretical framework laid the foundation of the prevalence of fatigue, the need for sleep, importance of trust, attitudes and behaviors on fatigue, fatigue risk management, sustainability, and recommendations.

Themed interviews with the operator's key managers were conducted to find their most prevalent problems involving fatigue. Then a quantitative questionnaire was created to investigate the research questions of the thesis and the results were conclusive. They showed that fatigue and fatigue under-reporting are a common occurrence and crew do not trust change will occur from reporting fatigue. Crew also feel that not enough action is taken regarding fatigue reports. However, with only 10 % of employees always reporting fatigue it is difficult to justify the need to act. Other key findings were that cabin and flight crew generally share the same attitudes and behaviours towards fatigue, fatigue reporting and the operator's fatigue management procedures.

With the threat of fatigue on flight safety and the potential cost savings from improving fatigue, recommendations were made. They were to allocate resources to improve fatigue management and fatigue mitigation, with education and training being one of the most important factors.

Key words
Aviation Industry, Fatigue Reporting, Fatigue Risk Management, Fatigue Mitigation, Safety

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Glossary & Abbreviations

*denotes an ICAO definition (ICAO Doc 9966).

***Biomathematical 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 (not a requirement) for predictive fatigue hazard identification within an FRMS. All biomathematical models have limitations that need to be understood for their appropriate use.

***Cumulative sleep debt**. Sleep loss accumulated when sleep is insufficient for multiple nights (or 24-hr days) in a row. As cumulative sleep debt builds up, performance impairment and objective sleepiness increase progressively, and people tend to become less reliable at assessing their own level of impairment.

EASA. European Union Aviation Safety Agency.

***Fatigue**. A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety related operational duties.

FRM. Fatigue Risk Management.

***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.

FTL. Flight Time Limitations.

IATA. International Air Transport Association.

ICAO. International Civil Aviation Organization.

***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.

***Safety management system (SMS)**. A systematic approach to managing safety, including the necessary organizational structures, accountability, responsibilities, policies and procedures.

***Safety risk**. The predicted probability and severity of the consequences or outcomes of a hazard.

SPI. Safety Performance Indicators.

1 Introduction to the problem concerning fatigue

The scope of this research thesis is to investigate the pilot's and cabin crew's fatigue reporting attitudes and behavior within the commissioned regional airline operator's environment. To understand fatigue reporting behavior, we must first investigate what fatigue is, how it is managed, and why managing fatigue is important to the safety of aviation. This is called fatigue risk management (FRM).

1.1 Background and prevalence of fatigue

Fatigue has been a significant problem in modern society mostly due to high workload demands, long duty periods, disrupts in the circadian rhythms, accumulative sleep debt, as well as social and societal demands (Caldwell et al 2019, Sadeghniiat-Haghighi and Yazdi 2015).

For many years now, fatigue among pilots and cabin crew has been a genuine concern in the aviation industry (Caldwell et al. 2019, ECA 2012, FMG 2015). To ensure safety and efficiency, the aviation industry relies on well rested, competent, trained people that are not only physically fit but mentally fit as well. There have been several studies to confirm pilot and cabin crew fatigue to be a common, dangerous and an under-reported problem (Caldwell et al. 2009, ECA 2012, ICAO Doc 9966, Van Den Berg et al. 2020). Fatigue can be hazardous in aviation, as it degrades various human performance capabilities, which can contribute to an accident or incident (ECA 2012, FMG 2015, ICAO Doc 9966).

Aviation is a safety-critical industry in which high-risk activities are organized every day of the year, around the clock. These activities are very demanding on the mental and physical capacity of everyone working within the aviation industry, causing fatigue.

Furthermore, the drastic reduction of number of flights due to the COVID-19 pandemic during the years 2020 - 2022 had a negative impact on aircrew's resilience to stress and fatigue (EPAS 2023-2025). Exacerbating these impairments, the financial pressures that airlines are facing, force operators to make non-optimal adjustments within the organization's resource allocation (EPAS 2023-2025). In an already competitive environment with low profit margins, these issues will lead to challenges with crewing flights and operational/roster planning. Therefore, fatigue is expected to continue to be a significant safety hazard within the aviation industry (EPAS 2023-2025).

IATA as well as EUROCONTROL foresee that despite the current socioeconomic challenges, the aviation industry will continue to recover, and it is forecasted that the revenue passenger kilometres (RPK) will grow past pre-pandemic values by 2024 and nearly double by 2040 when compared to 2019 values (EUROCONTROL 2022, IATA 2022). This means that there will be need for more efficient operations as the importance to fill each seat grows, and when there are no more seats to fill, new investments must be made for new aircrafts which will require more staff. IATA as well as EUROCONTROL foresee pilot shortage to be a great problem in the future (EUROCONTROL 2022, IATA 2022). This growth will continue to put pressure on airlines as they attempt to keep up with the pace, which will strain the aircrew even further.

Moreover, fatigue is known to cause businesses additional cumulative expenses in the form of increased health care expenditures and missed days of work, further degrading their already low profit margins making it even more difficult to stay alive in a competitive environment (Rosekind et al. 2010). Therefore, the importance of wellbeing just from an economic point of view makes sense to lower these additional medical expenses, missed days of work as well as improve employee retention. If operators are able to cut down on the expenses caused by fatigue, they will be able to better position themselves in a growing competitive market.

Recognizing the hazards that fatigue poses to safety within the aviation industry, the European Union Aviation Safety Agency (EASA) recommends enhancements to fatigue management (EPAS 2020-2023). This is one of the reasons why judicial changes have been made to regulations regarding flight time limitations (FTL) and fatigue risk management (EAR for Air OPS 2023). However, even though the duration of rest periods is well defined and regulated, this is not the case with the quality of sleep (EPAS 2020-2023). There are many fatigue risk management guides, models, and software that have been created to help operators with successful implementation of fatigue risk management, ICAO Doc 9966, and Fatigue Management Guide for Airline Operators to name a few (BAM 2023, CASA 2014, Doc 9859, ICAO Doc 9966, FMG 2015).

The difficulties that many operators have, however, is that fatigue reporting is an under-reported problem which makes it difficult for decision makers to dedicate resources to something that the data does not clearly show to be a problem. Therefore, it is important to have a holistic understanding of the shared responsibilities concerning fatigue and fatigue reporting. The shared responsibilities involve the regulator, operator, and employees.

Nevertheless, despite fatigue being a concern, the aviation industry remains to be one of the safest modes of transportation in the world. Regardless, fatigue is something that must be managed to not only keep the aviation industry as safe as possible and accident free but also to improve the social and economic sustainability of airlines (ECA 2012, FMG 2015, ICAO Doc 9966).

1.2 Research Questions

The main research question was to investigate the effectiveness of the operator’s fatigue risk management. To help investigate the main research question, three sub-research questions were created for this thesis that have been added into an overlay matrix which can be seen in table 1 below. The overlay matrix helps readers navigate between the theory part of the question, the results, and the survey questions easily.

Table 1. Overlay Matrix

Investigative Questions	Theoretical Framework (chapter)	Results (chapter)	Survey Questions
1. What are the attitudes and behaviors of the operator's pilots and cabin crew towards fatigue reporting?	2.1, 2.3, 2.4, 2.7	4.1, 4,2, 4.3	9 - 19
2. Is fatigue among the operator's cabin and flight crew a common occurrence?	2.1, 2.4, 2.7	4.1, 4,2, 4.3	3 - 12
3. Are the fatigue reporting procedures at the operator effective in helping to mitigate fatigue among cabin and flight crew?	2.2, 2.3, 2.4, 2.5, 2.7	4.1, 4,2, 4.3	13 - 19

1.3 Scope of the thesis

In the scope of this thesis, the author will be investigating the attitudes and behavior of fatigue reporting within a short haul regional airline operators' point of view. There are many causes of fatigue, however, in this report the main focus will be on fatigue caused by sleep loss and inadequate recovery sleep.

Fatigue and fatigue risk management is not a new topic in aviation and the topic has been vastly researched to improve aircraft safety as well as the wellbeing of all the employees involved in aviation. As the topic of fatigue is vast and many things are connected to each other, it is difficult to strictly limit what is in scope and what is out of scope. However, the author tried to take a holistic approach of the topic on fatigue and only include subjects that would be most relevant from the commissioner's point of view therefore bringing the most value.

As the commissioner follows the prescriptive fatigue risk management approach and has a bio-mathematical model in use which is considered to be an FRMS approach, these were included within the scope of the thesis. Also, as it became evident that many of the middle management are extremely busy and have limited resources at use, a financial perspective in the form of economic sustainability was brought up. The goal of this is to bring the point of view that it makes financial sense for the operator to invest resources into fatigue management and fatigue mitigation.

What this thesis work aims to achieve is to shed some light on the fatigue topic in general, investigate whether fatigue is a common occurrence within the operator’s environment, how the cabin and flight crew perceive fatigue, what their attitudes and behavior regarding fatigue reporting are, and whether the crew feel the operator’s fatigue mitigating procedures are effective. This includes investigating what fatigue is, what are the main causes of fatigue, looking into fatigue mitigation and fatigue risk management approaches, searching for scientific research papers and articles, reviewing guides, and looking at what recommendations have been suggested that could be taken to further improve the effectiveness of fatigue management procedures.

Through the research work done on this thesis, it is the authors hope to bring value to the commissioner in helping to point out areas that could be improved on, giving recommendations, and the importance of making changes based on findings from this thesis.

1.4 Thesis Structure

This thesis has been structured as per the recommendations of Haaga-Helia’s thesis writing instructions. The first chapter has gone through the introduction and scope of the thesis. An overlay matrix has also been included for quick guidance on where information can be found based on the thesis research questions.

The second chapter will be based on the theoretical framework of the thesis. Here the author will discuss important topics concerning fatigue to give the reader an understanding of the subject. The second chapter has been divided into an introduction of fatigue, what are the main causes of fatigue, the importance of sleep, the fatigue reporting culture, fatigue mitigation, sustainability and finally a conclusion.

The third chapter will look into the research methods, reliability, validity and ethics of this thesis. Furthermore, the author will discuss how and why this thesis topic was chosen, the data collecting methods used, as well as the creation of the survey.

The fourth chapter will go through the survey results, key findings, conclusion, and the author’s journey on the thesis process and self-assessment.

Finally, the last parts of the thesis are the sources and appendices.

2 Theoretical framework of fatigue

Fatigue is widely understood to be a significant problem in modern aviation as several studies have concluded that fatigue is a detrimental factor on human performance (Caldwell et al. 2009, Caldwell et al. 2019, CASA 2014, Flynn-Evans 2016). There is diverse and considerable evidence regarding the effects of fatigue on safety, which conclude a higher risk of accidents and injuries as well as greater performance decrements to individuals suffering from fatigue (CASA 2014, Williamson et al. 2011). In 2020, the European Aviation Safety Agency (EASA) identified wellbeing and fitness for duties as a top safety issue for large airline operators (EASA 2020).

2.1 The prevalence of fatigue

Long working hours, shift work, and most significantly insufficient sleep and sleep opportunities are just some of the causes that make pilots and cabin crew particularly prone to fatigue. People who are sleep deprived think and move more slowly, make more mistakes, and have memory difficulties when compared to well-rested people (Caldwell et al. 2009).

Not only does fatigue cause the decline of individuals performance capabilities to complete safety-related tasks, but it also undermines the crew's ability to respond to complex unexpected events (FMG 2015). Low workload and boredom can also unmask physiological sleepiness lowering the individual's reaction time and increasing error rates (Caldwell et al 2009, ICAO Doc 9966). When fatigued, simple tasks as well as complex events can be difficult to perform, and mistakes are more likely (Caldwell et al. 2019, FMG 2015). These tasks may be from a simple event, such as a pilot attempting to land in unfavorable weather conditions, to a more extreme event such as cabin crew leading an emergency evacuation due to fire.

Furthermore, fatigued individuals are typically unaware of how severely their performance has been hindered and may think that they are safe to fly when in case, it is the exact opposite (Gawron, 2015). Caldwell et al. (2009) explain how the full impact of fatigue is often under-appreciated. Multiple studies found fatigue to be a safety concern and a common occurrence, with up to 80 – 90 % of pilots experiencing fatigue symptoms affecting their flight performance such as micro-sleep (Caldwell et al. 2009, Co et al. 1999, Gregory et al. 2010, Rosekind et al. 1994).

In 2012 the European Cockpit Association (ECA) conducted a comprehensive report on pilot fatigue which was based on surveys from multiple different EU countries between 2010 and 2012. In the surveys, more than 6,000 European pilots were asked to self-assess the level of fatigue they had been experiencing. Similar numbers were found from these surveys as from the previously mentioned studies.

Key findings from the ECA (2012) report were that pilot fatigue is a common, dangerous and an under-reported phenomenon in Europe. Of the surveyed crew members, 84 – 93 % of pilots and cabin crew had reported having to cope with fatigue while on flight duty. Additionally, 70 – 80 % of fatigued pilots would not file a fatigue report or declare themselves to be unfit to fly due to fear of disciplinary actions or stigmatization by their employer or colleagues. Moreover, only 20 – 30 % of pilots would file a fatigue report or report themselves to be unfit for flight duty. (ECA 2012).

Pilot fatigue and the reduction in human performance has been a cause of many aviation accidents. It has been estimated that 4 – 8 % of civil aviation incidents and accidents can be attributed to fatigued pilots (Caldwell 2005). Another study estimated that within the last two decades, fatigue has been a probable cause in 21 – 23 % of major aviation accidents (Caldwell 2012, Marcus and Rosekind 2017).

These studies show that fatigue among pilots and cabin crew has been a global concern for a long period of time. To gain a holistic understanding of fatigue we must first look at what causes fatigue and what different types of fatigue there are.

2.1.1 Definition of fatigue

It is difficult to find a comprehensive definition for fatigue that is universally agreed on, as fatigue is a complex phenomenon that can be attributed to many factors. Sadeghniiat-Haghighi and Yazdi (2015) explain that the term “fatigue” has a widespread usage in occupational medicine. Other terms in literature can be used instead of fatigue, such as drowsiness and sleepiness, which can make the differences difficult to distinguish. Sleepiness refers to the neurobiological drivers to induce sleep after spending a long time awake, whereas forceful physical exercise during the day will drain the bodies energy causing fatigue, but not the need for sleep (Sadeghniiat-Haghighi and Yazdi 2015).

There are many definitions of fatigue, but in this context, we refer to fatigue as the International Civil Aviation Organization (ICAO) defines it.

“*a physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person’s alertness and ability to adequately perform safety-related operational duties” (ICAO Doc 9966)*.

In short laymen terms, this means that if you have not slept enough and/or have exerted great physical labour, you will be tired and your ability to perform will be lowered.

Not only does fatigue impair task performance, but it also has a psychological effect causing a reluctancy to perform tasks as the body's energy reserves deplete (Ferrara 2001). Essentially fatigue causes physical and mental performance to be decreased until a point is reached where the brain sends a signal to the body to end any ongoing activity.

2.1.2 Causes of fatigue

There are many possible causes of fatigue, but the most common causes of pilot and cabin crew fatigue are attributable to irregular sleep and work patterns, long times awake, multiple sectors, long flying hours, early starts and night duties (ECA 2012, Gander et al. 1994, Powell et al. 2007). However, the most important cause of fatigue is the lack of restorative sleep (Caldwell et al. 2019, Flynn-Evans 2016).

One study conducted by NASA (2016) on flight and duty times of short-haul, night cargo, and long-haul operations found that short-haul operators were more prone to fatigue due to having the longest daily duty hours, averaging 5 flights per day, and having the shortest daily breaks (Flynn-Evans et al. 2016). Another study stated that the main causes of fatigue were restricted sleep caused by short rest breaks and early duty report times, high workload, as well as flying multiple sectors during a long day (Gander et al. 1998).

Other factors that increased the risk of cumulative fatigue included inadequate time for recovery sleep between consecutive duty days, and a high amount of flight duty over a longer period, such as in a month or year (Gander et al. 1994, Flynn-Evans et al. 2016).

2.1.3 Workloads influence on fatigue

There are three commonly identified aspects concerning fatigue from workload, which are the demand of the work, time on task, and the individual's ability (ICAO Doc 9966). Workload can influence an individual's ability to handle different sets of circumstances. A difficult situation may prove to be impossible as fatigue impairs and exceeds the individuals' capabilities, whereas low workload may unmask physiological sleepiness hindering performance and reaction time (ICAO Doc 9966). In both cases high and low workload can contribute to fatigue and cause a heightened risk as mistakes become more common (ICAO Doc 9966).

Studies show that workload is increased with the number of sectors in a flight duty period which causing mental fatigue (Cahill et al. 2019, ECA 2012, Powell 2007). Powel et al. (2007) also state that short haul flying carried out by two pilots results in a greater workload and higher fatigue levels compared to long-haul flights with three-pilot crews as there are no in-flight rest opportunities. Another study by Bourgeois-Bougrine et al. (2003) on pilots perceived fatigue found that the most fatiguing factors for short-haul pilots were attributed to long workdays (53 %) and successive early wakeups (41 %). Fatigue was exacerbated by the combination of long workdays with consecutive nights which may place further excessive physiological and mental load on the pilot's capacity (Bourgeois-Bougrine et al. 2003).

2.1.4 Irregular work patterns or shift work

Shift work refers to any work pattern that is done outside of the normal waking hours, where an individual might be working at times when they are supposed to be asleep. This means that any work done outside of the typical working hours, such as early starts, late finishes, night work, or extended work hours, can be considered shift work (ICAO Doc 9966). The more sleep is displaced from the optimum night times, the greater the difficulty there will be to get adequate sleep (ICAO Doc 9966). This is a problem, as it is unnatural to our evolved circadian body clock, which determines our preference to sleep at night. (ICAO Doc 9966).

Evidence shows that shift workers habituate to a lower level of general wellbeing, suffer from an increase of chronic fatigue, and are at an increased risk of occupational accidents when compared to non-shift workers (CASA 2014, ICAO Doc 9966, Spelten et al. 1993). Furthermore, studies show that shift workers are also more prone to disease and infections which is not only a health and wellbeing concern but also increases healthcare expenses (Cahill et al. 2019, Rosekind et al. 2010).

The circadian body clock cannot adapt immediately nor fully to a change in the rotating shift work schedules (ICAO Doc 9966). Fatigue-related impairment will increase whenever work-shifts overlap with the same hours of the circadian body clock where sleep should normally occur, especially if this continues across multiple consecutive days (ICAO Doc 9966). The body will accumulate sleep debt over this time, and this accumulated sleep dept can only be recovered with longer than the usual amount of recovery sleep (ICAO Doc 9966). Furthermore, it is more difficult to obtain adequate recovery sleep outside of normal sleeping hours, as a circadian alerting signal is sent to the body to wake up at the usual waking time (ICAO Doc 9966).

2.2 The need for sleep

There have been exhaustive and comprehensive studies done on sleep and it is not within this projects scope to discuss sleep in detail. However, as sleep is such an important factor in fatigue, it must be brought up to some extent.

The human body is programmed to sleep during the night and be active and awake throughout the day (Flynn-Evans, 2016). The basic needs of human physiology have remained the same in the entirety of aviation history while the pressure from operational demands exerted on crew members have continued to increase. There are individual differences, but in general sleep science dictates the optimal amount of sleep for most adults is between 7 and 9 hours each night and sleep cannot be sacrificed without consequences (Caldwell et al. 2019, Flynn-Evans et al. 2016, FMG 2015). Sleep plays a vital role in learning, maintaining alertness, memory, performance, mood, and in overall health and wellbeing (FMG 2015, ICAO DOC 9966).

Caldwell et al. (2019) describe that there are many factors that can influence an individual's sleep behaviour which include factors such as genetics, knowledge, beliefs, attitude towards sleep, as well as health and disease. These factors are embedded in a societal context that include home, family, the sleep environment, occupation, and socio-economic status, which can further influence the individual to get an adequate amount of recovery sleep (Caldwell et al. 2019). As sleeping requires the individuals own volitional behaviour to obtain a sufficient amount of sleep, societal demands can have a great effect on the individual's ability or choice to sleep over other activities (Caldwell et al. 2019). Therefore, it is important for an individual to understand the importance of adequate recovery sleep to restore the bodies functions as well as mitigate and negate fatigue.

2.2.1 Sleep determinants on alertness and performance

According to Flynn-Evans et al. (2016) there are four sleep related determinants on alertness and performance. These four determinants are nightly sleep duration, number of hours awake, sleep inertia, and circadian phase (Flynn-Evans et al. 2016).

Firstly, reducing the nightly sleep duration causes chronic sleep loss while the number of hours spent awake causes acute sleep loss. The need for sleep or homeostatic pressure increases the longer we stay awake which causes a reduction in alertness and performance. The only way to relieve this homeostatic pressure is with adequate restorative sleep. (Flynn-Evans et al. 2016).

Additionally, waking up from sleep is a process where various parts of the brain reactivate in sequence (Flynn-Evans et al. 2016). During this process when people are still not fully awake, they sometimes experience grogginess and disorientation known as 'sleep inertia' (Flynn-Evans et al. 2016, FMG 2015).

Finally, the circadian phase which is based on the time of day. The circadian body clock exerts strong influence over sleep as it controls the bodies naturally tendency to want to stay awake during the day and sleep during the night (Flynn-Evans et al. 2016, FMG 2015). This is sometimes described as the circadian rhythm.

2.2.2 Recovery sleep (REM Sleep and non-REM Sleep)

There are two different types of sleep, non-rapid eye movement (non-REM) sleep and rapid eye movement (REM) sleep. In REM sleep the *brain* is restoring itself, information from the previous day is being sorted and memories stored. In non-REM sleep the *body* is being restored through muscle growth and repairing tissue damage. Both stages are equally important as sleep can only be fully restorative if it contains unbroken cycles of non-REM and REM sleep. (FMG 2015).

2.2.3 Recovery from sleep restrictions

Studies show that it may take days or even weeks to fully recover from prolonged sleep restrictions which have effects on alertness and performance (Belenky et al. 2003, Rupp et al. 2009). Accumulated sleep debt will require recovery sleep longer than at least two nights of unrestricted sleep. If there has been continuous sleep restriction over multiple nights, then recovery will require more than two consecutive nights of unrestricted sleep (Belenky et al. 2003, ICAO Doc 9966, Rupp et al. 2009). This highlights the importance of longer periods of time off, such as annual leaves which help to recover from prolonged sleep restrictions.

Recovery sleep will also need to be longer than a normal night's sleep, as lost sleep is not recovered from hour-to-hour (Belenky et al. 2003, Rupp et al. 2009). Typically, on the first night of recovery sleep, there will be more non-REM sleep where the body is restoring itself and on the second night the brain will catch up with the REM sleep (Belenky et al. 2003, ICAO Doc 9966, Rupp et al. 2009).

Studies show that the negative consequences from chronic sleep deprivation and insomnia leads to negative effects such as reduced overall mental health and wellbeing, depression, reduction in emotion control, poor social skills, and mood disorders (Caldwell et al. 2019). The combination of reduced mental and physical performance caused by sleep deprivation leads to a reduction in safety, wellbeing, productivity as well as an increase of economic expenses (Caldwell et al. 2019, Flynn-Evans et al. 2016, Rosekind et al. 2010)

As the effects from sleep restrictions are cumulative, rosters must be allocated with extended opportunities for recovery sleep. If a roster has frequent daily sleep restrictions, then there must be more frequent recovery sleep opportunities (ICAO Doc 9966).

2.3 Attitudes and behavior on reporting and under reporting

It has now been established that fatigue can have extremely detrimental effects on flight safety. Despite the high prevalence of fatigue between cabin crew and pilots, under-reporting fatigue continues to be a significant issue (ECA 2012, ICAO Doc 9966). As mentioned earlier, an ECA report (2012) on pilot fatigue found that only 20 – 30 % of pilots actually filed a fatigue report when they felt unfit for duty.

A healthy reporting culture is of the utmost importance to understand the hazards and errors within an operational environment (Hershman 2012, von Thaden & Gibbons 2008, EUROCONTONROL 2006, Gu & Itoh 2013, Itoh et al. 2009). A healthy reporting culture is also known as 'Just Culture', where the operator encourages to file reports and individuals voluntarily report errors or other safety information without fear of reprisal (EUROCONTROL 2006, ICAO Doc 9966, McMurtrie & Molesworth 2018).

In the ECA (2012) report, it was determined that the reasons for under-reporting varied from simple inconvenience of filing a report after a long and exhausting workday to fear of stigmatization from the employer or colleagues. One of the most common barriers to filing a fatigue report was that pilots felt the reports did not change or achieve anything and feared it could have a negative impact on their performance evaluation. Furthermore, pilots who had previously filed a fatigue report were not motivated to continue filing reports. The ECA (2012) report speculated that this could have been due to pilots not seeing any results, changes, or that they could have already felt the negative consequences of reporting. (ECA 2012).

Furthermore, McMurtrie & Molesworth (2018) conducted a study in Australia on flight crews trust on the voluntary reporting system policies. They found that a high proportion of pilots either partially reported or did not report at all any safety-related information due to fear of reprisal, or that it was not worth the effort. They also found there were no differences in reporting attitudes or behavior when comparing rank or license type. (McMurtrie & Molesworth 2018).

2.3.1 Enhancing trust in the SMS reporting culture

McMurtrie & Molesworth (2018) determined that trust in the voluntary reporting system was a key aspect of success in the safety management system (SMS). They continue to state that the voluntary reporting of safety information is an important part of an organization's risk management strategy. Therefore, voluntary reporting provides the operator with the information required to understand the hazards within their operational environment. This information plays an essential role in maintaining the safety of commercial aviation as it helps manage risk (Amalberti, 2001). McMurtrie & Molesworth (2018) conclude that organization's must keep on improving their just culture to dispel any fears of reprisal when reporting safety-related information. Furthermore, recommendations were made that operators need to greatly improve their feedback procedures, give guidance on what to report, and optimize the reporting process to be quick and easy as to encourage more reporting (McMurtrie & Molesworth 2018).

If people are unwilling or unable to report fatigue hazards, the causes and consequences of fatigue will be difficult to detect (ICAO Doc 9966). The research community has identified high priority needs that must be developed concerning fatigue (Weiland et al. 2013, Bendak & Rashid 2020). These were enhancements in the culture of fatigue self-reporting and self-monitoring, as well as adjusting shift schedules to minimize cumulative effects on circadian rhythm disruptions (Weiland et al 2013, Bendak & Rashid 2020).

In addition to the recommendations from McMurtrie & Molesworth (2018), the guidance material from ICAO Doc 9966 shares even further recommendations on fatigue reporting. These recommendations include measures such as making clear expectations for individuals to report fatigue hazards, organization identifying hazards from fatigue reports, as well as clear and appropriate actions on how operators will respond to fatigue hazards (ICAO Doc 9966). These improvements and actions will show commitment from the operator and encourage staff to report fatigue hazards which will enhance safety culture (Weiland et al. 2013, ICAO Doc 9966).

2.4 Fatigue Risk Management

As established earlier, humans are by their innate nature diurnal organisms and poorly prepared for lengthy periods of continuous wakefulness, nighttime work, and substantial changes in their sleep schedules. Considering the pace of modern society and economic realities including work, family, and travel demands, it is unrealistic to entirely eliminate fatigue. However, even if fatigue poises a safety risk, the aviation industry provides one of the safest modes of transportation in the world and there are ways to manage and mitigate fatigue (FMG 2015).

2.4.1 Regulations on Fatigue Risk Management (FRM)

All airline operators are now required to have a Safety Management Systems (SMS) in place which identifies and manages all the threats and hazards within the company (CASA 2014, ICAO Doc 9859). The SMS ensures safe operation of aircraft through effective management of safety risk (CASA 2014, ICAO Doc 9859). ICAO has issued a Safety Management Manual (SMM) together with ICAO Annex 19 which integrates safety management guidance (CASA 2014, ICAO Doc 9859, ICAO Annex 19).

Fatigue management refers to the methods by which Service Providers and operational personnel address the safety implications of fatigue (FMG 2015, ICAO Doc 9966). EASA refers to the ICAO Doc 9966 in their Easy Access Rules for Air Operators (EAR Air OPS 2023) regarding Fatigue Risk

Management (FRM). ICAO Doc 9966 - Manual for the Oversight of Fatigue Management Approaches, is a general overview on the oversight of fatigue management approaches.

It is an operational requirement for airlines to manage safety by establishing organizational framework and structures, accountabilities, policies, and procedures that effectively identify hazards, analyze data, and mitigate risk (CASA 2014).

2.4.2 Shared responsibility of fatigue management

Another important factor to understand is that fatigue affects all parts of the waking activities and not only work demands. Therefore, fatigue management must be a shared responsibility between crew members, operators, and regulators (CASA 2014, FMG 2015, ICAO Doc 9858, ICAO Doc 9966).

The regulator is responsible for providing a regulatory framework and ensuring an acceptable level of safety is maintained by operators managing their fatigue-related risks. Crew members are responsible for ensuring enough recovery sleep during breaks, arriving fit for duty, and reporting any perceived fatigue hazards. The operators are responsible for implementing processes on monitoring and managing fatigue hazards, educating crew members on fatigue management, and planning rosters that enable crew members to perform their duties safely. These measures from crew members and operators require more than just a simple regulatory compliance check, as there is a need of plain action towards managing fatigue risk. (ICAO Doc 9966).

2.4.3 Fatigue Risk Management approaches

The International Civil Aviation Organizations (ICAO) Standards and Recommended Practices (SARPs) support three approaches for fatigue management (ICAO Doc 9966, ICAO SARPs 2023).

One approach is the prescriptive method where the operator complies with regulatory requirements within their Safety Management System (SMS) which is also used to manage other types of hazards. Another approach is for the operator to develop and implement their own Fatigue Risk Management System (FRMS), which is then approved by the regulator (FMG 2015, ICAO Doc 9966). The third option is to utilize a combination of these two methods.

These approaches share the same principles which are based on scientifically approved research, as well as knowledge on operational experience (ICAO Doc 9966). Both approaches should also consider other important factors such as the need for adequate sleep, planning daily rhythms, contribution of workload, risk factors from fatigue-impaired crew members, and the acceptable level of safety (FMG 2015, ICAO Doc 9966, ICAO annex 6).

These operational experiences and scientifically researched approaches ensure crew restore and maintain all aspects of waking functions to maintain the ability to perform their mental and physical workload as to not degrade their performance due to fatigue where safety risk would rise to an unacceptable level (ICAO Doc 9966).

2.4.4 Comparing prescriptive and FRMS approaches

Historically, fatigue risk has been regulated through Flight and Duty Time Limitation (FTL) schemes to limit maximum duty and minimum rest times (CASA 2014). Many existing FTL limits have remained the same even if scientific, technological, and operational advancements have been made on best operational practices (CASA 2014).

Crew schedules in commercial aviation are regulated by constraints in duty and flight time limits as well as minimum crew rest times. These constraints form part of the prescriptive flight time limitations (FTLs) that all airlines must abide by. FTLs goal is to protect crew against fatigue by adding a layer of safety in the aviation industry. However, FTLs tend to be rigid and limit operational flexibility and efficiency (Hellerström et al 2010).

The prescriptive fatigue management approach is more straightforward, as operators must establish their operations within the prescribed limits of the regulators flight time, flight duty periods, duty periods and rest periods (EAR for Air OPS, FMG 2015, ICAO Doc 9966). In addition to this, the operator must utilize their existing SMS processes to manage their fatigue hazards.

In a comparison study on FTLs, Hellerström et al. (2010) compared different regulatory rules with optimized crew schedules and found that it is possible to protect against fatigue without sacrificing productivity. They compared different global aviation FTL regulatory rule sets against a biomathematical model called the Boeing Alertness Model (BAM) and found that the biomathematical model was more efficient in its roster planning. The BAM tool scored better on alertness levels, productivity, and protected crew better from fatiguing effects (Hellerström et al. 2010). This study summarized the need to improve on the prescriptive FTL rules by adopting a more efficient and flexible approach through a biomathematical model incorporated within an FRMS.

In recent years, many airline operators have been moving towards the adoption of a performance-based crew management system and technique rather than the prescriptive method (CASA 2014). These performance-based crew management systems are also known as Fatigue Risk Management Systems (FRMS).

ICAO defines an FRMS as follows:

“a data-driven means of continuously monitoring and maintaining 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 DOC 9966)

The FRMS approach abides by these same rules and regulations as the prescriptive approach, however it grants the operator the opportunity to utilize advances in scientific knowledge to improve on their specific flight operations by adding flexibility (FMG 2015, ICAO Doc 9966). An FRMS is a holistic risk management approach that identifies specific risks and hazards, then addresses them to improve safety (CASA 2014). This is done by continual evaluation of processes, monitoring fatigue systems, training and educating employees, and providing constant feedback (CASA 2014).

As all operators are required to have a Safety Management System (SMS) in place, implementation of an FRMS can be eased by building it on top of the already working SMS processes, rather than creating an entirely new system. Additionally, as the ICAO SARPs recognize three FRM methods, implementing FRMS can be done in phases. Operators may choose to manage none, some, or all their operations under an FRMS. However, even if an FRMS may bring flexibility and operational efficiency, costs and complexity need to be taken into consideration as not all operators are large enough to justify the implementation of an FRMS (FMG 2015, ICAO Doc 9966).

Fatigue management is an important concept for organizations concerned with health, safety, and productivity of their employees and should be included as part of the safety management system (SMS) (Caldwell et al. 2019). More detailed information on FRM and how to implement FRMS can be found in the ICAO Doc 9966 and the Fatigue Management Guide for Airline Operators (ICAO Doc 9966, FMG 2015). However, as mentioned earlier, one useful tool to help manage crew fatigue in FRMS is the use of biomathematical models which will be discussed further in the next chapter.

2.5 Biomathematical Models

The Civil Aviation Safety Authority (CASA) has done a thorough study comparing seven different biomathematical models in 2014 which the ICAO Doc 9966 also refers to. The CASA (2014) study was designed to help operators decide whether to incorporate a biomathematical model into their FRMS and which of the seven models compared might suit their operational needs best. Again, it is not within the scope of this thesis to go through biomathematical models in detail, but it is important to understand what biomathematical models are and how they are used, and what their role is regarding fatigue risk management.

Biomathematical models are computer program tools used for predicting crew member performance, alertness, and fatigue levels based on scientific knowledge and factors that contribute to fatigue (Caldwell et al. 2019, CASA 2014, ICAO Doc 9966). Fatigue levels are predicted and quantified based on sleep history, time of day and workload with a set of integrated equations which are converted into a simple numerical score representing fatigue risk (Caldwell et al. 2019, CASA 2014). This fatigue score can then be used to compare or evaluate schedules against an upper fatigue limit (CASA 2014). Failure to evaluate validated upper limits on fatigue within the operational environment can undermine the quality of the FRMS and lead to staff having minimal confidence in the system (CASA 2010).

2.5.1 Benefits and limitations of biomathematical models

One important application of biomathematical models is to help develop optimal crew schedules and improve safety by reducing fatigue-related risks (Caldwell et al. 2009, CASA 2014, Gundel et al. 2007). A recent study by Sprajcer et al. (2022) concluded that components from FRMS such as biomathematical models have improved safety and fatigue metrics. Properly used, biomathematical models can be a helpful tool in FRMS, as they help visualize the dynamic interactions of processes such as work, sleep loss, recovery sleep, and the circadian biological clock (ICAO Doc 9966).

However, these biomathematical models are based on mass averaged data to predict the average individual's fatigue levels, therefore, subjective individual differences as well as uncertain pre-duty conditions are not taken into consideration (CASA 2014, ICAO Doc 9966, Van Dongen et al. 2007). Additionally, biomathematical models neglect other individual factors such as personal or work-related stressors affecting fatigue levels or fatigue mitigation strategies such as exercise or caffeine consumption (ICAO Doc 9966). Examples of these individual influencing factors are diverse, such as having a long commute to work, being woken up by a young child in the middle of night, or life stressors due bereavement or moving into a new house (CASA 2014).

The most reliable use of current biomathematical models may prove good for predicting fatiguing factors such as time awake or work/rest patterns, however, the models do not define what is an acceptable level of fatigue nor what this output might be (CASA 2014, ICAO Doc 9966). This limits the model's effectiveness to be more comparative, where the merits of one duty roster is compared with another but it cannot be definitively answered whether a particular work schedule is acceptable or safe (CASA 2014).

Biomathematical models may be good at observing the short-term acute effects of fatigue between work and rest, however, they assume that any fatigue generated during the work week will be nullified during rest periods (CASA 2014, ICAO Doc 9966). Another shortcoming of biomathematical models, is that they do not effectively take the chronic effects of fatigue regarding safety into consideration (CASA 2014). Furthermore, studies show that chronic fatigue is exacerbated by shift work (CASA 2014, Rouch et al. 2005). Additionally, biomathematical models overlook the added risk of occupational accidents and injuries that shift workers are more prone to (CASA 2014, Fransen et al. 2006, Tucker and Folkard 2013).

These limiting factors of biomathematical models are important for operators to address in their evaluation processes of fatigue risk management, as disregarding them may hinder their economical sustainability by increasing long term operational costs through increased medical expenses as well as a decrease in available crewing resources which can lead to delayed or even cancelled flights (NSC 2017, ICAO Doc 9966, Hafner et al. 2016, Tucker and Folkard 2013).

It is accepted that biomathematical models are incomplete, as scientists continue to improve on the models to find out where they fail and how to improve on them (ICAO Doc 9966). Many sources warn that even if biomathematical models can be very beneficial and informative, operational decisions should not solely be based on these models (Caldwell et al. 2019, CASA 2014, ICAO Doc 9966). Additional methods that can be used to identify additional fatigue factors associated with flight duty are, to assign a comparable fatigue value to a specific flight duty, identify effective mitigation methods for a flight duty, and to assign a starting point value for a flight duty at different times which can then be compared for a safety case (ICAO Doc 9966, Tritschler 2015).

2.5.2 Use of biomathematical models

The benefits of these optional biomathematical models are clear as they are increasingly being utilized as a broader part of fatigue management programs which are then further improved by integrating actigraphy (smart watches) to generate actual sleep data (Caldwell et al. 2019, CASA 2014, Dawson et al. 2017, Simple Flying 2023). Therefore, understanding the benefits and limitations of biomathematical models is important, as they provide a mechanism to quantitatively incorporate some of the latest data-driven, scientific knowledge that can be used within an FRMS (CASA 2014). The benefits from a biomathematical model can further be enhanced by enriching data generated by the model with a continuous improvements' philosophy within the operator's culture (CASA 2014, ICAO Doc 9966).

Operators using a biomathematical model within their fatigue risk management system must identify and include proactive complementary strategies to manage fatigue (CASA 2014). It is important for the whole operational staff to be educated in interpreting biomathematical models as well as the models' strengths and weaknesses (CASA 2014, ICAO Doc 9966, Sprajcer et al. 2022). This includes educating management, pilots, cabin crew, as well as office staff such as crew planning.

Outputs of biomathematical models may give the illusion of being exact, precise, and quantitative despite them being a qualitative measure on subjective fatigue (CASA 2014). Finally, the CASA (2014) report concludes that biomathematical models should constantly be reviewed, refined, and updated to ensure the integrity of the organizations fatigue risk management culture and operational practices.

2.6 Industry Sustainability

Safety is the gold standard that airlines aim to achieve with an impeccable record as any incident or accident could have devastating effects. As discussed earlier, fatigue has been a cause of many aviation accidents and incidents. Research has shown that these accidents and incidents are usually due to a multitude of chained unfortunate events (Reason 1997). Air crew is considered to be the last line of defence in stopping these chains of unfortunate events (Reason 1997). However, as it has been determined, fatigue can cause crews performance level to drop in such a way that safety is threatened and risk increases.

Avoiding any sort of loss of life itself should be enough of a reason to improve safety. However, aviation is a business-driven environment where profits must be made for shareholders. Therefore, the regulators have set an 'acceptable level of safety' standard. The idea behind acceptable level of safety is to reach a point where aviation is safe, but still profitable. The cost implications alone of a catastrophic event should raise enough concern for airlines to address the concern of mitigating fatigue. However, if this is not reason enough, then there is the social and economic sustainability that can also be considered.

The global aviation industry has aligned itself with the United Nations 2030 Agenda for Sustainable Development Goals (ICAO 2022). ICAO has stated that 15 out of their 17 Strategic Objectives are strongly linked to the United Nations Sustainable Development Goals (ICAO 2023, UN 2023). According to ICAO's working paper on these UN SDG's, through generating connectivity, aviation is a key driver of economic and social development. Some of these goals concern good health and wellbeing as well as decent work and economic growth.

Furthermore, studies have found that the outcomes of fatigue can result in substantial costs to the employer in the form of missed days of work, increased health care expenses, workplace accidents and injuries, as well as a diminished performance and lower productivity (EUROCONTROL 2018, Hafner et al. 2016, NSC 2017, Rosekind et al. 2010). According to Rosekind et al. (2010), they estimate fatigued workers cost the employers between $ 1,200 to $ 3,100 per employee annually.

Another estimate by the National Safety Council (2017) was that a single employee with sleep problems can cost the employer up to $ 3,500 a year in lost productivity, absenteeism and increased health care costs costing an employer with 700 employees $1 million a year.

Using Rosekind et al. (2010) estimated cost of $ 1967 / employee annually, a company size of 1000 employees would incur annual expenses of approximately $ 2 million. Adjusting for inflation this would approximate to $ 2.8 million (Inflation calculator 2023). Being able to mitigate these expenses by even 5 % would generate annual savings of $140,000. These potential savings alone should give reason enough for employers to focus efforts on making meaningful changes to reduce fatigue in order to achieve greater economic sustainability. Moreover, further improvements could then be made for even more substantial savings as reducing crew fatigue will have a spillover effect on general wellbeing.

2.7 Fatigue Mitigation Recommendations

We have now discussed many of the key factors relating to fatigue and the final chapter will summarise previous chapters on fatigue mitigation, improvements to fatigue processes as well as recommendations.

As it can now be determined, fatigue is not a simple fix as there are many things to take into consideration. Based on the evidence shown, it could be said that fatigue and safety go hand in hand. The studies on fatigue and under-reporting clearly show that this is an issue. Trust needs to be restored and improved for the Safety Management System to work and for crew to feel that there is a reason to report fatigue. Furthermore, an important part of a working SMS culture is a continuous development culture.

Businesses must see that there is a value proposition for them to invest resources for improvement and change (Miller 2021). In the sustainability chapter a value proposition was shown in the form of social and economic sustainability. A company that shows commitment to social sustainability will incur less costs from medical expenses, have a higher employee retention, and have more healthy, productive, and effective workers. By developing wellbeing and reducing fatigue, the company's long term economic and social sustainability will be improved (Rosekind et al. 2010).

Caldwell et al. (2019) emphasizes the importance of understanding the dangers of fatigue and the importance of obtaining adequate sleep. Employees must understand that full recovery from fatigue may take longer than anticipated and how good sleeping habits are essential for ensuring optimal sleep quality (Caldwell et al. 2019). Employers must also understand the importance of adequate recovery time and enable the possibility of a proper work life balance.

Caldwell et al. (2019) conducted a thorough study on fatigue and its management in the workplace where they recommend over 40 fatigue countermeasures which are further based on scientific studies and findings. Going through these recommendations alone in detail would require another thesis work. However, on a more primitive level some of these countermeasure's cover educating employees, optimizing sleep opportunities, establishing routines, having a proper diet, frequent exercise, improving on shift schedules, and utilizing biomathematical models and FRMS (Caldwell et al. 2019). When using biomathematical models in an FRMS, it is critical to remember that it is only a part of an FRMS and to understand the biomathematical models' capabilities and weaknesses (CASA 2014).

Several other studies and guides conclude the importance of education as an effective measure for fatigue management and mitigation (Caldwell et al. 2009, Caldwell et al. 2019, FMG 2015, ICAO Doc 9966, Moore-Ede 2009, Van Den Berg et al. 2020). When considering who to educate, it is important for the entire company to receive training and education concerning fatigue and its management, but education should also include cabin and flight crews' family members as it is important for them to also understand the importance of adequate sleep as well and what effects fatigue might have outside of the work environment (Caldwell et al. 2019, EUROCONTROL 2018).

Moore-Ede (2009) recommends educating employees on the following subjects:

1. Hazards that fatigue can cause on work, social and family life.
2. How fatigue is affected by lifestyle choices
3. The importance of sleep and circadian rhythms to mitigate fatigue.
4. How to obtain adequate sleep, how to recognize sleep disorders and how to receive treatment.
5. Management's role in supporting staff with the information and resources needed.

Further recommendations include ensuring adequate crew resources to maintain workload balance to reduce fatigue-related problems caused by shiftwork, minimizing schedule-related fatigue by using biomathematical models, identifying specific schedules which carry a higher fatigue risk, improving and implementing fatigue countermeasures, ensuring employees are able to rapidly recognize signs of excess fatigue, and procedures to further mitigate fatigue or the risk caused by fatigue (Caldwell et al. 2019, Moore-Ede 2009).

In a study on fatigue risk management for cabin crew Van Den Berg et al. (2020) discus the importance of company support and sufficient rest for work-life balance. They concluded that airline operators should consider the importance of sufficient rest for adequate recovery and for facilitating a work-life balance in support of employee's health and wellbeing (Van Den Berg et al. 2020). They further recommend that operators improve on company support on fatigue related processes through communication, management engagement, as well as training and education (Van Den Berg et al. 2020). It is also important to consider company support for middle management, so they have the resources needed to find problems, suggest improvement, and implement tangible action (ICAO Doc 9966, FMG 2015)

As fatigue should be considered a shared responsibility between regulators, operators, and crew, fatigue management cannot be left to just one or two parties but must involve all three parties. The regulator has set out the parameters by which the operators must abide by, but they have also given the opportunity for operators to improve on these parameters. Once the operator has these regulations set in place, it is up to the operator to enforce these rules and recommendations. This requires active participation from crew and involvement of the operator. It is the operator's responsibility to train, educate and implement proper fatigue management procedures and communicate effectively. Once proper boundaries and limits have been established and the crew is knowledgeable, then it is up to the crew to take care of their own work-life balance, attain adequate rest, and arrive fit for duty. Crew must understand the importance of fatigue on safety and report whenever they notice fatigue which could affect flight safety. (ICAO Doc 9966).

EUROCONTROL's (2018) guide on fatigue and sleep management recommends individuals to pay attention to their sleep opportunities and find a balance with life and work. It is understood that shift work will require individuals to at times spend less time with their family and friends, as the job requires you to sleep enough to perform at an acceptable, alert state when on duty. Therefore, careful planning will help find daily times to spend with the family, times when you sleep, and times when you will see your friends (EUROCONTROL 2018).

There are many different guides on promoting healthy sleeping habits, nutrition, and exercise. As nobody else can know yourself better, it is important to recognize personal needs and what works for you. Caldwell et al. (2009) explain how there is no one size fits all approach that can counter fatigue for every person in every situation. Therefore, emphasis must be drawn to the individuals own responsibility to maintain their own health and wellbeing as far as practicable. However, as started earlier about shared responsibility, it is also up to the operator to help enable crew to maintain their health and wellbeing with the aforementioned methods.

Bendak & Rashid (2020) concluded in their research, that airlines should be encouraged to implement a fatigue risk management system specific for their operations. Bendak & Rashid (2020) state that FRMS should go beyond written regulation into a more social and cultural depths. They continue to state that an FRMS will help finding and pinpointing alternatives to manage crew fatigue in a flexible way that will reduce the level of operational risk (Bendak & Rashid 2020). Sprajcer et al. (2022) concluded that successful FRMS implementation is predicated on organizational culture, appropriate training and education on FRMS components, and most importantly commitment from both workers and management under a shared responsibility framework.

3 Research Methodology

The author has aviation experience since 2006 and as of writing this, is flying as a captain and has been flying for the commissioner of this thesis since 2011. Additionally, the author has been a ground instructor since 2016 and crew resource management instructor since 2021 giving even further insight in the operator’s training culture as well as fatigue risk management procedures. This means that the author has hands on experience of the commissioner's operational environment and culture. The benefit of this, as mentioned above, is that it gives greater insight and experience on the operational environment. However, the possible drawback could be that there are biases in the insights and opinions of the author. The author has attempted in the best way possible to remain objective and factual, especially when writing their own thoughts. There is no conflict of interest as this is a fully independent study conducted on the author’s own time.

Leedy & Omrod (2001) explain that in order to understand a phenomenon, a research process must be done by collecting, analyzing and interpreting data. Successful research systematically collects and manages data as it defines the objective and communicates the findings in accordance with the established framework and existing guidelines (Williams 2007).

To help the researcher understand the subject of interest, at least one research question should be created on the topic (Williams 2007). In this case, based on the commissioners need to investigate the subject of fatigue further, one main research question was determined. Three sub-questions were then created to assist the main research question relating to fatigue. These research questions helped the author focus their thoughts, manage efforts, and choose the appropriate research approach (Williams 2007).

Data collection on the thesis was gathered from a variety of sources. These included publicly available information sourced from the internet, peer-reviewed studies, journals, and academic articles, different manuals and guides, interviews with the operators’ managers and pilots as well as the authors own questionnaire. Data was also collected from not publicly available sources such as the operators own library consisting of the operational manuals, safety management manual, training materials, and key- and safety performance indicators on fatigue.

3.1 Research methods

Williams (2007) describes three common approaches to conducting research which are quantitative, qualitative, and mixed methods. Leedy & Omrod (2001) define that choosing one of these three approaches *is* the definition of a general research methodology approach.

For a structured framework, an overlay matrix (found in chapter 1.2) was created to determine which parts of the survey questions, theory and results contained the relevant information concerning the research questions. Once a structured framework is in place, the researcher will have an easier time performing their research, finding relevant information, and defining what to include and exclude in their research (Williams 2007).

3.1.1 Quantitative method

A quantitative research method involves gathering data, so that it can then be quantified and subjected to mathematical statistical analysis for systematic investigation of a social phenomenon (Creswell 2003, Williams 2007). The benefits of using a quantitative research method are that data can be collected in a quick and cheap way from a large number of diverse respondents to gain a general understanding of a group's behaviour (Williams 2021).

One way to generate the data from a group is using a closed type of survey. A closed type of survey is one which has predefined answers making it quick and easy for the respondent to fill out. The disadvantage, however, is that the predefined answers might not have the answer which the respondent is looking for. Therefore, careful consideration needs to be done when creating a closed questionnaire.

To investigate the main thesis research question and answer the three sub-questions, a closed quantitative research method was appropriate as a large amount of statistical data could be generated from both cabin and flight crew. This data could then be used to further investigate the fatigue phenomenon, the effectiveness of the operator's fatigue risk management, as well as the attitudes and behaviors of crew towards fatigue reporting. Careful consideration of the questions, answers and simplicity was also in mind, and it was determined a quantitative survey with closed questions would best fit this focus group of pilots and cabin crew as they might not want to spend much of their time filling a long open survey.

A quantitative survey research method is also beneficial at capturing the phenomenon at the time, which was one of the purposes of the study (Williams 2007). Data collected by the survey can then be clearly communicated with statistics in an unbiased way using graphs and charts which has been done within this thesis (Williams 2021).

3.1.2 Qualitative method

Williams (2007) Describes qualitative research as a holistic approach that involves discovery. Creswell (2003) continues that qualitative research is an effective model occurring in its natural setting enabling the researcher to develop an even greater understanding of the subject by immersing themselves in the actual experience.

The qualitative method used in this thesis was in the form of a theme interview. Theme interview is an efficient way of collecting data from experts to gain a deeper understanding of the problem that must be solved by the research project. The benefit of a theme interview is that it flows more as a conversation and provides flexibility to probe for details or discuss issues. One way of collecting data in an interview is by carefully considering open-ended questions relevant to the research topic, however not all questions need to be predetermined in a theme interview. The disadvantage of theme interviews is that it requires experience and skillful navigation around the subject, also it can be difficult to analyze results. The author, however, had experience in the aviation industry since 2006 and had prepared well for the interviews by studying several manuals, guides, research articles and papers on the fatigue subject, making notes, and preparing open-ended questions.

Key managers who were directly involved with fatigue management were identified to be interviewed on the subject. Each interview held with the key managers lasted between 1 – 2 hours and had the same objective in mind, “what are the operator’s fatigue management procedures?”. Fatigue risk management is a vast subject, and it can be difficult to pinpoint a topic to investigate within this field. However, the themed interviews helped the author to understand the nature and processes of fatigue risk management within the operator’s environment and find a more narrowed down topic as well as the main research question that could then further be investigated for this thesis to benefit the commissioner.

Several discussions were also held with pilots on the matter of fatigue to deepen the perspective of the operative crew. Furthermore, a separate phone interview was held with a regulator specialist from Traficom, which helped gain understanding from the regulator’s perspective. These interviews with different departments in different roles helped the author to gain a holistic understanding of fatigue as well as the operators fatigue risk management culture.

3.1.3 Mixed methods approach

The mixed research approach method combines the quantitative and qualitative research methods in a complimentary way by incorporating collected and analysed data from both methods into a single research study (Creswell 2003, Williams 2007). Researchers are also able to use both deductive and inductive analysis within a mixed research study (Williams 2007). As this study investigated both quantitative and qualitative aspects, a mixed method research approach was used. Using a mixed method approach was an important factor in this thesis. The themed interviews helped the author gain a holistic understanding of the operator’s fatigue management environment and finding a topic that could be further investigated with a quantitative research method. The data generated by the quantitative research method was required to answer the main thesis research question and sub-questions and to understand the nature of the fatigue phenomena within the operator's environment.

3.2 Reliability, validity, and ethics of the research

The Finnish Advisory Board on Research Integrity (TENK) has created guidelines for conducting responsible research, which apply to all academic disciplines in Finland and must be adhered to (RCR Guidelines 2012). The general concept that covers all ethical viewpoints, honesty, and integrity is referred to as 'research integrity' (RCR Guidelines 2012).

The RCR Guidelines (2012) state that for research to be ethically acceptable, reliable, and credible, the research must be done according to responsible conduct of research. The responsible conduct of research guidelines dictate that the research integrity must conform to a certain set of rules. Some of these rules are that the researcher must perform their research with great integrity, meticulousness, and accuracy, be ethically sustainable, communicate in an open responsible way, as well as give credit to previous work citing their publications appropriately (RCR Guidelines 2012). This thesis was done following these rules of the previously mentioned acceptable ethics, responsibility, reliability, validity, and credibility principles.

Brink (1993) explains that the difference between good and bad research can all be about how meticulously key aspects of validity and reliability were followed. Good research is one that shares credible and trustworthy findings among its results (Brink 1993).

Reliability can be defined as the consistency and stability of the measurement scale in which the results can be repeated with a low variance and margin of error (Bannigan & Watson 2009, Brink 1993, McDowell & Newell 1996).

Even though results from a research measurement might be repeatable and reliable, they may not be valid. For research to be valid, it must also be truthful and accurate with its relevant scientific findings while measuring exactly what it has set out to measure and exclude irrelevant content (Bannigan & Watson 2009, Brink 1993). Therefore, validity and reliability are crucial components and go hand in hand when conducting research and developing the appropriate measuring instruments for the study (Bannigan & Watson 2009, Brink 1993).

Since this survey looks more into the subjective measures of how individuals perceive and feel fatigue, the results may not correlate exactly with objectively measured hard data. However, it is of the purpose of this study to find the subjective self-assessment of the respondents.

3.3 Creating the thesis topic

This thesis topic on fatigue was chosen by the commissioner's needs then narrowed down further by the author to the crew's fatigue reporting attitudes and behavior. In a kick-off meeting with the commissioner, several topics were discussed before landing on fatigue risk management. From here the author studied fatigue research, articles, guides, and manuals on fatigue risk management.

3.3.1 How and why the topic of fatigue reporting was chosen

The operator's procedures, manuals, training material, KPI's, and SPIs were analyzed to understand the topic thoroughly before interviews were held with several different key managers involved in fatigue risk management. These key managers were able to shed light on detailed processes within the company, as well as key performance indicators and safety performance indicators. Furthermore, valuable information was described which could not have been attained without these interviews. These interviews helped narrow the scope of the project even further, as the problem of fatigue and the reporting culture became more evident.

3.3.2 Specifying the topic to reporting attitudes and behaviors

According to a previous survey done by the operator, up to 72 % of employees who answered the survey found that the largest threat to flight safety was fatigue. Following trend lines from the operators KPI's on the year 2022 to 2023, the fatigue reports had been on a small incline from 0.3 % to 0.8 % per thousand flights. This incline can be due to crew starting to experience chronic fatigue or as discussed before with COVID-19 having effects on crews' resilience to stress and fatigue, possibly leading these numbers to a temporary rise before stabilizing at an acceptable manageable level. Regardless, as a majority number of employees find fatigue a threat to flight safety, this is an issue that must be addressed.

As the topic of fatigue risk management in aviation is vast and a lot of work could go into this subject, a more specific approach was needed to narrow down the scope even further for this bachelor level thesis. This proved to be a little more complicated than expected, as many things are related and connected to each other, and it is difficult to clearly define what is in scope and what is out of scope. Finally, the topic was narrowed down to the attitudes and behavior on fatigue reporting and whether the operator's fatigue mitigating procedures are effective, clear, and helpful from the perspective of cabin and flight crew.

3.3.3 Operators fatigue mitigation

The operator has several fatigue mitigation processes in place to name a few, bidding for preferred duty times, four monthly free day requests, harder limits on Flight Time Limitations (FTL) than what is required on work-shifts and rest times, a fatigue call procedure, and a biomathematical model for optimizing roster planning. According to data pulled from the operator's biomathematical software, there are fatiguing flights, which are to be expected in the aviation industry. However, the general median level of crew roster schedules is comparable with routine office day work. Nevertheless, despite these mitigation measures, the crew still perceives fatigue to be a concern to flight safety. Which raises the question, if according to the biomathematical model the crew should not be fatigued, then how is fatigue such a large concern?

To address the problem of employee fatigue, we must understand the topic a bit more. The question that must be asked is how big of a concern fatigue is among the operator’s employees and is the level of fatigue higher than perceived? A main research question was determined to investigate the effectiveness of the operator’s fatigue risk management in order to answer these concerns. Following this, a questionnaire was created for the operator to find out the cabin and flight crews' behavior and attitudes towards fatigue reporting. The question to the target group “Are the fatigue reporting procedures at the operator effective in helping to mitigate fatigue among cabin and flight crew?” was determined to be appropriate for the scope of this research thesis, the main research question, and sub-questions.

3.4 Data Collection of the Survey

Since the crew who are reporting fatigue are the pilots and cabin crew, they were chosen as the target group. Even though the work itself may differ greatly between pilots and cabin crew, they work the same shifts and as it has been determined, both groups suffer from fatigue. The benefits of including both groups were that a larger sample size could be generated for analysis and differences in reporting attitudes and behaviors could be determined.

3.4.1 Creating the questionnaire

The survey questions concerning fatigue and fatigue reporting were determined by analyzing common problems and findings found in other studies on the subject (ECA 2012, FMG 2015, ICAO Doc 9966, Operators 2022 Survey).

The survey created was a quantitative closed type of questionnaire with pre-determined answers using either numerical values for quantity or a 5-point Likert scale. A quantitative closed type of questionnaire was chosen due to the benefits of it being a useful tool to generate a great amount of data from a large number of respondents without wasting much of their valuable time. The Likert scale was chosen due to its benefits to easily measure and quantify results on opinions, attitudes, and behaviors which could bring further insight to questions rather than a simple yes/no survey (Bhandari & Nikolopoulou 2023)

Anonymity, relevance, time consummation, understandability, and simplicity were important factors taken into consideration when creating the survey to generate as many responses as possible. Before sending the official survey to the commissioner's cabin and flight crew, feedback was generated by sending a test survey to a handful of trial pilots in a separate company. Based on the test survey feedback from these trial pilots, changes and improvements were made to the official survey. The goal of a quick and easy survey was achieved, as the feedback received from the trial pilots determined that the survey was relevant and topical, simple to fill out, and only took a few minutes of their time.

The online survey was created using Google Forms. There were other options for the survey, such as the commissioner's own intranet survey platform, but it was determined that for the respondents to feel confident about the anonymity and transparency, it would be better for the survey to be from an outside source. Furthermore, Google Forms was a familiar tool to the author which made pulling the data and information easier for analysis.

3.4.2 Distribution of the survey

The questionnaire was sent via the operators' email distribution list and company intranet to the pilots and cabin crew. The operators' email distribution list consisted of a total of 634 employees, but among these 634 employees there were also office employees. Only pilots and cabin crew were asked to answer the questionnaire, however, it cannot be guaranteed that no other group of employees filled out the survey.

Out of the operators 288 pilots and 305 cabin crew (in total 593), 250 pilots (139 captains, 111 first officers) and 207 cabin crew (in total 457) were confirmed to be reached via the company's intranet. Due to having a lower response rate from pilots at first, the survey was also sent via the pilot union mailing list to 280 pilots which helped to get a greater response rate.

The questionnaire was open for one and a half weeks, which included two weekends. It was determined to be enough time to generate the responses needed. If there had been a lack of responses, further actions could have been taken and the questionnaire could have been left open longer. But as there were enough responses, the survey was closed as scheduled. A third of the responses came after the initial survey participation message was sent, another third after sending an email to the pilot union list and the last third after the final reminder was sent via the company's intranet.

3.4.3 Confidence and margin of error of the survey response

A total of 214 crew members responded to the survey, but one response was left entirely blank, so that has been filtered out from the analysis results.

Although a higher response rate was desired, the number of respondents is enough to analyze the results with high confidence and a low margin of error. Using a sample size calculator (SurveyMonkey 2023) we can determine a population size of 457 would require a minimum sample size of 209 responses to reach a 95 % confidence level with a 5 % margin of error. Even if we assume a population size of 593 (all pilots and cabin crew), the responses received would not be far off the target sample size of 234, raising the margin of error only to 5.4 %.

For the purpose of this research thesis, it is assumed that the population size of the operator is the number of employees reached via the operators' intranet. This is due to the fact that many of the employees are for one reason or another not actively working, due to reasons such as parental leave, medical leave, or student leave and as stated earlier, it will not have a large effect on the reliability of the results as previously described. Instead, it may even improve the validity of the survey as the respondents are assumed to be actively flying.

Of the 213 accepted responses, 78 were captains, 43 were first officers and 92 were cabin crew. The total response rate therefore was 47 % (48 % from the pilots and 44 % from the cabin crew). Interestingly, the response rate was quite different between captains and first officers, 56 % and 39 % respectively.

3.4.4 Creating categories for analysis

Out of the total accepted responses, a division was made into two different categories based on work position and work experience within the aviation industry. Creating these categories would help analyze the data based on position and experience to make relevant findings on crews' fatigue reporting attitudes and behaviors.

The first category, which was based on work position, had three groups, captains, first officers and cabin crew. The second category had four groups relating to experience, less than 1 year, 1 – 3 years, 4 – 8 years, and over 9 years.

When making these categories and groups however, the sample size gets smaller, and consideration should be made to the reliability, validity, and margin of error.

The first category with three groups would have a population of 139 captains, 111 first officers and 207 cabin crew. After dividing the respondents into these groups, if we maintain the confidence rate of 95 % then the margin of error would rise to 7.4 % for captains, 11.8 % for first officers, and 7.7 % for cabin crew.

The second category consisted of four groups which were less than 1 year (8 responses out of 252), 1 – 3 years (16 responses out of 260), 4 – 8 years (85 responses out of 329), and over 9 years (104 responses out of 348). Since there was no convenient way to determine the actual population size of the second category's groups, the reached population size of 457 (cabin + pilots) was used and from this amount the number of responses was deducted from the other work experience groups.

Due to the limited sample size from the first two groups in the second category of work experience, the error rate grew too large and the accuracy of these two groups cannot confidently be determined. Therefore, the results from these two groups may not be valid. With the two other groups, the 4 – 8 years of experience has a 9.2 % margin of error and the over 9 years of experience has an 8.1 % margin of error.

However, when combining the two most common experience groups together (4 – 8 years and over 9 years), they total 189 of the respondents. A separate category for this group was created which was named "Experienced crew". This group has a 95 % confidence level with a 5.4 % margin of error. Therefore, the results from this group can be considered valid and accurate.

4 Research Question Results, Analysis and Findings

To answer the thesis research questions, the author created a closed quantitative questionnaire for the commissioner's target group consisting of cabin and flight crew. The questionnaire was divided into four parts with a total of nineteen questions. The demographic was the first part of the survey (2 questions), second part was about feeling fatigued (6 questions), third part was about fatigue reporting (7 questions), and the fourth part was about the operator's fatigue procedures (4 questions).

When discussing percentages, a standard rounding rule for whole numbers will be used in the analysis for clarity. Therefore, there may be rounding errors as the total amount does not equal exactly 100 %.

Before moving to the parts of the questionnaire about feeling fatigued and fatigue reporting, the ICAO definition of fatigue was explained in order to remind the respondents of what is meant by fatigue in the context of the questionnaire.

For better presentation clarification, the data graphs presented in the analysis will be limited to prevent an excess number of charts and graphs. However, all charts and figures that were used to generate the data in this chapter can be found in appendix 1 and 2.

4.1.1 First part, The Demographic, Questions 1 and 2

In the demographic part of the questionnaire there were two questions, which were meant to find out the respondents work position and their flight experience within the aviation industry. Demographic information could then be used to analyze whether work position and work experience would have differences in fatigue reporting attitudes and behavior between cabin and flight crew.

The first question was about work position. The answers were divided into three groups, cabin crew, captains and first officers. In total, answers were 37 % captains, 43 % cabin crew, 20 % first officers.

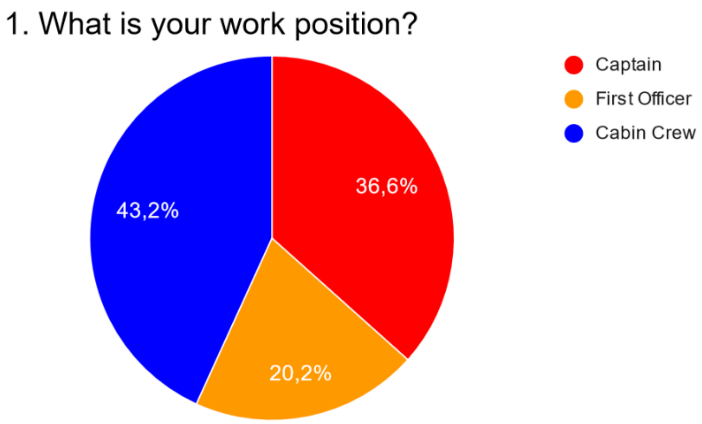

Figure 1. Work position of the respondents (n=213)

The second question was about the crew flight experience in the aviation industry. The crew surveyed were mostly experienced as shown in the results. Among the respondents, 49 % had over 9 years of flight experience and 40 % had 4 – 8 years of flight experience. Only 8 % of respondents had 1 – 3 years of experience and 4 % had less than 1 year or experience.

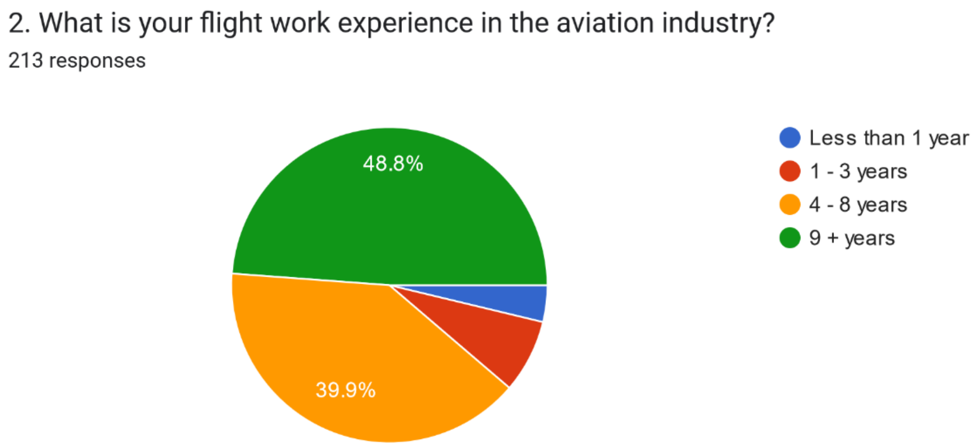

Figure 2. Work experience of the respondents

Figure 2.1 below shows a clear division of respondents based on work position and experience. Throughout the data analysis, these two factors on work position and work experience will be compared to determine whether they influence the attitudes and behavior on fatigue, fatigue reporting, and the crew's perspective on the operator's fatigue mitigation procedures.

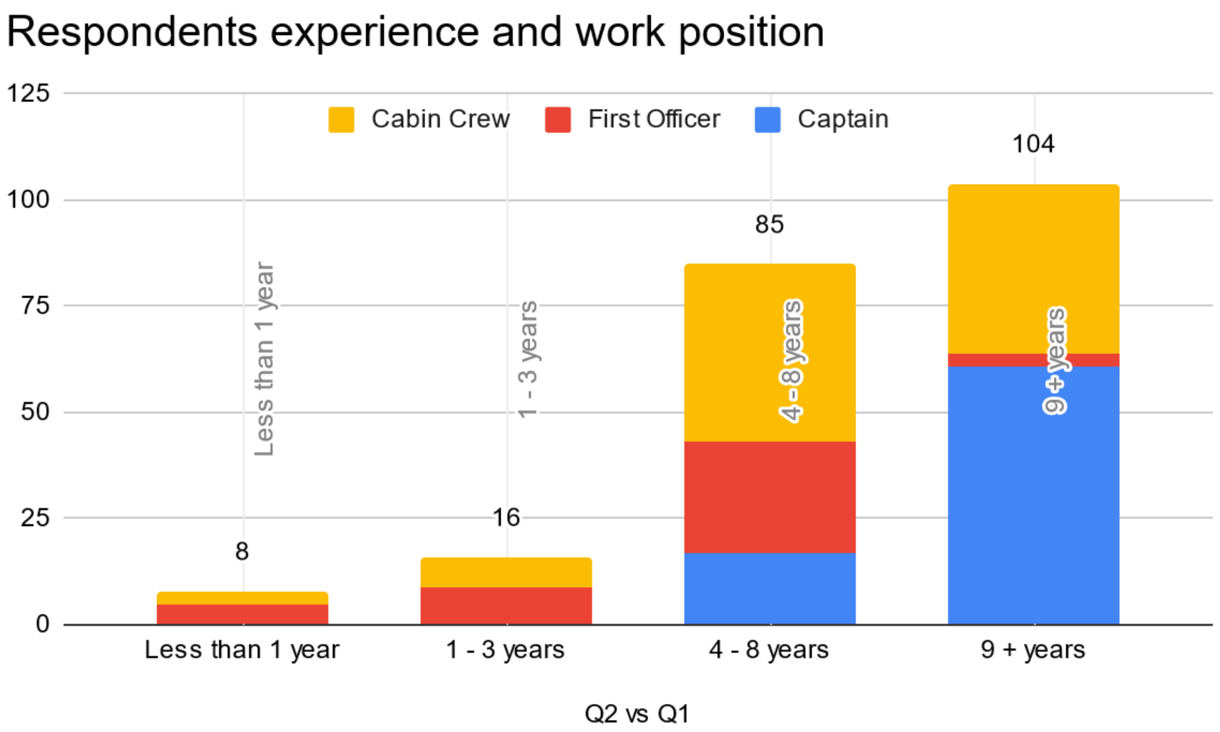

Figure 2.1. Work experience and work position respondents

Another way of looking at these numbers is that almost 90 % of the respondents have a long career in aviation and are rather experienced, which can give more credibility to the answers given in the survey.

4.1.2 Second part, Feeling Fatigued, Questions 3 to 8

The second part of the survey was about feeling fatigued. Questions 3 to 8 were asked to find how familiar the respondents were with fatigue. This was also part of the second research question, which was to answer whether fatigue was a common occurrence from the perspective of cabin and flight crew.

The third question was if the respondents had experienced the ICAO definition of fatigue during flight duty. Of the respondents 95 % admitted to having experienced fatigue during their career, 4 % were not sure and 1 % said they hadn't experienced fatigue during their flight career.

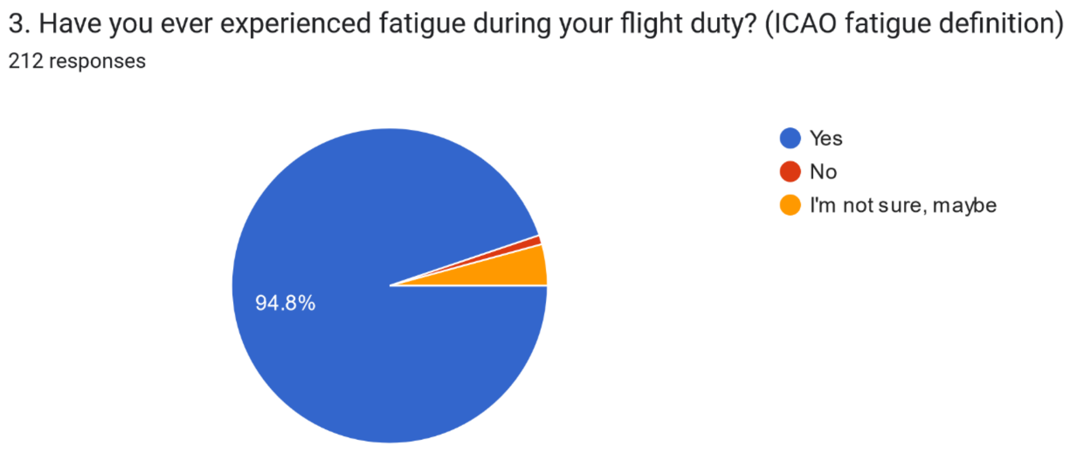

Figure 3. Respondents experience of feeling fatigued

The fourth question was to determine how often the respondents had been on duty feeling fatigued. The responses were as follows, 12 % very often, 23 % often, 45 % sometimes, 19 % rarely and 1 % never. These responses were in line with the third question as 99 % of respondents have admitted to feeling fatigued during duty.

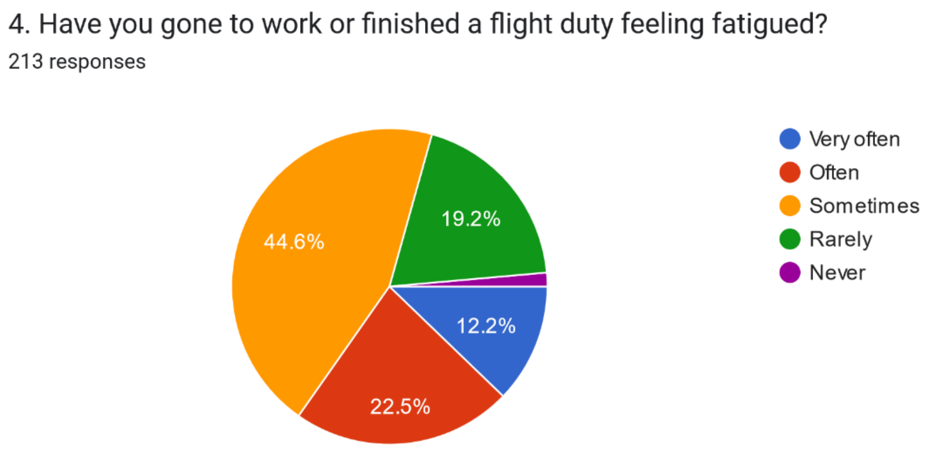

Figure 4. How commonly respondents experience feeling fatigued

Question 4 is one of the questions where work experience seems to affect how often individuals feel fatigued as can be seen from figure 4.1 below, this could suggest that the longer the work experience the greater the chronic fatigue.

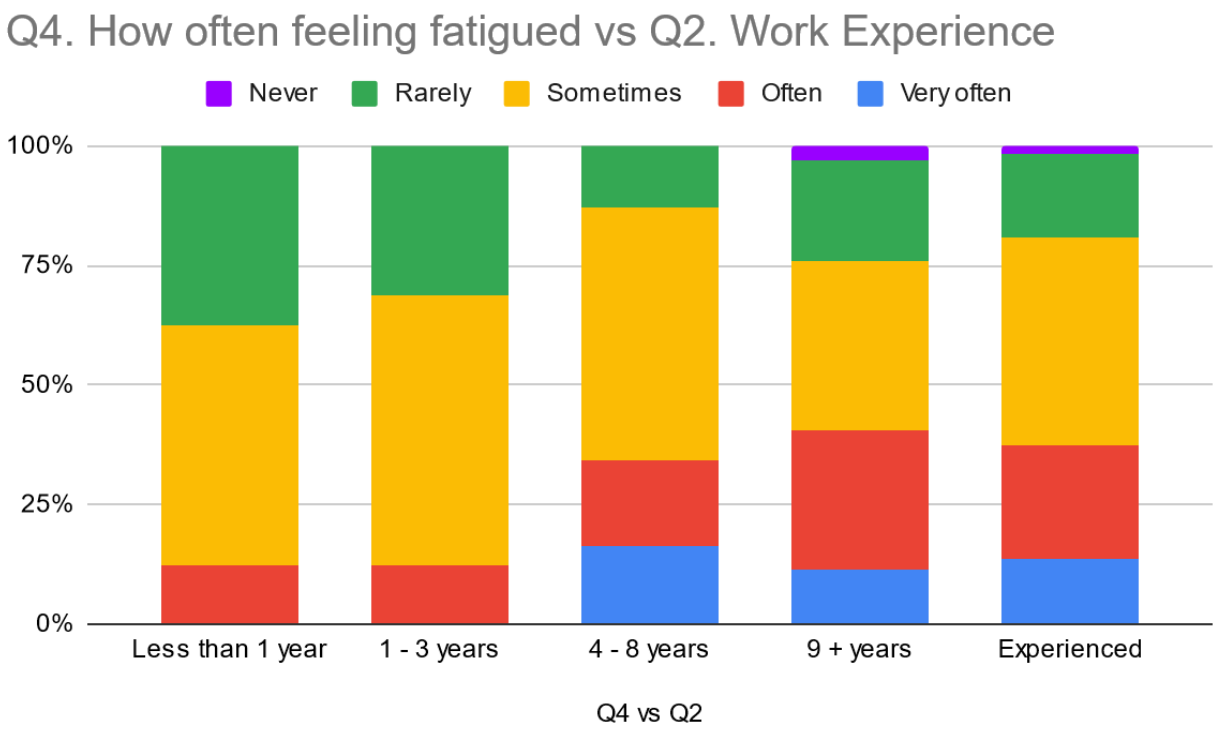

Figure 4.1 How commonly respondents experience feeling fatigued vs work experience

In the fifth question the respondents were asked to estimate how many times they had felt fatigued during their career. There were five different choices of answers that ranged from 0 to over 20. Of the respondents, 55 % estimated that they had experienced fatigue more than 20 times during their career. 12 % estimated that they had experienced fatigue 10 – 19 times, 18 % estimated 6 – 10 times and 15 % estimated 1 – 5 times. Only 1 % had estimated never experiencing fatigue.

It could be argued that a crew member who has been working for over ten years and experienced fatigue only a few times a year would answer feeling fatigued more than 20 times. However, these numbers were purposefully chosen, as the hypothesis was that it does not matter if someone has felt fatigued 20 or 50 times, they will not have reported fatigue so often. Therefore, using these same numbers, we can later compare the results with question nine on the quantity of fatigue reporting.

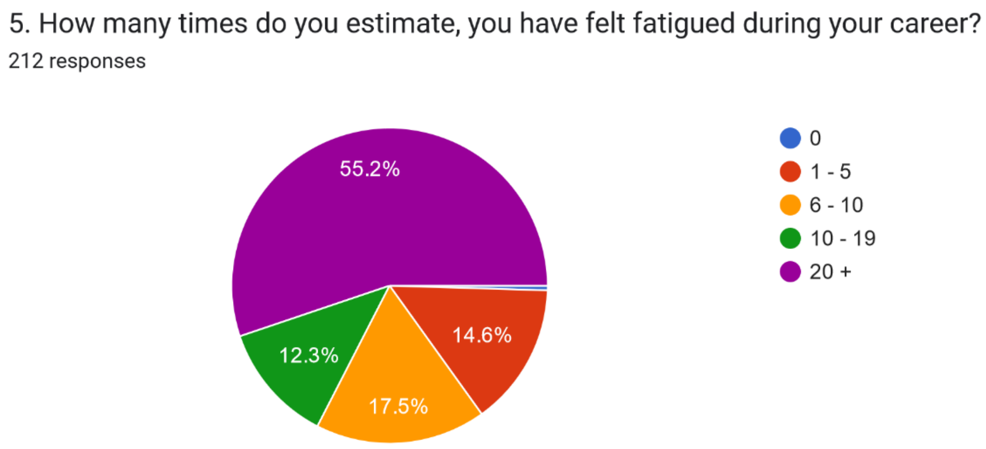

Figure 5. Respondents estimated quantity of feeling fatigued

Questions 2 to 5 show that the majority of respondents are experienced in the aviation industry and familiar with fatigue.

In figure 5.1 below, we can see that work position does not seem to have a great effect on feeling fatigued, rather it is to do with the length of work experience. Captains seem to have a little more estimated fatigue quantity than the rest, however, they also have the greatest responsibility which can possibly explain the little higher amount of feeling fatigued. As first officers have the least amount of work experience from the groups, their estimated amount of fatigue quantity is expected to be lower. However, each stacked column shows that all groups of crews feel fatigue as a common occurrence. This is further confirmed by question 6 and figure 6.1.

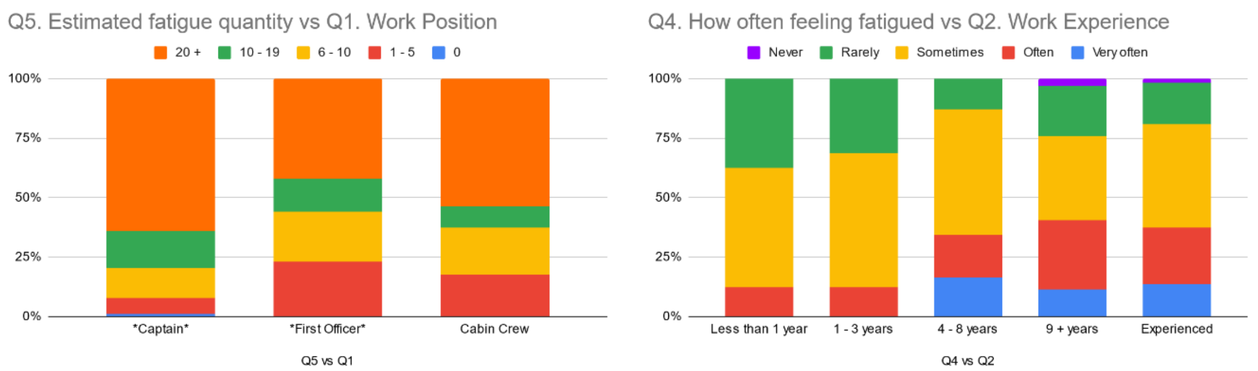

Figure 5.1 Respondents estimated quantity of feeling fatigued vs work position and experience

In question six, the respondents were asked to estimate how often they feel fatigued. There were seven different choices to answer ranging from daily to never. The most common responses were monthly, quarterly, and weekly with 33 %, 27 %, and 24 % respectively. 12 % estimated feeling fatigued yearly, 2 % estimated feeling fatigued less than yearly, 1 % estimated feeling fatigued daily, and 1 of the respondents answered never.

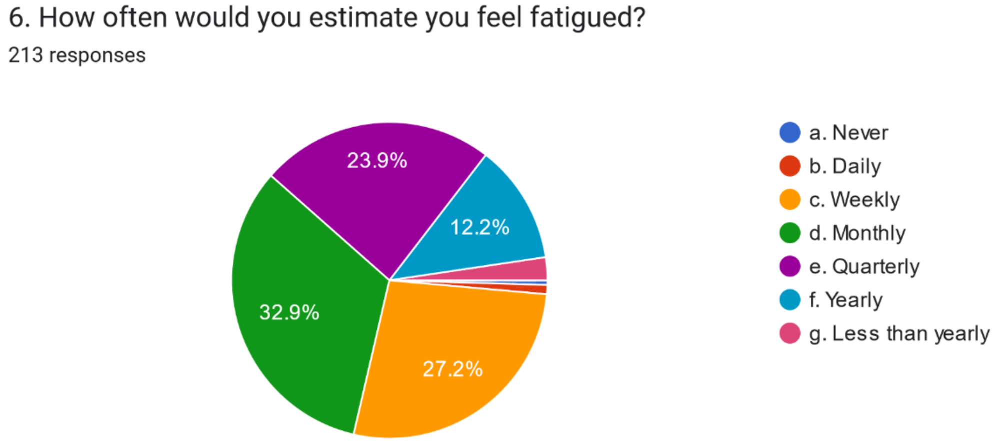

Figure 6. Respondents' estimation on how often they feel fatigued

As discussed in question 5, it can be seen from figure 6.1 below that fatigue affects each position equally. Interestingly even the less experienced crew members estimate feeling fatigued in similar fashion as more experienced crew members. This can possibly be an indication that shift work, rest between shifts, and work schedule are the causes of fatigue.

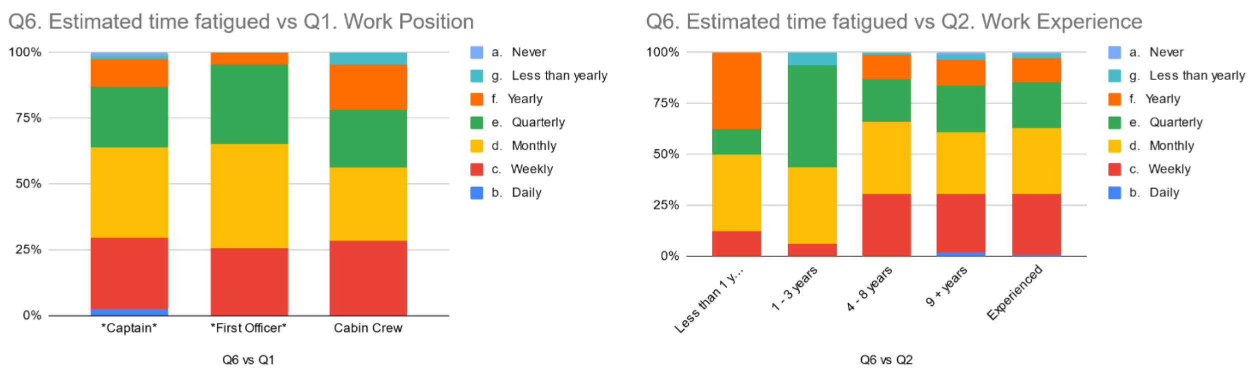

Figure 6.1 How often crew feel fatigued vs work position and work experience

The three most common answers from question 6 form 84 % of total responses. If the three most common answers are taken, which are monthly, weekly, and quarterly then quantified for the possible amount of fatigue reports based on these responses, the results would be staggering.

The yearly fatigue of a crew of 100 would total as follows:

Crew population size 100 (p)
Quarterly (4 times a year), population 24 % = 96 fatigue cases
Monthly (12 times a year), population 33 % = 396 fatigue cases
Weekly (52 times a year), population 27 % = 1404 fatigue cases
Total yearly fatigue 1896 (yftg).

The author created a formula to count the percentage of fatigue per thousand flights. Using the formula, population size (p) divided by 100 multiplied by yearly fatigue, would give us the amount of yearly fatigue reports. This number can then be divided by the number of flights flown a year (yflt), multiplied by 100 to then give us the percentage of fatigue per thousand flights.

(p / 100 * yftg) / yflt * 100 = % of fatigue per thousand flights

With these numbers we are able to calculate that there is a potential for fatigue reports to be as high as 15,8 % per thousand flights. Now obviously this number is staggeringly high and might not reflect the truth, but it does go to show that crew feel fatigue to be a more common occurrence than what has actually been reported. As feeling tired is a subjective feeling, it is also worth noting that it is difficult to determine if the respondents have answered based on how often they feel tired or if they actually felt fatigued to the point where the level of safety could be threatened and should not fly. These numbers have been calculated with simple math, but this particular question could merit further research with more robust data, measures, and calculations. Further research could also be done to find out a common industry standard of the commonality of perceived fatigue.

Question seven determines how often the respondents have witnessed another crew member experiencing fatigue. The same five predetermined amounts were given ranging from 0 to over 20 times. Of the respondents almost half (45 %) estimated witnessing another crew member experiencing fatigue more than 20 times. The ranges from 1 – 5, 6 – 10, 10 – 19, received an even distribution of 19 %, 17 % and 18 % respectively. Only 1 % of the respondents estimated not having witnessed another crew member experiencing fatigue at all.

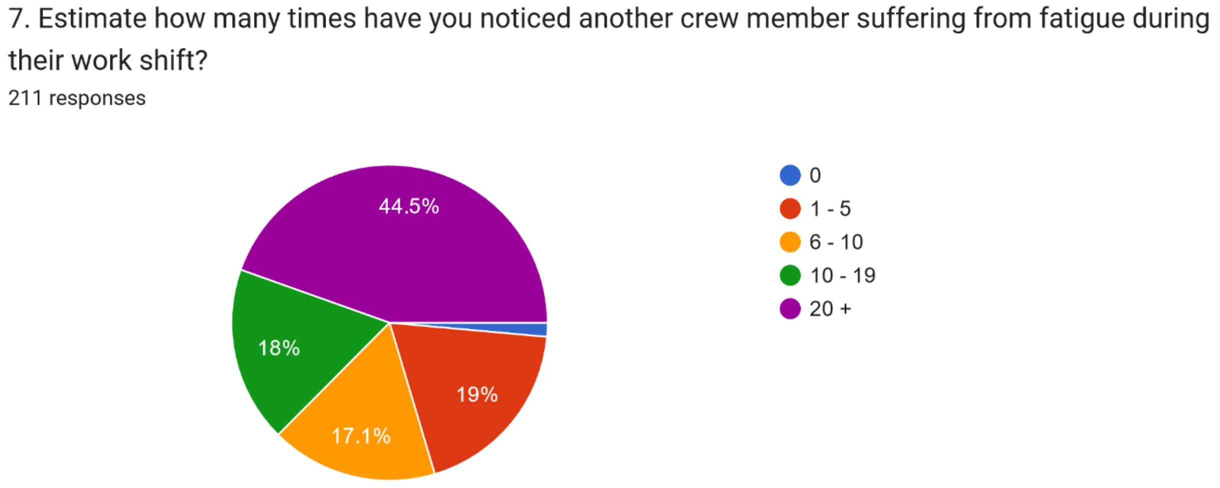

Figure 7. Respondents' estimation on how many times they have seen other crew fatigued

When looking at the data further to determine trends, all groups had witnessed fatigue with captains witnessing the greatest amount of fatigue and the longer the work experience the more fatigue was seen.

This question also reveals that crew fatigue is not just an internal feeling which individuals can simply fight off. As discussed in chapter two's theoretical part, fatigue has detrimental effects on crews' performance and individuals may not always be able to recognize being fatigued. Furthermore, it may be difficult to determine where the limit is between feeling tired and being fatigued in a way that you should not be flying.

Therefore, it could be helpful if other crew members would feel comfortable and confident enough to raise awareness to the other crew members' when noticing them feeling fatigued. As fatigue management is a shared responsibility between the operator and crew, this is possibly something that could be addressed and added into the operators training material considering fatigue risk management and crew resource management in order to lower the threshold of discussing fatigue in general and the stigma regarding fatigue.

In question eight, the respondents were asked to analyze which factors interfere the most to attain adequate rest. The top two answers were rostering rhythm changes as the clear favored choice at 77 %, then came not enough free time for recovery with 58 %. The next highest answers were workload (49 %), adequate crew resources (36 %), and personal reasons (32 %).

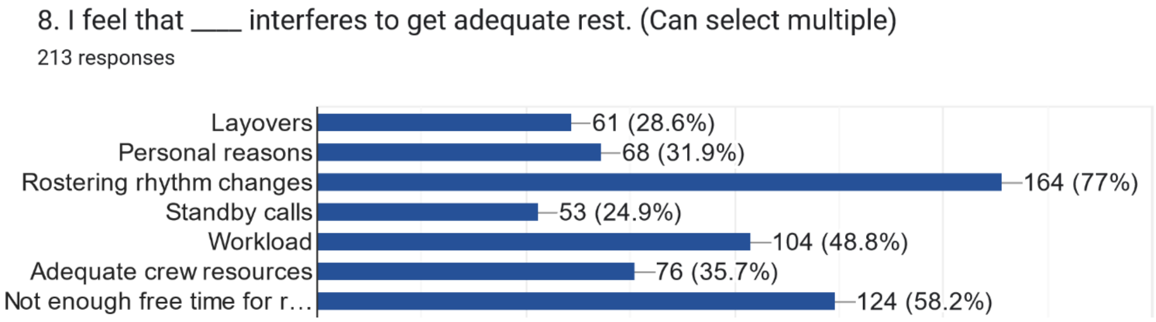

Figure 8. Respondents' opinion on sleep interfering fatigue causes

Once again it can be seen from figure 8.1 below, that the answers are quite evenly distributed based on work position and work experience.

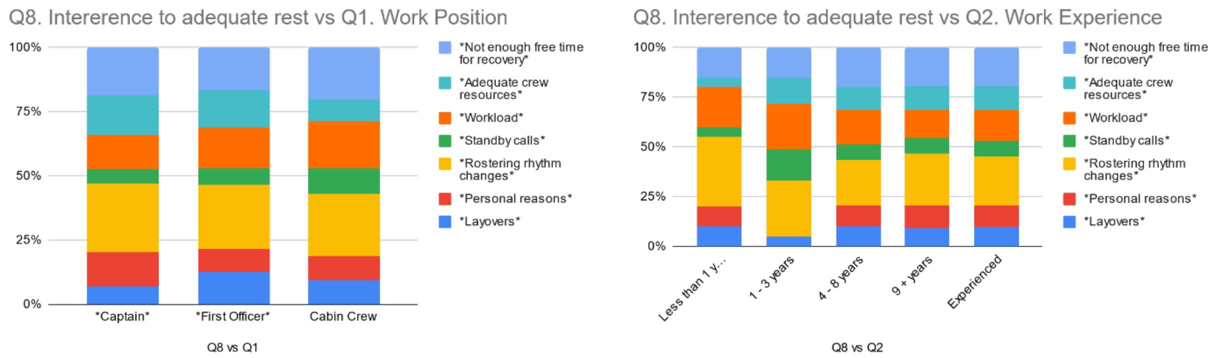

Figure 8.1 Sleep interfering fatigue causes vs work position and work experience

The answers can also further confirm in uniform, which was speculated earlier in question six, that shift work, work schedules and rest between work are the main reasons of fatigue among the respondents.

4.1.3 Third part, Fatigue Reporting, Questions 9 to 15

The third part of the questionnaire was about fatigue reporting attitudes and behavior.

Question 9 plainly reveals that fatigue reporting behavior is clearly an under-reported issue. One other way of looking at these numbers is that almost 90 % of the respondents have estimated making between 0 and 5 fatigue reports during their career. Looking back at question 5, 85 % of the respondents estimated feeling fatigued more often than 5 times. Only 2 % of the respondents estimated making over 10 fatigue reports during their career.

In the ECA (2012) report, it was determined that more than half of pilots have not submitted fatigue reports. These figures are in line with previous findings of under-reporting being a common problem as discussed in chapter two.

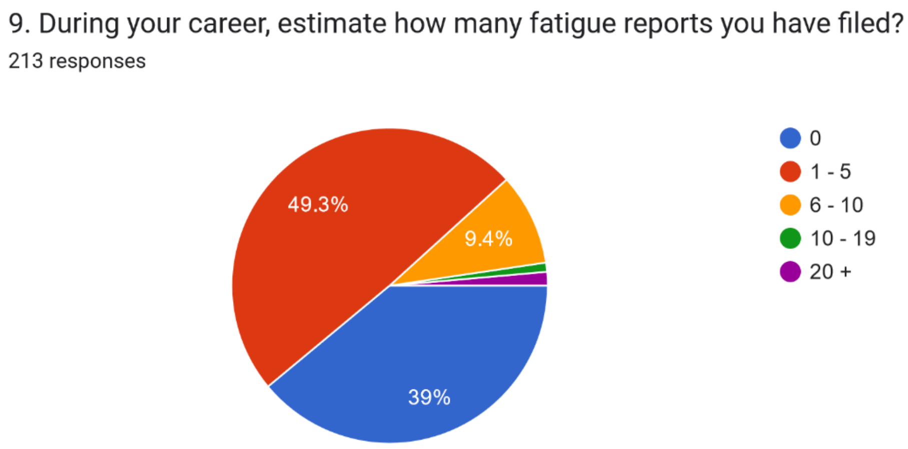

Figure 9. Respondents estimated quantity of reporting fatigued

Figure 9.1 below shows the correlation between question 5 and 9, which was the estimated times feeling fatigued and reporting fatigue. From here it can be determined that even though crew estimated feeling fatigued often, they do not file fatigue reports often. Of the crew estimating feeling fatigued over 20 times, 83 % had estimated only filing a fatigue report between 0 and 5 times.

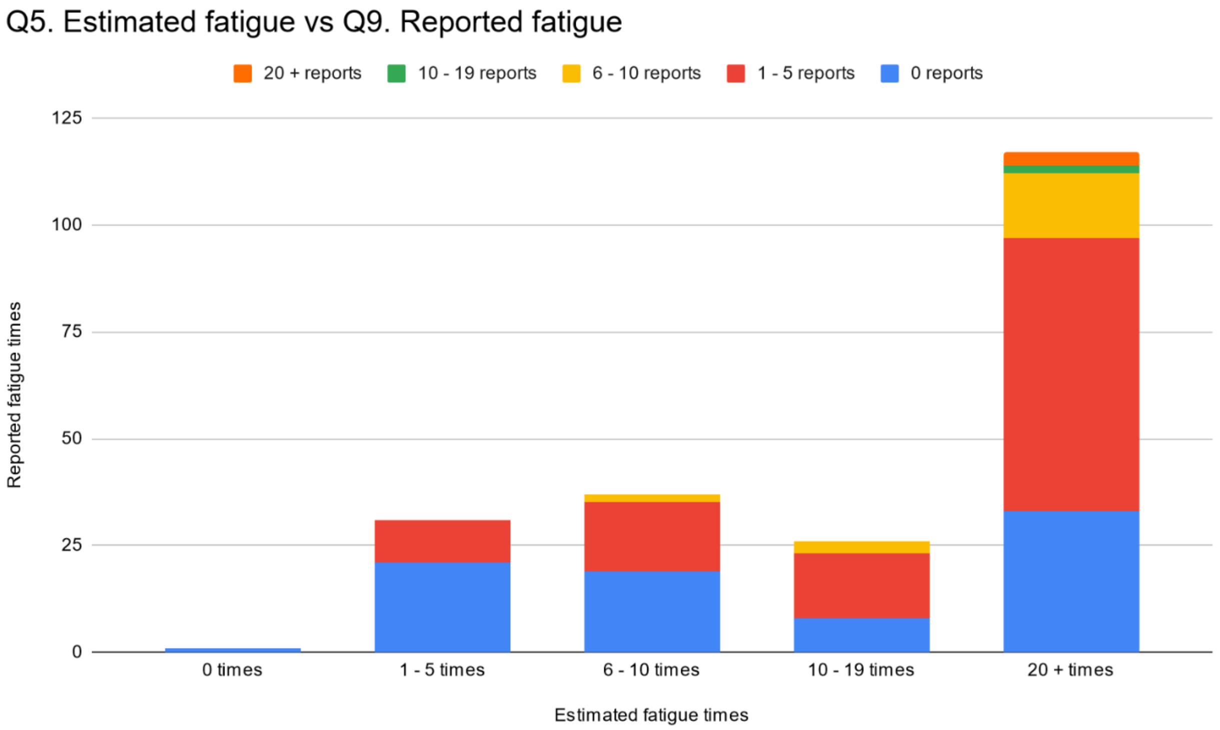

Figure 9. Estimated fatigue times vs reported fatigue

Question 10 aims to find whether crew report fatigue as a contributing factor in other reports. There are many different forms of reports, which can be mandatory or voluntary. The phrasing of the question was purposefully left ambiguous in order to cover a larger variety of reports in general. This would allow the author to see whether fatigue plays a larger role in reports in general or not. As seen from the results, crew are willing to admit fatigue as a contributing factor when submitting other reports, but it is also not uncommon that fatigue is left out of reports.

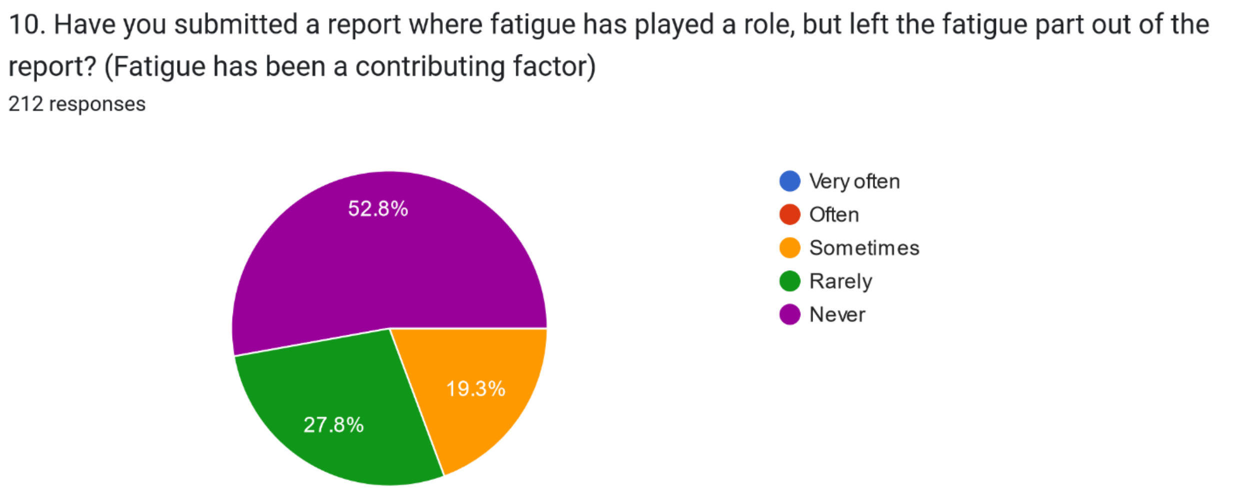

Figure 10. Respondents filing a report where fatigue has been a factor, but left it out of the report

The goal of question 11 is evident as it aims to determine an individual's willingness or in this case rather unwillingness to report fatigue. Results show that 90 % of crew omit filing a fatigue report even though they felt fatigued during duty and over a third of respondents answered it happens often.

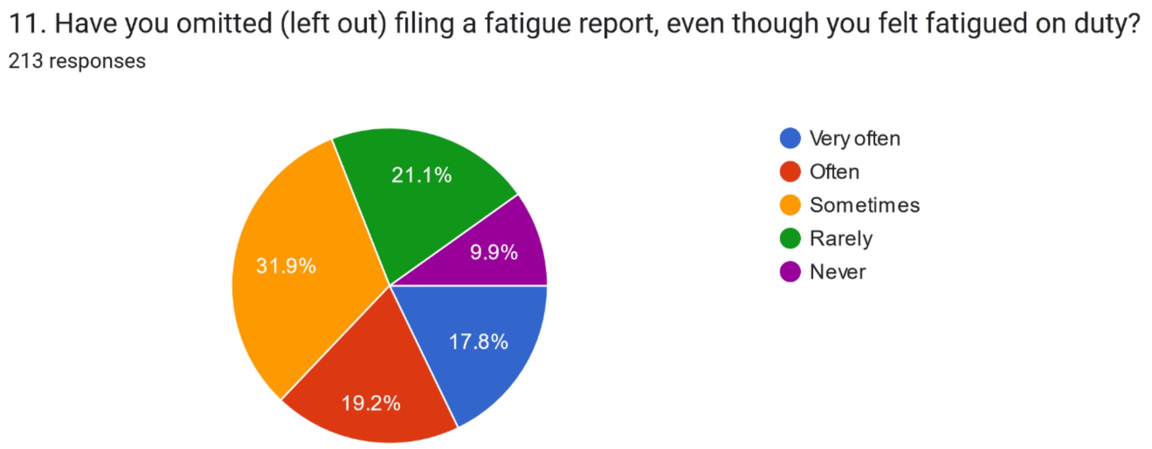

Figure 11. How often the respondent has left out filing a fatigue report

Once again when looking into the detailed information of answers, there were no meaningful differences in responses between different groups, showing once again that work position and work experience does not seem to have an effect on reporting attitudes and behavior in the operator's environment.

In question 12 the objective was to find out what the main reasons were to omit filing a fatigue report. The highest response for not submitting a fatigue report was the belief that it would make no difference (65 %). The second highest answer was that there was no incident or effect on flight safety with 52 %.16 % percent felt that they feared the consequences of reporting their fatigue. There was a possibility to fill in an open response to this question, some of the responses that came up were that they were too tired and that it would be a waste of time.

The second most common answer "There was no incident or effect on flight safety" is an interesting answer. It could be interesting to further investigate why over half of the respondents chose this answer. The implications from this answer could simply mean that respondents could not bother as nothing happened. It could also mean that they can't be bothered as it changes nothing, or they would rather not report because of being embarrassed, or they fear the consequences. Whatever the reason may be, it is an easy answer to choose, rather than reflecting on actual reasons behind the response.

It was discussed in the theoretical framework how trust and voluntary reporting play vital roles in the operator's Safety Management System (SMS). For an SMS to be effective, safety related data must be reported, and airlines must devote continuous efforts to maintain crew's confidence in the reporting system.

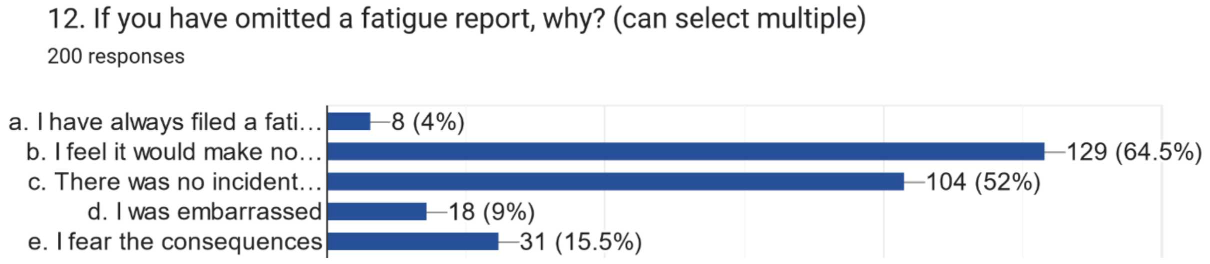

Figure 12. How often the respondent has left out filing a fatigue report

Question 13 is the first question which starts to investigate the third research question about the operator's fatigue mitigating procedures asking how encouraged respondents feel to file a fatigue report. It is interesting that in question 13, roughly the same number of people either agreed or disagreed with the statement of feeling encouraged to file a fatigue report with two fifths feeling indifferent.

Investigating the detailed information regarding this question does not reveal any further insight as once again, all groups of work position and work experience have answered very similarly. It could be argued that only a third of the employees do not feel encouraged to file a fatigue report and therefore, it is not that big of an issue. However, another way of looking at this response is that the respondents should feel confident and encouraged to file a fatigue report. Now only one third of respondents feel encouraged while two thirds of respondents do not feel encouraged. Furthermore, as has been determined, under-reporting is an issue, which means there is room for improvement in this sector.

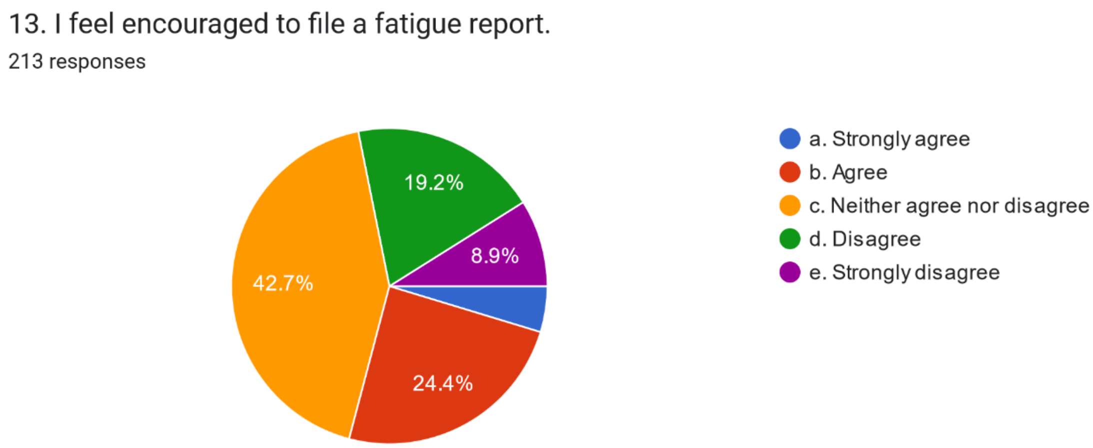

Figure 13. How encouraged do respondents feel to report fatigue

Question 14's aim was to enquire how familiar respondents were with the fatigue report form and if they feel it supports finding the root causes of fatigue. Question 14 has similar issues as the previous question where it is difficult to form a clear conclusion. There is a small increase of answers on the middle option of ‘neither agree nor disagree’. It is possible that the reason for a large number of respondents choosing ‘neither agree nor disagree’ is for the reason that the respondents do not know enough about the subject to give an opinion. It could also be said that since fatigue reporting itself is more uncommon, the respondents do not have in clear memory how the fatigue report form looks like and what information is inquired within the fatigue report form.

It was discussed earlier that the Fatigue Management Guide for Airline Operators had a detailed guide on a fatigue report form which would help identify fatiguing factors (FMG 2015 p. 128). Filling the recommended fatigue report form not only has the benefit of giving more detailed information of the fatigue root causes to the operator required to make changes, but it will also help the individual understand fatiguing factors, which can help with personal fatigue mitigation when applicable and possible.

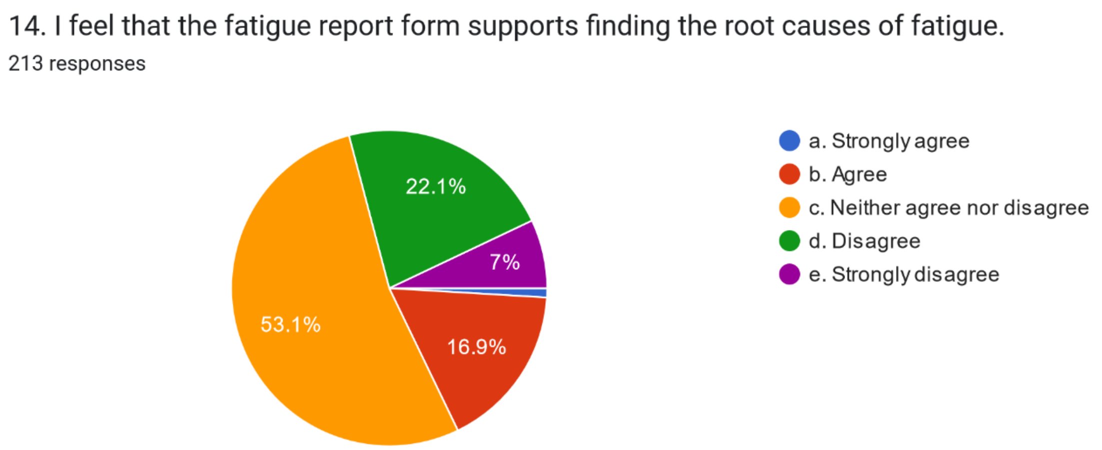

Figure 14. Respondents’ confidence that the fatigue report form helps finding the root cause of fatigue

The final question of fatigue reporting was question 15 to understand how respondents feel about the action taken on fatigue reports. There can be seen a clear change in attitude from fatigue reports as over half (53 %) of the respondents feel that not enough action is taken regarding fatigue reports. Once again, there were a large number of respondents (38 %) who neither agreed nor disagreed, which could indicate that they do not know enough about the subject to give an opinion. The results are clear though, as only 9 % of the respondents agree with this statement and it should be perspicuously communicated what the actions are regarding fatigue reports.

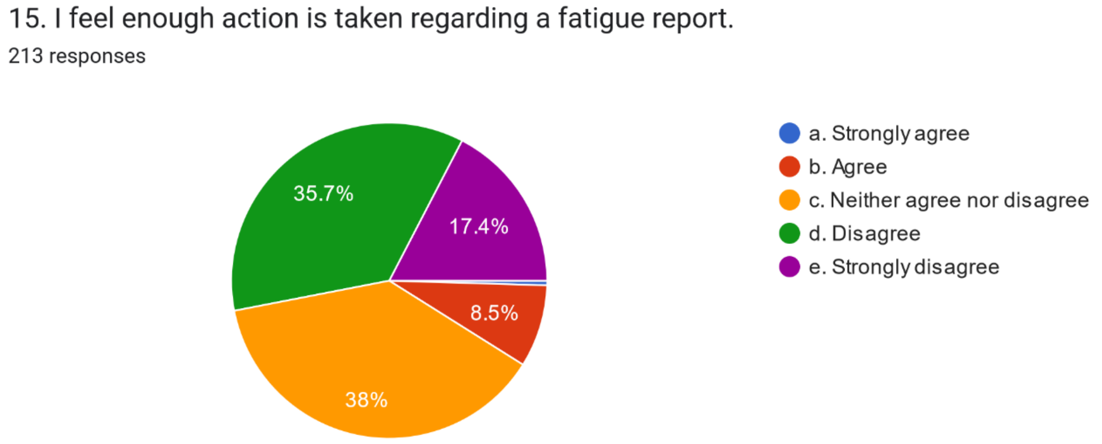

Figure 15. Respondents' confidence in that action is taken on fatigue reports

4.1.4 Fourth part, Operator's fatigue mitigation procedures, Questions 16 to 19

The fourth part of the questionnaire was about the operator's fatigue procedures.

Question 16 and 17 are very similar as they try to identify how the respondents feel about the operator's *procedures* and *actions* on fatigue reports.

When analyzing the results from question 16 a third of the respondents (34 %) feel that the operator's procedures are not so helpful or not at all helpful. 13 % feel that the operator's procedures on fatigue reports are very helpful or extremely helpful. Over half (53 %) answered that the operator's procedures on fatigue reports are somewhat helpful.

However, when looking back at the previous questions (question 13-15) and the similarity of answers on the middle option, it must be questioned whether the respondents actually feel that the procedures are somewhat helpful or is this a subject where the respondents did not know enough about and opted to choose the middle answer. It could easily be that they agree with the statement of being somewhat helpful, but it requires thought and consideration. If such a question is asked again, then the answers should be rephrased to avoid such ambiguity. As there is no way to definitively answer this speculation, it must be assumed that the respondents answered truthfully and the operator's procedures on fatigue reports are somewhat helpful.

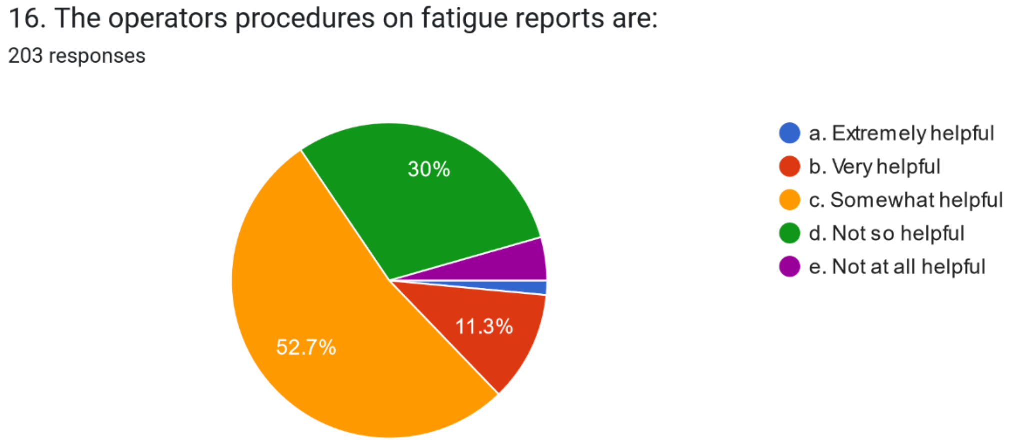

Figure 16. Respondents' belief in that the operators fatigue procedures are helpful

Question 17 has a more clearly defined response as it is based on the operator's actions on fatigue reports. Two thirds of the respondents (65 %) feel that the operator's actions on fatigue reports are not so helpful or not at all helpful. 30 % of respondents feel that the actions are somewhat helpful, and 5 % feel that the actions are very helpful or extremely helpful. Regardless of if there may be ambiguity or not, it is clear with two thirds of respondents feeling that the operator's actions are not helpful, that this area needs to be improved on.

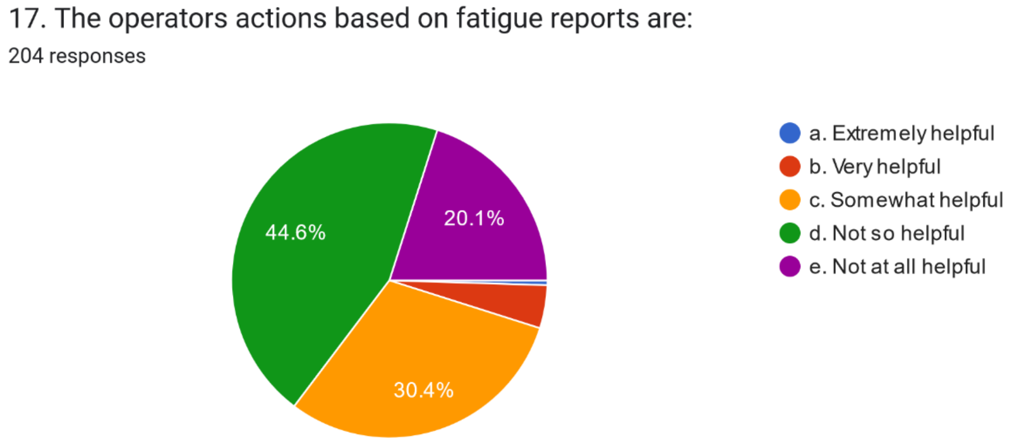

Figure 17. Respondents' perception of the operator's actions done on fatigue reports being helpful

Question 18 aims to find whether the respondent's attitude is open to the thought of filing more fatigue reports if they were more aware of the actions regarding fatigue reporting. Of the respondents only 3 % said they would not file more reports and one out of four (23 %) said it would make no difference. Three out of four (74 %) of respondents say they would file more fatigue reports if they were more aware of the actions on fatigue reporting.

It very well may be that there are plenty of action behind the scenes going on regarding fatigue reporting, but as it has been established, the respondents feel that the action needs to be seen and perspicuously communicated.

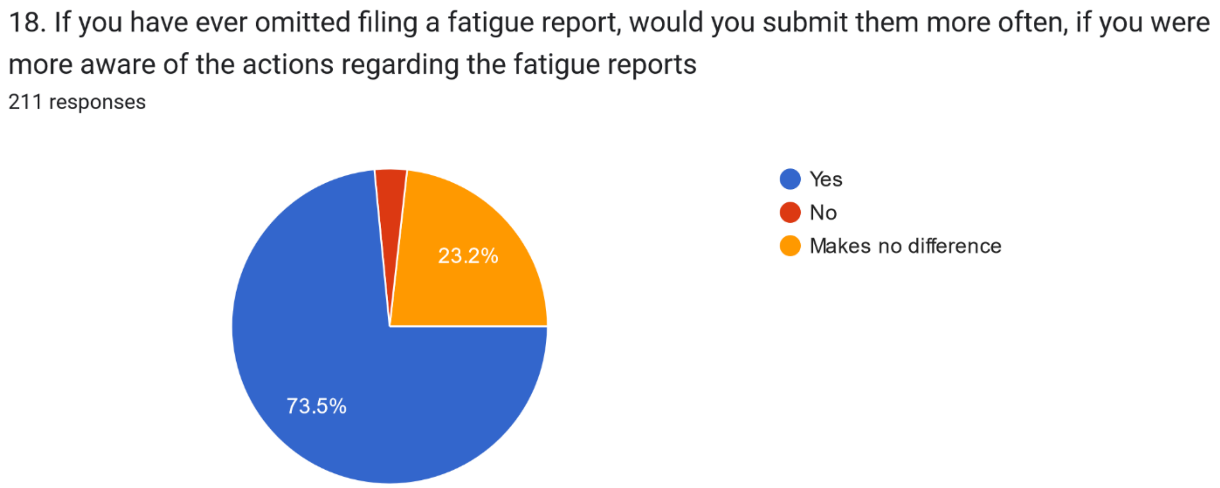

Figure 18. Respondents' attitude on filing fatigue reports more often if clear action were taken

The final question of the survey, question 19, was asked to determine whether the respondents feel it would be helpful to educate crew on the operator's processes on fatigue risk management. Three out of four (74 %) of the respondents agree that education on the operator's fatigue risk management processes would be helpful, one out of five (20 %) neither agree nor disagree, and only 6 % disagree with the statement.

This is a very positive result, as even though the respondents felt that they either did not know enough or they did not find the operator's actions and procedures on fatigue reporting helpful, they are still open to learning more about the operator's FRM procedures. As discussed in the theoretical framework, education is an important factor concerning fatigue risk management.

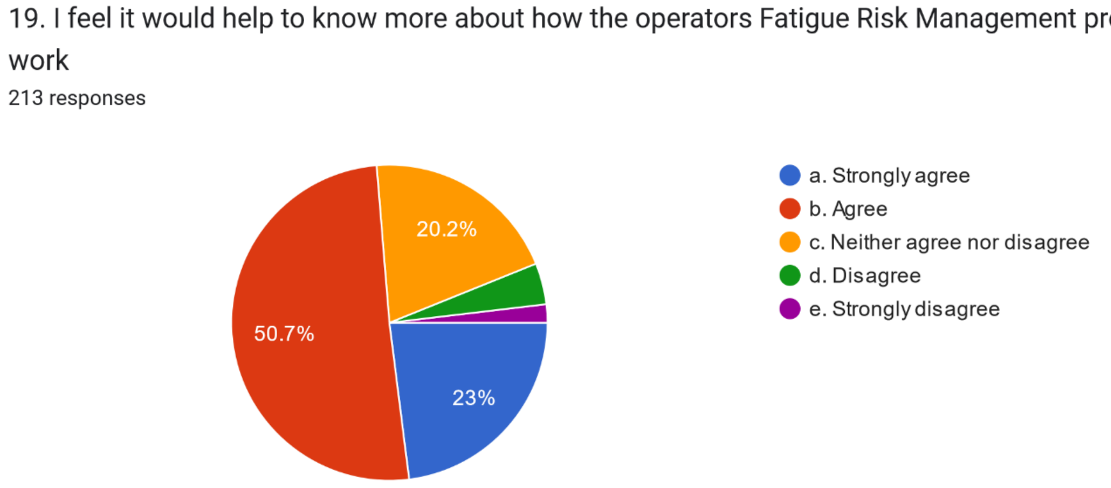

Figure 19. Respondents' attitude on learning more about fatigue risk management

4.2 Key Findings

The main research question was to investigate the effectiveness of the operator's fatigue risk management. For this, the thesis research sub-questions were created to find out if fatigue was a common occurrence, what were the attitudes and behaviors of cabin and flight crew towards fatigue reporting, and whether the operator's fatigue mitigating procedures were effective. As stated earlier, the objective of this study was to find the subjective opinions and self-assessments of the respondents on these matters.

There were a few questions where differences in answers would go together as expected with work experience, as the longer the work experience, the more an individual will have exposed themselves to fatiguing situations. But other than that, there were only small differences in the results between work groups and work experience and they were not meaningful enough to draw any clear conclusions.

However, this is one key finding as it can be indicative that attitudes and behavior regarding fatigue, fatigue reporting, and operator's fatigue culture are perceived the same way regardless of work position or work experience. This can be seen throughout the survey responses, which can be further inspected from appendix 2. Another reason why this is a key finding is that it is a telltale sign that the shared experiences of the crew are the most probable causes of fatigue. These causes can be seen from question 8's two most common responses which were rostering rhythm changes and inadequate time for recovery.

Based on the responses and analysis of the findings from the questionnaire's results, it can be determined that fatigue is a common occurrence within the operator's environment. More so than what the fatigue reports would determine as can be seen from questions 3-12. Question 4 found that 99 % of respondents have gone to work or finished flight duty fatigued. Question 6 found that 84 % of respondents estimated feeling fatigued either weekly, monthly, or quarterly. In question 7, 99 % of respondents have noticed another crew member suffering from fatigue. Finally, question 11 found only 10 % of respondents would always file a fatigue report.

It can also be said that while the crew is suffering from fatigue, they would rather suffer in silence than report the issue. From question 9 it can be seen that 88 % of the respondents estimated filing between 0 and 5 fatigue reports during their career. Again, in other words, question 11 determined that 90 % of respondents have omitted filing a fatigue report even though they have felt fatigued on duty. Question 12 investigated the reasons why respondents omitted fatigue reports and the most common responses revealed that this is due to the common perception that reporting fatigue will have no positive outcome to change. Rather reporting fatigue is seen in a more negative light, as respondents feel it would just be a waste of time and crew fear the consequences. However, it is hard to determine which came first. Has the culture of under-reporting manifested due to no changes made, or has no changes been made due to not enough fatigue reports being filed. Regardless of which came first, this data gives clear indication of there being a problem within the cabin and flight crews fatigue reporting behavior.

Finally, the last part of the survey was aimed at answering the third sub-question on the effectiveness of the operator's fatigue mitigation procedures. Question 13 reveals that 29 % of the respondents felt encouraged to file a fatigue report and question 15 reveals that 9 % of the respondents feel enough action is taken regarding fatigue reports. From question 17 it can be seen that 65 % of the respondents feel that the operator's actions taken on fatigue reports are not so helpful or not helpful at all. This reveals, at least from the perspective of the respondents, that they do not feel encouraged to file fatigue reports nor do they feel confident that enough action is taken nor that the action taken is helpful to mitigate fatigue. However, on a positive side, the final questions of the survey (question 18 & 19), revealed that even though the respondents felt that they either did not know enough, or they did not find the operator's actions and procedures on fatigue reporting helpful, they are still open to learning more about the operator's FRM procedures.

Companies often rely on data to make changes and it can be quite hard for an operator to justify the costs to implement change when only 2 % of the respondents have estimated making over 10 fatigue reports during their career. Operators must see the value proposition to implement change. If there is clear data on which cost effective changes can be made to improve economic sustainability, then it is easier for decision makers to dedicate the resources needed to implement these changes. Therefore, data must be generated to ease making changes. This means that the importance of reporting is emphasized, which can be achieved by educating all operational departments. However, the operator needs to be prepared to then allocate resources to implement actionable changes as inaction will lead to loss of trust in the reporting system.

As discussed in the theoretical framework, education is an important factor concerning fatigue risk management so having the employees willing to learn is a great precursor for this. It is recommended that the commissioner creates and develops training material, as well as takes steps to make changes based on the recommendations found in this thesis. Not only will this improve safety, but it will also improve trust, culture, wellbeing as well as economic and social sustainability within the company.

4.3 Conclusion and suggestions for development

The main research question was to investigate the effectiveness of the operator's fatigue risk management. With the help of the three research sub-questions and the quantitative questionnaire, it was determined that the respondents feel that the operator's fatigue risk management procedures are not effective enough in mitigating fatigue as it was discussed in the key findings. Therefore, improvements should be made to the operator's fatigue risk management procedures to enhance the effectiveness of mitigating fatigue. Company support and trust are key factors in the operator's Safety Management System (SMS). Education is a key part of improving safety culture in general. If a single few individuals would start to report fatigue, it is more likely that these individuals would be singled out as unique cases of fatigued employees rather than starting a possibly expensive internal change process. As it is difficult for an individual to create change around the fatigue reporting system, it is up to the operator to implement a meaningful change culture and educate employees on the importance of fatigue reporting.

Creating meaningful change takes time but will show commitment from the operator and lead to clear discovery and data of any latent problems concerning fatigue and its implications for safety. It can be difficult for a business to start this change process without a clear value proposition. However, it has been made clear throughout this thesis what the threats and benefits are of creating this change. Furthermore, it has been determined that employees suffer from fatigue and the data generated from this thesis can be used to jumpstart any project for improvements to mitigate fatigue.

Once the operator has started the change process and education for employees, it is then the employee's responsibility to report when they suffer from fatigue as the SMS philosophy is based on a continues improvement process. Without these reports, there is no data on which the employer can justify spending resources to make change. Finally, it will fall on the operator's responsibility to implement tangible actions based on these fatigue reports. Inaction to address any problems or concerns that employees may share will lead to the SMS system being undermined, hurting the long-term safety culture. Even when the data states that there is no concern and no further action is required, it is important to communicate this in a transparent way so crew can follow where the level of any issue or problems lay and have a clear understanding that fatigue is continuously being monitored.

Below are the next steps the author recommends the commissioner to take action on.

Figure 20. Visual summary of the next step actions to mitigate fatigue

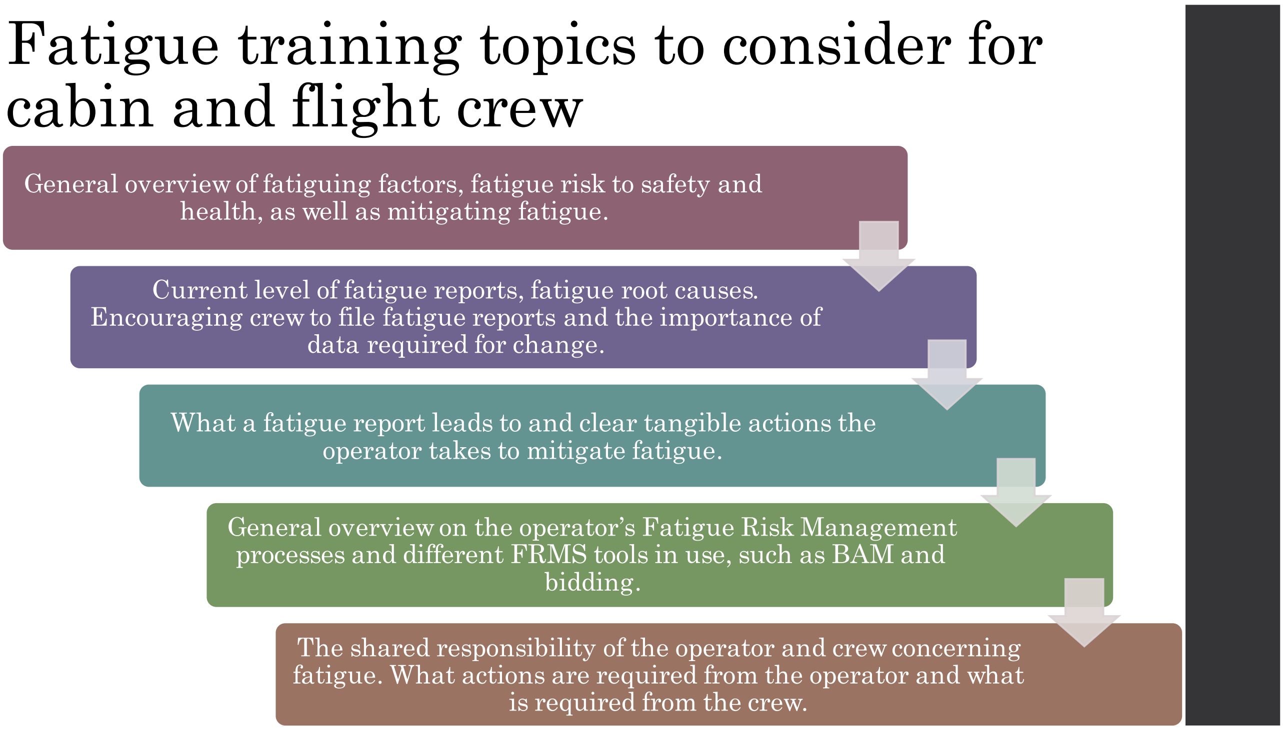

Figure 21. Fatigue training topics for cabin and flight crew

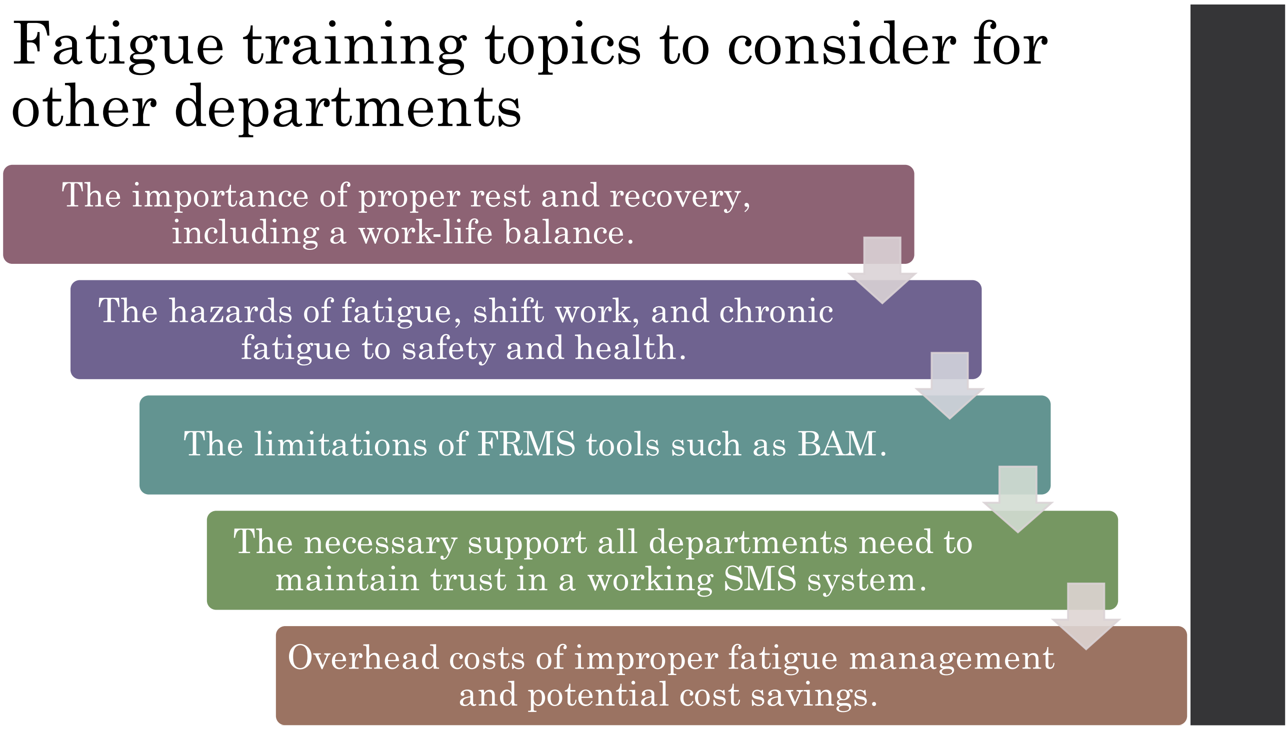

Figure 22. Fatigue training topics for other departments

Finally, listed below are some useful sources that can be used for further self-study on fatigue in aviation, countermeasures to fatigue, and fatigue risk management. These sources are also helpful in creating any new training material regarding fatigue risk management.

- Caldwell et al. 2009
- Caldwell et al. 2019
- FMG 2015
- ICAO Doc 9966
- EUROCONTROL 2018

The findings from this thesis and survey should be evidence enough that fatigue is a more common occurrence within the operator's environment than expected. Furthermore, under-reporting keeps fatigue as a latent issue. With the threat of fatigue on flight safety and crew health as well as the benefits for potential cost savings from reducing fatigue, recommendations were made to improve the fatigue management processes. With these improvements the operator can potentially enhance efficiency, crew health and wellbeing which will lead to operational excellence.

4.4 Thesis Process and Self-Assessment

The thesis process started already before my BBA studies, as I found plenty of interesting topics that could be investigated within the aviation industry. Therefore, it was interesting and motivating to start studying for a BBA degree in aviation business. However, once I began my studies the idea of completing a thesis felt like a scary thought, as I had no idea what it entailed or how demanding it might be. It turned out that there was no need to be scared, as even if it was very demanding, it was also a very manageable project and a great learning experience.

Fortunately, during my studies, I was able to learn a lot about academia, research, and writing which helped me prepare for the inevitable thesis research project. I learned that I was quite proficient in producing, at least in my opinion, quality text that was interesting to read. I was naturally interested in aviation as the subject is close to my heart which also further helped advance my studies.

Starting the thesis proved difficult, as whatever topic I landed on, I felt the need to find every single problem, solution, and suggest recommendations on how to implement changes and improve processes. It did not help that I had originally planned to allocate a minimum of six months for my thesis work, but for multiple reasons beyond my control, this timeline was reduced to three months if I wanted to stick with my original graduation goal. This just meant that I had to roll up my sleeves and work even more diligently to achieve my personal goals to finish my studies by the end of the year.

Finally, when landing on an appropriate thesis topic which the commissioner was also interested in, I was able to get to work. Thanks to the help from my thesis counselor, I was able to limit the scope of the thesis greatly which helped direct my efforts focusing on quality rather than quantity.

I created a thesis project plan and timeline which began in August 2023 and the goal was to finish the thesis project by the end of October 2023. This timeline was due to my return to flight work. In the project plan and timeline, I had made clear goals, objectives and milestones which would ease following the project. I was able to follow this project plan effectively working on the research thesis with any free time I had at hand. I kept a diary of my work, which included my thoughts I had generated from reading different studies as well as discussions from interviews held with different key individuals concerning the thesis topic. It seemed that even when I stopped working on the project, my mind would continue to race and actively think about the project, as I could not hit the pause button. However, I used this momentum to carry myself over the finish line to reach my original goal of finishing my studies by the end of 2023.

The thesis project taught me the importance of objective quality work and how important background research is to start any new project, as often many problems and solutions have already been investigated at least in some way before. This also helps understanding the topic and any issues further, which is a necessary precursor before being able to solve any problems. I also learned that I am not afraid to roll up my sleeves, immerse myself in any new subject and once I find myself working on an interesting topic, I work hard to achieve the best results possible.

Overall, my studies as well as the thesis project were a very rewarding experience, which I am proud to have finished and look forward to seeing what possible doors may open in the future.

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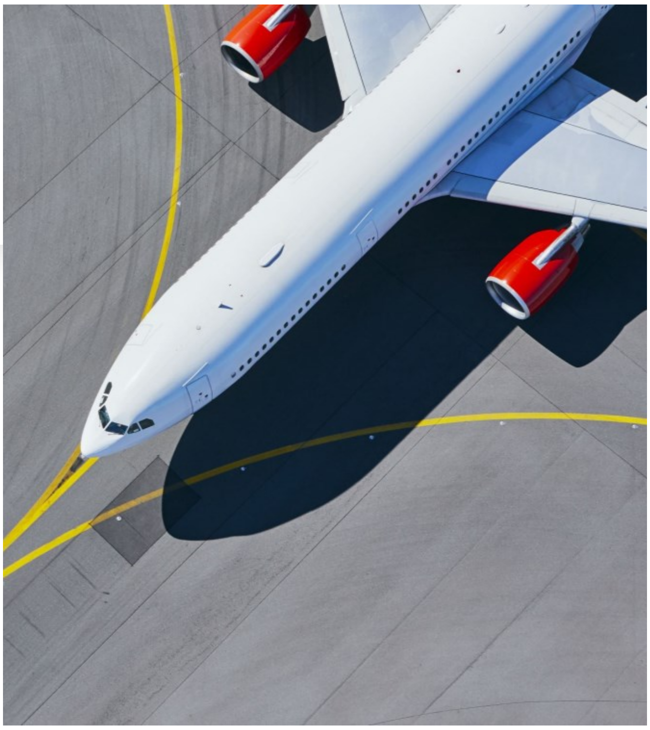
Appendix 1. Questionnaire and results

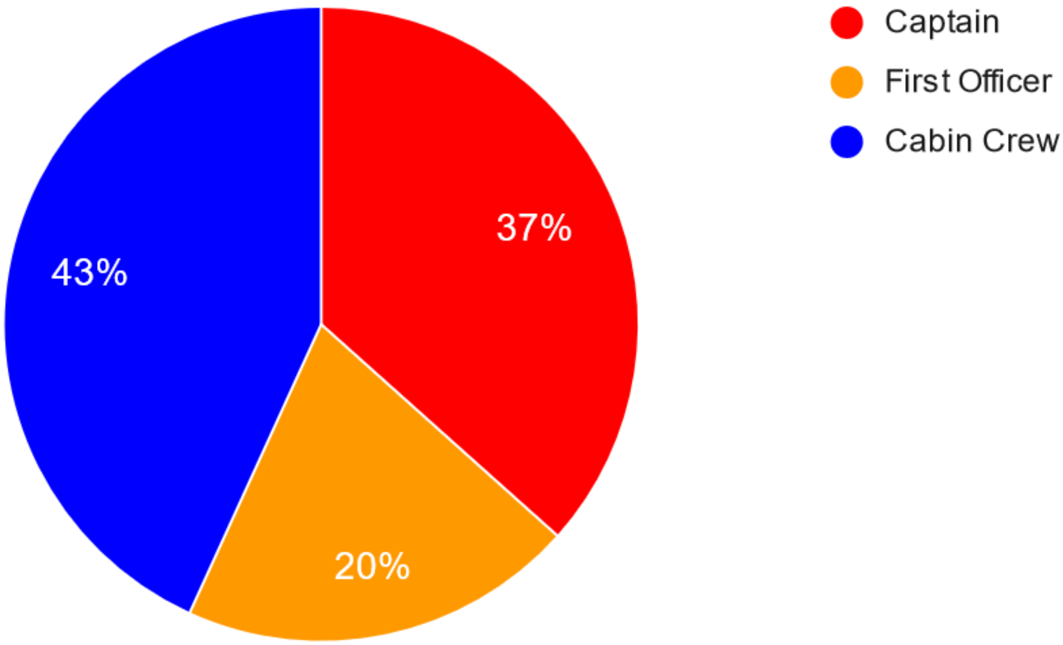
Questionnaire and results

This anonymous third-party multiple-choice survey has 19 questions and will only take a few minutes of your time. The results will be used in the authors bachelor's thesis, concerning the fatigue reporting procedures within the airline.

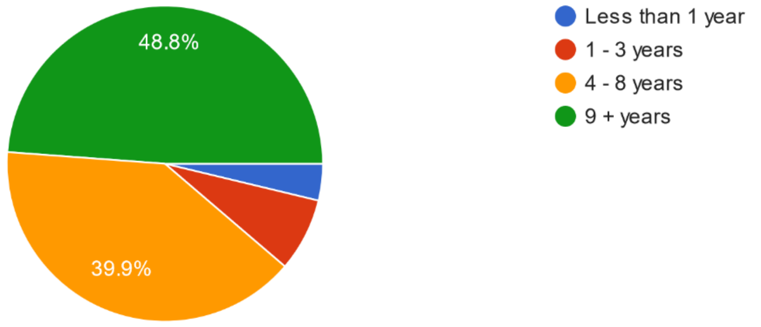


Demographic

1. What is your work position?

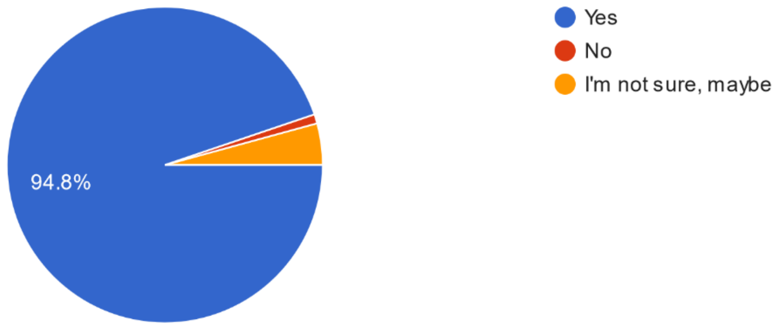


2. What is your flight work experience in the aviation industry?
213 responses

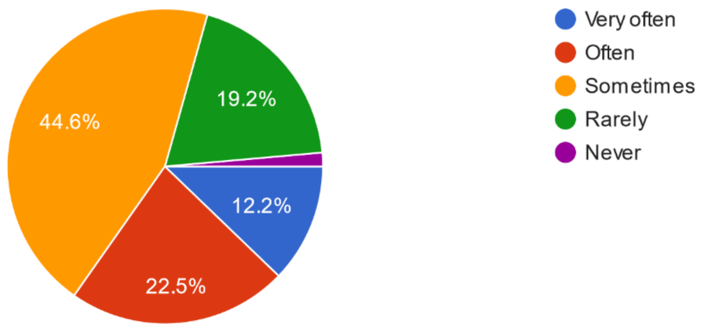


Feeling Fatigued

3. Have you ever experienced fatigue during your flight duty? (ICAO fatigue definition)
212 responses

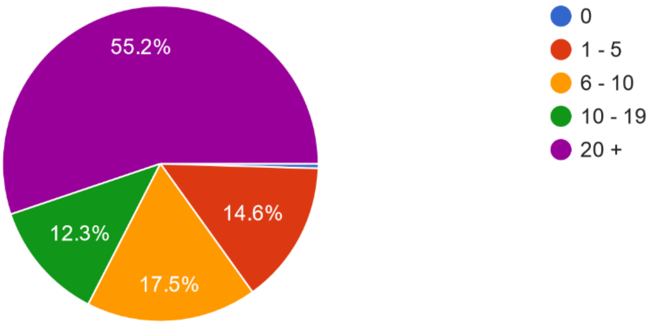


4. Have you gone to work or finished a flight duty feeling fatigued?
213 responses



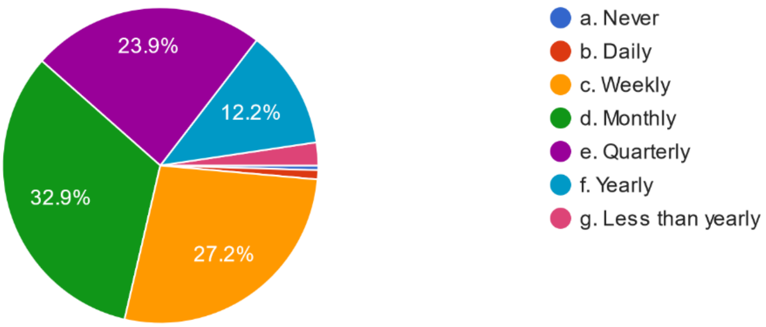
5. How many times do you estimate, you have felt fatigued during your career?

212 responses



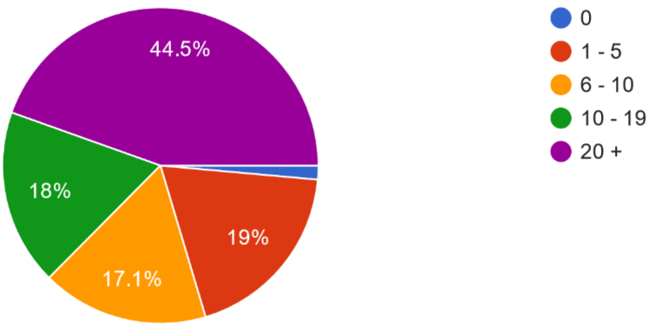
6. How often would you estimate you feel fatigued?

213 responses



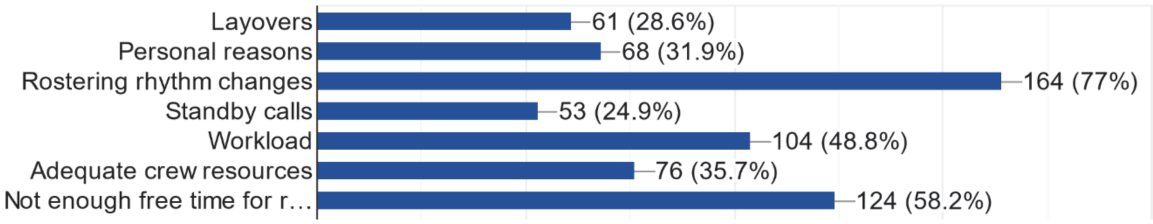
7. Estimate how many times have you noticed another crew member suffering from fatigue during their work shift?

211 responses



8. I feel that ____ interferes to get adequate rest. (Can select multiple)

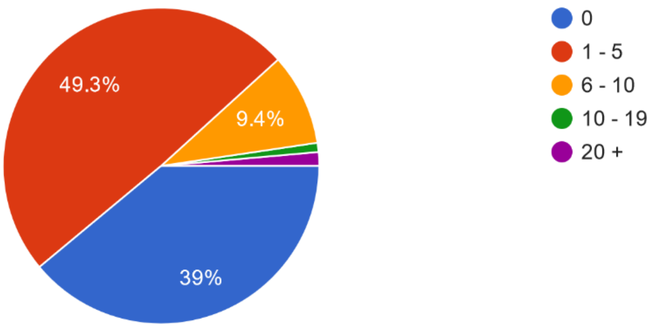
213 responses



Fatigue Reporting

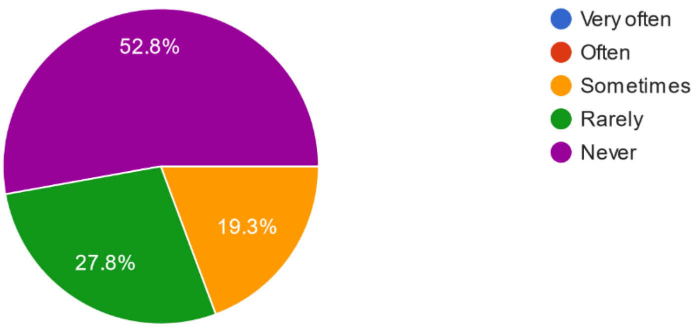
9. During your career, estimate how many fatigue reports you have filed?

213 responses



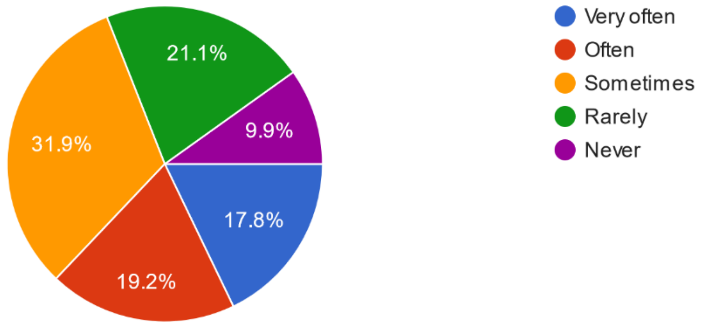
10. Have you submitted a report where fatigue has played a role, but left the fatigue part out of the report? (Fatigue has been a contributing factor)

212 responses



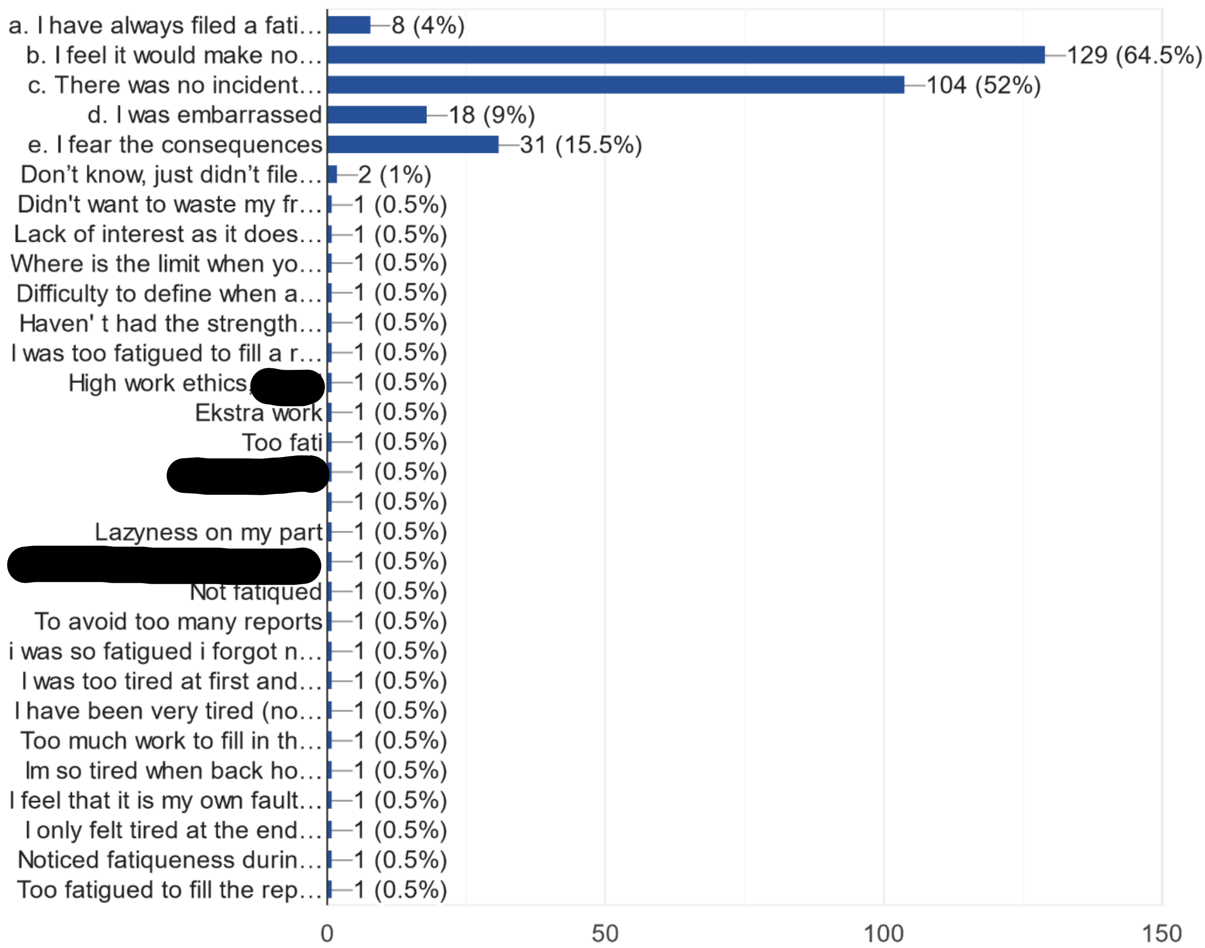
11. Have you omitted (left out) filing a fatigue report, even though you felt fatigued on duty?

213 responses



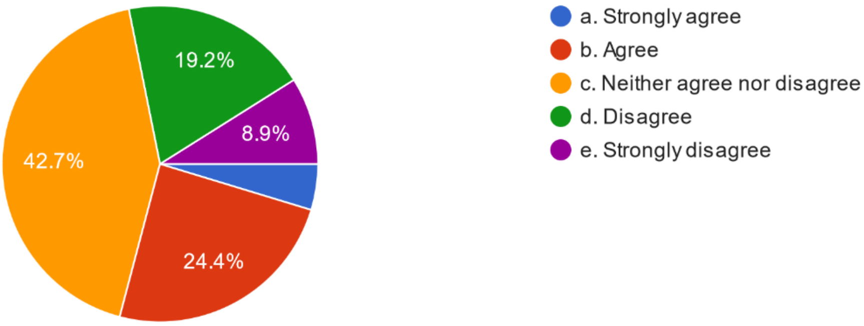
12. If you have omitted a fatigue report, why? (can select multiple)

200 responses



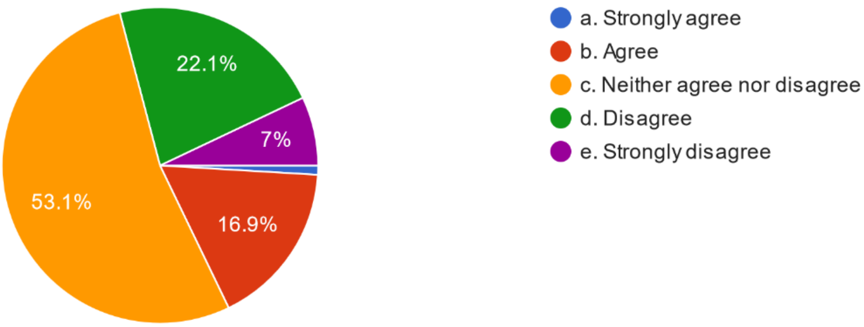
13. I feel encouraged to file a fatigue report.

213 responses



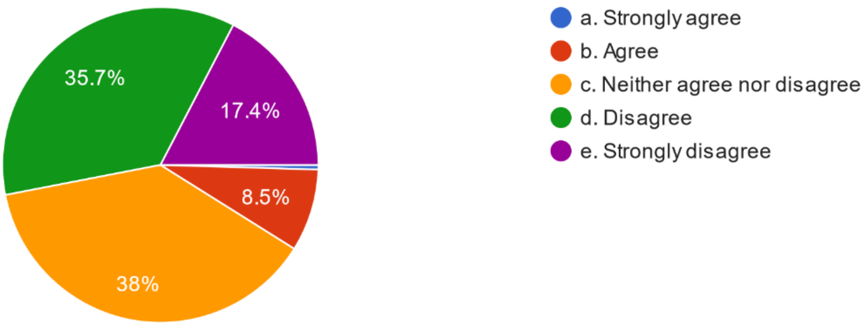
14. I feel that the fatigue report form supports finding the root causes of fatigue.

213 responses



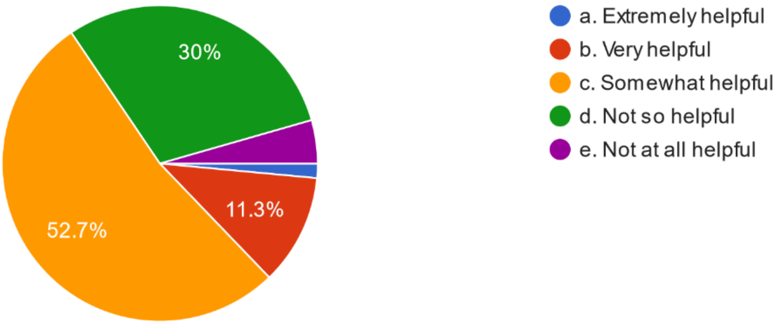
15. I feel enough action is taken regarding a fatigue report.

213 responses

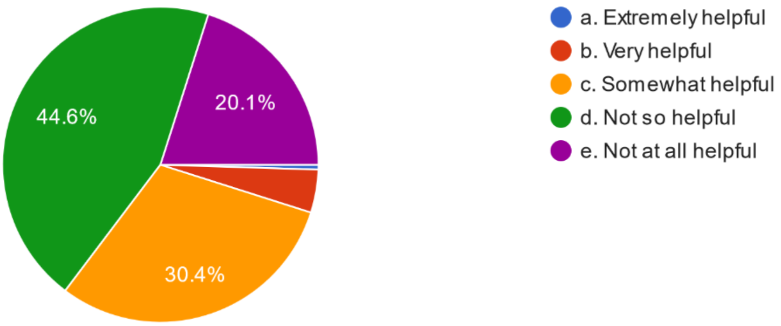


Operators Fatigue Mitigation Procedures

16. The operators procedures on fatigue reports are:
203 responses

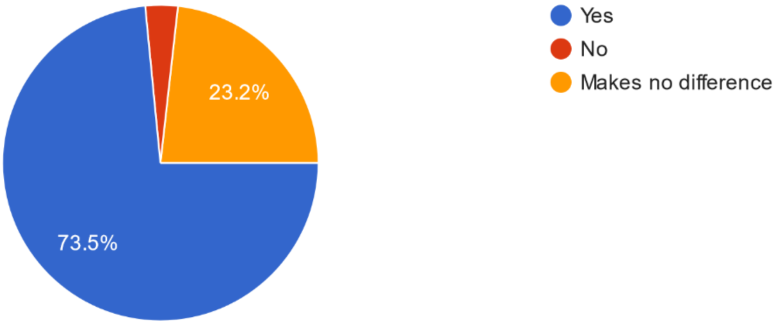


17. The operators actions based on fatigue reports are:
204 responses



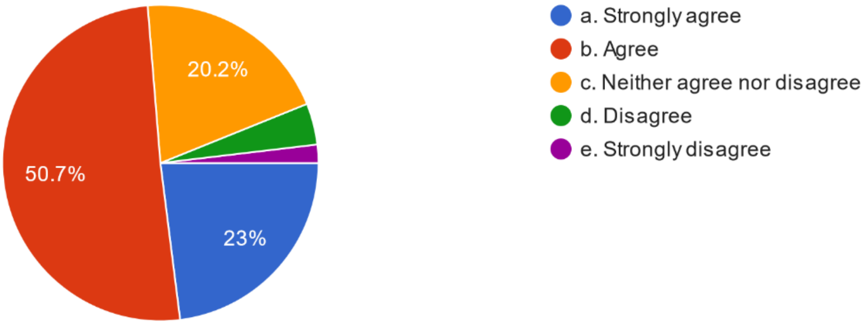
18. If you have ever omitted filing a fatigue report, would you submit them more often, if you were more aware of the actions regarding the fatigue reports

211 responses



19. I feel it would help to know more about how the operators Fatigue Risk Management processes work

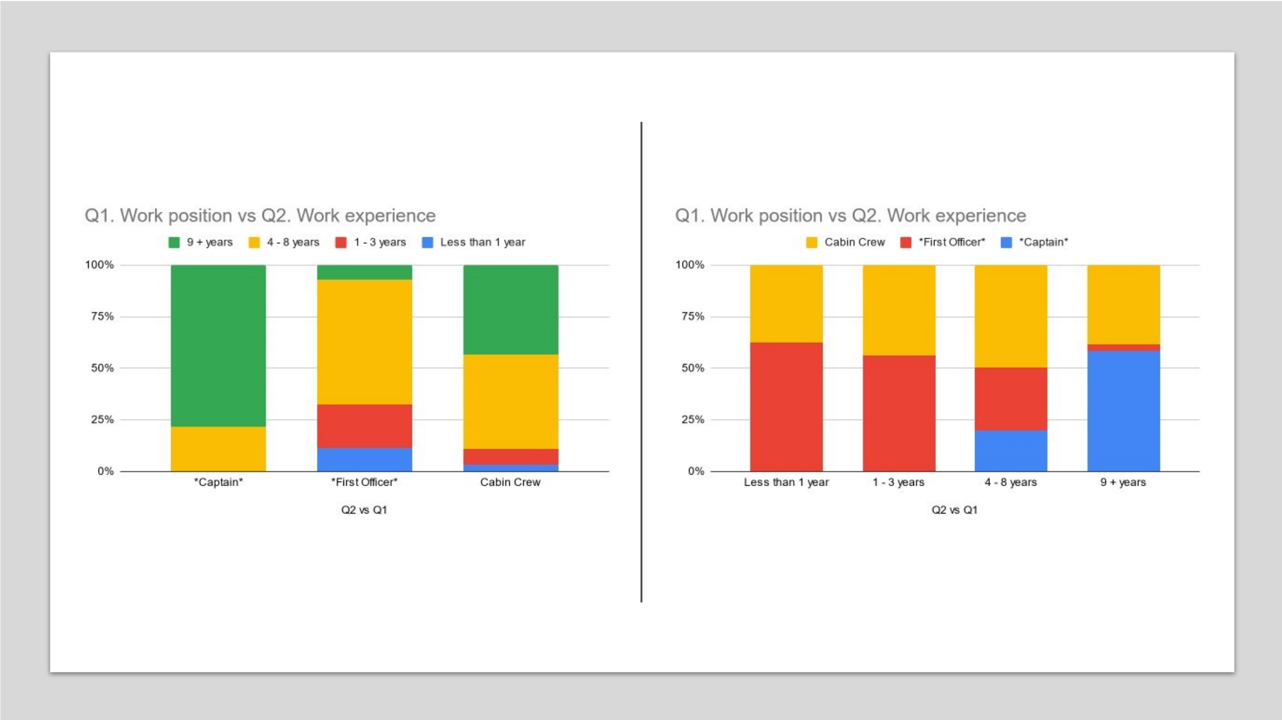
213 responses



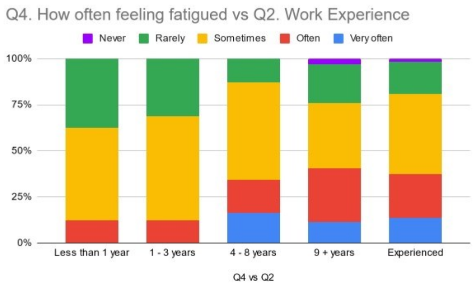
Appendix 2. Survey results and analysis

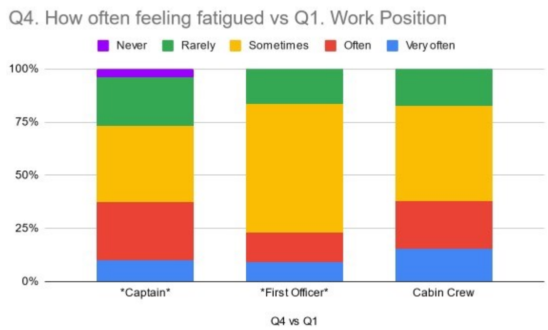
The following slides will compare the questionnaire information based on either crew position, crew experience, and only crew with more than 4 years of experience.

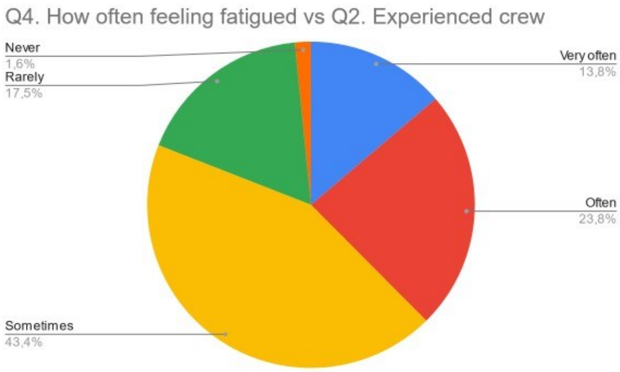
Demographic



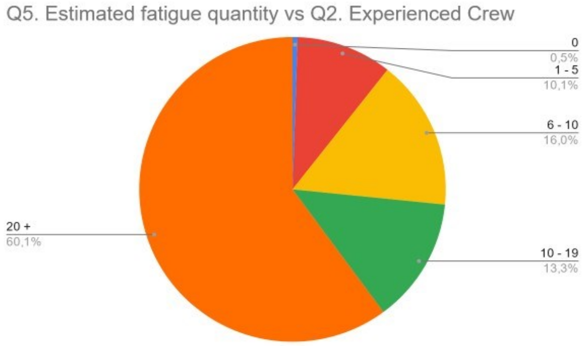
Feeling Fatigued

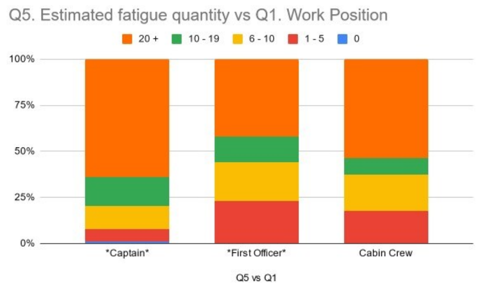


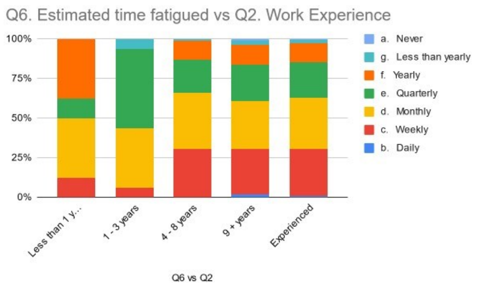


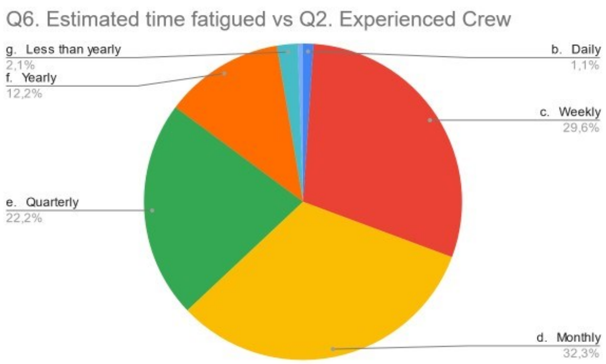


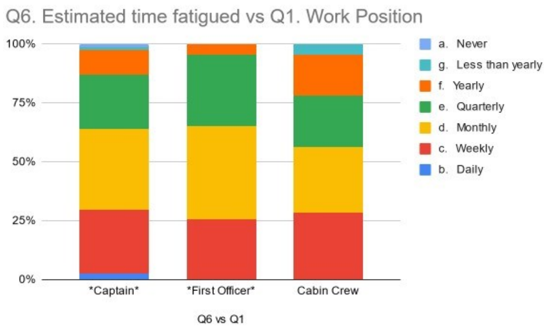

Q5. Estimated fatigue quantity vs Q2. Work Experience
20 +
10 - 19
6 - 10
1 - 5
0
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q5 vs Q2

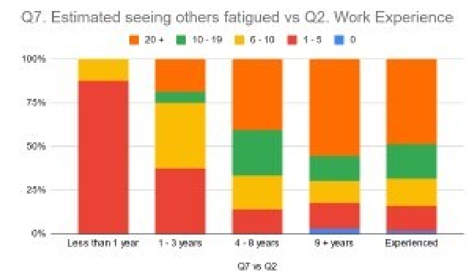

Q5. Estimated fatigue quantity vs Q2. Experienced Crew
0
0,5%
1 - 5
10,1%
6 - 10
16,0%
20 +
60,1%
10 - 19
13,3%

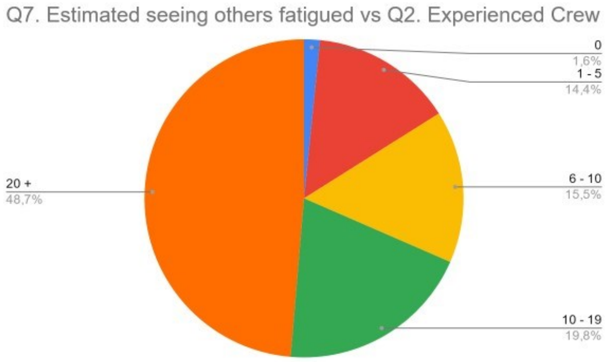

Q5. Estimated fatigue quantity vs Q1. Work Position
20 +
10 - 19
6 - 10
1 - 5
0
100%
75%
50%
25%
0%
Captain
First Officer
Cabin Crew
Q5 vs Q1

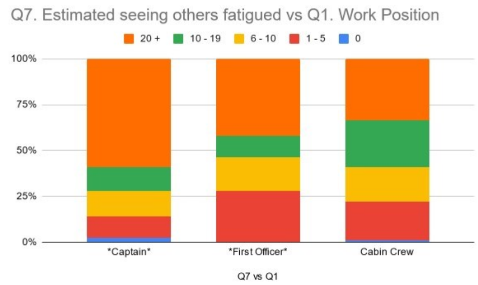

Q6. Estimated time fatigued vs Q2. Work Experience
a. Never
g. Less than yearly
f. Yearly
e. Quarterly
d. Monthly
c. Weekly
b. Daily
100%
75%
50%
25%
0%
Less than 1 y...
1 - 3 years
4 - 8 years
9 + years
Experienced
Q6 vs Q2

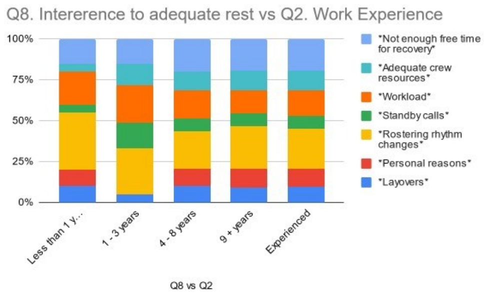

Q6. Estimated time fatigued vs Q2. Experienced Crew
g. Less than yearly
2,1%
f. Yearly
12,2%
b. Daily
1,1%
c. Weekly
29,6%
e. Quarterly
22,2%
d. Monthly
32,3%

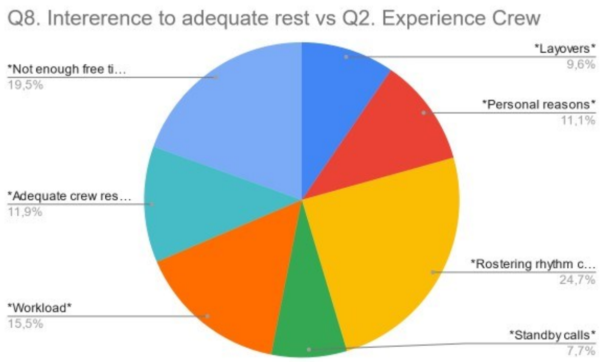

Q6. Estimated time fatigued vs Q1. Work Position
a. Never
g. Less than yearly
f. Yearly
e. Quarterly
d. Monthly
c. Weekly
b. Daily
100%
75%
50%
25%
0%
Captain
First Officer
Cabin Crew
Q6 vs Q1

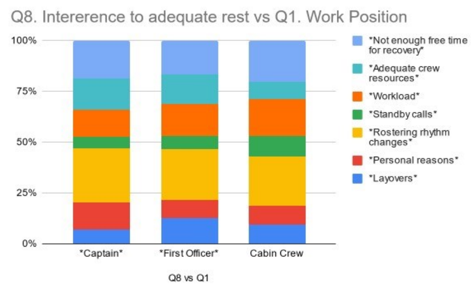

Q7. Estimated seeing others fatigued vs Q2. Work Experience
20 +
10 - 19
6 - 10
1 - 5
0
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q7 vs Q2


Q7. Estimated seeing others fatigued vs Q2. Experienced Crew
0
1,6%
1 - 5
14,4%
20 +
48,7%
6 - 10
15,5%
10 - 19
19,8%

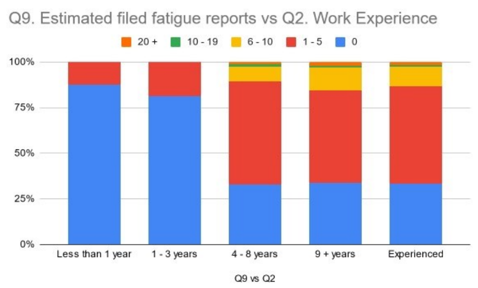

Q7. Estimated seeing others fatigued vs Q1. Work Position
20 +
10 - 19
6 - 10
1 - 5
0
100%
75%
50%
25%
0%
Captain
First Officer
Cabin Crew
Q7 vs Q1

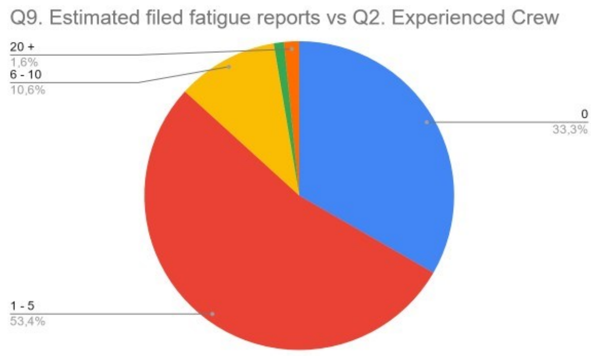

Q8. Intererence to adequate rest vs Q2. Work Experience
100%
75%
50%
25%
0%
Not enough free time for recovery
Adequate crew resources
Workload
Standby calls
Rostering rhythm changes
Personal reasons
Layovers
Less than 1 y...
1 - 3 years
4 - 8 years
9 + years
Experienced
Q8 vs Q2

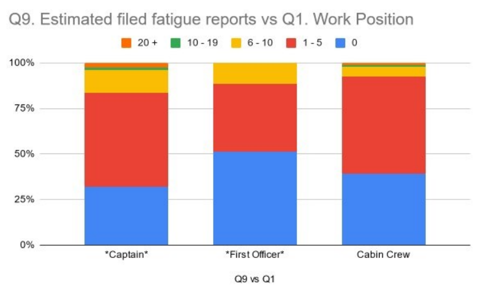

Q8. Intererence to adequate rest vs Q2. Experience Crew
Layovers
9,6%
*Not enough free ti...
19,5%
Personal reasons
11,1%
*Adequate crew res...
11,9%
*Rostering rhythm c...
24,7%
Workload
15,5%
Standby calls
7,7%

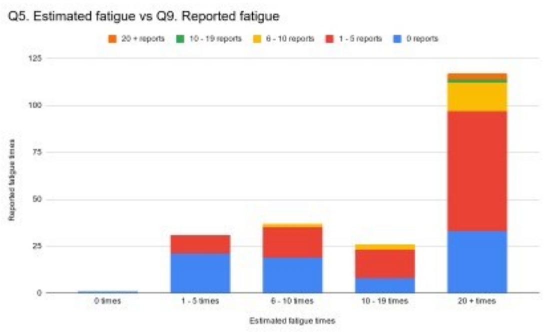

Q8. Intererence to adequate rest vs Q1. Work Position
100%
75%
50%
25%
0%
Not enough free time for recovery
Adequate crew resources
Workload
Standby calls
Rostering rhythm changes
Personal reasons
Layovers
Captain
First Officer
Cabin Crew
Q8 vs Q1

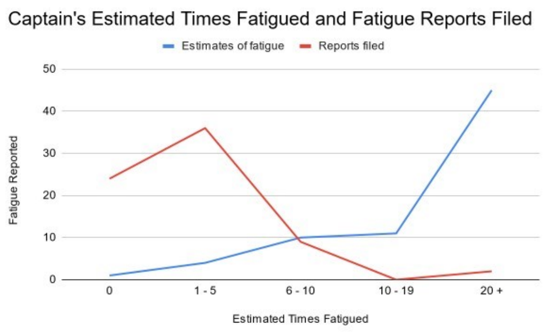
Fatigue Reporting

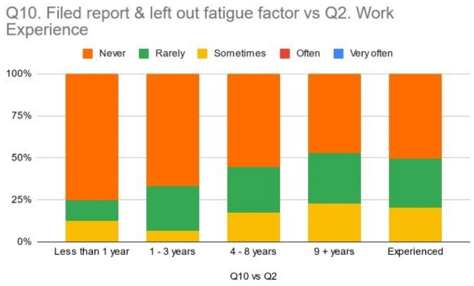


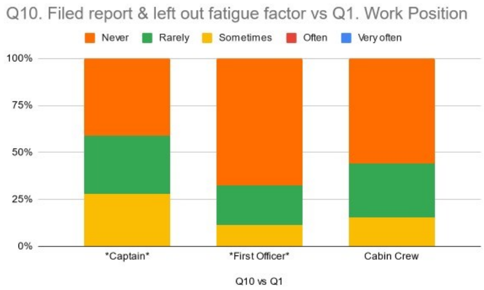


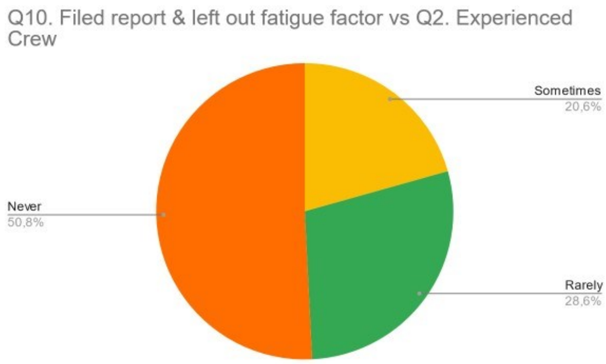


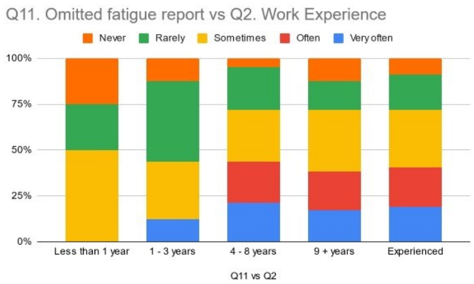


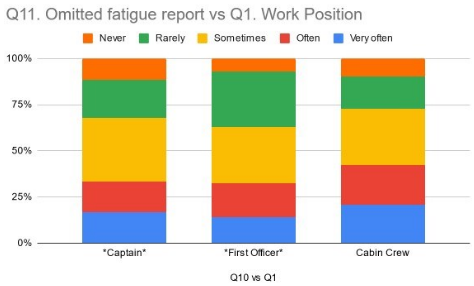


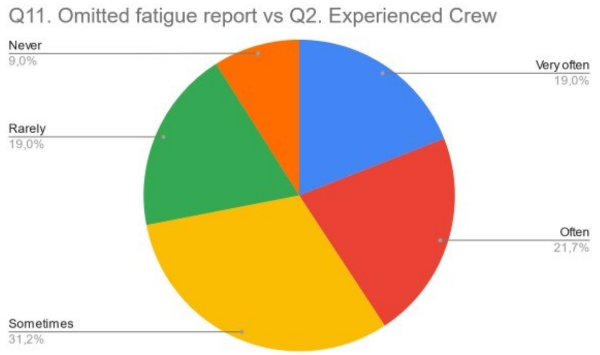

Q10. Filed report & left out fatigue factor vs Q2. Work Experience
Never
Rarely
Sometimes
Often
Very often
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q10 vs Q2

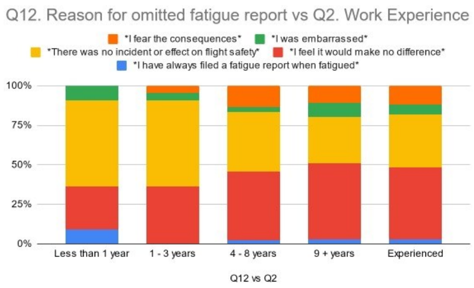

Q10. Filed report & left out fatigue factor vs Q1. Work Position
Never
Rarely
Sometimes
Often
Very often
100%
75%
50%
25%
0%
Captain
First Officer
Cabin Crew
Q10 vs Q1

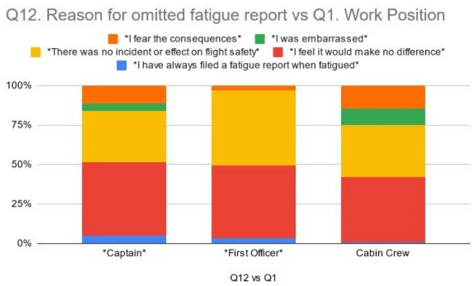

Q10. Filed report & left out fatigue factor vs Q2. Experienced Crew
Sometimes
20,6%
Never
50,8%
Rarely
28,6%

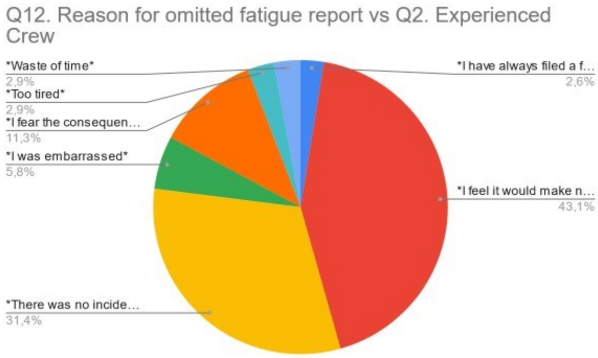

Q11. Omitted fatigue report vs Q2. Work Experience
Never
Rarely
Sometimes
Often
Very often
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q11 vs Q2

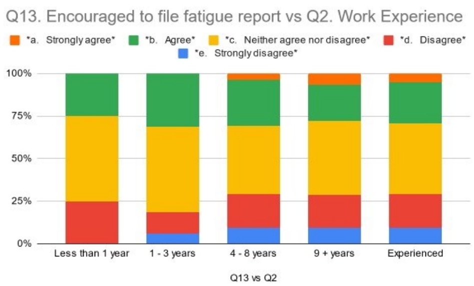

Q11. Omitted fatigue report vs Q1. Work Position
Never
Rarely
Sometimes
Often
Very often
100%
75%
50%
25%
0%
Captain
First Officer
Cabin Crew
Q10 vs Q1

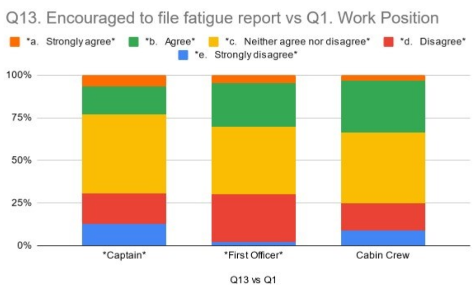

Q11. Omitted fatigue report vs Q2. Experienced Crew
Never
9,0%
Very often
19,0%
Rarely
19,0%
Often
21,7%
Sometimes
31,2%

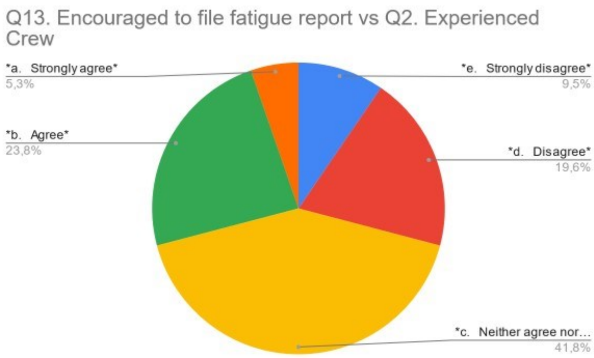

Q12. Reason for omitted fatigue report vs Q2. Work Experience
"I fear the consequences"
"I was embarrassed"
"There was no incident or effect on flight safety"
"I feel it would make no difference"
"I have always filed a fatigue report when fatigued"
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q12 vs Q2

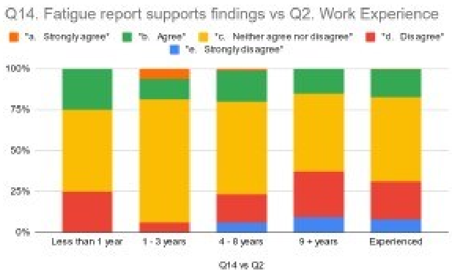

Q12. Reason for omitted fatigue report vs Q1. Work Position
"I fear the consequences"
"I was embarrassed"
"There was no incident or effect on flight safety"
"I feel it would make no difference"
"I have always filed a fatigue report when fatigued"
100%
75%
50%
25%
0%
"Captain"
"First Officer"
Cabin Crew
Q12 vs Q1


Q12. Reason for omitted fatigue report vs Q2. Experienced Crew
"Waste of time"
2,9%
"Too tired"
2,9%
"I fear the consequen…
11,3%
"I was embarrassed"
5,8%
"There was no incide…
31,4%
"I have always filed a f…
2,6%
"I feel it would make n…
43,1%

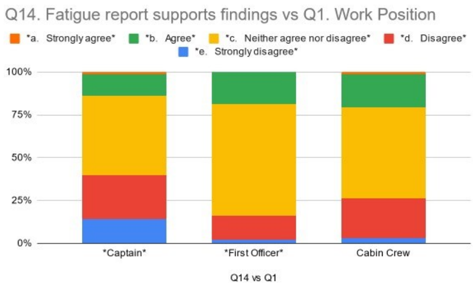

Q13. Encouraged to file fatigue report vs Q2. Work Experience
"a. Strongly agree"
"b. Agree"
"c. Neither agree nor disagree"
"d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q13 vs Q2

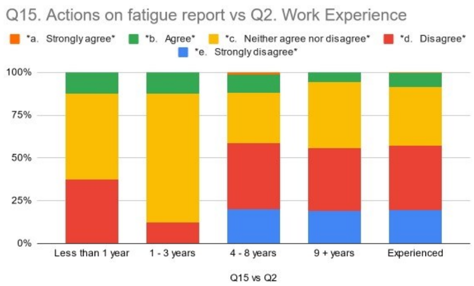

Q13. Encouraged to file fatigue report vs Q1. Work Position
"a. Strongly agree"
"b. Agree"
"c. Neither agree nor disagree"
"d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
"Captain"
"First Officer"
Cabin Crew
Q13 vs Q1

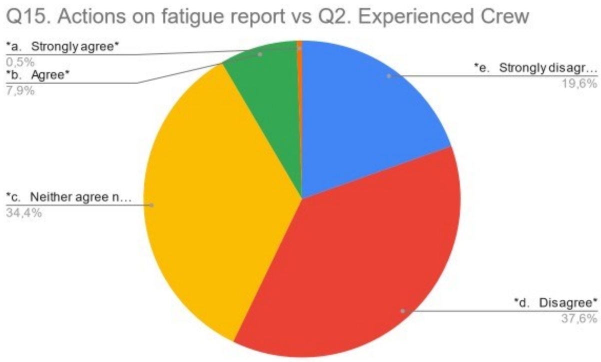

Q13. Encouraged to file fatigue report vs Q2. Experienced Crew
"a. Strongly agree"
5,3%
"b. Agree"
23,8%
"e. Strongly disagree"
9,5%
"d. Disagree"
19,6%
"c. Neither agree nor…
41,8%

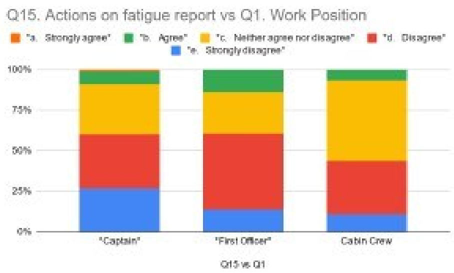

Q14. Fatigue report supports findings vs Q2. Work Experience
"a. Strongly agree"
"b. Agree"
"c. Neither agree nor disagree"
"d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q14 vs Q2


Q14. Fatigue report supports findings vs Q2. Experienced Crew
"a. Strongly agree"
0,5%
"b. Agree"
16,9%
"e. Strongly disagr…
7,9%
"d. Disagree"
23,3%
"c. Neither agree n…
51,3%

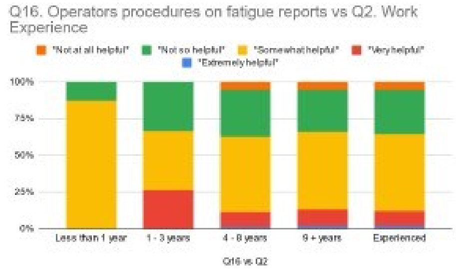

Q14. Fatigue report supports findings vs Q1. Work Position
"a. Strongly agree"
"b. Agree"
"c. Neither agree nor disagree"
"d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
"Captain"
"First Officer"
Cabin Crew
Q14 vs Q1

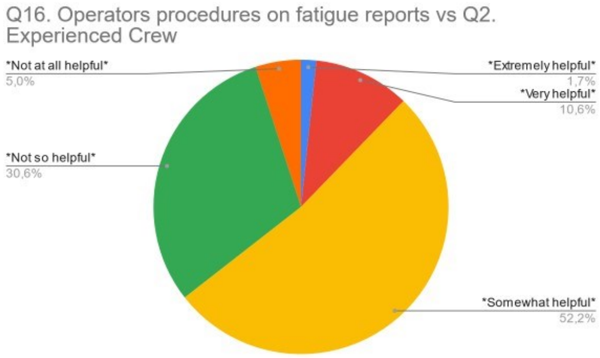

Q15. Actions on fatigue report vs Q2. Work Experience
"a. Strongly agree"
"b. Agree"
"c. Neither agree nor disagree"
"d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q15 vs Q2

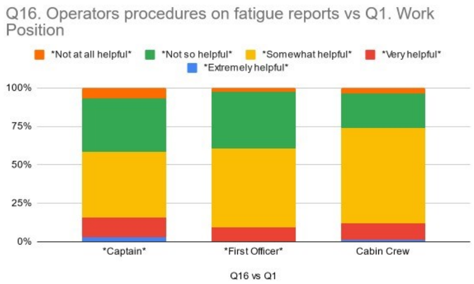

Q15. Actions on fatigue report vs Q2. Experienced Crew
"a. Strongly agree"
0,5%
"b. Agree"
7,9%
"e. Strongly disagr…
19,6%
"c. Neither agree n…
34,4%
"d. Disagree"
37,6%

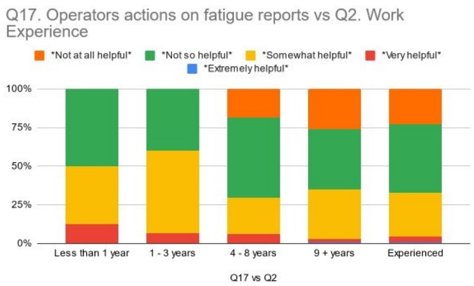

Q15. Actions on fatigue report vs Q1. Work Position
"a. Strongly agree"
"b. Agree"
"c. Neither agree nor disagree"
"d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
"Captain"
"First Officer"
Cabin Crew
Q15 vs Q1

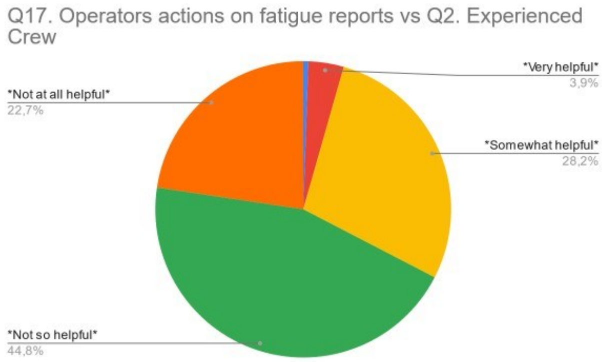
Operators Fatigue Mitigating Procedures

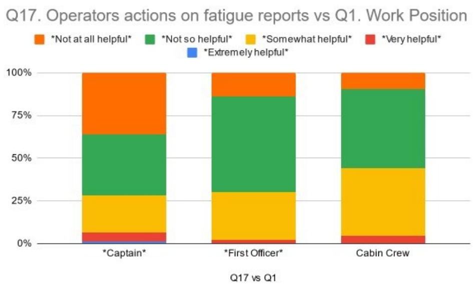




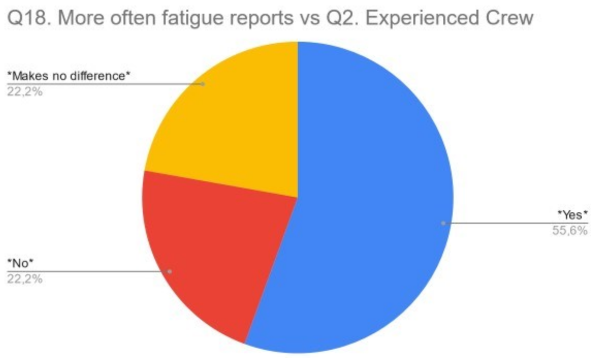


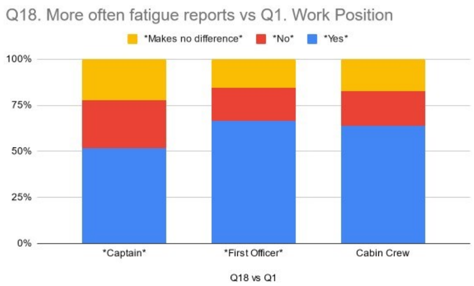


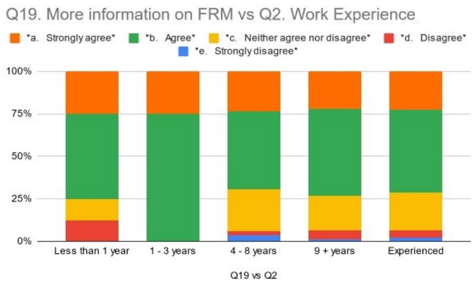


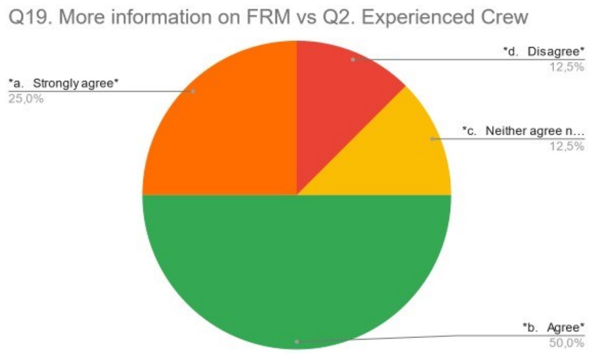


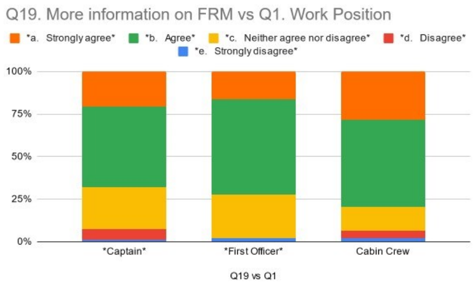

Q18. More often fatigue reports vs Q2. Work Experience
"Makes no difference" "No" "Yes"
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q18 vs Q2


Q18. More often fatigue reports vs Q2. Experienced Crew
"Makes no difference"
22,2%
"Yes"
55,6%
"No"
22,2%


Q18. More often fatigue reports vs Q1. Work Position
"Makes no difference" "No" "Yes"
100%
75%
50%
25%
0%
"Captain"
"First Officer"
Cabin Crew
Q18 vs Q1


Q19. More information on FRM vs Q2. Work Experience
"a. Strongly agree" "b. Agree" "c. Neither agree nor disagree" "d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
Less than 1 year
1 - 3 years
4 - 8 years
9 + years
Experienced
Q19 vs Q2


Q19. More information on FRM vs Q2. Experienced Crew
"d. Disagree"
12,5%
"a. Strongly agree"
25,0%
"c. Neither agree n...
12,5%
"b. Agree"
50,0%


Q19. More information on FRM vs Q1. Work Position
"a. Strongly agree" "b. Agree" "c. Neither agree nor disagree" "d. Disagree"
"e. Strongly disagree"
100%
75%
50%
25%
0%
"Captain"
"First Officer"
Cabin Crew
Q19 vs Q1

Appendix 3. Interview Questions

Interview Questions for Key Managers

1. Miten crew plannerit ovat koulutettu ymmärtämään väsymystä?
2. Mitkä ovat crew planningin toimenpiteet vähentääkseen lentomiehistön väsymystä sekä parantamaan vireystilaa?
3. Mitkä työkalut ovat crew planningillä käytössä työvuorosuunnitteluun?
4. Mitkä ovat näiden työkalujen heikkoudet sekä vahvuudet meidän operoinnissamme?
5. Onko jotain oleellista planningin toiminnassa mikä olisi hyvä tuoda lentäville paremmin esille?

Interview Questions for Key Managers

- Mitä tapahtuu fatigue raportille, kun se on vastaanotettu?
- Missä vaiheessa fatigue raportit johtavat jatkotoimenpiteisiin?
- Kuinka fatigue raporteista viestitään miehistölle?

Interview Questions for Key Managers

1. Mitkä ovat yhtiön väsymyshallinta toimenpiteet?
2. Missä vaiheessa fatigue raportit johtavat jatkotoimenpiteisiin?
3. Kuinka väsymyksen hallinasta viestitään miehistölle?

Appendix 4. Project Plan & Timeline