THE REPORTED PREVALENCE OF AIRCREW FATIGUE AND THE CONTRIBUTING FACTORS WITHIN THE SOUTH AFRICAN AVIATION INDUSTRY

BY

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THESIS

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ABSTRACT

Background and aim: Fatigue in aviation results from the complex interaction of various factors (both work and non-work-related) that are important to understand when attempting to manage it. Managing fatigue effectively is important given that it has and continues to influence crew wellness and aviation safety. One of the ways of managing fatigue is through appropriately designed Flight Time Limitations (FTLs) however; in South Africa there have been calls from the unions and the crew to update these in line with the latest science and operational demands and insights. Doing this requires the generation of context specific data, which this thesis aimed to provide as an initial step. Firstly, this study aimed to explore the reported prevalence of fatigue across the South African aviation industry. Secondly, it elucidated what factors (both work and non-work related) crew perceived contributed to fatigue and lastly, the crew‟s perceptions regarding the current FTLs were explored. **Methods:** To realize the aims of the study, an online survey was developed using existing literature initially, and through consulting with and getting information from aviation industry stakeholders and other experts in the field of aviation and fatigue. This consultation (which occurred over a number of iterations of the survey) ensured that there was a balance between the scientific and the actual operational perspectives on how best to explore crew perceptions around fatigue. The finalized survey was divided into five parts: part one was consent to participate; part two included questions pertaining to the participants‟ demographic information; part three included questions pertaining to the crews‟ perceptions around fatigue (its prevalence, its impact on safety and how it affected crew); part four explored crew‟s perceptions on fatigue contributory factors, both work and non-work related; finally part five included questions pertaining to crew perceptions about the current South African FTLs, specifically their concerns, suggestions for improvement and any aspects they considered as fatigue mitigating. The survey was made available via the South African Civil Aviation Authority‟s (SACAA) website as well as via the industry stakeholder‟s networks that encouraged all crew across the different sectors of the industry to participate. All numerical data collected were analysed descriptively through inferential statistics, while the qualitative data were analysed using thematic analysis. **Results:** 194 participants completed the survey, 167 were from cockpit and 27 were from the cabin crew. The results of the study highlight that there is a high perceived prevalence of fatigue. The crew also recognized that fatigue is a significant safety risk, but less indicated that fatigue interfered with their ability to do their duties. Crew reported that the length of duties, number of sectors flown, insufficient sleep at night, early sign-on‟s, late sign-offs, working too many consecutive days in a row, inadequate or irregular sleep before and during periods of duty, night flying, bad weather, severe turbulence, having young children or dependents to look after, financial stress, extended commuting to get to and from work, and poor diet were some of the work and non-work-related contributory factors to fatigue. In line with these findings, questions around the perceived concerns about the current FTLs revealed that crew were concerned about unclear definitions of the civil aviation regulations (CARs), the lack of control of disruptive rostering schedules, periods of high workload due to the number of sectors flown per duty, the length of duty periods and effects of being on standby duty, inadequate rest between duties and strings of duty. The crew also had concerns regarding the Flight Duty Periods (FDPs) where the crew were concerned with the flying limits being used as targets by the operators, a lack of science applied to the FDPs, and that the current FDPs are outdated. The recommendations included limiting disruptive rostering schedules by altering standby provisions for the crew, instilling a block roster schedule, disallowing double signing on and off on the same day, and reducing split shifts. The crew also recommended adjusting duty durations by adjusting daily and monthly limits, tapering duty lengths, but also limiting discretionary extensions. Increasing rest provision was another recommendation suggested by the crew and included increasing the number of rest days off as well as the minimum hours of rest between duties needs to be increased. The fatigue mitigating aspects were minimal if any. **Conclusion:** Overall the study revealed that there is a high perceived prevalence of fatigue within this sample of the South African aviation industry and that the concerns outlined by crew around the contributory factors to fatigue are consistent with previous research, but also reflect the unique operating context of South Africa. This study serves as a base from which to explore more specific areas of the crew working time that are disruptive to sleep. This may help operator‟s roster duties in a more predictable way to limit the incidence of fatigue, while also offering the opportunity for the regulator and other stakeholders to focus their efforts on how to better design the current FTLs to limit the prevalence and risks associated with crew fatigue.

Keywords: Fatigue prevalence, work and non-work related factors, Flight Time Limitations (FTLs), survey

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CHAPTER 1

1. INTRODUCTION

The demands of modern aviation often require crew to work under stressful conditions, for extended periods, completing multiple takeoffs and landings, at times of day during which they should sleep and in time zones that conflict with their innate circadian rhythms, the result of which is the development of crew fatigue (Caldwell, 2004; Caldwell, 2005; Powell *et al.,* 2008; Caldwell *et al.,* 2009; Avers & Johnson, 2011; Caldwell *et al.,* 2012; Gander *et al.,* 2014; International Civil Aviation Organisation (ICAO), 2015; Reis *et al.,* 2016; Kandera *et al.,* 2019; Sallinen *et al.,* 2020; Efthymiou *et al.,* 2021; Åkerstedt *et al.,* 2021; Wingelaar *et al.,* 2021). These demands may interfere with the crew‟s ability to obtain adequate sleep and rest, which can in turn, result in sleep loss and fatigue, which can accumulate over a string of duties. Combined with the demands of trying to balance work and personal life, crew fatigue has and continues to pose threats to crew wellbeing and performance ability and flight safety (Caldwell, 1997; Gander *et al.,* 1998; Caldwell and Caldwell, 2003; Powell *et al.,* 2007; European Cockpit Association, 2012; Honn *et al.,* 2016).

In recognition of the ongoing challenges that fatigue has and continues to present to aviation safety, operators are required to manage fatigue through the implementation of one of two approaches or, in some instances, a combination of them. The first, the prescriptive approach, requires the compliance of the operator in terms of the duty time limits that are defined by the state while managing fatigue as part of their broader Safety Management System (SMS) programs (Gander, 2005; Gander *et al.,* 2011; ICAO, 2015). Fatigue management using an SMS requires shared responsibility between the state, operators, and individuals (ICAO, 2015; Honn *et al.,* 2019). The state‟s responsibility is to provide a regulatory framework that limits the effects of working times that are associated with the development of fatigue. These include placing limits on the number of consecutive duty periods, the length of duty periods in relation to the time at which duty starts, limiting the cumulative number of flight and duty periods per week, month and year, and providing adequate rest following periods of duty (Brown, 2006; Cabon *et al.,* 2008; ICAO, 2015). The operators have the responsibility to ensure the crews fly within the prescribed legal limits set down by the state. In addition, the operators are required to provide education on how to recognize and manage fatigue, while also implementing or rostering work schedules that enable individuals to obtain enough sleep and rest between duties to ensure that the crew are fit to report for their next duty (Brown, 2006; Cabon *et al.,* 2008; ICAO, 2015). The operators are also responsible for managing and monitoring fatigue hazards, such as those presented by extended duties, early starts, late finishes, flying at night, trans-meridian travel, and high sector duty periods (Gander, 2005; Gander *et al.,* 2011; ICAO, 2015; Federal Aviation Administration, 2018). Lastly, individual crew members have the responsibility to arrive fit for duty, which requires them to have made appropriate use of non-work periods to obtain adequate sleep and rest, while also reporting fatigue hazards or concerns, or whether they are impaired due to fatigue (Gander, 2005; Gander *et al.,* 2011; ICAO, 2015).

The second approach to managing fatigue in aviation is risk-based and requires the operator to implement a Fatigue Risk Management System (FRMS) that can only be implemented with the state"s approval (Gander, 2005; Brown, 2006; Gander *et al.,* 2011; ICAO, 2015). An FRMS approach provides operators with an opportunity to use advances in scientific knowledge to improve safety, fatigue management, efficient use of resources, and increased operational flexibility (Gander, 2005; Gander *et al.,* 2011b; ICAO, 2015). An FRMS approach allows the operator to operate outside the prescribed flight and duty limits (the prescriptive approach) and focuses on the management of actual fatigue risks, which are identified and mitigated iteratively and continuously by the operator to ensure safe operation (Brown, 2006; Cabon *et al.,* 2008; FAA, 2013; Gander *et al.,* 2014a; ICAO, 2015; Gander *et al.,* 2019). However, the implementation of an FRMS is labour intensive and costly and requires operators to plan, monitor, and submit evidence of the effectiveness to the Regulator/state on an ongoing basis (Gander *et al.,* 2011). These are however beyond the scope of this thesis.

With respect to Flight and Duty limits prescribed by the state, ICAO makes two broad recommendations that are critical for when regulatory bodies are designing or amending these limits prior to implementation. Firstly, the limits need to reflect a balance between the latest scientific evidence concerning sleep and circadian-related sciences, as well as the latest operational experience and insights (ICAO, 2015). Secondly, the design of these limits should also consider the unique operating context in which they are to be applied while also being underpinned by context-specific data. In light of these recommendations and the changes in both scientific understanding and operational demands, various regulatory bodies across the world have made amendments to their Flight and Duty Limitations. These include the Federal Aviation Administration (FAA) in the United States of America, European Aviation Safety Agency (EASA) in Europe, Civil Aviation Safety Authority (CASA) of Australia, the Civil Aviation Authority of New Zealand, and Transport Canada Civil Aviation (TCCA)) of Canada (ICAO, 2015; EASA, 2017; Government of Canada, 2018). Some of the changes have included the provision of longer rest periods, changes relating to shortened flight duty times with more time for recovery, as well as reductions in the number of consecutive duties, managing the crews‟ workload by limiting the number of sectors per duty, reducing the number of consecutive night flights, as well as reducing the consecutive early sign-on‟s and late finishes (ICAO, 2015; EASA, 2017; Government of Canada, 2018; Civil Aviation Authority of New Zealand, 2021; Åkerstedt *et al.,* 2021). While there are no universally acceptable working arrangements, such attempts at reducing that impact of disruptive and fatiguing duties do reflect attempts at trying to limit the impact of sleep loss and fatigue on aviation safety.

In South Africa, a low-to-middle income country (LMIC), the Airline Pilots‟ Association of South Africa (ALPA-SA) initiated a similar call to action in 2016 where union stakeholders called on the Regulator to make changes to South Africa‟s current Flight Time Limitations (FTLs). This sparked a debate within the South African aviation industry and other stakeholders (the Airline Pilots Association of South Africa, the Airlines Association of Southern Africa, and the South African Civil Aviation Authority) around the appropriateness of the current FTLs. This group, following several years of debate about the status of the current Flight Time Limitation regulations, agreed that the current regulations did not reflect the latest understanding of sleep and fatigue science, nor did they reflect the changes in the operational demands in South Africa. As argued by ICAO (2016) the management of fatigue, through appropriately designed regulations and rostering practices, requires context-specific data underpinned by the latest science and operational insight. Out of this call, emerged this research project, which aimed to assist by exploring, as an initial step, the perceptions of the crew from across the industry about the prevalence of and contributory factors to fatigue in the South African aviation industry. This data would then form the basis for future research and decision-making around any proposed changes to the FTLs in South Africa.

Apart from the industry-driven interest, to date, there has been extensive research in other contexts relating to the prevalence of, and contributors to fatigue in aviation (Rosekind *et al.* 1996; Caldwell, 1997; Gander *et al.* 1998a, 1998b; Co *et al.* 1999; Bourgeois-Bougrine *et al.* 2003; Caldwell and Caldwell, 2003; Signal *et al.* 2003; Petrie *et al.* 2004; Caldwell, 2005; Jackson and Earl, 2006; Powell *et al.* 2007; Powell *et al.* 2008; Caldwell *et al.* 2009; Caldwell, 2012; European Cockpit Association, 2012; Roach *et al.* 2012; Reis *et al.* 2013; Vejvoda *et al.* 2014; Caldwell and Caldwell, 2016; van Leeuwen *et al.* 2017; Lee and Kim, 2018; European Union Aviation Safety Authority, 2018; Cabon *et al.* 2019; van den Burg *et al.* 2020; Bendak and Rashid, 2020; Åkerstedt *et al.* 2021), but there has been comparatively less in South Africa. Thus, there is a need to understand, in the first instance, the reported prevalence of fatigue among crew across the aviation industry in South Africa, while also identifying common work and non-work related factors that crew perceive to contribute to fatigue. Additionally, given that that all crew cockpit and cabin crew and short-haul and long-haul crew) are required to work under the same current FTLs, but may have different demands placed on them during their duty, it is important to gain insights from the crew on their perceptions of these regulations, specifically regarding what role they play in the mitigation (or accentuation) of fatigue.

In light of this, the overall aims of the study were to quantify the reported prevalence and severity of fatigue in the industry; to understand both the work and non-work-related factors that the crew perceived contributes to fatigue; and garner perceptions about the current FTLs in various parts of the South African aviation industry.

The objectives of the study are as follows:

1. The first objective was to quantify the perceived prevalence and severity of fatigue and its impact on the crew from all parts of the aviation industry, both in scheduled and non-scheduled aviation settings.
2. The second objective was to quantify the perceived work and non-work-related factors for the cockpit, cabin crew and short and long-haul crew that contribute to fatigue in the South African aviation industry
    2.1. To explore any differences in the reported fatigue contributing factors between cockpit and cabin crew and short and long haul crew.
3. The third objective was to garner perceptions around the current South African Flight Time Limitation regulations concerns regarding the current FTLs, recommendations to address the concerns and determine if the crew perceives whether there is any fatigue mitigating aspects of the current FTL regulations.

CHAPTER 2

2. REVIEW OF LITERATURE

2.1 The aviation industry: an overview

The global, passenger-carrying airline industry is made up of over 5000 airlines that operate more than 25 000 commercial aircraft and provide services to over 3700 airports worldwide (International Civil Aviation Organisation, 2016; Wyman, 2021). The annual growth of world air travel has averaged approximately 5% over the past 30 years (Mazareanu, 2020). During 2019, the world‟s airlines flew more than 38.3 million scheduled flights and transported over 4.5 billion passengers (International Civil Aviation Organisation, 2019). This growth was made possible by a range of developments within the industry - with improvements in aircraft technology, it is now possible for more passengers to access air transport and for flights to be longer than before (e.g: Ultra Long Range) (Federal Aviation Administration, 2010; Mazareanu, 2020; International Air Transport Association, 2020). At the beginning of 2020, however, the Coronavirus pandemic caused a major decrease in global passenger numbers, resulting in only 1.8 billion passengers making use of aviation transport during that period (Mazareanu, 2020). This resulted in a 60% loss in global air passenger traffic (International Air Transport Association, 2020; Mazareanu, 2020). Consequently, the airline industry, as a whole, during 2020, lost US$ 371 billion in revenue (ICAO, 2021).

From an African perspective, the aviation industry pre-COVID-19 supported 6.2 million jobs and contributed US$ 55 billion (ZAR 841. 373 billion) of GDP to the African economy (ICAO, 2019). There were 41 million domestic, and 74 million international passengers who flew to and from Africa during 2019 (Wilhem, 2021). However, due to the COVID-19 pandemic, there has been a decrease in both regional and international annual passenger numbers, with a 26 million and 35 million passenger loss from 2019 to 2020 respectively (Wilhem, 2021).

The South African aviation industry is estimated to have contributed US$9.4 billion (ZAR133. 96 billion) to South Africa‟s gross domestic product (GDP) since 2017 (International Air Transport Association, 2016; IATA, 2018). An additional US$5.1 billion gross value was added due to the spending of foreign tourists in the country, which meant that 3.2% of the country‟s GDP is supported by the aviation industry and specifically from tourists arriving by air (IATA, 2016). Additionally, the South African aviation industry employs over 70 000 South Africans, and the purchasing of goods from local suppliers has created an additional 130 000 jobs (IATA, 2016). Every year, around 390 000 aircraft land in or take off from South Africa from both scheduled and non-scheduled aviation operations, with the majority from scheduled aviation (IATA, 2016).

Scheduled aviation includes all passenger and cargo flights that operate on regularly scheduled routes, whereas non-scheduled aviation includes all other civil flights, both commercial, private, and non-commercial operations, such as aerial firefighting, crop spraying, and medical emergency services to name but a few (ICAO, 2019). Within the South African aviation industry, there are several different parts (summarised in Table 1), all of which are governed by the Civil Aviation Regulations (CARs) (Department of Transport, 2012). These include Part 93 (Corporate aviation operations and high-performance aircraft); Part 121 (Air transport operations: carriage on aircraft of more than 19 passengers or cargo); Part 127 (Commercial helicopter operations); Part 128 (Helicopter aerial work and certain other air operations); Part 135 (Small air transport operations); Part 137 (Aerial work operations); Part 138 (Air ambulance operations) (Department of Transport, 2012).

Table 1. The different Parts of the South African Civil Aviation Regulations.

Classifying body	**Part**	**Description**
South African Civil Aviation Authority (SACAA)	Part 93	Corporate aviation operations and high performance aircraft.
	Part 121	Air transport operations: carriage on aircraft of more than 19 passengers or cargo.
	Part 127	Commercial helicopter operations.
	Part 128	Helicopter aerial work and certain other air service operations.
	Part 135	Small air transport operations.
	Part 137	Aerial work operations.
	Part 138	Air ambulance operations.

Safety in the aviation industry

Although the aviation industry is considered ultra-safe (Wingelaar-Jagt *et al.,* 2021), many factors may threaten aviation safety (IATA, 2018). Broadly, these include, inter alia, the effects of climate change, weather, infectious diseases like COVID, bio-hacking, insider threats that present potential internal risks to airlines, civil unrest which may impact the crew during their layovers away from home base, flights that operate in the airspace of conflict zones, human trafficking, contraband smuggling, inadequately documented passengers, and terrorism (IATA, 2018). With specific reference to crew suitability to operate, a significant challenge, which has and continues to affect crew performance, while being complex to manage, given its multifaceted nature is fatigue (Caldwell, 1997; Åkerstedt, 2000; Caldwell and Caldwell, 2003; Goode, 2003; Kandera *et al.,* 2019; Levin *et al.,* 2019; Wingelaar-Jagt *et al.,* 2021). Various personal and work-related factors contribute to fatigue and include circadian rhythm disruptions, flying across time zones, disrupted sleep, consecutive duties, early starts and late finishes, extended duties, inadequate rest and night flying (Caldwell *et al.,* 2009; Gander *et al.,* 2009; Hartzler, 2013; Lee and Kim, 2018). Prior to unpacking the factors that contribute to fatigue in aviation settings, it is important to define what the term means.

2.2 Definition of fatigue in the context of aviation

Understanding fatigue is critical in several industry settings, including aviation (Caldwell, 2004; Taneja, 2007; Civil Aviation Safety Authority, 2013; Caldwell and Caldwell, 2016). For this thesis, as outlined by the International Civil Aviation Organisation (ICAO), fatigue is defined as a *‗physiological condition of reduced physical or mental performance capability which results from sleep loss, extended wakefulness, circadian phase, and or workload (mental and or physical activity) which can impair a person‘s alertness and ability to perform safety-related operational duties adequately‘,* ICAO (2019, p. 1).

2.3 Fatigue in aviation and its role in accidents

While difficult to determine the effects of fatigue on aviation safety, an indicator of the risk it presents to safety is to highlight when it has been implicated in aviation accidents and incidents. The following section will provide an overview of accidents that have involved fatigue (refer to Table 2) (Baker *et al.,* 2001; Speers and McCulloch, 2014). The section thereafter will be an overview of factors that are unique to aviation that contributes to fatigue and the final section will look at the different approaches used to mitigate fatigue.

Table 2. Insight into how pertinent the risk presented by fatigue in the aviation industry is, and these accidents serve as a means of demonstrating the risks that fatigue, alongside other factors, may present to safety. The cases range from the year 1994 to the year 2016. The letters in **bold** indicate factors that contributed to the accidents.

Date	Airline/Location	Description and factors implicated in the accidents
21 December 1994	Air Algerie	The aircraft crashed, killing five people (aircrew and passengers). **The flight crew was fatigued**; they had had **10-hours of flight duty**, with **five flight sectors** which included **six approaches to land** (Air Crash Investigations Branch, 1996).
6 August 1997	Korean Air	A Boeing 747-300 aircraft crashed on approach to landing, killing all 223 passengers and crew on board. **Captain"s fatigue was cited in the report as a contributing factor to the crash** (National Transportation Safety Board, 2000).
18 August 1998	Guantanamo Bay	The pilot stalled the aircraft upon approach to landing. He was unable to monitor the aircraft"s safe flight. **The crew had been on duty for 18-hours, flying for 9 of them and was suffering from circadian rhythm disturbance, plus a lack of sleep** (Moebus Aviation, 2008). **Fatigue was the cause and in this incident, it was the first time fatigue was cited as the primary cause** (Moebus Aviation, 2008).
1 June 1999	American Airlines	A Douglas MD-82 aircraft overran the runway upon landing and crashed, killing the captain and ten passengers. **Pilot"s had been on duty for just under 14-hours** (Moebus Aviation, 2008).
25 June 2007	Stockholm/Arlanda	Cathay Pacific 747F aircraft collided with the ground surface at Stockholm airport Arlanda. An investigator said the **crew had been awake for 18-20 hours and fatigue was a major factor** (Navara and Nelson, 2007).
12 February 2009	Colgan Air/Buffalo	The Bombardier Dash 8-Q400 aircraft crashed, killing all fifty on board passengers and crew members. **Fatigue was cited as a contributing factor and the co-pilot had to frequently commute across the United States of America in order to report for duty** (CASA, 2013).
25 January 2010	Beirut to Addis Ababa	An Ethiopian flight 409 aircraft crashed in the Mediterranean Sea shortly after take-off which killed all 90 people on board. The final cause of the accident was not conclusive but **one of the contributing factors to the accident was fatigue** (Directorate General of Civil Aviation, 2011). **The captain of the aircraft had had a heavy meal for dinner which inhibited him from having a proper sleep before the day of the crash** (Directorate General of Civil Aviation, 2011). **In combination with tiredness, emotional stress, imbalances of blood chemistry as well as fatigue and stress were concluded to be contributing factors to the accident** (Directorate General of Civil Aviation, 2011). **The captain had also accumulated than 180 hours of flying and it was a new type of aircraft within the last 51-days which meant he was often flying at different hours of the day** (Directorate General of Civil Aviation, 2011). Even though the number of hours he had been flying was within the legal limits, it could have created some **periods of acute fatigue** due to a **combination of mental activity that is required to fly a new aircraft as well as the physical activity (excessive) that is associated with a tight schedule** (Directorate General of Civil Aviation, 2011).
19 March 2016	FlyDubai/Rostov-On-Don	A Boeing 737-800 aircraft crashed in the southern Russian city Rostov-On-Don, killing all 62 passengers and crew on board due to **11 consecutive days of flying with only one day for recovery (day and night flights) caused the pilot to fatigue which resulted in the fatal accident** (Bonnet and Arand, 2003; Interstate Aviation Committee, 2019).

With reference to Table 2, several key factors appear to be common contributory factors to crew fatigue in the accidents outlined above. In most cases, the crew had been on duty for an extended period, which in turn means that they had been awake for an extended time, which, as will be discussed below, is associated with increased sleepiness and reductions in alertness. Another common characteristic of many of these accidents was in some cases, crew worked consecutive duties, which may have resulted in the crew not getting adequate sleep and rest, which can lead to cumulative sleep loss and fatigue. Aside from these, duties at night, having to complete complex tasks like landing after extended duties and high numbers of sectors and dealing with circadian disruption due to the demands of flight were other factors implicated in these findings. While not exhaustive, these examples highlight the complex, multifaceted nature of fatigue in aviation. It is therefore not surprising that, for 40-years, the National Transportation Safety Board (NTSB) has issued over 200 safety recommendations that focused on fatigue (Marcus and Rosekind, 2017). In addition, fatigue has been on the NTSB‟s most-wanted list of safety-related priorities since as far back as 1990 (Caldwell, 2012), with other states (the European Union, Canada, Australia and New Zealand) (Civil Aviation Authority of New Zealand, 2017; European Union Aviation Safety Agency (EASA), 2018; Government of Canada, 2018; Civil Aviation Safety Authority, 2020) also recognizing the risks that fatigue can present to aviation safety.

Prevalence of fatigue in the aviation industry

Previous research has explored factors that have contributed to fatigue as well as the prevalence of fatigue to gain insights into whether fatigue is a risk factor for the crew (Bourgeois-Bougrine *et al.,* 2003; Petrie *et al.,* 2004; Jackson and Earl, 2006; Avers *et al.,* 2009; Caldwell, 2009; European Cockpit Association, 2012; Reis *et al.,* 2013; Caldwell and Caldwell *et al.,* 2016; van Leeuwen *et al.,* 2017; Van Dijk *et al.,* 2019; Cabon *et al.,* 2019; van den Burg *et al.,* 2020; Wen *et al.,* 2021). While limited, the use of self-reports of fatigue and the associated contributory factors are useful to get an initial overview of the extent of the problem, as reported by the crew who do the work (EASA, 2018). Below, in Table 3 is a summative overview of previous research that has explored the reported prevalence of and factors associated with fatigue from pilots and cabin crew over 17 years (ranging from 2003 to 2021) from different parts of the world. The published results attained are therefore important for both researchers and operators to get a sense of crew experiences and perceptions concerning their experiences of fatigue.

Table 3. Prevalence of fatigue-related studies and surveys and an overview of factors that contributed to crew fatigue over a 17-year period (2003 to 2021).

Author(s) and year	**Country/area**	**Part of industry**	**Total no. of participants/respondents**	**Method of data collection**	**Prevalence of fatigue and factors associated with fatigue**
Bourgeois-Bougrine *et al.* (2003)	France	121	739	An online fatigue survey for short-haul and long-haul pilots.	There were 739 airline pilots in this study. Self-reported manifestations of fatigue in 60% of long-haul flight pilots and 49% of short-haul flight pilots included reduction in alertness and attention and a lack of concentration.
Petrie *et al.* (2004)	New Zealand	121	253	Fatigue survey for all Air New Zealand long-haul pilots only.	33 (13%) of participants reported significant fatigue from their job. Overall, 33 (13%) responded that they experienced significant fatigue from their job as a pilot three times a week or more, and 43 (17%) reported experiencing fatigue only once every two-weeks or less. There were no significant differences in the scores of this item by the fleet. Overall, 162 (64%) of the pilots reported significant fatigue from their job once a week or more.
Jackson and Earl, (2006)	United Kingdom (UK)	121	162	Online fatigue-based survey for short-haul pilots only.	114 (75%) reported severe fatigue and 81% reported it to be worse in the last two years. Severe fatigue was reported more frequently by low-cost airline pilots than scheduled airline pilots.
Avers *et al.* (2009)	United States of America	121	10550 completed surveys	A retrospective survey for flight attendant"s only.	84% (8862) of respondents reported being fatigued whilst on duty. In addition, the study found that ling duty hours, consecutive duty days, length of layovers, long delays, breaks, and nutrition were issues of concern for the flight attendants.

European Cockpit Association (ECA), (2012)	Europe	121	6000	Self-assessment of fatigue via a survey for cockpit and cabin crew from Austria, Denmark, France, Germany, Netherlands, Norway, Sweden, and the United Kingdom.	85% of the Austrian pilots (n=422) were too fatigued for flight duty while on the flight deck. More than 85% of the Danish pilots (n=575) admitted that they were too fatigued for flight duty. 90% of the French pilots (n=800) who experienced fatigue attributed it to their job. 92% of the German pilots (n=2807) have experienced fatigue and should not have been flying, and 93% admitted to making a mistake in the cockpit due to fatigue. 72% of the Dutch pilots (n=660) have regularly felt not fully rested after a normal night‟s sleep. 50% of the Norwegian pilots (n=389) admitted to falling asleep in the cockpit. 30% of Swedish pilots (n=625) fell asleep on duty every now and then due to fatigue. Whereas 70% admitted to making mistakes that was the result of tiredness or fatigue. 45% of the United Kingdom‟s pilots (n=492) were suffering from clinically relevant levels of fatigue. In addition, 45% of the pilots also admitted that their abilities in flight were often compromised by fatigue.
Reis *et al.* (2013)	Portugal	121	456	A questionnaire for Portuguese commercial airline pilots only, who had flown in the last six months.	The prevalence of reported fatigue by the participants was 89.3% for long-haul and 94.1% for short-haul.
van Leeuwen *et al.* (2017)	Sweden	121	598	Web-based survey for Swedish Airline Pilots Association for short and long-haul pilots only, on working conditions, sleep, health and fatigue.	Errors and fatigue prevalence were attributed to both short and long-haul pilots.
Van Dijk *et al.* (2019)	Europe	121	15680	An online fatigue based survey for both cockpit and cabin crew.	In this study the participants identified fatigue causal factors, including: long duty days; followed by early starts; and flying during hours when the participants would normally sleep.
Cabon *et al.* (2019)	European Union Commission	121	413	A survey using bio-mathematical models on cockpit crew only.	136-148 (33-36%) of participants experienced high levels of subjective fatigue.

van den Burg *et al.* (2020)	New Zealand	121	25	Three focus group discussions on cabin crew only.	The participants attributed the cause of their fatigue to insufficient rest, workload, work environment, and lack of company support.
Wen *et al.* (2021)	The United States of America, United Kingdom, United Arab Emirates, Hong Kong, Singapore, Australia, and New Zealand	121	930 responses	An anonymous online survey distributed to active cabin crew.	63% of the participants reported high levels of fatigue; 46.9% experienced excessive daytime sleepiness; and 68% were at risk for shift work disorder.

As summarised in Table 3, prevalence rates differ across different contexts and operations, and it is difficult to get a sense of this given the extent of the problem given the different approaches that researchers have taken (Avers *et al.,* 2009; ECA, 2012). However, there are several common factors that crew reported to contribute to fatigue. These included but are not limited to, long duty hours, early starts, night flying, periods of high workload, inadequate rest, and a lack of company support when fatigue-related issues are raised. While there are evident limitations with self-reports, overall, these studies point to the fact that fatigue does present a concern for the crew (Bourgeois-Bougrine *et al.,* 2003; Petrie *et al.,* 2004; Jackson and Earl, 2006; Avers *et al.,* 2009; Caldwell, 2009; European Cockpit Association, 2012; Reis *et al.,* 2013; Caldwell and Caldwell *et al.,* 2016; van Leeuwen *et al.,* 2017; Van Dijk *et al.,* 2019; Cabon *et al.,* 2019; van Den Burg *et al.,* 2020; Yu, 2020; Wen *et al.,* 2021).

2.3.1 Contributing factors to fatigue in aviation

As defined by ICAO, fatigue results from extended wakefulness, disruptions to sleep and circadian rhythmicity, and the impact of workload. Therefore, it is important to understand sleep and its role in human well-being and performance, while appreciating what factors, both personal and work-related, may affect crew getting adequate sleep and therefore, experiencing fatigue (Powell *et al.,* 2007; Powell *et al.,* 2008; Croft, 2009; Caldwell *et al.,* 2009; Srinivasan *et al.,* 2010; Zhu and Zee, 2012; Paragliola *et al.,* 2021).

2.3.1.1 Sleep in humans

As argued by many researchers, one major contributor to fatigue is disruptions to sleep and circadian rhythmicity (Schernhammer *et al.,* 2003; Powell *et al.,* 2008; Caldwell *et al.,* 2009; Srinivasan *et al.,* 2010; Williamson *et al.,* 2011; ICAO, 2016; Potter *et al.,* 2016; Watson and Van Dongen, 2020; Mason *et al.,* 2021). Therefore, it is important to characterise what sleep is, how it is controlled, and to understand what factors disrupt sleep.

Sleep is a regular and inevitable state characterised by a decline in behavioural responsiveness and consciousness to the surrounding environment (Boly *et al.,* 2008; Carskadon and Dement, 2011; Chiu and Prober, 2013; Vorster and Born, 2015; Bayne *et al.,* 2016; Libourel and Herrel, 2016). Sleep fulfills important biological functions and plays various important roles that are essential for life (Schultes *et al.,* 2005; Zielinski *et al.,* 2016). During sleep, many important processes take place, which enables the body to physically recover and repair. It also aids in brain development, hormone regulation, assists in body metabolism, cardiac function, and aids in autonomous nervous and immune systems repair and function (Spiegel *et al.,* 1999; Meier-Ewert *et al.* 2004; Schultes *et al.,* 2005; Copinschi, 2005; Van Cauter *et al.,* 2008). Sleep is also important for memory consolidation and learning (Diekelmann and Born, 2010; Ackerman and Rasch, 2014; Boyce and Adamantidis, 2017; Xia and Storm, 2017; Chouchou *et al.,* 2018). Although memories are encoded when humans are awake, sleep allows for effective consolidation and stabilisation of memories and for them to be integrated into long-term memory (Brown *et al.,* 2012; Besedovsky *et al.,* 2012; Rasch and Born, 2013; Besedovsky *et al.,* 2019).

While sleep need differs across age groups and between individuals, for adults (ages 24-64), the average recommended sleep duration ranges from six hours to nine hours (Van Dongen *et al.,* 2003; Simpson and Dinges, 2007; Sallinen *et al.,* 2008; Hor and Tafti, 2009; Goel *et al.,* 2009; Hirshkowitz *et al.,* 2015). The ability for individuals to obtain this required amount of sleep is affected by a range of factors, which directly or indirectly affect the mechanisms that control sleep. Prior to reviewing factors that disrupt sleep, it is important to have an understanding of these regulatory mechanisms.

2.3.1.1 The two-process model of sleep regulation

While the regulation of sleep is complex and involves multiple systems in the body, the two-process model of sleep regulation offers a tangible overview of two key processes that drive sleep-wake behaviour (Borbely, 1982; Daan *et al.,* 1984). The sleep-wake cycle is regulated by two mechanisms: the sleep-homeostatic process (Process S) and the circadian process (Process C) (Borbely, 1982; Daan *et al.,* 1984) which is expanded upon below.

2.3.1.1.2 Process S

Sleep-wake homeostasis („Process" S in Figure 1) refers to the build-up of sleep-inducing substances within the brain, for example, Gamma-Aminobutyric acid (GABA), which is a neurotransmitter that reduces stress, eases anxiousness, creates a calmness of mood, and induces sleep (Gottesmann, 2002; Winkelman *et al.,* 2008; Borbely *et al.,* 2016; Fang and Rao, 2017). Process S is a biochemical system that operates like a pressure system, in that the longer an individual is awake, the higher the sleep pressure is, and the only way to reduce the sleep pressure is to sleep (Borbely *et al.,* 2016; Fang and Rao, 2017). Figure 1 shows the wave-like system associated with Process S (Borbely *et al.,* 2016).

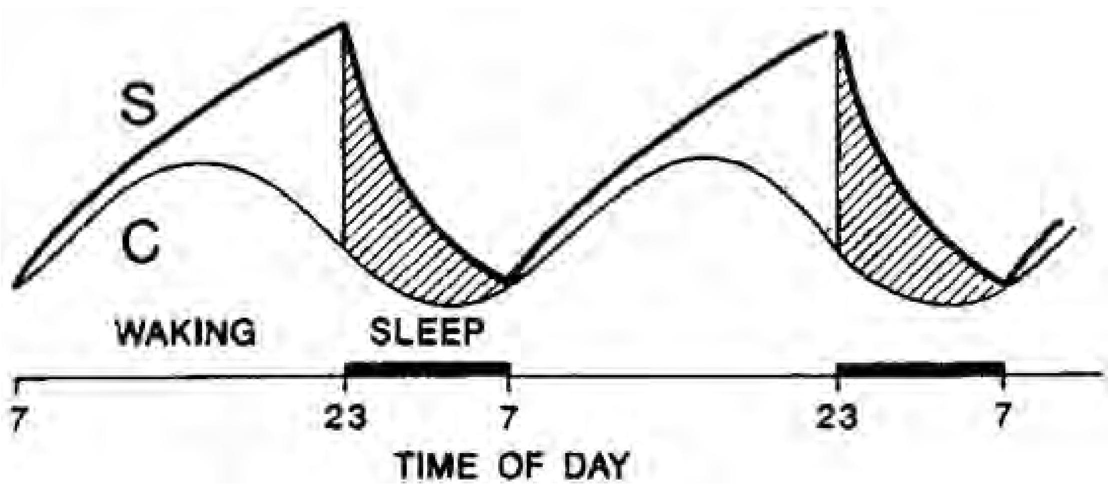

Figure 1: Two process model of sleep regulation over 48 hours (taken from Borbely, 1982).

2.3.1.1.3 Process C

The circadian process („Process C‟ in Figure 1) also influences the timing of sleep and coordinates the body‟s response to changes in the light-dark cycle of day and night (Czeisler *et al.,* 1999; Carrier and Monk, 2000; Blatter and Cajochen, 2006; Farhud and Aryan, 2018). In addition, the circadian rhythm, which is evident in many physiological and behavioural processes, is roughly a 24-hour rhythm that originates from the master clock‟s interaction with the external environment (Ralph *et al.,* 1990; Blatter and Cajochen, 2006; Zhu and Zee, 2012; Potter *et al.,* 2016; Farhud and Aryan, 2018).

The master clock, or suprachiasmatic nucleus (SCN), is situated in the anterior region of the hypothalamus (Ralph *et al.,* 1990; Zhu and Zee, 2012; Potter *et al.,* 2016). The master clock regulates the timing of periods of physiological arousal and wakefulness, and the circadian rhythm in various physiological processes such as the release of cortisol and melatonin (Schwartz and Roth, 2008). These hormones are released during different times of the day and at night and in turn, influence behavioural factors such as alertness and performance, such that humans are more alert during the daylight hours and more likely to sleep at night (Carrier and Monk, 2000; Blatter and Cajochen, 2006; Vansteensel *et al.,* 2007). Various other physiological processes also demonstrate circadian rhythmicity, including body temperature, urine output, feeding schedule, and metabolism (Güldür and Otlu, 2017).

The alignment between the biological clock and changes in the external environment is referred to as entrainment and occurs when the clock becomes synchronised to zeitgeber‟s or time givers (Roenneberg *et al.,* 2003). The most important zeitgeber is light (Freedman *et al.,* 1999; Panda *et al.,* 2002). Light (both artificial and natural), is detected via the eyes due to a combination of the rods, cones, and a retinal photopigment called melanopsin (Weaver, 1998; Roenneberg and Merrow, 2016; Lewis *et al.,* 2018). The retinal signals are then transferred to the SCN through the collaterals of the optic nerves, which then synchronise the daily rhythm to about 24-hours (Weaver, 1998; Roenneberg and Merrow, 2016; Lewis *et al.,* 2018).

The circadian rhythm of certain physiological responses demonstrates clear peaks and troughs at different times of the day. For adults, the strongest drive to sleep occurs between 2:00 am and 4:00 am (referred to as the circadian trough or nadir or, in the context of aviation, the Window of Circadian Low, see Figure 1. Depending on age and chronotype (the degree of morningness or eveningness), the acrophase or peak can occur in the late afternoon or early evening and is known as the forbidden zone for sleep (where Process C is at its highest point, Figure 1). At this point, Process C and the associated physiological changes interfere with the onset of sleep, therefore making it difficult for individuals to sleep. Conversely, the circadian rhythm can also make individuals feel more alert during certain times of the day even after extended periods of wakefulness (Vansteensel *et al.,* 2008; Potter *et al.,* 2016). Taken together, these processes simultaneously, albeit asynchronously, regulate sleep-wake behaviour. It is the disruption of these processes by various personal and work-related factors in the aviation industry that need to be taken into account, as these may contribute to sleep loss and circadian disruption, and increased the risk of fatigue.

2.4 Personal factors that influence sleep

Several personal factors (non-work related) influence an individual‟s ability to obtain adequate quantity and quality of sleep. These include (but are not limited to) age; health status; lifestyle behaviours and commuting. In addition, other factors influence sleep such as sleep disorders, use of medication, and medical conditions to name but a few (Bercovitch and Tsai, 2012; Lim, 2012), however, these are beyond the scope of this thesis. As a point of departure, while beyond the scope of an operator‟s responsibilities to manage in the context of aviation, understanding the impact of these personal and non-work-related factors, alongside work-related factors, on sleep, is important to understand and manage fatigue.

2.4.1 The impact of age on sleep

Throughout life, the need for sleep changes but from adulthood, the need for sleep remains relatively stable (between seven and nine hours) (D‟Ambrosio and Redline, 2014). However, the ability to obtain that correct amount of sleep changes (Co *det al.,* 1999; Ohayon *et al.,* 2004; Espiritu, 2008; Crowley, 2011; D‟Ambrosio and Redline, 2014; Gadie *et al.,* 2016; Li *et al.,* 2018). Furthermore, there are changes in hormone production and release with increasing age, where less melatonin is secreted, and this may play a role in disrupted sleep experienced by older adults (Vitiello, 2006). A meta-analysis of 65 studies with 3577 participants across their lifespan, reported that there was also a pattern of changes which included an increase in non-rapid eye movement (NREM) sleep, as well as a decrease in rapid eye movement (REM) sleep for those who fall into the elderly population (65-years and older) (Ohayon *et al.,* 2004; Redline *et al.,* 2004; Danker-Hopfe *et al.,* 2005; Carrier *et al.,* 2011; Gadie *et al.,* 2016). Furthermore, for older adults, their sleep is typically characterised by reduced deep NREM sleep and increased light NREM sleep (Ohayon *et al.,* 2004). Additionally, as people age, there is a decreased ability to maintain sleep, which may be accompanied by an increase in the number and duration of awakenings, decreased slow-wave sleep (deep sleep), and reduced nocturnal sleep duration (Vitiello, 2006; Espiritu, 2008; Klerman and Dijk, 2008; Cirelli, 2012; Gadie *et al.,* 2016; Mander *et al.,* 2017; Muehlroth and Werkle-Bergner, 2020). Furthermore, for older adults, sleep timing generally shifts earlier, resulting in earlier bed and wake times and lighter, shorter and less restorative sleep from around the age of 50 (Dijk *et al.,* 2000; Monk, 2005).

In aviation settings, parental status (which changes with age) can affect the crews" sleep, especially crew who are young parents and have children under the age of three (Reis *et al.,* 2016). The effects of sleep loss due to having small children can contribute to fatigue during their duties, as compared to the crew who have grown-up children and are less likely to have their sleep disturbed. Therefore, the crew who have grown-up children may not be as affected by poor sleep due to their age (Reis *et al.,* 2016).

2.4.2 Lifestyle behaviours

Several lifestyle behaviours may affect sleep which includes, inter alia consuming caffeine, smoking, and the consumption of alcohol (Ohida *et al.,* 2001; Reut and Lana, 2013; St-Onge *et al.,* 2016).

Caffeine is widely used in modern society for multiple reasons such as increasing alertness (van Dongen *et al.,* 2001; Barry *et al.,* 2008; Jachne *et al.,* 2012; Souissi *et al.,* 2013; Patterson *et al.,* 2016; Agoston *et al.,* 2018). Caffeine is an adenosine-receptor antagonist, which accounts for increased alertness levels and results in the dissipation of grogginess and tiredness (van Dongen *et al.,* 2001; O"Callaghan *et al.,* 2018). Additionally, caffeine also acts on A1 and A2A (adenosine receptors) which are related to functions of the brain that are associated with promoting sleep and suppressing arousal (Bonnet *et al.,* 1995; Ribeiro and Sebastiao, 2010; Roehrs and Roth, 2008; O"Callaghan *et al.,* 2018). If caffeine is consumed close to bedtime, sleep onset can be delayed due to the inhibition of the caffeine binding to the adenosine receptors (Roehrs and Roth, 2008; O"Callaghan *et al.,* 2018).

Concerning nicotine, studies that have explored its impact on sleep show that smokers tend to have a longer sleep onset latency than non-smokers (Soldatos *et al.,* 1980; Redline *et al.,* 2004; Zhang *et al.,* 2006; Sahlin *et al.,* 2009; Jaehne *et al.,* 2012). Cross-sectional studies have found that smoking is associated with problems going to sleep, staying asleep, and daytime sleepiness; increased frequencies of having trouble sleeping, delaying bedtime and wake-up time, and shorter sleep duration (Phillips and Danner, 1995; Johnson and Breslau, 2001; Pasch *et al.,* 2010; Stea *et al.,* 2014). In addition, smokers also have shorter sleep duration than non-smokers (Zhang *et al.,* 2006; Jaehne *et al.,* 2012).

Alcohol consumption in moderate quantities (no more than two drinks per day) (Green *et al.,* 2007) has been shown to decrease REM sleep throughout the night, which leads to disrupted sleep and reduced recovery (Chakravorty *et al.,* 2016; He *et al.,* 2019). However, as alcohol is a Central Nervous System (CNS) depressant, its consumption can assist in the onset of sleep (Chakravorty *et al.,* 2016). In contrast, heavy drinking (more than four drinks a day) (Reid *et al.,* 1999) has been associated with increased sleep onset, but an increased interference with the maintenance of sleep throughout the night (Chakravorty *et al.,* 2016). In addition, as the blood alcohol levels decrease (as the night progresses) the first two stages of NREM sleep tend to increase, as does REM sleep, and multiple awakenings occur (Chakravorty *et al.,* 2016).

Poor diet

There is a significant body of evidence to suggest that carbohydrate intake has a role in sleep (Phillips *et al.,* 1975; Kwan *et al.,* 1986; Afaghi *et al.,* 2007; Afaghi *et al.,* 2008; Lindseth *et al.,* 2013; Yajima *et al.,* 2014). High-carbohydrate intake and low-carbohydrate diets have been associated with changes in sleep architecture (St. Onge *et al.,* 2016). Carbohydrates may affect REM sleep, REM-onset latency, and non-REM sleep (Yajima *et al.,* 2014). However, foods such as milk products, fish, fruit, and vegetables, have been shown to improve sleep quality (Smith and Kendrick, 1992; Yajima *et al.,* 2014).

2.4.3 Relationship problems

Conflicts can occur at home, between family members or significant others or they can occur at work, between colleagues and other employees (Frone *et al.,* 1992; Allen *et al.,* 2000; Jansen *et al.,* 2004). However, the conflicts at work may also interfere with family life, which may lead to conflicts at home with family, and vice-versa (Jansen *et al.,* 2004). Allen *et al.* (2000) reported consequences associated with conflict from work with family and this can lead to job dissatisfaction, burnout, distress, marital dissatisfaction, and depression. Additionally, work-family conflict has been reported as a risk factor for an increased need for recovery from work and work-related fatigue (Jansen *et al.,* 2003). Disruptive sleep could also be a consequence of work-family conflict due to the effects of stress placed on the individuals, which may shorten the sleep duration and affect the quality of sleep (Kim and Dimsdale, 2007). Furthermore, irregular working hours such as shift work, working during evenings and weekends can directly affect the balance between work and non-work domains and social participation (Bittman, 2005; Lyonette and Clark, 2009; Arlinghaus *et al.,* 2019), but the effects of working time arrangements will be discussed later in this thesis.

2.4.4 Commuting

Commuting is referred to as travelling to and from work (Brown and Whitehurst, 2011). It is difficult to measure how a commute affects individuals due to factors such as the length of the commute, as well as the effects of being delayed by traffic, to name but a few (Brown and Whitehurst, 2011; National Research Council, 2011)). Commuting can affect sleep if commuters have to travel far to get to their place of work as this may require waking up earlier to get ready for work, but also to commute to work to get there on time (Brown and Whitehurst, 2011). Therefore, reduced time in bed could reduce the hours of attainable sleep. Conversely, there are other activities to be carried out after commuting home, such as eating dinner, showering or bathing, winding down, and eventually sleeping, and these may all take up time that ends up reducing the hours of sleep attainable before having to wake up the following day (Brown and Whitehurst, 2011; National Research Council, 2011).

2.5 Work-related factors that contribute to fatigue in scheduled aviation

In addition to various personal and lifestyle factors that affect sleep and contribute to fatigue, many work-related factors need to be considered as well. These include, but are not limited to, the nature of the operation (short-haul, medium, and long-haul flights); whether the operations involve trans-meridian travel and the length of the duty periods; the characteristics of duty which include early starts and late finishes, night flights and flying a number of sectors; the effects of standby or reserve duty, layovers and rest periods. Apart from working time related factors, task-related demands and workload for cockpit and cabin crew do play a role in crew fatigue.

Finally, environmental factors and how they interfere with or increase crew workload will be discussed.

2.5.1 Nature of flight operations

2.5.1.1 Short-haul and long-haul flights

Short-haul flights

Short-haul flights are defined as those that last no more than three hours in duration (Wilkerson *et al.,* 2014). Previous research has reported that for short-haul aircrew, increased fatigue is experienced when duties include early starts, late finishes, high workload, extended duty periods, or combinations of these factors (Bourgeois-Bougrine *et al.,* 2003; Jackson and Earl, 2006; Powell *et al.,* 2007; Croft, 2009; Vejvoda *et al.,* 2014; Honn *et al.,* 2016; Flynn-Evans *et al.,* 2018; Åkerstedt *et al.,* 2020). While discussed in more detail below, early starts for the crew (both pilots and cabin crew) refer to duties that commence at or before 6 am, with this definition differing by country or context (Mangie, 2011). Early starts are associated with poor quality and, insufficient sleep as the crews" duty may start at, or before 6 am, which may result in the crew spending less time in bed sleeping and having to get out of bed early to get to work to commence duties (Jackson and Earl, 2006; Powell *et al.,* 2007; Croft, 2009; Åkerstedt *et al.,* 2020). This may affect the crews" sleep-wake behaviour, which may affect alertness levels whilst on duty (Flynn-Evans *et al.,* 2018; Åkerstedt *et al.,* 2020) Furthermore, the crews" alertness and fatigue risk may be influenced by inadequate or poor-quality sleep as a result of rising early (Flynn-Evans *et al.,* 2018; Åkerstedt *et al.,* 2020).

Late finishes refer to duty periods finishing in the period between 22:00 and 23:59-hours local time, however, this definition may differ between countries (South African Civil Aviation Authority, no date). Late finishes are associated with less nighttime sleep, due to the times that the crew finishes, and still have to wind down, once the crew is at their respective household or hotel (Vejvoda *et al.,* 2014; Honn *et al.,* 2016; Flynn-Evans *et al.,* 2018). Extended wakefulness is commonly associated with late finishes, which can also contribute to fatigue (Vejvoda *et al.,* 2014; Flynn-Evans *et al.,* 2018; Åkerstedt *et al.,* 2021). Secondly, as crew end duties late, this may also affect the quality and amount of sleep they can obtain (Flynn-Evans *et al.,* 2018; Åkerstedt *et al.,* 2021; Arsintescu *et al.,* 2021). In addition, recovery may be inadequate if the crew are due for an early start the following day (Vejvoda *et* *al.,* 2014; Honn *et al.,* 2016; Flynn-Evans *et al.,* 2018). This is referred to as a quick return, and is often associated with poor recovery (Schultz, 2018).

Furthermore, short-haul crews experience a high workload often as a result of having to complete a high number of sectors per duty, leading to multiple take-offs and landings (Jackson and Earl, 2006; Powell *et al.,* 2007; Croft, 2009). These aspects of duty are the most taxing tasks to be carried out (for pilots) and require extensive concentration and alertness (Bourgeois-Bougrine *et al.,* 2003; Jackson and Earl, 2006; Powell *et al.,* 2007; Croft, 2009). For the cabin crew, short sectors are associated with high workloads given the need to attend to passengers‟ needs throughout the flight. During short sectors, the cabin crew has less time to get work completed (cleaning the cabin, report writing, stock-take) as the sectors flown are within short proximity to one another (Avers *et al.,* 2009; Avers *et al.,* 2011; van den Burg *et al.,* 2020). Therefore, this increases the workload for the cabin crew due to the pressure associated with getting the work completed in time for take-off for the next sector (Avers *et al.,* 2009; Avers *et al.,* 2011; van den Burg *et al.,* 2020).

Furthermore, depending on the nature of the operation, the short-haul crew also experiences extended duty periods (Spencer and Robertson, 2002; Hartzler, 2013; Lee and Kim, 2018). Extended duty periods result in extended wakefulness, as the crew is required to be awake for lengthy periods whilst on duty which can range from a few hours up to 14-hours (Hartzler, 2013; Lee and Kim, 2018). The effects of extended wakefulness may affect alertness, performance and interaction with each other and passengers (Hartzler, 2013; Lee and Kim, 2018).

Long-haul flights

Before defining long-haul flights, there are also medium-haul flights, which are between three to six hours in length (Klisauskaite, 2021). Long-haul flights refer to operations that are longer than six hours in duration (Wilkerson *et al.,* 2014). Long-haul flights can include early starts, late finishes, extended wakefulness, night flying, disrupted circadian rhythms due to trans-meridian travel, disrupted sleep-wake behaviour, and the need for layovers away from home base (Gander *et al.,* 1998; Gander *et al.,* 1998d; Lamond *et al.,* 2006; Roach *et al.,* 2010; Roach *et al.,* 2011; Chapman *et al.,* 2012; Roach *et al.,* 2012; Fowler *et al.,* 2017).

As previously discussed, much the same as the crew who fly short-haul, the crew who fly long-haul also tend to have early starts and late finishes (Roach *et al.,* 2010; Roach *et al.,* 2011; Chapman *et al.,* 2012). In addition, to the late finishes, extended wakefulness is common in long-haul flights (Roach *et al.,* 2010; Roach *et al.,* 2011; Chapman *et al.,* 2012). This is due to the length of time that the crew are required to be awake for during the night, whether it is in the cockpit, or in the cabin attending to the passengers' needs throughout the flight (Roach *et al.,* 2010; Roach *et al.,* 2011; Chapman *et al.,* 2012; Roach *et al.,* 2012; Fowler *et al.,* 2017). One of the outcomes of long-haul flights can be sleep loss as the crew is awake during times when they normally would be asleep (Roach *et al.,* 2010; Fowler *et al.,* 2017). However, when the crew are afforded time to sleep, this may be against their natural inclination to sleep (Fowler *et al.,* 2017). This does often result in poor quality and truncated sleep and the associated changes in alertness and performance capability (Roach *et al.,* 2010; Roach *et al.,* 2011; Fowler *et al.,* 2017).

Furthermore, another common factor associated with long-haul flights is trans-meridian travel where the crew has to cross multiple time zones during the trip (Sack, 2009; Inder *et al.,* 2015). This can result in circadian misalignment for the crew due to crossing several time zones too rapidly, which does not allow the circadian rhythm to re-align, resulting in jet lag (Co *et al.,* 1999; Waterhouse *et al.,* 2007; Fowler *et al.,* 2017; Roach *et al.,* 2019). Jet lag occurs due to a mismatch between the body clock, which was synchronised to the time cues at the departure time zone, whereas the timing of sleep and waking need to be synchronised to time cues in the destination time zone (Waterhouse *et al.,* 2004). The effects of jet lag on the crew can be poor sleep in the new-night time, and this includes delayed sleep onset after eastward flights and early waking after westward flights (Waterhouse *et al.,* 2007; Inder *et al.,* 2015). Furthermore, the crew can also have increased fatigue, performance decrements, and concentration problems because of jet lag (Waterhouse *et al.,* 2007; Roach *et al.,* 2012; Fowler *et al.,* 2017).

To reduce the impact of extended duties, the crew will sleep in designated rest bunks during their rest breaks in-flight. However, the quality and quantity of sleep obtained during long-haul flights is considerably less as compared to sleep obtained in a bedroom or hotel room during the nighttime (Rosekind *et al.,* 2000; Signal *et al.,* 2005; Gander *et al.,* 2013). Roach *et al.* (2010) reported that sleep opportunities in onboard rest facilities during a long-haul flight yielded a similar result as that of the amount of sleep obtained sleeping in a bed at home. The authors indicated that sleeping in onboard rest facilities does not affect the amount of sleep that is obtained, but that onboard sleep affects the quality of the sleep obtained (Roach *et al.,* 2010; Signal *et al.,* 2013). This is however dependent on when the sleep is scheduled, and whether it is during the day or at night (Roach *et al.,* 2010). The authors suggested that the quality of sleep obtained in onboard rest facilities is relatively low due, in part, to the combined effects of environmental factors, such as the comfort of the bed, or psychological factors, such as crew may find it difficult to take their mind off the flight when attempting to sleep (Rosekind *et al.,* 2000).

There are however other factors that may interfere with the crew when they are flying long-haul flights, such as ultra-long-range flights (which are non-stop flights, carrying an economically meaningful payload of either passengers or cargo over a distance above 13000km) (Baxter and Bardell, 2017). This may entail crew flying through several time zones, without stopping until landing at the destination airport. The effects on the crew, irrespective of the onboard rest facilities, are circadian rhythm disruptions and sleep-related problems, a lack of recovery time due to the length of the flight, as well as the length of the layover period may affect the recovery of the crew due to the effects jet lag has on sleep (Gander *et al.,* 2013; Lamp *et al.,* 2019; van den Burg *et al.,* 2019).

An important part of managing the fatigue associated with long-haul travel is effectively scheduled layovers, which offer the chance for the crew to recover from and prepare for upcoming duties (Roach *et al.,* 2012). A key consideration for layovers is their length. Short layovers (not more than 1-2 days) are advantageous in that they limit the time for the crew to adjust to the new time zone, while also reducing the associated disruptions to sleep associated with the new time zone (Roach *et al.,* 2012). However, short layovers may result in the crew not being able to fully recover from the inbound trip demands (Boulos *et al.,* 2002; Lahti *et al.,* 2007; Eastman and Burgess, 2009; Roach *et al.,* 2012; Burke *et al.,* 2013; Fowler *et al.,* 2017).

Literature has shown that to resynchronise a circadian rhythm in a new time zone requires four to six days of recovery, however, this is dependent on the number of time zones that have been crossed (Desir *et al.,* 1981; Sapolsky *et al.,* 2000; IATA *et al.,* 2011; Zhu and Zee, 2012; Paragliola *et al.,* 2021). For the crew, this is not always possible, as they would have crossed multiple time zones, resulting in desynchronised circadian rhythms, potentially inadequate recovery from the layover, which could affect their performance and alertness for the outward flight (Lamond *et al.,* 2006; Roach *et al.,* 2012; Fowler *et al.,* 2017). Conversely, long layovers (between three and four days) can be advantageous to the pilots especially as they can maximize the time off to recover from one demanding period of duty, and prepare for the next (Roach *et al.,* 2012). Long layovers also provide the body clock with more time to adapt to the new time zone in the layover airport (Roach *et al.,* 2012). Roach *et al.* (2012) identified that the fatigue levels of the crew had returned to pre-trip levels by the second layover day after flying an eastward flight for 13.5 hours across seven time zones. This indicated the benefits of longer layovers for the crew from a fatigue perspective.

2.5.2 Characteristics of flight duty

2.5.2.1 Flight rostering and flight schedules

Apart from the nature of the operations, the characteristics of the duty or how duties are rostered need consideration (Bourgeois-Bougrine *et al.,* 2003). In today‟s airline industry, airlines are trying to encourage crew to adopt a fixed roster pattern (Novak *et al.,* 2020). A fixed roster pattern involves a pattern where there are both working days as well as days off where the amounts of days are fixed (Novak *et al.,* 2020). There is some level of predictability that could guarantee the crew members can establish their working time and their time off (Novak *et al.,* 2020). However, some crew is expected to work over weekends, throughout the night, and during holidays, and this makes for an unpredictable shift pattern that disadvantages the crew (Caldwell, 2012; Quesnel *et al.,* 2019; Novak *et al.,* 2020). There are a number of variations of fixed roster patterns that exist and the length of working time depends on the type of operation (Novak *et al.,* 2020). Short-haul crew in South Africa more often than not can expect to work six consecutive days (SACAA, no date). However, for long-haul crew, it is nearly impossible to schedule a fixed roster due to the nature of their operations (Novak *et al.,* 2020). A fixed roster pattern requires a certain amount of aircraft to be situated at the airport to allow a sufficient number for the pairing combinations (Novak *et al.,* 2020). A fixed roster pattern is seen as a workable fatigue-mitigating element, as the crew are afforded more than three consecutive days off (Novak *et al.,* 2020).

However, often rosters are quite irregular (indicating that the roster is ever-changing, with many early starts and late finishes, throughout the week) which in turn can affect the quality of rest, sleep, and recovery for the crew (Caldwell, 2012; Novak *et al.,* 2020). The results of irregular rosters may lead to sleep loss, and a lack of recovery due to the crew potentially ending their shift late and having to start early the next morning. This may occur over consecutive days, resulting in the crew getting less sleep each night due to the duties commencing early and ending late at night (Caldwell and Caldwell, 2016). Furthermore, working consecutive days in a row (consisting of early starts and late finishes), and only having one day off does not afford the crew enough time to recover especially when there is a late duty before the day off, and an early start after the day off (Caldwell and Caldwell, 2016; Flynn-Evans *et al.,* 2018; Arsintescu *et al.,* 2021; Åkerstedt *et al.,* 2021). Therefore, a fixed roster pattern would be more advantageous to the crew, to prevent consecutive early starts and late finishes, and affording the crew with more time to recover before commencing their next duty as the crew would be able to plan their sleep schedules (Novak *et al.,* 2016).

2.5.2.2 Extended duty periods

Extended duty periods refer to duties that last up to 12-hours, and are the result of a combination of irregular rosters, long distances flown, and having to fly many sectors during a duty period (Caldwell *et al.,* 2009; Previc *et al.,* 2009; SACAA, 2013). Extended duty periods are commonly associated with long-haul flights and have been shown to contribute to the fatigue experienced by the crew (FAA, 2011; Williamson *et al.,* 2011; Hartzler, 2013; Gawron, 2016; Reis *et al.,* 2016; Lee and Kim, 2018). Extended duty periods can result in extended wakefulness which increases sleepiness as the crew may be awake for extended periods. These effects are also influenced by the nature of long-haul flights, the scheduled timing of the duty, which may occur at a time when the crew would normally be asleep but are forced to be awake (Williamson *et al.,* 2011; Hartzler, 2013; Gawron, 2016; Reis *et al.,* 2016; Lee and Kim, 2018; Åkerstedt *et al.,* 2021). Additionally, extended duties can also be the result of, or exacerbated by operational delays and extensions which, at times, are sometimes necessary and unavoidable (Bendak and Rashid, 2020).

2.5.2.3 Consecutive duties

Literature has shown that short-haul crew members can be scheduled to work four to five consecutive days, which may include disruptive duties such as early starts and late finishes, times of high workload occurring during the day, and night flights on those consecutive days (O‟Hagan *et al.,* 2016; Marqueze *et al.,* 2017; Pellegrino and Marqueze, 2019). While the number of days that can be worked in a row is often controlled, many consecutive workdays, combined with disruptive rostering practises, result in inadequate time for recovery; sleep loss, and cumulative fatigue

(Bourgeois-Bougrine *et al.*, 2003a; Yuliawati *et al.*, 2015). This is due to the time crew would end up getting to bed, winding down, and sleeping (which may be after 11 pm), and the time they would have to wake-up (which may be before 6 am), may not afford the crew adequate sleep or enough rest over consecutive days (Marqueze, 2019; Goffeng *et al.,* 2019; Gillet and Tremblay, 2021).

2.5.2.4 Early starts and late finishes

Early starts

Early starts are duties that commence at or before 6 am, with this definition differing by country or context (Mangie, 2011), while very early starts, are duties that start between 2 am and 4:59 am (Åkerstedt *et al.,* 2021). Co *et al.* (1999) reported that early starts may truncate the normal sleep period, and this can result in sleep loss. The authors reported that crew attempt to go to sleep earlier than normal in order to get their adequate amount of sleep. However, the natural tendencies of the circadian clock lengthens the day, rather than shortening it, which may make it physiologically impossible to sleep earlier (Co *et al.,* 1999). Additionally, there may be late finishes (discussed further down) which may also inhibit the crew from sleeping early. Early starts are typically associated with shortened and poor sleep quality prior to the start of duty (Caldwell, 1997; Parris, 2003; Roach *et al.,* 2012; Ingre *et al.,* 2014). This stems from the fact that early starts may require aircrew to wake up earlier to get to work on time. As a result, the crews‟ hours of sleep are reduced, which results in the crew experiencing increased sleepiness, which in turn affects alertness and performance ability while on duty (Caldwell, 1997; Parris, 2003; Caldwell, 2005; Avers and Johnson, 2011).

Several studies have indicated that for short-haul operations, reported fatigue is often attributed to early start times, combined with other duty characteristics, such as long duty periods (Caldwell, 1997; Gander *et al.,* 1998; Bourgeois-Bougrine *et al.,* 2003; Parris, 2003; Jackson and Earl, 2006; Powell *et al.,* 2007; Åkerstedt *et al.,* 2021). Spencer and Robertson (2002) reported that the fatiguing effects of early starts become more pronounced when the crew has to complete consecutive early starts, without a rest day. This is consistent with the findings by Åkerstedt *et al.* (2021) who reported that over seven days, working consecutive early duties was associated with increased levels of self-reported fatigue.

Late finishes

Apart from early starts, another working time characteristic that affects crew sleep and rest are duties that finish late at night. A late finish refer to when a duty period finishes between 22:00 and 23:59-hours local time, however, this definition may differ between countries (South African Civil Aviation Authority, no date). Previous research has reported that fatigue experienced (by pilots and cabin crew) was moderate to severe when the flight duty period (FDP) ended late at night after short-haul flights (Jackson and Earl, 2006; Vejvoda *et al.,* 2014; van den Burg *et al.,* 2020). Sallinen *et al.* (2021) reported a high probability of fatigue at the top of descent due to the association and impact late finishes have on the crew. This was consistent with Vejvoda *et al.* (2014) who reported that the final landing after a late finish FDP resulted in crew being awake for extended hours, which was associated with higher self-reported fatigue than reports following early starts. Late finishes may also influence the time available for recovery, particularly if the crew has to be on duty in the morning after a late finish (Parris, 2003; Jackson and Earl, 2006; Powell *et al.,* 2007). Very late finishes may also result in crew attempting to sleep into the daytime – sleep during the day is usually shallower and shorter, mainly due to the circadian-modulated drive for alertness, daylight, and noise from the environment (Caldwell, 2005; Jackson and Earl, 2006; Powell *et al.,* 2007).

Flying at night

Nighttime duties are those that are scheduled from 15-minutes after sunset to 15-minutes before sunrise, however, this is not consistent for all countries (SACAA, 2009). These operations require the crew to operate against their natural inclination to sleep at night and be awake during the day (Gundel *et al.,* 1995; Samel *et al.,* 1997; Calitz, no date; Ingre *et al.,* 2014; Sallinen *et al.,* 2020; Sallinen *et al.,* 2021). Sallinen *et al.* (2021) reported that night FDPs are often associated with extended periods on duty and are a significant predictor of fatigue at the top of descent, particularly if the duty period encroaches on the Window of Circadian Low (WOCL). Furthermore, night flights disrupt the crews" natural circadian rhythm (Gundel *et al.,* 1995) due to them having to fight against a natural inclination to sleep at this time of the day. Additionally, the crew then have to sleep during the day, due to the circadian modulated drive for wakefulness, light and societal noise. This can lead to cumulative sleep loss and sleep debt (Van Dongen *et al.,* 2003), which can also affect crew alertness and concentration in subsequent duties (Caldwell, 2005; Ingre *et al.,* 2014).

2.5.2.5 Effects of standby or reserve duty

Standby or reserve duty is defined as a period during which a crewmember is required to remain at a specified location to be available to report for flight duty, at the discretion of the operator (SACAA, no date). This type of duty (whether at the airport or the crews‟ household) can create anxiety for the crew as they may, at any time, be called to duty (Berger, 1999; Bamberg *et al.,* 2012). An additional challenge presented by standby duties is that they often result in extended wakefulness, and, if they occur at night, disrupted sleep-wake behaviour for the crew (Co *et al.,* 1999; Arnedt *et al.,* 2005; Bamberg *et al.,* 2012; Ziebertz *et al.,* 2015). This can present a risk if the crew is called to duty towards the end of their standby period. Research surrounding the impact of standby and reserve duty on sleep and fatigue in aircrew is limited. However, previous research by Van den Burg *et al.* (2019) reported that the standby facilities at airports need to be improved to ensure that the cabin crew are fresh and rested if they are called for duty. Therefore, as there is limited research on standby or reserve duty, there is a need for more research on this type of work for cabin crew and cockpit crew.

2.5.2.6 Other work-related factors

Quick turnarounds refer to the time required to unload the aircraft after it has arrived at the gate, and prepare the aircraft for the next departure (Schultz, 2018). Quick turnarounds are associated with low-cost airlines that fly short-haul and these reduce the amount of time that the crew has to rest before the next flight due to the limited amount of time before the next flight departs (Samel *et al.,* 1991). In addition, the time between when the workload of the crew ends (once the aircraft has come to a complete stop and all the passengers have disembarked) the crews‟ workload will increase in a short space of time as the crew prepares for the next flight departure. Therefore, quick turnarounds reduce the time that the crew has to recover and rest.

2.5.2.7 Rest periods

A rest period is defined as a continuous period, after and or before duty, during which the crew is free of all duties (SACAA, no date; Caldwell *et al.,* 2009; Efthymiou *et al.,* 2021). Currently, under the Civil Aviation Regulations, crewmembers are allocated nine-consecutive hours of rest between duties (SACAA, no date). The rest period is an important phase to reverse the effects of exertion, mental and physical, to allow for recovery (Techera *et al.,* 2016). Therefore, the crew need to get adequate sleep before duty by maximizing sleep before the start of duty, while also being provided with adequate sleep post-duty, to help with recovery (Rudari *et al.,* 2016; Karhula *et al.,* 2017; van den Burg *et al.,* 2020; Efthymiou *et al.,* 2021). However, if the rest period is inadequate (less than nine hours), this may limit the chance for crew to obtain consolidated quality and quantity sleep, while also attending to other biological and social needs. This may affect their alertness in subsequent duties, and recovery especially if the crew had been working strings of duty, or irregular duties such as early starts, late finishes, and extended duties (Rudari *et al.,* 2016; Karhula *et al.,* 2017; van den Burg *et al.,* 2020; Efthymiou *et al.,* 2021).

Moreover, the timing of the rest period may also impact the crew if the rest period falls between duties, which may require the crew to rest when there are external factors inhibiting their rest, such as rest during the day time which can be accompanied by noise from the environment (Rudari *et al.,* 2016; Efthymiou *et al.,* 2021). The rest period is not only about sleep, but rest, to fulfil basic physiological needs and spending time with family. Gander *et al.* (2014) reported on concerns related to augmented crew flights, where the interaction of flight timing (the time of day or night when the flight departed) with circadian phase (as the crew would have been aligned to the departure time zone) and flight duration influenced in-flight sleep and fatigue levels of the crew. Therefore, these factors require careful thought when planning different flights. Van den Burg *et al.* (2019) reported that the duty periods for cabin crew in particular only end once the aircraft"s engines have been turned off, however, cabin crew still have to attend to passengers who are disembarking the aircraft. Therefore, the rest period, which may appear to be 12-hours, is reduced due to other duties that are needed to be carried out. This can influence the time the cabin crew has available for rest.

2.5.3 Task-related demands

2.5.3.1 Workload of cockpit and cabin crew

2.5.3.1.1 Number of sectors

The number of sectors flown in a duty period is a significant contributor to crew fatigue. For cockpit crew, this may result from the effects of multiple take-offs and landings (Powell *et al.,* 2007; Hormann *et al.,* 2015; Yuliawati *et al.,* 2015; Honn *et al.,* 2016). The Federal Aviation Administration (2010) stated that short-haul schedules (in particular) can include the completion of four to five sectors each day and these are among the more fatiguing schedules to fly, which can lead to changes in alertness and performance ability. In addition, the take-offs and landings are deemed as taxing tasks and periods of high workload for pilots (Bourgeois-Bougrine *et al.,* 2003; Powell *et al.,* 2007; Hormann *et al.,* 2015; Yuliawati *et al.,* 2015; Honn *et al.,* 2016). Co *et al.* (1999) reported that regional crew (short-haul) face high workload phases (take-off, cruise, landing) about five times as compared to long-haul, which may create a high chance for fatigue-induced performance decrements to manifest themselves. Powell *et al.* (2007) reported that the number of segments flown, irrespective of the duration of the flight, was associated with a linear increase in perceived fatigue. This was consistent with the findings of Sallinen *et al.* (2021) who found that the number of sectors was the only FDP characteristic to predict high levels of fatigue at the top of descent, during FDPs that occurred during the day.

In a laboratory setting, Honn *et al.* (2016) reported the effects of multiple take-offs and landings to one take-off, extended duty, and landings. The study found that the pilots" performance on the Psychomotor Vigilance Test (PVT) indicated greater fatigue during the five-sector simulated duty periods as compared to the single, simulated long haul segment duty (Honn *et al.,* 2016). However, the limitations of the study were that it was conducted in a laboratory, using a simulated aircraft. It is still evident, however, that multiple take-offs and landings do affect performance and self-rating of alertness (Bourgeois-Bougrine *et al.,* 2003; Powell *et al.,* 2007).

Concerning cabin crew, multiple flight sectors may result in a potential increase in the workload due to monitoring a higher number of passengers; at times, cabin crew can attend to up to 700 passengers throughout five to six sectors, while having to perform multiple safety and service tasks per flight (Goffeng *et al.,* 2019). Additionally, during the night there are differences between the cockpit and cabin crew with regards to fatigue at the top of descent. Sallinen *et al.* (2021) reported the differences between the cockpit and cabin crew as a result of the workload, before and during the top of descent (Sallinen *et al.,* 2021). At the top of descent, the cabin crew is potentially in a seated position after a busy work period, whereas the pilots are in a period of high workload phase, due to the top of descent phase as a more taxing phase than the cruise phase for pilots (Sallinen *et al.,* 2021). However, other factors, such as those discussed above, need to be taken into account as contributors to fatigue during this phase of the flight and the number of sectors complete

2.5.3.2 Environmental factors

An important factor that contributes to fatigue is that of the environmental factors and how this affects the workload of the crew (Lee, 2010; Bendak and Rashid, 2020). These include lightning, convective turbulence, airframe icing, and precipitation to name but a few (Buck and Buck, 2013). These factors increase workload and therefore require more attention and heightened vigilance by the crew whilst in-flight (Buck and Buck, 2013). In addition, noise from within the aircraft and any associated turbulence affect aircrews‟ sleep architecture, as well as subjective sleep quality during in-flight rest (Kulesa, 2003; Buck and Buck, 2013; Zaslona *et al.,* 2018). It is, however, important to stress that a number of these factors interact to affect sleep, workload, and fatigue of crew, and that it is difficult to isolate their effects, which makes their management challenging.

In summation, it is evident that crew fatigue in aviation results from the complex interaction of various work and non-work related factors. Thus, managing fatigue requires an appreciation of these factors abovementioned factors but making use of the latest science, technological advancements, and operational experience.

2.6 Approaches to managing fatigue in the aviation industry

The next section will deal with approaches put in place to managing fatigue, firstly, through prescriptive limits recommended by the International Civil Aviation Organisation (ICAO), and secondly using more modern methods such as Fatigue Risk Management Systems (FRMS) (Gander *et al.,* 2011; Caldwell *et al.,* 2012). The last sub-section will summarize the changes that were made to FTL regulations in Europe, Canada, Australia, and the United States of America (USA), given that these may be similar to those that may need to be addressed in the South African Civil Aviation Regulations.

Fatigue in the aviation industry can be managed through the application of prescriptive flight and duty rules that will inform part of the broader safety management system (SMS) and or using a fatigue risk management system (FRMS) (Figure 2) (Gander *et al.,* 2011; Caldwell *et al.,* 2012; ICAO, 2016). For the prescriptive approach, the state is responsible for establishing prescriptive limitations and requirements when it comes to the prescriptive approach to manage flight and duty and the associated fatigue risks (Cabon *et al.,* 2008; ICAO, 2019). The state will take into account the types of work, context, and conditions in a particular region, such as geography, infrastructure, and climate (Gander *et al.,* 2011; ICAO, 2019).

Using this prescriptive approach requires the state to prescribe work period „ceilings", and „floors", for periods of non-work as well as risks that may be associated with types of work (ICAO, 2019). These include limiting duty hours, adjusting hours according to the number of sectors and the time at which duties start, reducing consecutive night duties, taking into consideration the acclimatisation state of the crew (following time zone crossings), and controlling the number of time zone crossings (ICAO, 2019) which can disrupt the sleep-wake cycle of aircrew. The state should always ensure that the operator manages their fatigue risk at an acceptable level through an existing safety management system (SMS - proactively seeks to mitigate risks before they result in aviation incidents or accidents (Dekker, 2005; ICAO, 2015)) process which falls within the prescriptive requirements and limitations (Gander, 2005; Gander *et al.,* 2011; ICAO, 2019).

However, for an SMS to be effective, it requires operators to maintain a safety-training program that ensures the crew are trained and competent to perform their SMS duties while understanding their responsibilities when it comes to reporting for duty in a fit state and reporting fatigue hazards (Houston *et al.,* 2012). Therefore, SMS places an expectation on the operators to incorporate fatigue management topics when conducting awareness and training programs (Gander, 2005; Gander *et al.,* 2011; ICAO, 2019).

Fatigue Risk Management System (FRMS)

While not the focus of this study, it is important to highlight how, depending on the nature of the operations, the rigid nature of prescriptive approaches can be overly restrictive and affect operations in cases where operators have to fly outside of these prescribed limits. In this case, operators can apply to have a Fatigue Risk Management System approved by the regulator. An FRMS is defined as "a data-driven means of continuously monitoring and managing fatigue-related safety risks, based on scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel is performing at adequate levels of alertness" (ICAO, 2012, p. 82). An FRMS allows operators the opportunity to use advances in scientific knowledge to improve safety, increase operational flexibility, and use resources more efficiently (Step 3 on Figure 2) (Brown, 2006; Gander *et al.,* 2014; ICAO, 2019; Spracjer *et al.,* 2022). FRMS"s focus is on the management of actual fatigue risk in the context of which it applies (aviation in this context) instead of predicting fatigue risk in general (Gander *et al.,* 2014; ICAO, 2019; Spracjer *et al.,* 2022). When applying an FRMS, it still requires maximum duty times and non-work periods (minimum rest) for aircrew, but these would be proposed by the operator and, if they differ from the limits that have been provided, they must be approved by the state (Gander *et al.,* 2011; ICAO, 2019; Spracjer *et al.,* 2022). To get approval, the operator would be required to illustrate to the Regulator that they have appropriate processes, and mitigations, to achieve an acceptable level of risk, which may be incurred (Booth-Bourdeau *et al.,* 2005; Brown, 2006; Gander *et al.,* 2011; ICAO, 2019). FRMS, however, is beyond the scope of this thesis but is still relevant in the context of fatigue in aviation.

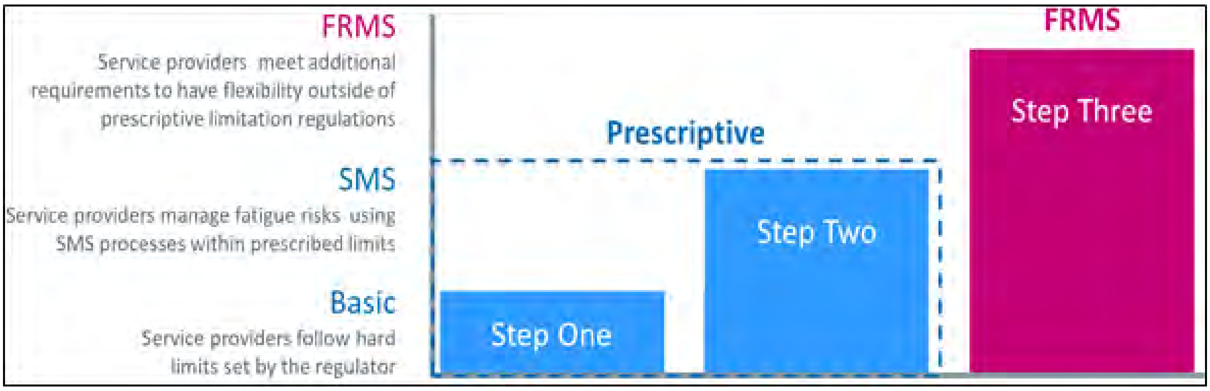

Figure 2: The three-step approach to managing aircrew fatigue (taken from ICAO, 2016).

Flight Time Limitation (FTL) regulation changes made in Europe, Canada, Australia, and the United States of America (USA)

FTL regulations, which fall under the prescriptive approach, have been implemented in an attempt to manage aircrew from fatigue (Caldwell *et al.,* 2009; Missoni *et al.,* 2009; SACAA, 2013). Historically, fatigue was managed through attempts to manage the hours of work. However, the changes in the operation of the industry as a result of technological advancements, the latest scientific input from research, and the use of operational experience, a more nuanced appreciation was required to ensure that different times; the number of sectors, the duration of duty and the degree of acclimatisation needed to be factored in. Countries within Europe and several different countries from around the world (the United States of America (USA), Canada, and Australia), have in recent years, reviewed, and adjusted their FTLs, as a result of the application of the latest science, research, and operational experience. While not intended to be comprehensive, the following provides an overview of the laws that were changed across different countries around the following parameters: reduced annual flying times; reduced lengthy duty periods; introduction of FRMS; introduction of flight time specification schemes due to the complexity of airline operations and how they vary as per operational demand; extension of the Flight Duty Period (FDP) due to in-flight rest facilities available on long-haul flights; reserve duty crew must be notified of reserve duty 10-hours in advance with crew still afforded 8-hours of rest prior to the reserve duty; amended rest periods that must take into consideration the changing nature of the industry (more rest following periods of disruptive schedules); the crew are unable to operate if they report that they are unfit for duty; adjusting densely packed rosters with flights both during the day and night; and a further suggestion to reduce consecutive early starts and late finishes (Caldwell *et al.,* 2009; European Union Aviation Safety Agency, 2017; Government of Canada, 2018; Houston, 2018; European Union Aviation Safety Agency, 2019; Efthymiou *et al.,* 2021).

Summary and rationale of the study

Fatigue has and continues to be an important safety challenge in aviation, with research around the world highlighting that it continues to pose a risk to crew well-being and broader aviation. Previous research has also shown that crew fatigue is the result of the complex interaction of many personal and work-related factors that require extended periods of duty, high workloads, and disruptions to the mechanisms that are necessary for the crew to get adequate sleep. There has been ample research into the extent of and contributors to crew fatigue in aviation settings across the world, with little to none in South Africa. Understanding crew perceptions around the prevalence and contributors to fatigue in the country will provide important insights for regulators, operators and crew to make informed decisions about how to manage fatigue more effectively and holistically. Therefore, this study‟s aims are to determine the reported prevalence of aircrew fatigue, and the perceived contributory factors to fatigue, as well as garnering the perceptions around the current South African FTL regulations.

CHAPTER 3

3. METHODOLOGY

3.1 Study Design

The study adopted a cross-sectional design, in that perceptions from the crew in the industry were explored through the dissemination of an online survey. Central to ensuring that the survey asked the right questions, the contents of the survey were designed, developed, and refined with the assistance of various aviation industry stakeholders.

This ensured that there was a balance between both the scientific and operational insights, as recommended by ICAO when trying to obtain context specific data for, in this case, understanding how best to design Flight and Duty period regulations to effectively manage fatigue.

The benefits of combining scientific and operational expertise and resources are that it can assist in answering broader and more complex scientific questions while ensuring that the research is responsive to the needs of industry (Washington, 2004; Nystrom *et al.,* 2018).

The development of the survey occurred over multiple phases and involved various academic and aviation industry stakeholders. Figure 3 provides an overview of the phases that the survey went through, from its initial design, until it was released to the crew in the industry.

PHASE 1 – 2019

Development of the initial survey: Research team only (PhD academic staff, PhD students, Master"s student) - **24/02/2019**.

↓

PHASE 2 - 2019

Refining the survey to suit the context - **21/03/2019**

Research team plus academic Staff and senior Postgraduate students from the Department of Human Kinetics and Ergonomics (HKE) at Rhodes University.

Feedback received from staff and Postgraduate students - **28/03/2019**.

Survey was refined and shortened.

↓

PHASE 3 - 2019 & 2020

Feedback responses from the aviation industry and a fatigue in aviation academic - **6/05/2019-25/11/2020**.

Survey sent to the South African Civil Aviation Authority (SACAA).

Distributed to all parts of industry by SACAA. Survey sent back to expert in aviation fatigue.

More feedback received from industry and fatigue in aviation academic to make the survey more applicable to the context - **23/01/2020.**

↓

FINALISATION, ETHICS AND DISTRIBUTION OF THE SURVEY - 2020

Final feedback from all stakeholders.

Ethical considerations granted - **27/02/2020**.

Survey sent out for participation - **20/03/2020**.

Figure 3: Overview of the design process of the survey from its development, to its release and distribution.

3.2.1 Phase 1: Development and design of the survey

The initial draft of the survey consisted of questions that were sourced from previous studies that explored fatigue prevalence and contributory factors in regional, short, and long haul airline operations. These studies (Co *et al.,* 1999; and Bourgeois-Bougrine *et al.,* 2003) involved several flight characteristics that were relevant to the study aims and objectives. Additionally, the Stop-bang questionnaire (Chung *et al.,* 2009) (which is used to test for sleep apnoea); the Insomnia Severity Index (Morin, 1993) which is used to test for insomnia severity; and the Epworth Sleepiness Scale (which is a scale used to assess daytime sleepiness) were also included (Johns, 1991). The study's initial survey was divided into four different parts (summarized in Table 4). The full version of the initial survey is appended (for the adaptations from

Johns (1991), Co *et al.* (1999), and Bourgeois-Bougrine *et al.* (2003), please refer to Appendix A).

Table 4. Schematic overview of the different sections of the initial survey.

Questionnaire section	**Categories of questions**
Part 1	Demographic characteristics: age, sex, race group, job title etc.
Part 2	Sleep-related questions (including sleepiness and insomnia (Morin *et al.,* 2009)): sleep at home, time taken to fall asleep, number of awakenings during the night, etc.
Part 3	Duty characteristics: length of flights, number of sectors,
Part 4	Perceptions towards fatigue: severity of aircrew fatigue, prevalence of aircrew fatigue, etc.

Part 1 included questions related to demographic characteristics, such as participant age, sex, race group, job title, flying experience, time zone of domicile, time taken to travel from home to domicile, the typical mode of transport from home to domicile. These questions were included as previous studies by Co *et al.* (1999) and Bourgeois-Bougrine *et al.* (2003) used surveys in their methodologies when exploring fatigue in aviation.

Part 2 of the initial survey included questions that asked about sleep at home and baseline sleep characteristics (Co *et al.,* 1999 and Bourgeois-Bougrine *et al.,* 2003; Morin *et al.*, 2009). More specifically, these questions included questions related to the number of nights of sleep at home between trips; bedtime on off-duty days; time taken to fall asleep on off-duty days; the average number of times woken up when sleeping at home, and the causes of any awakenings during the night; the average time taken to fall asleep once awakened; the total amount of sleep attained whilst sleeping at home; the average length of naps; whether the medication was taken to assist with sleep; whether alcohol was used to assist with sleep; whether the participant was a night owl or morning lark type of sleeper. Additionally, the Stop-Bang sleep apnoea questionnaire (Chung *et al.,* 2008), the Insomnia Severity Index (Morin, 1993), and the Epworth Sleepiness Scale (Johns, 1991), were also included in the initial survey questions (Co *et al.,* 1999 and Bourgeois-Bougrine *et al.,* 2003; Chung *et al.,* 2008; Morin, 1993).

The Stop-Bang questionnaire

The Stop-Bang questionnaire was developed to be an easy-to-use screening tool and consists of eight yes or no items that are related to clinical features of sleep apnoea (Chung *et al.,* 2008). Questions from a Stop-Bang questionnaire were included and the rationale behind this related to the importance of quantifying the impact of snoring, tiredness, observed sleep apnoea, high blood pressure, neck circumference, and male gender (STOP-Bang) (Chung *et al.,* 2008). Although sleep at home may be regarded as a secondary contributory factor to fatigue, it was important to gain insights into practices outside and away from work as this would affect alertness while on duty.

The Insomnia Severity Index (ISI)

The Insomnia Severity Index (Morin, 1993) is a seven-item report questionnaire used for assessing the severity, nature, and impact of insomnia. The usual recall period is the last month, and the dimensions which are evaluated are the severity of sleep onset; maintenance of sleep; early morning awakening problems; sleep dissatisfaction; interference of sleep difficulties with daytime functioning; noticeability of sleep problems by others; and distress caused by the sleep difficulties. A five-point Likert scale is used to rate each item from zero to four (no problem-very severe problem, respectively), which yields a total score ranging from zero to 28. The cut-off scores for the ISI are as follows: absence of insomnia (0-7); sub-threshold insomnia (8-14); moderate insomnia (15-21); and severe insomnia (22-28) (Morin, 1993).

The Epworth Sleepiness Scale

The Epworth Sleepiness Scale measures the general level of daytime sleepiness, was included in the initial survey (Johns, 1991). The scale requires the respondent to rate their propensity to doze or fall asleep during eight common activities, which then determine daytime sleepiness (Johns, 1991).

Part 3 aimed to explore the characteristics of duty and included questions related to flight schedules. These included questions relating to the length of flights; the number of flights per month; the amount of ground time between flights; the number of times per month length of duty exceeding 8 hours; the number of times exceeded 7-consecutive day flight time limit; duration of duty day; what the longest duty was at current airline; the number of times a month that crew stayed away from home; and quality and characteristics of accommodation away from home base. These questions were adapted from previous studies (Co *et al.,* 1999 and Bourgeois-Bougrine *et al.,* 2003). These questions were included to gain insights into what aspects of the aircrew's duty were challenging (concerning fatigue), to determine areas of concern or poor implementation, and how regulations were applied.

Part 4 included questions that were specific to the crew's experience of and perceptions towards fatigue and included questions on the perceived severity of aircrew fatigue; the prevalence of aircrew fatigue; how the crew perceived that fatigue affects safety; how fatigue affects performance during different phases of flight; and finally, strategies to coping with fatigue. The questions were included in the study as they were similar to questions from studies (Co *et al.,* 1999 and Bourgeois-Bougrine *et al.,* 2003).

3.2.2 Phase 2: Initial refinement of the survey

The second phase aimed to refine the initial draft of the survey and involved the research team presenting the proposed aims and objectives of the study, and the initial draft survey to all the staff and Postgraduate students in the Department of Human Kinetics and Ergonomics, at Rhodes University. This group included five academic staff with extensive experience in Human Factors and Ergonomics research and, 35 senior Postgraduate students in a workshop (for the research seminar presentation, please refer to Appendix B). The academic staff and Postgraduate students were split into groups (which included a balance of Honours, Masters, Doctoral students, and staff), and were presented with a hard copy of the survey from Phase 1, and asked to provide feedback on their hard copy for the research team following the presentation. This assisted the research team in adapting the survey's questions to make it more specific and focused. The general feedback from the workshop was that the survey was **too long**; the survey may negatively impact the number of participants who completed it due to **its length**; and that it **deviated from the focus**, which was to determine the perceived prevalence of fatigue in various parts of the industry and the factors that may be contributing to this (for more detailed feedback from the Human Kinetics and Ergonomics Department academic staff and senior Postgraduate students' please see Appendix C).

Based on the feedback, the survey was refined further. This was achieved through reducing a significant amount of content, thus shortening the survey and refining its focus to better suit the aims of the overall study and requirements of the industry stakeholders. The refined survey comprised of five parts - *Part 1* required to consent to participate; *Part 2* addressed personal/demographic characteristics of the participants; *Part 3* addressed the perceptions of whether fatigue was a concern and perceptions around awareness of fatigue; *Part 4* addressed the perceived factors that contribute to crew fatigue in the workplace, while *Part 5* aimed to explore crew perceptions of the current Flight Time Limitation Legislation in South Africa. Table 5 provides an overview of questions included in this second iteration of the survey, where they were adapted from, and an explanation of why they were added to the survey (please see Appendix D for PART 2 to PART 5 which is a full breakdown of the number of questions, the content of each part, where the questions were adapted from and the rationale behind their inclusion in the survey).

Table 5. Overview of Phase 2 refinement of the nation-wide survey.

Section overview	Content	Adapted from	Rationale for questions (why)
PART 1: CONSENT TO PARTICIPATE **PART 2: PERSONAL INFORMATION** There were 15 questions in total.	Basic demographics: age, sex, race group, job title etc.	(Co *et al.,* 1999; Bourgeois-Bougrine *et al.,* 2003).	This section required the participants to give consent to participate in the study. This section aimed to characterise the sample.
PART 3: CREW PERCEPTIONS AROUND FATIGUE There were 10 questions in this section. There was 1 open-ended question and 9 close-ended questions.	The severity of fatigue in general, from a personal level, during flight. The awareness of fatigue and if it had changed in the last 5 years in the industry and on a personal level. Questions pertaining to feelings during different phases of flight.	(Co *et al.,* 1999)	This section aimed to determine perceptions of whether fatigue was a major concern whilst the participants performed their jobs and how aware they were of it.
PART 4: CONTRIBUTORY FACTORS TO FATIGUE This section had 66 questions. 64 of them were close-ended questions and two were open-ended questions.	This section was broken into two: work-related factors and non-work related factors that are associated with or contribute to fatigue.	(Co *et al.,* 1999; Bourgeois-Bougrine *et al.,* 2003) and previous literature on fatigue in aviation.	This section aimed to obtain an idea of the major factors which crew perceived to be contributory to fatigue.
PART 5: SA FLIGHT TIME LIMITATIONS LEGISLATION This section had 3 questions, all of which were open-ended.	Concerns on the current Flight and Duty Period (FDP) regulations, recommendations to address the concerns and the current, effective mitigating aspects of the regulations.	Suggestion by the industry stakeholders.	This section aimed to obtain the participants' perceptions regarding the current FDP regulations; recommendations on how to go about amending them, as well as perceptions regarding which effective, fatigue mitigating aspects were available.

3.2.3 Phase 3: Feedback responses from the aviation industry and industry researcher academic

Following the refinement in Phase 2, the survey was first sent to two inspectors from the South African Civil Aviation Authority (SACAA), who then distributed it to the national fatigue-working group. This group was composed of representatives from the Airline Pilots' Association of South Africa (ALPA-SA) and included four senior airline Captains who were union representatives. The survey was also circulated to a representative from the Airlines Association of Southern Africa (AASA), who in turn, consulted the relevant members of the five major airlines in South Africa. The survey was also sent to other parts of the industry including the South African Red Cross Air Medical Services (AMS); Aerial Farming Services; Corporate Aviation Operations and High-Performance Aircraft; Commercial Helicopter Operations; Helicopter Aerial Work; and Certain Other Air Service Operations. This was important given that the survey aimed to gather data from these parts of the industry that had not been explored in the South African aviation industry previously. This wide consultation was also a necessary part of being inclusive and participatory.

Feedback was then received from the industry (refer to Table 6), specifically from the South African Red Cross Air Medical Services (AMS); the Airlines Association of Southern Africa (AASA), and the five major South African airlines at the time; and Aerial Farming Services. As part of this phase, the survey was sent to a researcher who has extensive experience in researching fatigue in aviation. The academic was involved in the European Commission's Effectiveness of Flight Time Limitation (FTL) adjustments research that was conducted in 2017 (refer to Table 6). This was important as the European FTL's were amended due to input from the academic, and the inclusion of his expertise was key to ensuring the questions asked could be compared to previous research. The academic suggested using a Samn-Perelli scale (Samn and Perelli, 1982) (which is used to subjectively manage fatigue) was used for some of the questions pertaining to fatigue (please see Appendix E for more extensive feedback from the industry and responses by the research team).

Table 6. Summaries of feedback from the industry stakeholders and fatigue in aviation academic as well as the response from the researchers.

Organisation	Industry feedback suggestions and comments	Research team response
South African Red Cross Air Medical Services (AMS)	1. Non-flying related questions and work-related factor questions: What non-flying work duties do you have? Does a pilot fly an aircraft without autopilot? Does the pilot have to do extra work to supplement income?	1. The suggestions were added to the survey; however, the wording of the questions was changed - under Part"s 2 and 4 respectively.
	2. When flying what are the symptoms of stress that you have experienced?	2. This question was ultimately removed as it was not the focus of the study.
	3. A lack of currency/recency will increase stress levels thus expediting the effects of fatigue?	3. This question was ultimately removed as it was not the focus of the study.
Airlines Association of Southern Africa (AASA) & Anonymous airlines	**Airline 1:** 1. Use of objective fatigue measures? 2. Management survey to be taken into account... different survey.	1. Given the time constraint, objective measures would be difficult to measure. 2. We agreed with this comment.
	Airline 2: 1. Questions pertaining to travel, by adding from home to place of work.	1. The questions were amended under Part 2 of the actual survey.
	Airline 3: 1. Questions pertaining to work and non-work-related factors.	1. The questions were added under their respective sections - work-related factors and non-work-related factors - under Part 4 of the actual survey.
	Airline 4: 1. FDP regulations should be based on scientific grounds only.	1. This was the only method we felt would give accurate results due to the time constraints and the context.

	Airline 5: 1. Demographic related question: which province are you based? 2. When serious crew fatigue occurs, how significant…? 3. Extended commuting to be put under non-work-related factors. 4. What level of fatigue is acceptable in your opinion?	1. The question was added under Part 2 of the actual survey. 2. This question was added and rephrased: When serious crew fatigue occurs, how significant a safety issue is it? - under Part 3 of the actual survey. 3. This was agreed upon and amended as such - under Part 4 of the actual survey. 4. This question was added under Part 3 of the actual survey.
Aerial Farming Services	1. Add aerial work. 2. Add a „not applicable" box. 3. Additional work-related factor questions pertaining to crop spraying and fire-bombing.	1. The option of aerial work was added as an additional flight duty characteristic - under Part 2 of the actual survey. 2. The „not applicable" box was added - under Part 4 of the actual survey. 3. The work-related factors pertaining to crop spraying and fire-bombing were added - under Part 4 of the actual survey.
Aviation researcher	1. A suggestion was made to use a Likert scale for certain questions so as to measure the respondent"s attitudes by asking the extent to which they agreed or disagreed to the said questions. Additionally a Samn-Perelli scale was suggested as it is a scale used for fatigue related questions. 2. Questions pertaining to the cruise and take-off/landing phases to be asked separately. 3. Questions pertaining to the effective (fatigue mitigating) aspects of the current regulations.	1. The use of a Likert scale and Samn-Perelli scale were agreed upon by the research team and the two were used for the relevant questions - under Part 3 of the actual survey. 2. We agreed with this comment and added them as separate questions to the survey - under Part 3 of the actual survey. 3. We agreed with this comment and added it to the survey - under Part 5 of the actual survey.

Following this iteration, the overall structure of the survey (refer to Table 7) covered four main areas: participant demographic information; the perceived prevalence of fatigue; the contributory factors of fatigue which included both work-related and non-work-related factors; and questions regarding the perceived concerns about and recommendations for the current FTLs (for the complete and final version of the survey please refer to Appendix F). The survey was loaded onto Google Forms®, and the survey was then finalized in March 2020. The average time taken to complete the survey was approximately 15-minutes.

Table 7. Overview structure of the final survey.

Part or section of survey	**Content of each section**	**Number of/ types of questions**
PART 1	Consent to participate in the study.	1 (close-ended)
PART 2	Questions pertaining to the participants" demographic information.	14 (10 open-ended, 4 close-ended)
PART 3	Questions pertaining to the crews" perceptions around fatigue.	10 (1 open-ended, 9 close-ended)
PART 4	Questions pertaining to the contributory factors to fatigue: ● Work-related factors ● Non-work related factors	66: ● Work-related - (1 open-ended, 50 close-ended) ● Non-work related - (1 open-ended, 14 close-ended)
PART 5	Questions pertaining to the South African Flight Time Limitation legislation.	3 (all 3 open-ended)

In summary, Part 1 included one close-ended question that asked for consent of the participants to participate in the study. Part 2 had ten open-ended questions and four-close ended questions, the ten open-ended questions pertained to the participants" demographic information and included questions relating to the participants" age; sex, race group; job title; which part of the aviation industry the participants worked in and the length of time the participants had been at their job; the participants" flying experience; the province where they are based; their characteristics of flight duty; a question pertaining to time zone changes; the time zone of the participants" domicile; the time taken to get to and from work; the participants typical mode of transport used to get to work; and the non-flying duties carried out by the participants. Part 3 had one open-ended question and nine-close-ended questions were pertaining to the crews" perceptions around fatigue and these included: a question related to how much of a problem fatigue was in the participants part of the industry; the severity of fatigue when it occurs; how much of a problem fatigue was to the participants personally in their job; how often the participants became fatigued while flying or performing their job; two questions pertaining to if awareness of crew fatigue had changed over the last five years in the industry in general and for the participants respectively. There were also questions pertaining to flight phases of take-off and landing and a separate question pertaining to the cruise phase as to how the participants felt during those three phases. The final question in part three asked if fatigue interfered with the participants" ability to carry out their duties. Part 4 had sixty-six questions, broken down into work-related (one open-ended question, fifty close-ended questions) and non-work related (one open-ended question, fourteen close-ended questions) factors and had Likert scale options as part of the answer. Part 5 had three open-ended questions, pertaining to concerns, recommendations and fatigue mitigating aspects of the current South African FTLs.

3.3 Ethical approval process

Before the commencement of this study, ethical clearance was granted by the Rhodes University Human Ethics Committee (HEC) (reference number HKE-2018-02). Upon approval from the HEC, the gatekeeper's permission was then provided by the South African Civil Aviation Authority (SACAA), Airlines Association of Southern Africa (AASA), and Air Line Pilots" Association of South Africa (ALPA-SA) (for the gatekeepers permission letter please refer to Appendix G and for the ethical clearance form, please refer to Appendix H) which enabled the study to proceed.

3.4 Participants

The study aimed to garner responses from all pilots, management (who fly), and cabin crew, from all parts of the aviation industry including, Part 93 (Corporate Aviation Operations and High-Performance Aircraft), Part 121 (Air Transport Operations); Part 127 (Commercial Helicopter Operations); Part 128 (Helicopter

Aerial Work and Certain Other Air Service Operations); Part 135 (Small Air Transport Operations), Part 137 (Aerial work operations) and Part 138 (Air Ambulance Operations) and other aviators involved in non-scheduled aviation.

3.5 Procedure

The survey was made available to all the stakeholders via the SACAA's website, which contained a Google Forms® link to the survey. In addition, the SACAA emailed the survey to all the parts of the aviation industry to participate in the study. The survey was also shared with members of the working group (ALPA-SA and AASA) who were asked to share it with their networks. The survey was accompanied by a letter of invitation to participate, which explained the aims of the study, the requirements of the participants, and their rights around participation (please refer Appendix I, which is the letter to the participant; which also contains a link to the actual survey). Therefore, the sampling strategy was a combination of purposive and convenience sampling.

Timeline of the study

The web-based survey was released on Friday 20 March 2020. The survey was completely anonymous in order to reduce concerns regarding self-presentation (the participants conveying a particular impression of themselves to others so as to minimize their own discomfort) as the participants‟ actions could not be monitored (Jones and Pittman, 1982; Ongs and Weiss, 2000). However, on the 26th of March 2020 due to the COVID-19 pandemic, and the National lockdown, the duration of data collection was shortened following this recommendation by the aviation-working group. This stemmed from the fact that all airlines and non-essential aviation activities were grounded. This meant that aircrew was not flying at all, in most instances unless they were involved in aid flights or repatriation flights. Therefore, the study was discontinued from the 19th of April 2020.

3.6 Data analysis

All the data were downloaded by the researchers and exported to a Microsoft Excel 2016® spreadsheet. Thereafter, the data were cleaned and checked for duplicates, after which descriptive statistics (means, standard deviations, medians, and inter-quartile ranges (first and third quartile)) were performed.

Analysis of the quantitative parts of the survey

All quantitative data were then tested for normality using the Shapiro Wilk test. The data were not normally distributed, which meant that non-parametric statistics were applied. All data, unless otherwise specified, are expressed as median and inter-quartile range (IQR 1 - 3). Additionally, comparisons were made, where relevant, between cockpit and cabin crew; and between short-haul and long haul operations. In addition, when it came to the comparisons between short and long-haul, those who reported flying aerial work and mixed types of operations were excluded. However, their responses are available in the appendices. All comparisons (between cockpit and cabin crew and between long haul and short-haul crew) were made using the Mann-Whitney U test (for summaries of the statistical measures undertaken, please refer to Appendix J). The statistical analyses were carried out using StatSoft STATISTICA 10® (TIBCO Software Incorporated) with a significant *p*-value of less than 0.05.

Analysis of the qualitative data in the survey

A thematic analysis was performed on the open-ended responses from the survey. The method used in this study was adapted from Braun and Clarke (2006) that involved six steps. The crew responses to these open-ended questions were placed onto Microsoft Word 2016® documents. The first step was to review the research question. The second step involved the researcher reading all the responses from the participants, and writing summary memos (Braun and Clarke, 2006). The third step involved the researcher creating a research journal, and developing a coding strategy, whereby the data were captured using a Microsoft Excel® 2016 spreadsheet (Braun and Clarke, 2006). The next, or fourth step, required the researcher to code for the broad topic areas or themes, and this was carried out by assigning an appropriate 'parent' theme (Braun and Clarke, 2006). The fifth step involved the researcher refining each theme name, and generating actual names for each theme, and this was to ensure the theme names were applicable for the chosen themes (Braun and Clarke, 2006). The sixth step involved the researcher reviewing the coding, and this was to get an idea of how to refine the codes further (Braun and Clarke, 2006). Following this, the codes were re-organized, to create a catalogue, to access them quickly. This step included the researcher merging codes that emerged as similar, therefore, limiting redundancy (Braun and Clarke, 2006). Finally, the themes were used for descriptive or graphical analysis, whereby the data were exported and tables were created using a Microsoft Word 2016® document. Direct quotations from the participants' comments were used as supporting evidence for each theme where relevant.

CHAPTER 4

4. RESULTS

4.1 Participant characteristics

A total of 194 participants completed the online survey. The median age of the participants was 41 (33 – 51) years. More males (n=157) than females (n=37) completed the survey, with the majority of the participants holding the rank of „Captain" (n=106), followed by „First officer" (n=61), while „Cabin crew" (n=27) also completed the survey.

4.1.1 The number of years worked at current job and flying experience

The median was lower for the „number of years in their current job" as compared to the „number of years worked in the industry" (Table 8). For the „flying experience in hours", the captains reported the most hours, followed by the first officers, and then the cabin crew.

Table 8. Number of years worked at current job, flying experience and number of years in the industry. *A total of 27 cabin crew members who partook in the study, however, only 7 responded to the question relating to flying experience in hours). **As the question relating to the number of years worked in the industry was a voluntary question, not all the 194 participants responded to the question.

	# of responses	IQR (Q_1 – Q_3)
Number of years worked at present job	194	9 (4 – 19)
Flying experience(in hours)		
Captains	102	14000 (8000-17900)
First officers	54	7500 (4000 – 1246)
Cabin crew	7*	2000 (1150 – 3000)
Number of years worked in the industry	126**	18/(10 – 28)

4.1.2 Participants from different parts of the industry and their characteristics of flight duty

For the „Part of industry" (Table 9) most participants (n=177) were part of scheduled aviation Part 121, while (n=8) participants were from Part 137 (aerial work). Only five participants were from other – non-scheduled operations. The other participants (n=1) were from Part 135 – small air transport operations, and three participants flew across different parts (Parts 127, 128, 135 and 138). The sample was predominantly composed of crew involved in short-haul operations (n=139), followed by long-haul (n=32), with some respondents from „other (combination of short and long-haul)" (n=14) and „aerial work" (n=9).

Table 9. Overview of crew participants from the different sectors of the industry.

	Responses (n)	%	Cockpit crew (n)	Cabin crew (n)
Part of industry				
121	177	92.24	-	-
137	8	4.12	-	-
Other	5	2.58	-	-
135	1	0.52	-	-
127/128 /135	1	0.52	-	-
121 /135 /138	1	0.52	-	-
135 /137	1	0.52	-	-
Characteristics of flight duty				
Short-haul	139	71.65	123	27
Long-haul	32	16.49	32	-
Other (combination of short and long-haul)	14	7.22	30	-
Aerial work	9	4.64	9	-

4.1.3 The province or country the participants were based in

For the „Province/country based in" section (Table 10), „Gauteng" recorded the highest number of responses, followed by the „Western Cape", then „Kwa-Zulu Natal", followed by participants who lived „Outside of RSA", then a combination of „Western Cape/Mpumalanga", then „Mpumalanga", followed by the „Free State" and „Limpopo".

Table 10. Province/country participants were based in.

	Responses (n)	%
Province/country based in		
Gauteng	113	58.25
Western Cape	54	27.84
Kwa-Zulu Natal	12	6.19
Outside of RSA	6	3.09
Western Cape/Mpumalanga	5	2.58
Mpumalanga	2	1.03
Free State	1	0.52
Limpopo	1	0.52

4.1.4 Time zone changes and time zone of domicile

The majority (n=141) reported not experiencing time zone changes (Table 11). For the „Time zone of domicile" section, most participants reported Standard South African time („GMT/UTC +2), followed by „GMT/UTC -2" as their domicile time zone.

Table 11. Changes in time zones and time zone domicile.

	Responses (n)	%
Time zone changes		
No	141	72.68
Yes	53	27.32
Time zone of domicile		
GMT/UTC +2 (South African time)	187	96.39
GMT/UTC -2	2	2.03
GMT/UTC +1	1	0.52
GMT/UTC +4	1	0.52
GMT/UTC +7	1	0.52
GMT/UTC +3	1	0.52
Not a clear question	1	0.52

4.1.5 Time taken to get to and from work and method of transport used

The number of minutes it took to get to and from work (Table 12) was compared across captains (irrespective of the part they worked in), first officers and cabin crew. The captains and first officers reported taking the longest to get to and from work, followed by the cabin crew, however, there were statistically significant differences between the cockpit and cabin crew members regarding commuting time (U (N = 156, N = 27,) = 1548.50, z = 2.20, p = .028). The cabin crew, were more likely to take longer to get to and from work as compared to the cockpit crew. When comparing those who flew short-haul with long haul, the participants who flew long-haul took significantly longer to get to and from work, (U (N = 138, N = 32,) = 1340.50, z = -3.47, p< .01), as compared to those who flew short-haul.

Most respondents reported using a „self-drive surface transport‟ to get to and from work, followed by „flying as a passenger‟, then a combination of the two (self-drive surface transport; flying as a passenger) and finally „public transport (taxi; bus; train)‟ recorded the lowest number of responses (Table 12).

Table 12. Length of time taken and mode of transport to get to and from work.

	Responses (n)	%	/IQR (Q_1 – Q_3)
Time taken to get to and from work (minutes)			
Captains	108	-	60 (32.50 – 90)
First officers	59	-	60 (30 – 90)
Cabin crew	27	-	40 (30 – 60)
Mode of transport to and from work			
Self-drive surface transport	168	86.60	-
Flying as a passenger	14	7.22	-
Self-drive surface transport/ Flying as a passenger	9	4.64	-
Public transport (taxi; bus; train)	3	1.55	-

4.2.1 Operational (non-flying) duties and non-operational duties

In response to the questions about non-flying related duties, there were 338 responses by the participants, which were then divided into operational and non-operational duties (Table 13). With respect to operational duties, crew reported „Training" as the most frequent activity, „Pre-flight paperwork" was the second highest, followed by „Reporting, then „Post-flight paperwork"; „Briefings", „Instructions", „Planning", „Handling dangerous goods", „On call times" (being on standby duty) and „Rosters" (checking the roster duties). In terms of the non-flying-related duties, „Admin work" was most commonly reported activity, followed by „Management duties", „Pilot union work", „Crew Resource Management (CRM) facilitator", „Workshops", „Family responsibilities", and „Engineering".

Table 13. Summary of reported flight and non-flight related duties by respondents.

	Responses (n)	%
Operational (non-flying) duties		
Training – (refresher training, recurrent training, bi-annual training)	99	29.29
Pre-flight paperwork – (paperwork before the flight)	74	21.89
Report writing – (flight reports if there were any issues; general standard flight reports)	51	15.09
Post-flight paperwork – (paperwork after the flight)	40	11.83
Briefings – (pre-flight briefing to crewmembers)	13	3.85
Instructions – (waiting to be told what to do)	5	1.48
Planning – (pre-flight weather checks; route analysis)	5	1.48
Handling dangerous goods – (transportation of goods which are risks to health, safety, property and the environment)	4	1.18
On call times – (standby duty; office standby duty)	3	0.89
Rosters – (checking flying rosters for duties)	1	0.30
Non-operational duties		
Admin work – (reading and sending emails; handing in fuel slips; refuelling; stock count; office duties; overseeing trustee funds; property rental; reading new published notices and documents; checking audits; updating iPad software)	30	8.88
Management duties – (managing the Electronic Flight Bag system; aircraft management)	5	1.48
Pilot union – (members or representatives of the pilot union)	3	0.89
CRM facilitator – (Crew Resource Management facilitator)	2	0.59
Workshops – (ancillary projects)	1	0.30
Family responsibilities – (having family time after work)	1	0.30
Engineering – (servicing aircraft)	1	0.30

4.2 Reported prevalence of fatigue

When asked about their perceptions of how much of a problem fatigue is in their part of the industry (refer to Figure 4 graphic (A)), 50.52% (n=98) of the participants reported that fatigue was „A very serious problem‟, whereas, 40.21% (n=78) recorded it as „A relatively serious problem‟. This was followed by 8.76% (n =17) of the participants who indicated that it was „A minor problem‟ and lastly 0.52% (n=1) of the participants recorded it as „Not a problem at all‟. When comparing cockpit and cabin crew, there were no significant differences in response to this question (U (N = 158, N = 27,) 1833.00, z = -1.31, p = .186). There were also no significant differences between short-haul and long-haul crew (U (N = 139, N = 32,) 2088.00, z = -0.60, p = .543).

With regard to safety implications when serious fatigue occurs (refer to Figure 4 graphic (B)), 76.29% (n=148) of the participants agreed that it is „A very serious problem‟, while 20.62% (n=40) reported it as „A relatively serious problem‟. Only 3.09% (n=6) of the participants found it to be „A minor problem‟. There were no significant differences between cockpit and cabin crew (U (N = 158, N = 27,) 1851.00, z = -1.51, p = .129) or between short and long haul crew (U (N = 139, N = 32,) = 1944, z = 1.54, p = .121).

Regarding the question about how much fatigue affects individuals personally in their job (Figure 4 graphic (C)), 29.90% (n=58) of the participants recorded it as „A very serious problem‟, whereas 46.91% (n=91) found it to have been „A relatively serious problem‟, 20.62% (n=40) of the participants found it to have been „A minor problem‟, while 2.58% (n=5) of the participants found it to be „Not a problem at all‟. There were no significant differences between cockpit and cabin crew, (U (N = 158, N = 27,) 1690.50, z = -1.71, p = .061) or between short-haul and long-haul crew (U (N = 139, N = 32,) = 2089.00, z = -0.57, p = .563).

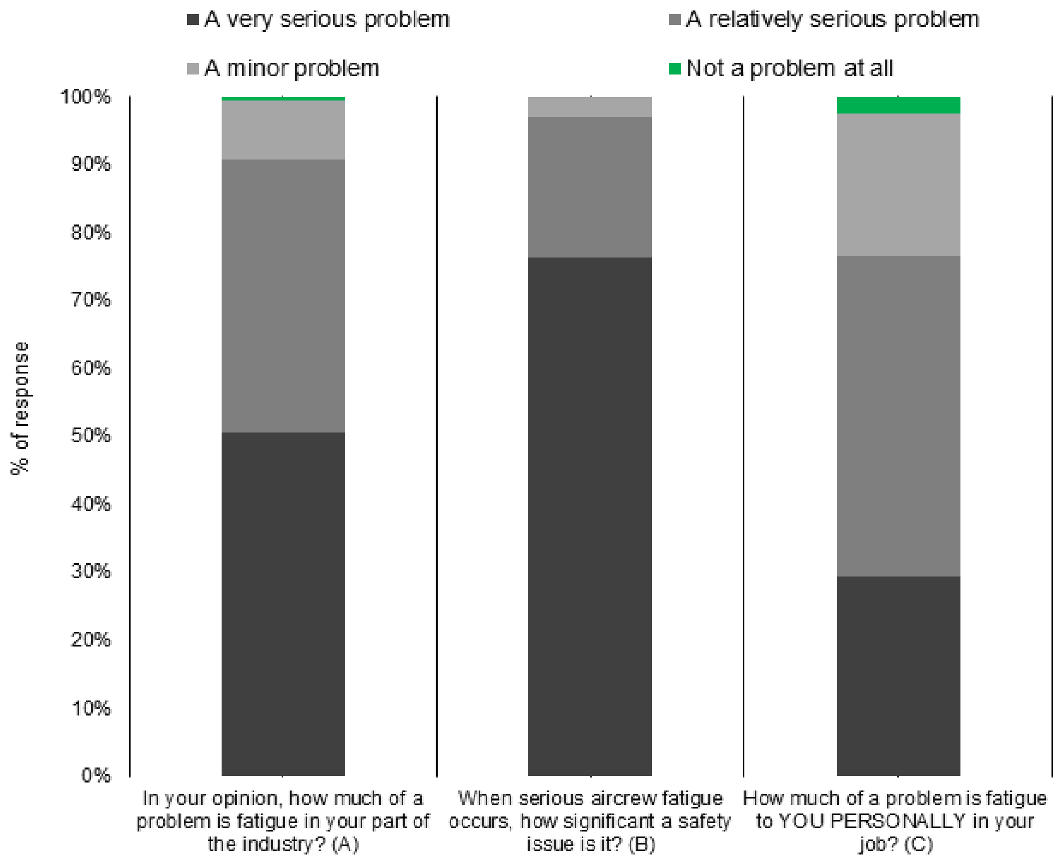

Figure 4: The percentage of responses in relation to questions on fatigue in the aviation industry (left, graphic A), the severity with regards to safety (middle, graphic B), and for the participants in their job (right, graphic C).

4.2.2 Fatigue interference whilst performing duties

With regard to crew perceptions on how fatigue interfered with their ability to carry out their duties (left side of Figure 5), 1.03% (n=2) of the participants answered „On every trip", 11.34% (n=22) of the participants answered „On most trips", 19.59% (n=38) of the participants answered „On about half your trips", whereas 50.52% (n=98) of the participants answered „Occasionally", and finally 17.53% (n=34) of the participants answered „Very rarely". There were no significant differences between cockpit and cabin crew (U (N = 158, N = 27,) = 1953.00, z = 0.75, p = .448). When comparing the participants who flew short-haul with those who flew long-haul, there were also no significant differences, (U (N = 139, N = 32,) = 2042.00, z = -0.78, p = .43).

For the second question, which was related to how often the crew experience fatigue while flying or performing their job (right side of Figure 5), 5.15% (n=10) of the participants answered „On every trip", 26.29% (n=51) of the participants answered „On most trips", 31.96% (n=62) answered „On about half your trips", 29.38% (n=57) of the participants answered „Occasionally" and, 7.22% (n=14) of the participants answered „Very rarely". There were significant differences between cockpit and cabin crew (U (N = 158, N = 27,) = 1504.00, z = 2.55, p =.01), with cockpit crew being more likely to report experiencing fatigue than cabin crew. When comparing the participants who flew short-haul and those who flew long haul, there were also significant differences (U (N = 139, N = 32,) = 922.00, z = -5.39, p <.01). The long-haul crews" ratings were more likely to report experiencing fatigue than short-haul crew.

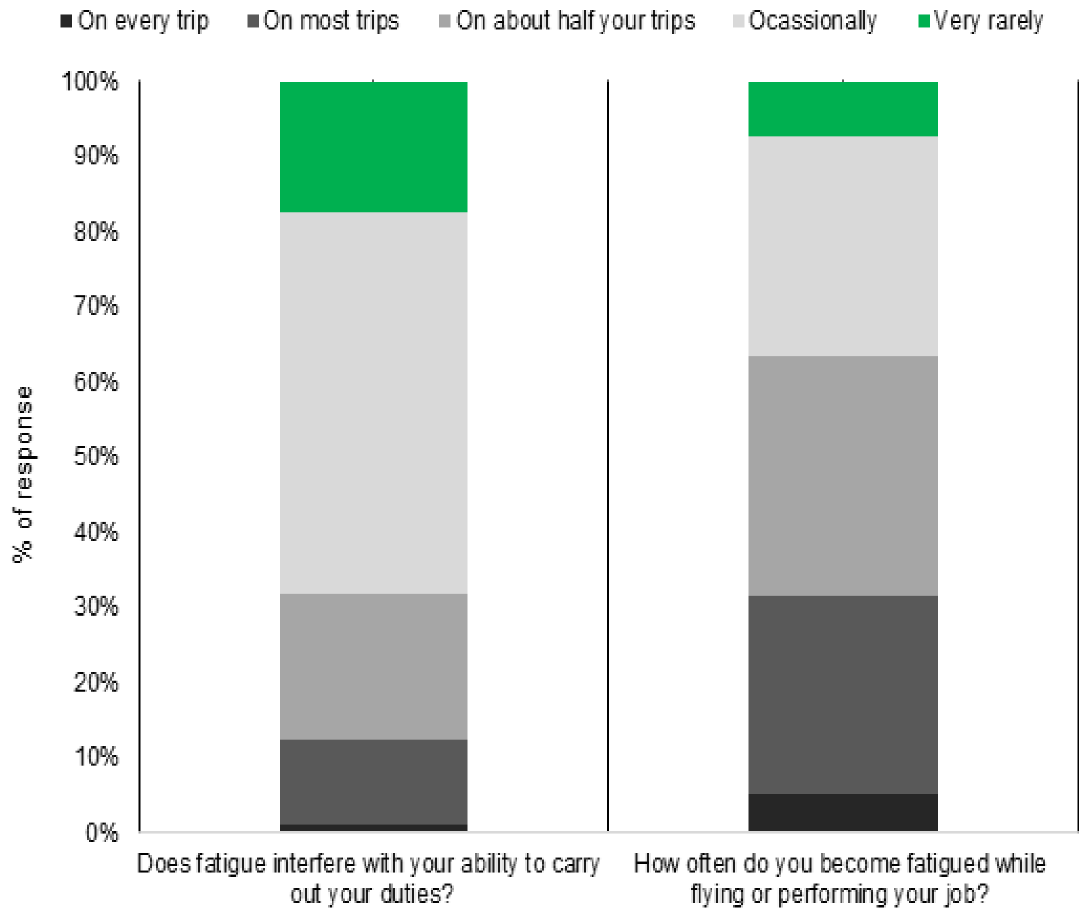

Figure 5: The percentage of responses as to how the participants perceived fatigue to interfere with their ability to carry out their duties.

4.2.3 Awareness of aircrew fatigue in the last five years in the aviation industry in general

For the first question „Do you think that AWARENESS of crew fatigue has changed in the last 5 years IN THE INDUSTRY in general?" (left side of Figure 6), the general impression was that it had increased a lot, with 22.16% (n=43) of the participants acknowledging this, 53.61% (n=104) of participants agreed that awareness of fatigue has increased, 22.16% (n=43) of participants felt there was no change, whereas 1.55% (n=3) felt that awareness of fatigue has decreased, and 0.52% (n=1) of the participants felt awareness of fatigue has decreased a lot. Therefore, over 75% of respondents agreed that awareness around fatigue had increased in the industry over the last five years. In comparing the awareness of fatigue in the industry in general between the cockpit and cabin crew, there were no significant differences between them, (U (N = 158, N = 27,) = 2102.00, z = 0.71, p =.896). There were no significant differences between short-haul and long-haul (U (N = 139, N = 32,) = 1970.00, z = 1.10, p =.271).

4.2.3.1 Awareness of aircrew fatigue in the last five years in the aviation industry for the participants

For the second question, „Do you think AWARENESS of crew fatigue has changed over the last 5 years, FOR YOU?" (right side of Figure 6), 15.46% (n=30) of the participants agreed that awareness of fatigue has increased a lot for them, 52.06% (n=101) of the participants felt awareness of fatigue has increased for them, 28.35% (n=55) of the participants felt there was no change in awareness for them, 3.61% (n=7) felt that awareness of fatigue has decreased for them and 0.52% (n=1) of the participants felt that awareness of fatigue has decreased a lot for them. Thus, over 68% of respondents agreed that awareness around fatigue had increased for them over the last five years. In comparing the awareness of fatigue for the participants, and between the cockpit and cabin crew, there were no significant differences between crew type and reported awareness, (U (N = 23, N = 13,) = 127.00, z = -0.72, p =.468). However, when making a comparison between short-haul and long-haul, there were significant differences between the short-haul and long-haul crew, (U (N = 29, N = 7,) = 48.50, z = 2.26, p = .02), with the short-haul crew more likely to report an increased awareness than the long-haul crew.

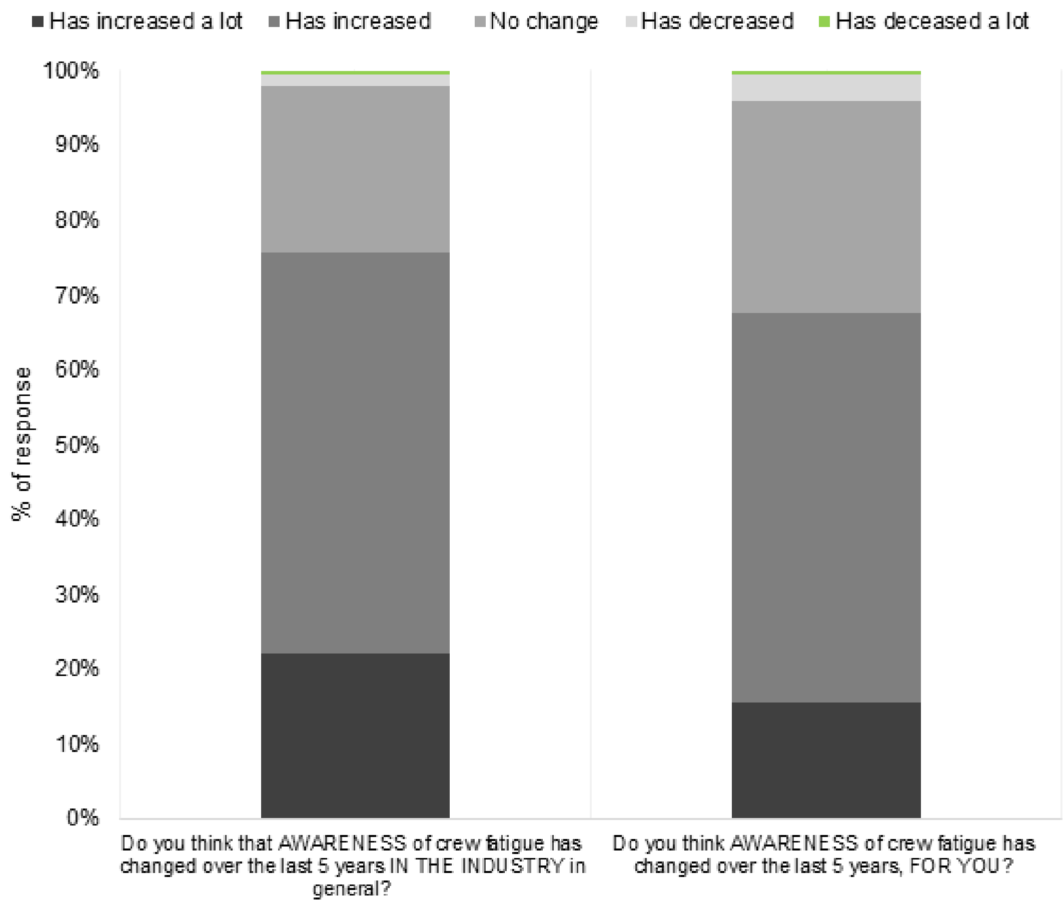

Figure 6: The percentage of responses to questions that related to the awareness of crew fatigue and if it has changed over the last five years across the industry (left) and for each participant (right).

4.2.3.1.1 Thematic analysis of awareness of aircrew fatigue in the aviation industry, in general in the last five years

Tables 14 and 15 below provide a summary of the emergent themes, followed by an explanation, and then below the themes are sub-themes and direct quotations to support the data from the participants‟ perceptions towards increased awareness in the aviation industry in general in the last five years. The tables are separated into positive (Table 14) and negative reasons as to why the participants perceived that the awareness had changed (Table 15).

Table 14. Positive responses and the summary of themes, under which an explanation is given, followed by sub-themes and direct quotations to support the data.

Theme 1: Attend fatigue workshops	
The participants found that attending fatigue related workshops assisted in increasing their awareness of fatigue. *"we nowadays attend fatigue workshops".* *"We have had a workshop on fatigue management".*	
Sub-theme: Company courses provided	*"The company has a course on this".* *We get to have more knowledge on fatigue each time to attend training, which happens every year.*
Sub-theme: Communication on fatigue	*"communication on fatigue has increased".* *"We are more aware of it via communication from the company and also crew resource management".*
Theme 2: FTL adherence	
The current FTLs are being adhered to for the safety of the aircrew. *"Strict adherence to FDP has been observed and flights cancelled due to possible exceedance".*	
Theme 3: The ability to complete fatigue reports	
Aircrew now fill in fatigue reports if they are too fatigued to carry out their duties. *"You can now file a fatigue report and take the day off where previously you had to call in sick".* *"Some degree of focus and documentation (Fatigue Reporting)".* *"fatigue report systems".*	
Theme 4: Increased scientific input and fatigue management	
Applying science and Fatigue Risk Management Systems have increased the awareness and dangers of fatigue for aircrew. *"Have fatigue risk management program".* *"Through FRM training".*	
Sub-theme: Scientific input	*—Combined with more published material regarding fatigue studies, that is being pushed by crew in individual airlines has resulted in a general increase in knowledge regarding actual fatigue".* *Many studies on fatigue.*
Theme 5: Increased pressure from unions	
The pilot unions have applied pressure to ensure the safety of the aircrew. *"Awareness has increased due to pressure from unions".*	

With respect to reasons why crew perceived that awareness around fatigue had changed in the industry, there were eight broad themes identified, five of which were positive, while the remaining three were negative responses. From a positive perspective, participants reported that awareness had increased due to increased opportunities to attend fatigue workshops, which included company courses on fatigue and increased communication about fatigue (Table 14). Another common theme revolved around how participants felt that the FDP regulations were being adhered to, with one crewmember reporting how flights have been cancelled due to fatigued crew (Table 14). The participants also reported that they could complete fatigue reports if they are too fatigued to fly, which should afford them with more rest time due to being off duty because of being too fatigued to fly (Table 14).

Furthermore, from a positive perspective the participants reported that awareness had increased due to an increased application of scientific input and fatigue management from the operators. This assisted the participants in becoming more aware of the importance of making use of science with regard to fatigue, but also identifying methods of managing fatigue better (Table 14). Moreover, the participants also reported that increased pressure from pilot unions being applied to ensure the pilots" safety is taken into account regarding operations and duties.

Table 15. Negative responses and the summary of themes, under which an explanation is given, followed by sub-themes and direct quotations to support the data.

Theme 1: Effects of current rostering practices	
For some of the aircrew, they are struggling due to the increased demands placed on them with regards to flying.	
Sub-theme: Increased flight pairings	*"it has increased a lot due to an increase in pairings (flights)".* *"My schedule on some days or consecutive days indicates this. Late sign offs with an off day and then a night stop or early sign after an off day".*
Theme 2: Experiences of cumulative fatigue onset	
Cumulative fatigue results from an accumulation of irregular sleeping times, which may be for days, weeks or months (Van Dongen *et al.,* 2003).	

"Most of my colleagues have now also reached the cumulative fatigue stage resulting in a much greater awareness of the problem due to its shared nature versus 5 years ago. Several incidents at work have highlighted the threat posed by the fatigue level reached, thereby contributing to increasing awareness of the issue".

Theme 3: No change	
Some of the aircrew believe there has been no change in awareness of aircrew in the industry, or aircrew refuse to report being too fatigued to fly as they feel very little will get done to improve their situation due to systemic barriers. *"No change in laws managing fatigue".* *There is no change.*	
Sub-theme: Aircrew not reporting	*The issue of fatigue has come into more awareness overall, but probably not to the extent that it should - because crew and pilots don't report it.*
Sub-theme: Ignored by management	*"it looks like it is ignored from management level".* *"Nothing changes operationally when management is informed about crew being fatigue. It is normally a laughing matter of just brushed off".*
Sub-theme: Misconception of fatigue equal to being tired	*"There is a misconception that fatigue is equal to being tired. Crew and the industry do not understand the difference".*

However, there were also negative perspectives reported by the participants (Table 15). The participants reported that awareness around fatigue had increased due to the increased demands being placed on crew, captured in a sub-theme where a the effects of increased pairings, combined with disruptive duties, were factors that participants suggested drove increased awareness of fatigue. The final negative response was that there is no change, and this is because there has been no change in the way that fatigue has been managed, because there has been no change in the law, or no response by management to reports or continued misconceptions around what fatigue is (for more responses from the participants regarding if awareness of crew fatigue has changed over the last five years in the industry in general, please refer to Appendix K).

4.2.4 Aircrews"feelings during the take-off/landing, and cruise phase

For the first question, „During the take-off/landing phases, how do you typically feel?" (Figure 7), 19.07% of the participants felt fully alert, and wide-awake during the takeoff or landing phase. 23.20% of the participants felt very lively, responsive, but the participants were not at their peak. 22.16% felt okay, somewhat fresh, 18.04% felt a little tired, less than fresh. 12.37% of the participants felt moderately tired, and let down, whereas 5.15% of the participants felt extremely tired, and had difficulties concentrating.

For the same question however, when comparing the cockpit crew with the cabin crew, there were no significant differences, (U (*N* = 158, *N* = 27,) = 2061.00, z = -0.28, *p* =.776). In making a comparison between the participants who flew short-haul and those who flew long-haul, there were no significant differences (U (*N* = 139, *N* = 32,) = 1894.50, z = -1.32, *p* =.183).

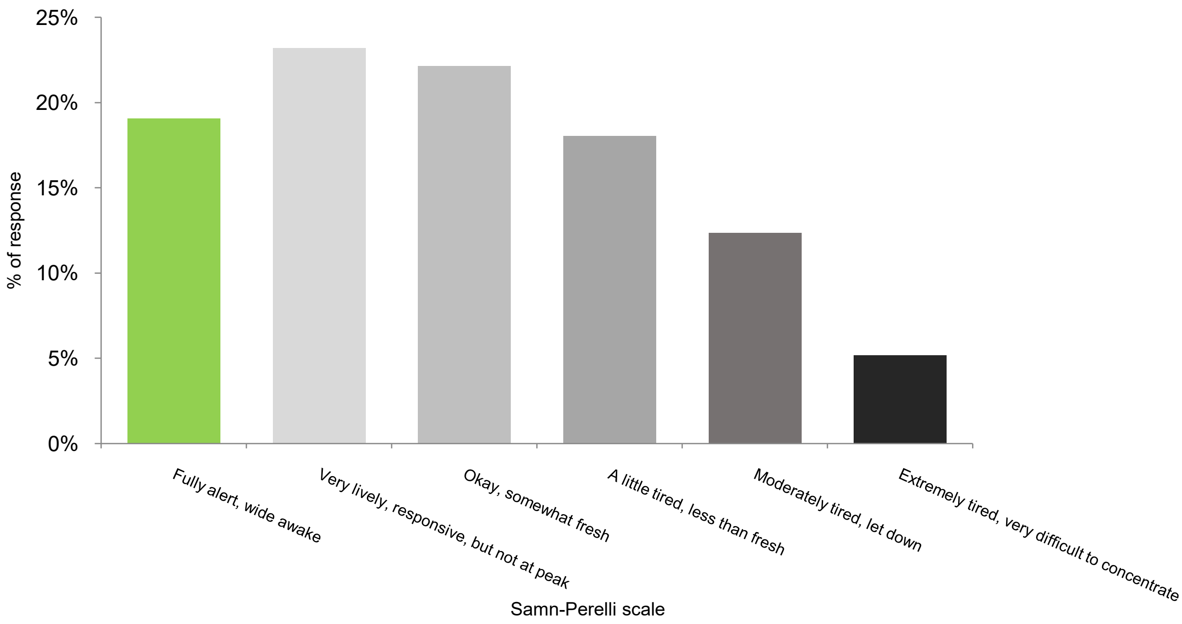

Figure 7: The percentage of responses of all participants pertaining to their perceptions during the combined phases of take-off/landing.

For the second question, „During the cruise phase, how do you typically feel?" (Figure 8), 2.41% of the participants responded with „Extremely tired, difficult to concentrate", 15.66% responded with „Moderately tired, let down", 33.13% responded with „A little tired, less than fresh", 36.75% responded with „Okay, somewhat fresh", 9.64% responded with „Very lively, responsive, but not at peak", and lastly, 2.41% responded with „Fully alert, wide awake". When exploring the relationship of cockpit and cabin crew in relation to the cruise phase, there was a significant difference between the cockpit and cabin crew, (U (N = 158, N = 27,) = 456.00, z = 6.79, $p < .01$). The cockpit crew were more likely to report feeling fatigued during the cruise phase as compared to the cabin crew. In exploring the relationship of short-haul and long-haul crew, there were significant differences during the cruise phase, (U (N = 139, N = 32,) = 1351.50, z = -3.45, $p < .01$) with the long-haul participants more likely to feel fatigued during the cruise phase as compared to the short-haul participants.

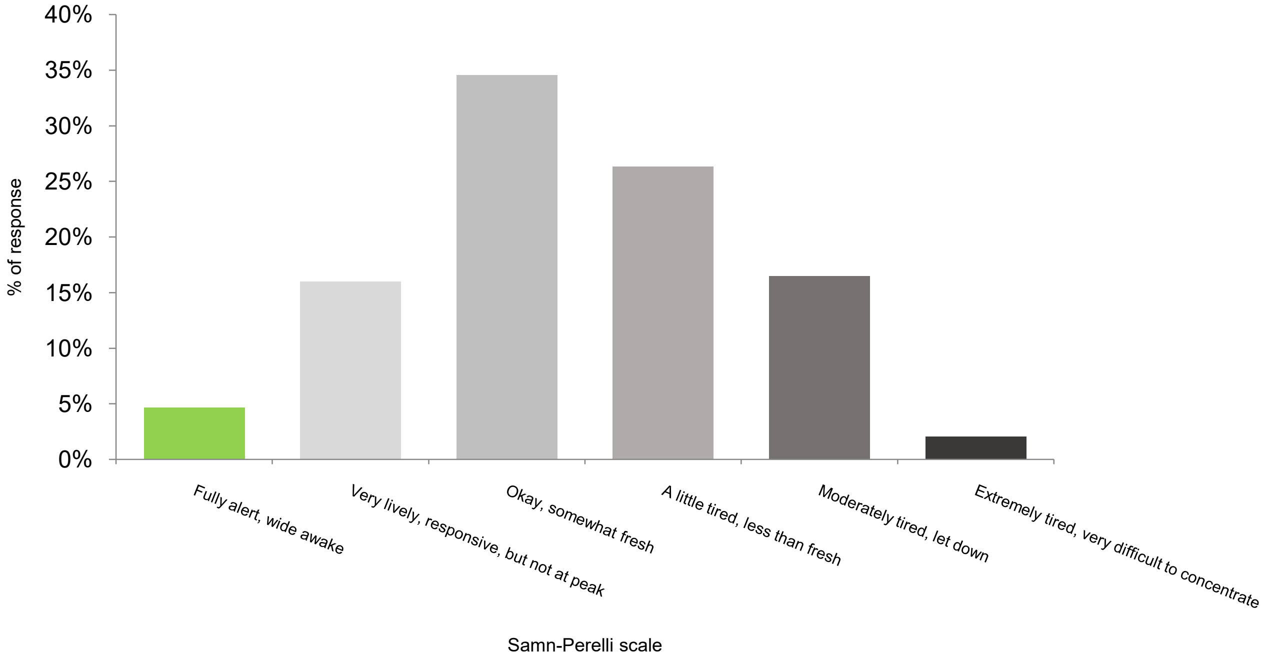

Figure 8: The percentage of responses of all participants pertaining to their perceptions during the cruise phase.

4.3 Perceived work-related factors that contribute to aircrew fatigue

With reference to Figure 9, the most commonly reported work-related contributory factor was „Long duty hours‟ (n=94; 48.45%). This was followed by „Number of sectors‟ (n=63; 32.47%) which was supported by comments from cockpit crew members who said, *—Long duty days or many sectors following a night stop";* and *—Ridiculous amount of sectors (flights) performed due to no existing limitations on sectors, recently operated 18 sectors (19 if a positioning sector preceding 3 operating sectors is included) of which the last 3 days totalled 12 sectors???"*. This was echoed by one cabin attendant who commented that, *—Sector combinations. By the second flight most flight attendants are exhausted".*

„Not enough night time sleep‟ (n=55; 28.35%) was the third most commonly cited factor, followed by „Early sign on‟s (before 6am)‟ (n=53; 27.32%) and „Late sign offs (after 11pm)‟ (n=53; 27.32%). These concerns regarding early starts and late finishes were reflected in comments from some cockpit crew who expressed, *—Early morning sign on (05h15) followed by late night sign off (22h00+)"* and *—6 days in a row when you start at 5am and day 6 ends at 11pm"*; and *—Scheduling of early morning duties for consecutive days then a brief (2days) off period and then consecutive late night duties makes it impossible to establish a reasonable sleep routine and get quality sleep"*.

In relation to „Too many consecutive work days in a row‟, 26.80% (n=52) of the participants agreed that this always contributed to fatigue and this was supported a comment from one participant, *too many early sign on in a row. To wake up at 3am for 6days in a row [adds] to fatigue.* Following this, „irregular rostering‟ was commonly cited by the participants as always contributing to fatigue, which was exemplified in the comments, *—Being rostered for e.g. 4 early reporting times, before 630am. Then on the 3rd or 4th day to start at 1400 and then fly till 2330. To be off for 2 days to start again at 500am. There is never enough time to recover from the changes in circadian rhythms"*. Furthermore, another participant commented that; *—Constant circadian disruption during 5 or 6 days‘ work due to no proper structure between early and late duties".*

Additionally, participants cited: „Irregular/inadequate sleep before periods of duty‟, 24.74% (n=48); „Irregular/inadequate sleep during periods of duty‟, 21.65% (n=42); „Flying at night‟ (*n* =40; 20.62%); „Successive night flights‟ 18.56% (n=36); „Long idle time between flights‟ 17.53% (n=34), and „Unscheduled/Organisational delays‟ 17.01% (n=33) as contributory to fatigue.

„Insufficient rest breaks between duty periods/shifts‟ was reported by 17.01% (n=33) and accompanied by comments, *―To be off for 2 days to start again at 500am. There is never enough time to recover from the changes in circadian rhythms"*. Another crew member commented *―When finishing late at night at least 2 nights‟ recovery is required"*.

„Split duties‟ 16.49% (n=32) was the next most cited contributory factor, followed by „Short turnarounds (between sectors)‟; 16.49% (n=32); „Having to rest away from home‟ 15.98% (n=31); „Unplanned changes in shift/schedule‟ 14.43% (n=28); „Pressure to get work done‟ 13.40% (n=26); „Flying with inexperienced crew‟ 12.37% (n=24); „Periods of inactivity while on duty‟ 11.34% (n=22); „Quality of on-board rest facility‟ 10.31% (n=20).

The least commonly cited contributory factors were, „No autopilot function on aircraft‟ 9.28% (n=18); „On call work‟ 8.25% (n=16); „Insufficient time for pre and post flight duties‟ 7.73% (n=15); „Poor cockpit or cabin design/layout‟ 6.70% (n=13); „Flying during early afternoons‟ 5.67% (n=11); „Congested airspace‟ 5.67% (n=11); „Monotony of the job‟ 4.64% (n =9); „Equipment problems (service trolleys onboard)‟ 3.09% (n=6); „Too much non-flying work (report writing/incident reporting etc)‟ 2.58% (n=5); „Extra work to supplement income‟ 2.58% (n=5); and finally „Dealing with passengers‟ 2.58% (n=5). There were also other work-related factors that were predominantly from non-scheduled aviation that had minimal responses from the participants and were therefore not included in this particular set of results (for all responses from the participants regarding the work-related factors, please refer to Appendix L).

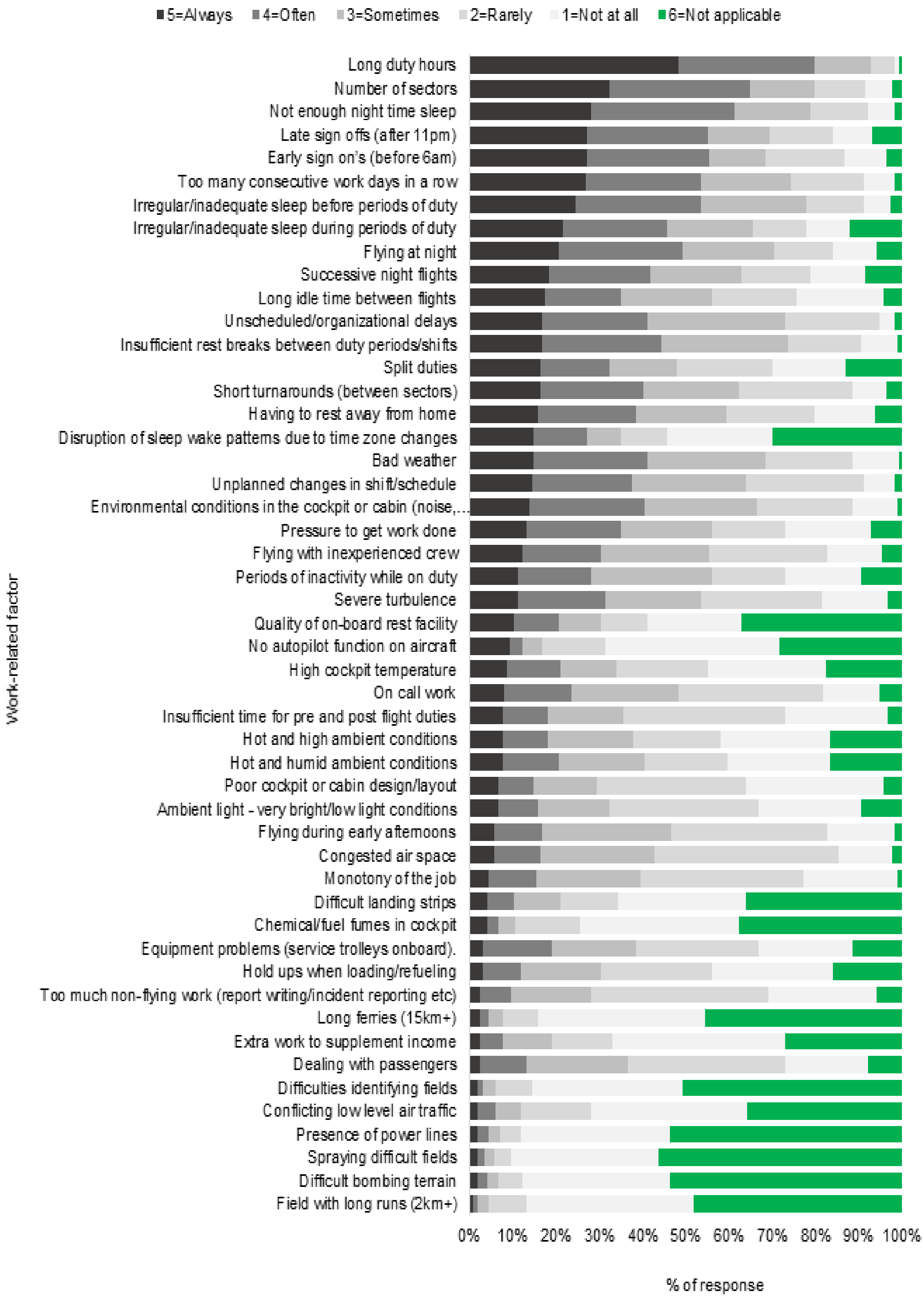

Figure 9: The percentage of responses of all participants pertaining to work-related factors.

4.3.1 Comparison between cockpit and cabin crew of all the work-related factors

In making a comparison between the cockpit crew and the cabin crew with regard to all the work-related factors, the cockpit crew were more likely to report feeling fatigued due to: „Congested airspace"; „Having to rest away from home", as well as „Poor cockpit or cabin design or layout"; „Irregular or inadequate sleep before periods of duty", and „Irregular or inadequate sleep during periods of duty" as contributory to fatigue. Furthermore, the ratings for „Not enough night time sleep"; and „Flying at night", as well as „Split duties"; and „Bad weather", were significantly higher for cockpit crew as compared to the cabin crew. Moreover, „Disruption of sleep wake patterns due to time zone changes"; „Environmental conditions in the cockpit or cabin crew", the fact that there was „No autopilot function on aircraft", and „Successive night flights", with „Long idle time between flights" contributed to cockpit crew fatigue. „High cockpit temperature", as well as „Severe turbulence"; „Flying at night" as well as the effects of „Ambient light - very bright or low light conditions", and finally „Conflicting low level air traffic", were also reported to more likely contribute to the cockpit crews" fatigue as compared to the cabin crew.

4.3.1.2 Comparison between short-haul and long-haul flights for all the work-related factors

When comparing the participants who flew short-haul with those who flew long-haul, the short-haul were more likely to report: „Number of sectors"; „Early afternoon flights"; „Insufficient rest breaks between duty periods or shifts" and „Short turnarounds (between sectors) as contributory to fatigue. In addition, „Early sign-on"s (before 6am)"; „Late finishes (after 11pm)"; „Irregular/inadequate sleep before periods of duty", were also significantly higher for short-haul, compared to the long-haul crew. Moreover, „Unplanned change in shift or schedule"; „Too many consecutive work days in a row", with „Insufficient time for pre and post flight duties", and „Long idle time between flights", were also contributory to short-haul crew fatigue. Furthermore, „High cockpit temperature"; „Pressure to get work done", and „Periods of inactivity while on duty" were also contributory to fatigue for the short-haul participants as compared to participants who flew long-haul.

Conversely, the participants who flew long-haul flights were more likely to report: „Irregular/inadequate sleep during periods of duty"; „Disruption of sleep wake patterns due to time zone changes"; „Flying at night" and „Quality of onboard rest facility", as more contributory to fatigue as compared to the participants who flew short-haul (for the statistical results and comparisons, please refer to Appendix M).

4.4 Non-work related factors that contribute to aircrew fatigue

For this section, the „Always" and „Often" scale options have been combined and this was because the percentage of participants who recorded „Always" was lower than the percentage of participants who recorded „Often". For graphical representation, and for statistical analysis, the two options were combined. This meant that Figure 10 has one less scale option.

„Having young children/looking after dependents" (n=52; 26.80%) was cited as the most common non-work related factor that contributes to fatigue, with „Financial stress" (n= 50; 25.77%), „Poor diet" (*n* = 34; 17.53%) and „Extended commuting to and from work" (*n* = 34; 17.53%) being the next most commonly cited factors.

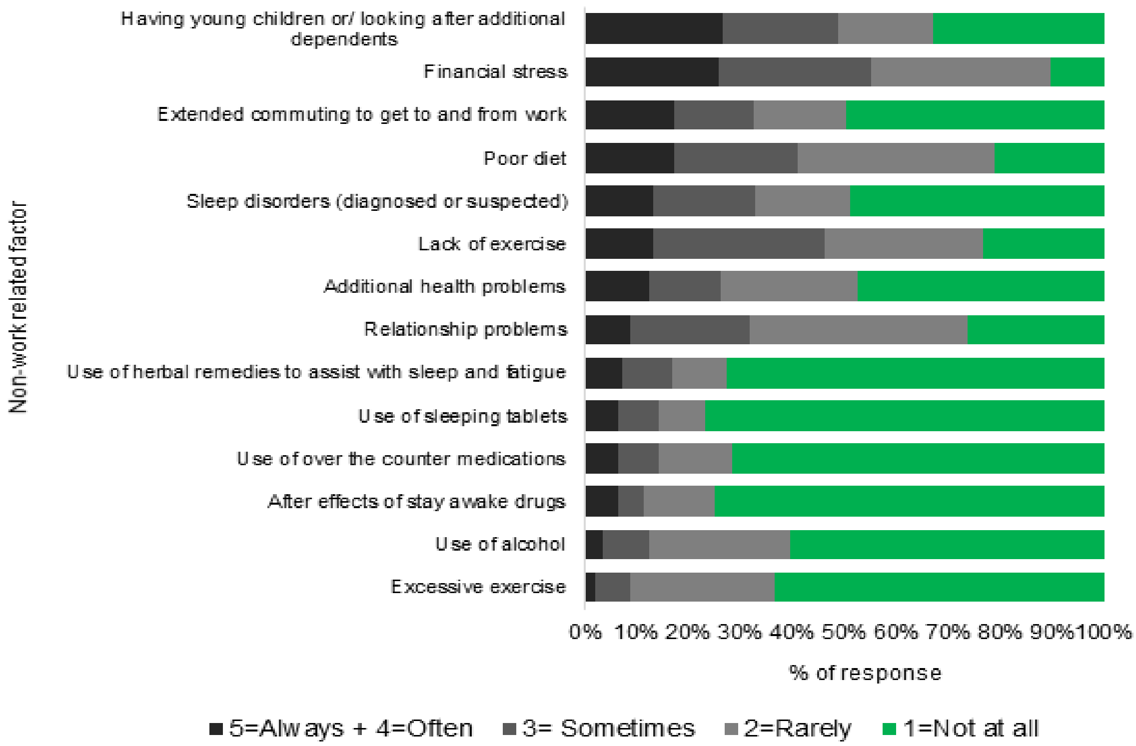

Figure 10: The percentage of responses of all 14 of the non-work-related factors in order of severity.

4.4.1 Comparison of cockpit and cabin crew for all 14 non-work-related factors

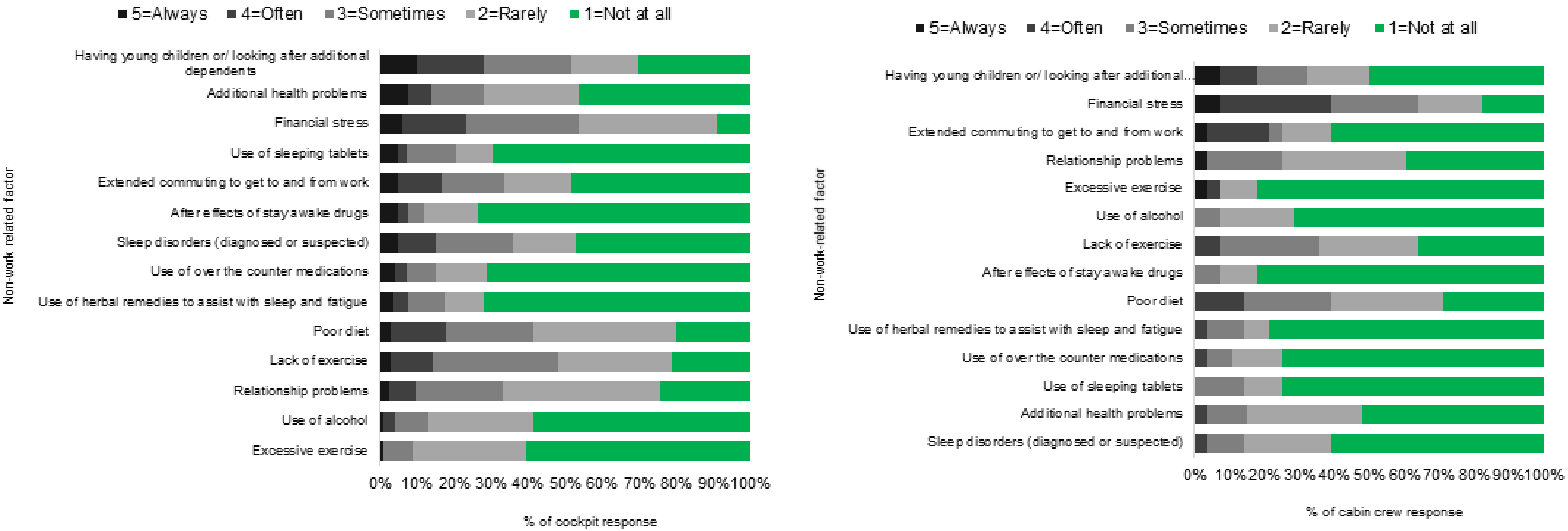

Figure 11: The percentage of cockpit (left) and cabin crew (right) responses in relation to all 14 non-work-related factors.

In making a comparison between the cockpit and cabin crew, the cockpit crew were likely to report „Having young children or looking after dependents", (U (*N* = 158, *N* = 27,) = 1576.50, z = 2.22, *p* = .02), as contributory to fatigue as compared to the cabin crew. In addition, when comparing the participants that flew short-haul with those who flew long-haul, the participants who flew short-haul rated „Having young children or looking after dependents", (U (*N* = 139, *N* = 32,) = 1517.50, z = 2.87, *p* = .003), higher than those who flew long-haul.

4.4.1.2 Thematic analysis of non-work-related factors

The participants provided comments on how they felt about the non-work-related factors, which contributed to fatigue the most (refer to Table 16). However, it became evident that participants could not separate the work-related from the non-work-related factors as the work-related factors affected their personal lives as well. This therefore demonstrates the intersection between home and work-life boundaries.

Table 16. Summary of themes and sub-themes of the non-work related factors. This is accompanied by an explanation of the theme, with direct quotations to support the themes identified.

Theme 1: Disrupted sleep	
Due to the nature of their jobs and roster systems, some of the participants found that their sleep was often disrupted and contributed to fatigue. *"Manage healthy sleep patterns of at least 8-hours per night is very difficult to manage when roster periods are ever changing".* *"Not getting adequate sleep is a huge factor".*	
Theme 2: Stress	
Stress can affect individuals in a number of different ways and some of the participants felt that stress was contributory to fatigue. *"Still experiencing massive amounts of stress".* *"having to deal with my ex-wife in respect of matters relating to my son as well as providing financial needs".*	
Theme 3: Relationship problems and work-family conflict	
Due to the nature of the participant‟s jobs, in the aviation industry, the participants described the impact of the rostering structure regarding their relationship. *-relationship stress”.* *"I have to jumpseat to another city and back at least once a month in order to visit my son due to his mother divorcing me because she couldn't stand my roster anymore".*	
Sub-theme: Poor family time	*"Not seeing your children for 3 days, arriving home late at night after they went to be, waking up early because of guilt feeling to see them before they leave for school".* *"Wife is also a shift worker. Can be extremely challenging to stay on the same page especially when night stopping or when minimum rest with early sign on's".*
Theme 4: Commuting	
Travelling time for some participants to travel from their domicile to work and back. *"143km to airport and 143km back home after the flight".*	
Theme 5: Disrupted social life	
The rostering structures tend to disrupt aircrews‟ social lives which contributes to fatigue in the sense that they socialise when they should be asleep but as their rosters are erratic, their times for socialising are reduced significantly. *"Often, my social life is severely affected".*	
Theme 6: Political interferences	
Political related issues create uncertainties for the aircrew in terms of their job security. *"State interference and capture issues, indiscriminate application of BEE and subsequent unsure job security most of the time!"*	
Theme 7: Family safety	

The high crime rate in South Africa poses a concern for the safety of the participants and their families, especially if the aircrew are not home all the time.

"Living in a country where my safety and that of my family is constantly at threat from savage criminals whether I am home or not".

There were seven broad themes that emerged regarding the non-work related factors (Table 16). Crew reported concerns around **disrupted sleep**, as a result of their current rosters that do not afford the crew with adequate sleep. **Stress** was also cited by crew and this related to financial stress. Crew also expressed concern in relation to how their work affected their **relationships** as they struggled to **balance work-home** life due to their operations, while extended **commuting** was also mentioned. **Disrupted social life**, related to the daily operations of the industry, as crew are on duty for extended periods of time and do not have lengthy day‟s off, leading to a poor social life. The penultimate non-work-related factor was linked to **political interference**, which, at the time of the survey, was affecting the financial sustainability of some operators and by extension, the crew that worked for them. Finally, **family safety**, and this related to the high crime rates in South Africa, creating anxiety for crew when they are away from their families (and for more responses from the participants, regarding the non-work-related factors, please refer to Appendix N).

4.5 Perceptions on the South African Flight Time Limitations Legislation

The final part of the survey asked participants to share their views on the current Civil Aviation Regulations (CAR) relating to FDPs. There were three open-ended questions, which related to the current South African Flight Time Limitations legislation. This provided the participants with the opportunity to comment on concerns about the current regulations make recommendations on them and comment if there were any perceived fatigue mitigating aspects of the current regulations. The three Figures below (Figures 12, 13, and 14) illustrate the most common themes from the thematic analysis, which pertain to the three-open ended questions. The tables below (Table 17, 18, and 19) highlight the themes and sub-themes that emerged, as well as comments from the participants that support these themes.

Perceived limitations of the current FDPs

A total of 231 references for the perceived limitations of the current civil aviation regulation (CAR) FDPs (Figure 12) were analysed. Broadly, seven themes emerged from the analysis, including concerns around „**Definitions**‟ in law (3.89%); „**Applicability**‟ of the law (4.32%); „**Disruptive rostering**‟ (5.62%); „**High workload**‟ (6.92%); „**Duty length concerns**‟ (20.78%); „**Inadequate**

rest" (22.08%). The final thematic area captured „**Perceptions and attitudes**" (36.36%) regarding the current CARs, which made up the largest portion of the responses.

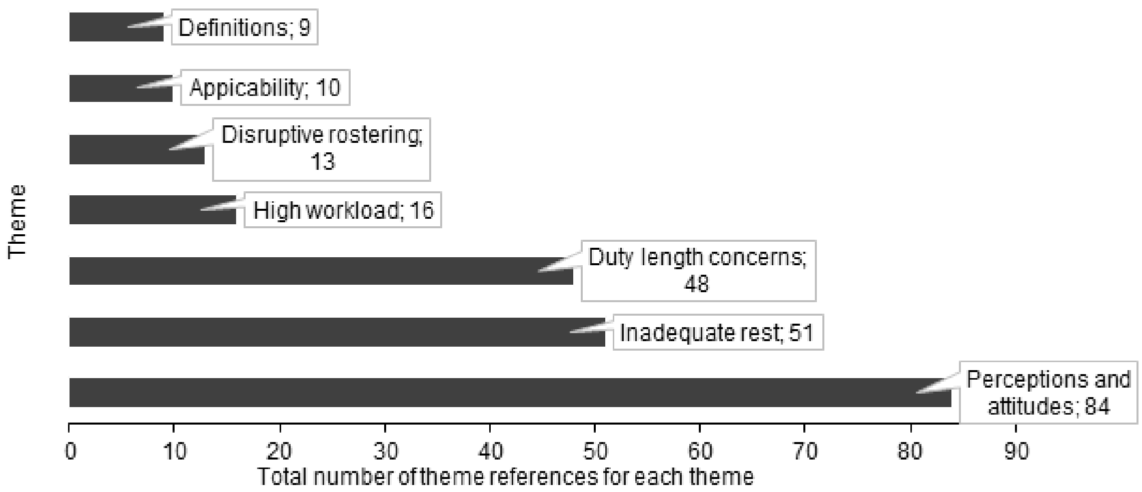

Figure 12: The total number of theme references regarding the perceived limitations of the current CAR FDPs.

Table 17 provides a detailed overview of the main themes, associated sub themes and examples of supporting narratives from crew responses. The theme around „**Definitions**" referred to concerns that participants had around the definitions within the current regulations. More specifically, one example was the definition of a local night, where a crewmember said, *and ~~no~~ clear definition of a local night by SA CAA"*. The definition of a sector was also highlighted, where a crewmember said *"Flight and duty limits base their time restrictions on; sign on time and number of sectors. A sector is defined as the time between when an aeroplane first commences to move…until it finally comes to rest after landing. This time does not take into account the pre-flight time. I.E. The time when the crew are preparing/setting up the aircraft before the start of the 'sector'.* Lastly, the definition of the window of circadian low (WOCL) was mentioned, where a crewmember said "*undefined wocl definition in South Africa*".

The theme of „**Applicability**" revolved around how the current regulations were not appropriate to all parts of the industry, such as those who operate in regional airlines or other unique operations such as those in Part 137 (Aerial work) where the operating times differ significantly from those in scheduled aviation. This was supported by a crew member who said, *"The law is not specific to regional airline operators".*

The theme related to „**disruptive rostering**" highlighted concerns that crew had around how the law did not specify the number of early starts and late finishes that could be rostered in a row. A crewmember had the following to say, *"Allowing early then late duty with insufficient time between each for a sleep routine to be established - 3 early morning followed by 2 late night duties in a 5-day period".* There were also concerns expressed about the stipulations around night flying, where a crewmember wrote, *―Long duties during night flying",* and split duties. In addition, a crew also commented, *―They don't take enough account of sleep deprivation due to time zone shifts"* which related to specific duties and the impact of time zone changes.

„**High workload**" was also cited as a concern, and this reflects the number of sectors flown per duty leading to multiple take-offs and landings per sector. A crewmember commented with, *―FDP limits for 4 sectors: an average working day could easily be 4 sectors and exceed 10 hours' duty consistently such is the case for me. This cannot be sustained without developing chronic fatigue".*

Concerns around the „**length of duty**" were the third most prominent theme and this related specifically to the permissible length of the duty period limits, and effects of being on standby/reserve duty. A crewmember commented with, *―Length of allowable duty is too long, the last sector on a long day is always subject to fatigue at some level. Too little provision is made for the cumulative effects of successive late night duty is made, duties starting in the afternoon/evening and continuing into the night need to be shortened".*

„**Inadequate rest**" was next, and this relates to the perception that there is inadequate rest between strings of duty, supported by comments such as, *―Ten hour rest period. Make it twelve hours and it would be much better"* and between duties, where a participant said, "*Lack of rest between duties"*.

The final theme was the participants" „**perceptions and attitudes**", and this captured participant perceptions about the FDPs, rather than specific areas of concern within the law and the rostering practices. The first sub-theme was that the flying limits were being „used as targets", as exemplified by one participant who wrote, *―Our limits are being treated as targets in times of high workload"*. Another concern was that there was very „little science" applied to the FDPs, where a crew member said, *―All of it. It is archaic and light years behind the latest available scientific data and recommendations and presents a significant safety risk"* and that the current FDPs are „outdated", and a crewmember commented, *―The entire FDP section is inadequate and outdated"* (for more responses from the participants with regard to concerns around the current South African Flight and Duty Period regulations, please refer to Appendix O).

Table 17. Summary of themes, sub-themes and responses to concerns regarding the current FPD regulations.

Theme 1: Definitions	
There are unclear definitions of certain aspects of the current CARs.	
"no clear definition of a local night by SA CAA".	
"Flight and duty limits base their time restrictions on; sign on time and number of sectors. A sector is defined as the time between when an aeroplane first commences to move…until it finally comes to rest after landing. This time does not take into account the pre-flight time. I.E. The time when the crew are preparing/setting up the aircraft before the start of the 'sector'.	
Sub-themes:	
1.1 Local night definition	*"Local night definition".*
1.2 Sector definition	*"Flight and duty limits base their time restrictions on; sign on time and number of sectors. A sector is defined as the time between when an aeroplane first commences to move…until it finally comes to rest after landing. This time does not take into account the pre-flight time. I.E. The time when the crew are preparing/setting up the aircraft before the start of the 'sector'. This time on the ground is a critical time. The aircraft is being pre-flighted (pre-checks being completed) and the crew are managing, ATC, cargo and passenger loading, refuelling, etc. The definition of sector, needs to change to include this time".*
1.3 WOCL definition	"*undefined wocl definition in South Africa*".
Theme 2: Applicability	
This theme reflects the participants" thoughts on the applicability of the current regulations to different parts of certain operations.	
"The law is not specific to regional airline operators".	
"I think FDP for Part 135 is well thought out. My concern is that proposed regulations for Part 137 aim to put a pilot on duty for 42 to 49 days without one day of rest".	
Theme 3: Disruptive rostering	
The current rostering structure is disruptive which creates sleep-related issues that contribute to fatigue.	
"Allowing early then late duty with insufficient time between each for a sleep routine to be established - 3 early morning followed by 2 late night duties in a 5-day period".	
"Routine of sign on/flight times. Can be awake at 3am for a 5am sign on today and have an afternoon sign on the next day flying until midnight. Can mean 4 days irregular/minimum sleep for 2 days of duty".	
Sub-themes:	
3.1 Early sign-on	*"Too many early sign on's in a row".* *–It allows for a week of early sign ons (before 6am) It should not allow more than 3 early sign ons in a row".*
3.2 Late duties	*–Signing off after midnight and signing on on the same day as long as it's after 12pm to accommodate 12 hours' rest, without regard that those 12 hours, you still need to drive home and still have to see to your family".*
3.3 Night flights	*–Consecutive night flights".* *–long duties during night flying".*
3.4 Specific flights	*–We have a flight that departs Lagos late at night and arrived in Jhb early (5am) the next morning. This flight is rostered as 2 crew flight. It is seldom possible to sleep before this flight, and it is not possible to sleep during the flight. So effectively, one is awake all night without any preceding sleep. I find this flight extremely tiring/fatiguing. All other flights that operate through the night have 3 crew members".* *–No relief crew on certain flights (Lagos to Johannesburg)".*
3.5 Split duties	*–Split duties".*

	―Split duties. Length of FDP with Capt. discretion".
3.6 Time zone changes	*―Time zone changes".* *―They don't take enough account of sleep deprivation due to time zone shifts".*
Theme 4: High workload	
This refers to the number of sectors carried out per day, as a high number of sectors results in multiple take-offs and landings which are taxing activities that add to the aircrew"s workloads. *―FDP limits for 4 sectors: an average working day could easily be 4 sectors and exceed 10 hours' duty consistently such is the case for me. This cannot be sustained without developing chronic fatigue".*	
Theme 5: Duty length concerns	
The participants felt that the current duty lengths are too long and need to be adjusted. *―Length of allowable duty is too long, the last sector on a long day is always subject to fatigue at some level. Too little provision is made for the cumulative effects of successive late night duty is made, duties starting in the afternoon/evening and continuing into the night need to be shortened".*	
Sub-themes:	
5.1 Duty period limits	*―6 day On / 2 days Off is not ideal!!"*
5.2 Standby/reserve	*"Also, the 16-hour standby rule that I found to be absolutely ridiculous".*
Theme 6: Inadequate rest	
The current rest periods are not adequate in order for aircrew to fully recover. *―minimum rest periods, longer duty periods, application of sacaa limits to long range operations are not correct".*	
Sub-themes:	
6.1 Rest between duties	*―Lack of rest between duties".*
6.2 Rest between strings of duty	*―insufficient rest days to switch to day flying, i.e. reset circadian rhythms".*
Theme 7: Perceptions towards FDPs	
Some of the participants had negative perceptions of the current FDPs in terms of them being outdated, antiquated and not underpinned by science. *―Our limits are being treated as targets in times of high workload. Likewise, recovery periods are shortened to the barest minimum in cases. Since fatigue is such a nebulous concept to companies, and just costs them money, naturally, companies treat commercial pressures as overriding, and this kind of thing comes about. Likewise, long duty days can form part of the schedule that companies are fully aware will often result in extensions just for the crew to get home - nothing is done about this as there is no requirement for companies not to plan unrealistic schedules based on wishful thinking, that doesn't account for the realities of airline scheduling and turnarounds in difficult or busy conditions (i.e. everything is planned on best-case scenarios)".* *―Old antiquated system, no consideration for FRMS".*	
Sub-themes:	
7.1 Limits as targets	*―Our limits are being treated as targets in times of high workload".*
7.2 No concerns	*―The duty times are ok but we might lose them or revert to worse regulations".*
7.3 No science	*―lack of updated legislation based on international best practise".*
7.4 Outdated FDPs	*―The entire FDP section is inadequate and outdated".*

Recommended changes to the current FDPs

There were 161 references for the recommendations to address the concerns that participants had regarding the current FDP regulations (see Figure 13). Following the thematic analysis, it emerged that many of the recommended changes fell under the theme of **attitudes and perceptions**

(9.94%), an example of which was health effects. Additionally, crew made references to **specific interventions** (11.18%) (discussed below), while also calling for the **modernisation of the regulations** (11.18%), and **limiting disruptive rosters** (13.66%). The participants referred to the need to **adjust duty durations** (14.29%). Some of the participants perceived there to be **no recommendations** (14.29%). The most common recommendations involved the calls for **increased rest provision** (25.46%). Below, the broad themes and sub-themes are presented in more detail.

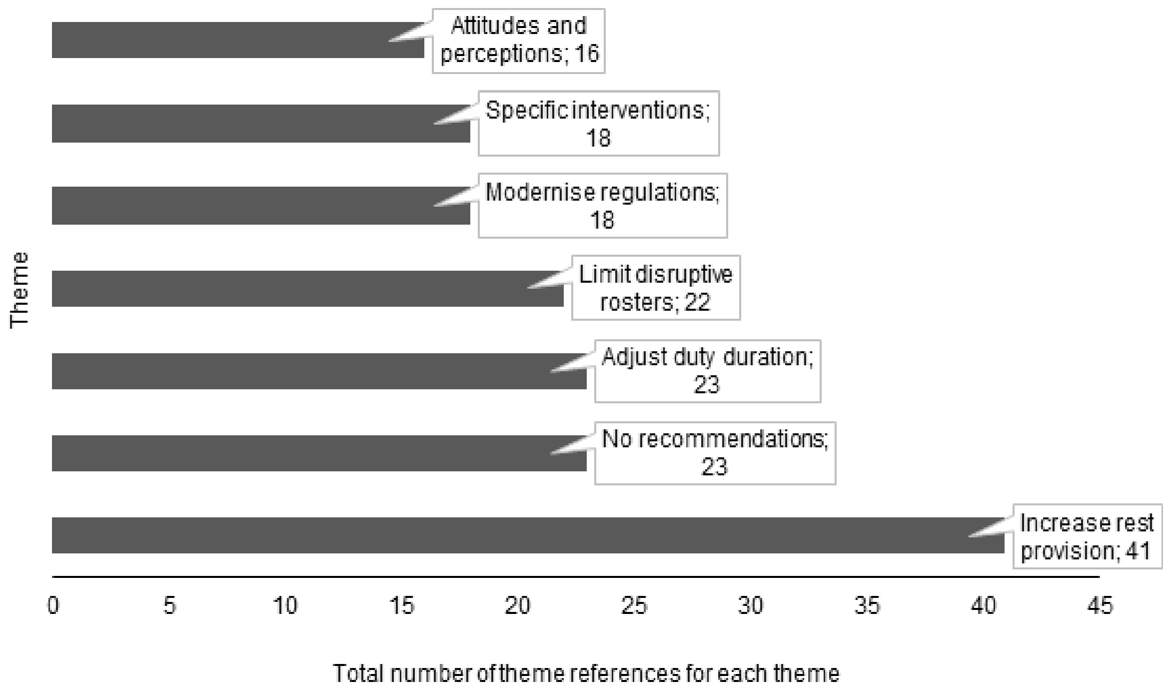

Figure 13: The recommended changes to address the perceived limitations of the current FDPs.

With regard to the first theme (refer to Table 18), which took the form of „**attitudes and perceptions**", crew suggested the need for more restrictive regulations as well as the re-evaluation of the FDP tables, but these comments were not accompanied by further evidence or suggestions. The second theme revolved around „**specific interventions**" made by participants (refer to Table 18), and this included, altering definitions within the Civil Aviation Regulations (CARs), integrating FRMS in operations, having additional crew on certain flights, part specific regulations, reducing the number of sectors, and rostering by chronotype. „**Modernising regulation**s" was the next emergent recommendation, and included aligning the regulations with the rest of the world (refer to Table 19), and this was highlighted by a comment by a crewmember who said, —*R-evaluate fdp limitations to reduce fatigue and increase safety. Adopt FAA and EASA fdp limits".*

The next thematic area revolved around the importance of „**limiting disruptive rostering schedules"** (refer to Table 18), where participants specified altering standby provisions, instilling a block roster schedule, disallowing double signing on and off on the same day, and reducing split shifts as possible interventions under this theme. In support of the block roster suggestion, who wrote, *—Dsigning a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period (off) - 4 days' late flights. Rest period. That the body can to a degree have recovering time and time to adjust".*

The broad thematic area related to „**adjusting duty durations**" had a number of sub-themes (refer to Table 18), including calls to adjust the monthly and daily limits down, tapering the length of duties with increasing number of duty days and a call for limiting discretionary extensions. One participant wrote, "*They have to re look and reduce the duty times that pilots and cabin crew can work. Currently the aviation industry is running all on the limit".* Some participants suggested increasing duty period lengths, but compensating this with more time off, which was likely linked to the comment about installing a block roster arrangement.

The second last theme was that there were „**no recommendations"** (refer to the bottom section of Table 18), where a crewmember commented with the following, *—Keep the current FDP rules in place",* implying that the current regulations are adequate as they are.

The final and most suggested theme was to „**increase rest provision**" (refer to the bottom section of Table 18), and this was supported by a crewmember who said, *—I can recommend that subsequent to a 6-day flying period, three days off needs to be given to an individual. There should be no 1 day off".* This included suggestions around increasing the minimum number of rest days off as well as the minimum hours of rest between duties needs to be increased (for more responses by the participants with regard to the concerns, and recommendations to address the concerns, please refer to Appendix P).

Table 18. Summary of themes, sub-themes and responses to recommended changes to FDPs.

Theme 1: Attitudes and perceptions
Some of the participants had their own attitudes and perceptions regarding the current FDPs.
—The regulations need to get aligned with pace and demand of modern life. We are not androids".
—Changed ASAP before disaster, not after it".
Sub-themes:

1.1 Health effects	*—management must understand that we shorten our lifespan and compromise our own health with the long flights and continuous night shift. it has irreparable damage to our bodies".*
1.2 More restrictive regulations	*—Stricter FDP for high frequency short haul operations".* *—Enforce stricter Flight and Duty regulations on the operators".*
1.3 Re-evaluated FDP table	*—Re-evaluate the FDP table".* *—re-evaluate legislation".*
Theme 2: Specific interventions	
There were some specific interventions suggested by the participants – alter definitions, integrating FRMS, having additional crew on-board, etc. *"Have companies look at having early morning crew and late crew. Designing a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period(off) - 4 days' late flights. Rest period. That the body can to a degree have recovering time and time to adjust".*	
Sub-themes:	
2.1 Alter definitions	*—a clear definition of a local night by SA CAA".*
2.2 FRMS integration	*—Scientific FRMS system incorporated into roster generation system with binding limits. Currently we have a knee jerk system, if enough pilots complain about a pairing, the pairing is changed".*
2.3 More crew	*—I feel a 3rd crew member would reduce the fatigue and increase the safety of this flight".*
2.4 Part specific regulations	*—Part 137 operations may well operate safely for longer periods than Part 135 (without rest days) but not for uninterrupted stints of 6 to 7 weeks. I would suggest one rest day every 14 days for Part 137 operations with a compulsory 12-day break after a 6-week tour. There should be a limitation that if the Part 137 flying hours are within 80% of the stipulated Part 135 hours, then Part 135 limitations regarding rest should be adhered to (1 day every 7 days and 2 days within every 14-day period etc.)".*
2.5 Reduce sectors	*—Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons".*
2.6 Roster by chronotype	*—There should be measures in rostering to identify morning larks and night owls and roster them accordingly - frequently they are rostered the wrong way around which is completely avoidable".*
Theme 3: Modernise regulations	
The regulations need to be modernised with the rest of the world. *—Re-evaluate fdp limitations to reduce fatigue and increase safety. Adopt FAA and EASA fdp limits".*	
Sub-themes:	
3.1 Align with other regulations and guidance	*—As an IATA airline there should be a universal outline which must be adopted, this must have variances according to your geographical location. Basic state maximums which some airlines adapt are brutal especially in those airlines where labour interaction is not encouraged".*
3.2 Inclusion of more science and operational experience	*—Readdress the entire FDP scheme using real-world, accurate and new data from studies of sleep and the effects of fatigue".*
Theme 4: Limit disruptive rosters	
Some of the participants felt that disruptive rosters need to be limited – standby provision, block roster, limiting quick returns, split shifts.	

—Split duty needs to be looked at. Or duty with long gaps and no rest facilities provided (we often sit with the public for up to 6hrs in an airport lounge between legs). Circadian rhythm disruptions (some late sign offs, then early sign ons and then back to late)”.

—Designing a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period (off) - 4 days‘ late flights. Rest period. That the body can to a degree have recovering time and time to adjust”.

Sub-themes:	
4.1 Alter standby provisions	*—A home standby needs to be split a duty of only 8 hours”.*
4.2 Instill a block roster schedule	*—Block roster of 5 on and 4 off to give sufficient time at home for rest”.*
4.3 Limit quick returns (double sign-on/sign-off on the same day)	*—NO sign off early in the morning just to sign on later the afternoon again (I don‘t mean split duty)”.*
4.4 Extend rest away from home	*—To please extend rest time away from home, to balance the amount of early morning and late night flights. To look into long pairings when sleeping away from home”.*
4.5 Split shifts	*—Split duty needs to be looked at. Or duty with long gaps and no rest facilities provided (we often sit with the public for up to 6hrs in an airport lounge between legs)”.*

Theme 5: Adjust duty durations

Some of the participants felt the duty durations need to be adjusted – altering monthly FDPs, rest periods, discretionary extensions, and taper duty lengths.

—They have to re look and reduce the duty times that pilots and cabin crew can work. Currently the aviation industry is running all on the limit”.

—Flight duty limits that take into account the short haul fatigue issues. Encouraging operators not to push flight and duty to the maximum routinely”.

Sub-themes:	
5.1 Alter monthly FDPs	*—Reduce monthly/annual hours by 15%”.* *—Lower monthly limit for consecutive months of flying”.*
5.2 Increase duty times	*"Work for longer periods with longer time off periods”.* *—Five weeks on every day and two weeks off”.*
5.3 Limit discretionary extensions	*—The discretionary extension of FD is often forced on Captains by rostering - no standbys available and other excuses. This should be discouraged”.*
5.4 Reduce daily FDPs	*—Shorter duty days and longer rest periods between duties”.* *—Shorter duty days. If more than 3 sectors... shorted sectors to be considered”.*
5.5 Taper duty lengths	*—Long duty periods should be followed with consecutively shorter periods until an off day”.* *—Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons”.*

Theme 6: No recommendations

Some of the participants felt the current regulations are adequate.

—Keep the current FDP rules in place”.

—Not too many concerns”.

Theme 7: Increase rest provision

As it stands, the participants felt that longer rest periods are required – between duties and number of days off in order to recover and reduce fatigue.

—Definitely look at increasing the minimum rest period”.

—Increase the rest period/period between sign on/off times. The average person requires 8 hours of rest, with the current regulation and travel times to work, the rest period is not sufficient”.

Sub-themes:	
7.1 Minimum number of days off	*—I can recommend that subsequent to a 6-day flying period, three days off needs to be given to an individual. There should be no 1 day off”.* *—3 days consecutive off is needed for proper rest”.*
7.2 Minimum rest within the duty day	*—More time off between flights”.*

Perceived mitigating elements of the current regulations

There were 105 references for the perceived mitigating elements of the current SACAA CARs relating to FDPs (refer to Figure 14). The crews‟ perceptions regarding perceived mitigating elements of the current SACAA CARs were a „**Just culture needed‟** (1.90%); „**Negotiation**‟ (2.86%); „**Perceptions**‟ (4.76%); „**Fatigue reporting and training**‟ (7.62%); „**Rostering practices**‟ (9.52%); „**Enough rest provided**‟ (22.86%); and „**No fatigue mitigation**‟ (50.48%).

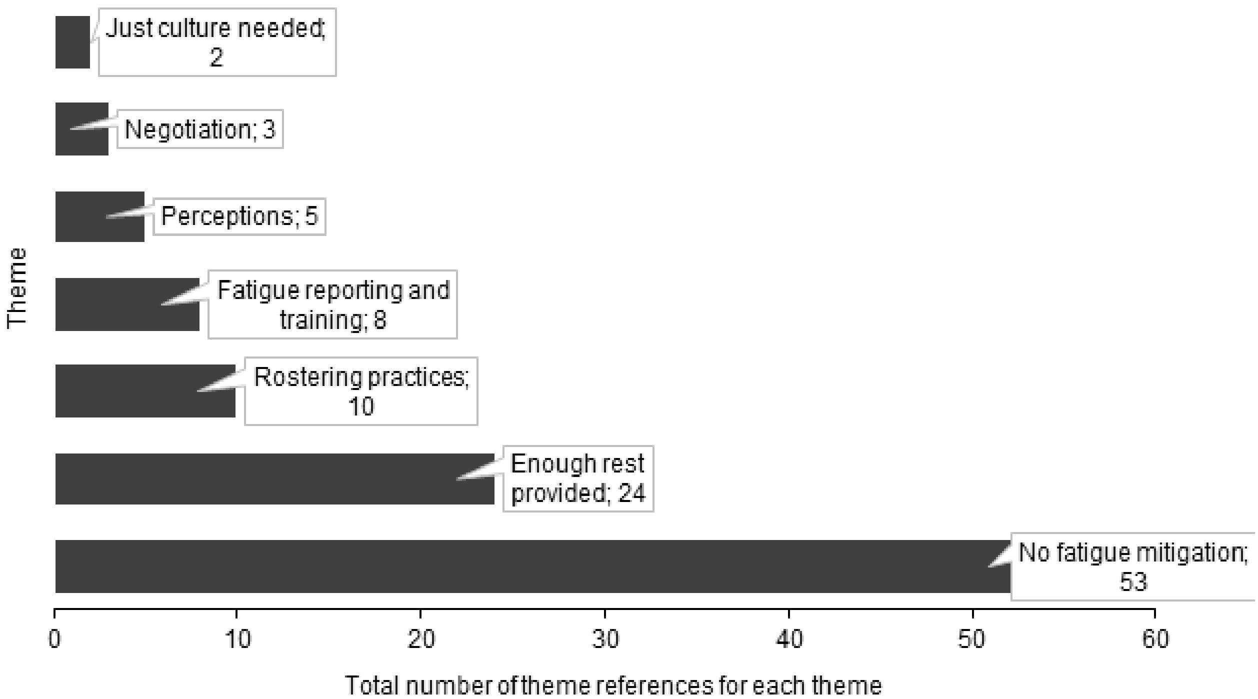

Figure 14: The total number of responses regarding the perceived fatigue mitigating elements of the SACAA CAR on FDPs.

There were six perceptions regarding the perceived mitigating elements of the current FDPs (Table 19). The first perception was that the current regulations are manageable as they are, but the culture within the aviation industry surrounding safety and fatigue is un-just. Therefore, without a „**just culture**‟, crew would not be able to report fatigue-related issues without feeling as if they will be prejudiced for it. One crew member commented and provided an example of the culture instilled within the industry, *—The CAHRS (Confidential Aviation Hazard Reporting Form) system is flawed and needs revising. The installation of a true —Just Culture" will go a long way to addressing this problem. The blanket imposition of a R10 000 fine on anyone reporting a transgression does not engender a reporting culture".*

The second theme (refer to Table 19) related to the ability to „**negotiate**" through collective bargaining is key in getting respite from the targets set by the operators. On this, but not in line with the question asked, one participant wrote, *—Although NASA has done great studies on the fatigue management, the only way we have got some respite is by negotiating concessions with management by labours involvement.ie at SAA we get 3days of after any 4day pairing, and we also have east west protection. This agreement however hangs in the balance as management try to get more productivity out of its crews in order to employ less pilots to max profit".*

The „**ability to report fatigue and attend training**" was also mentioned by participants as a positive development. One of the participants wrote, "*fatigue reporting"* and *—CRM courses where fatigue is discussed".*

„**Rostering practices**" was the next element and where participants expressed concern around how this needed to change, such as limiting the number of consecutive early sign-ons, a crewmember commented, "*Not more than a certain amount of early morning flights in a row on certain occasions".* The participants also reported that the number of sectors flown per week has improved, whereby a crewmember said, *—The number of 4 sector flights per week has been limited"*.

The crew felt they are „**afforded enough rest"** between strings of duty, where a crew member commented, *—flights are seldom rostered to the absolute minimum time off between flights and thus generally speaking enough rest is attainable".* The crew are able to rest in-flight that is beneficial to the crew, and one crewmember commented, *—My company allows short controlled napping on the flight deck during cruise".*

The final perception regarding fatigue-mitigating elements of the current FDPs had negative responses from the participants. The respondents believed there are no fatigue mitigating elements with regard to crew who fly short-haul, where a crewmember said, *—None whatsoever. They do not take the effects of short haul operations in consideration at all. The current regulations are archaic".* Furthermore, the crew believed the current aviation standards are not in line with the modern aviation industry‟s standards, where a crewmember said, —*The fatigue limits are outdated and not scientifically established”* (for more responses from the participants with regard to the current, effective mitigating aspects of the current regulations, please refer to Appendix Q).

Table 19. Summary of themes, sub-themes and responses to the current, effective mitigating aspects.

Theme 1: Just culture	
Some of the participants felt a „just culture‟ should be mandatory.	
—The CAHRS system is flawed and needs revising. The installation of a true —Just Culture” will go a long way to addressing this problem. The blanket imposition of a R10 000 fine on anyone reporting a transgression does not engender a reporting culture”.	
Theme 2: Negotiation	
The participants felt that more negotiations with the operators and crew were important for roster scheduling.	
—Although NASA has done great studies on the fatigue management, the only way we have got some respite is by negotiating concessions with management by labours involvement.ie at SAA we get 3days of after any 4day pairing, and we also have east west protection. This agreement however hangs in the balance as management try to get more productivity out of its crews in order to employ less pilots to max profit”.	
Theme 3: Fatigue reporting and training	
The participants are allowed to fill out fatigue reports if they feel too fatigued to fly and they are provided training on fatigue management.	
Sub-themes:	
3.1 Fatigue management training	*—Airlines have incorporated fatigue risk management awareness but there is still a —stigma” attached to declaring oneself as in a fatigued state”.*
3.2 Mandatory fatigue reporting	*—fatigue reports”.*
	—There are systems in place for reporting. On consultation with colleagues, we evidently report often, but nothing tangible changes, all that has now happened is a drop in actually reporting because it bears little to no results”.
Theme 4: Rostering practices	
The participants felt that the rostering structures put in place need to be re-thought out, especially for flight deck extension, hours per week, number of sectors, number of early sign-on‟s, and recognition of time zone changes.	
Sub-themes:	
4.1 Flight deck extension	*—Maximum time allowed on duty has saved us from being forced into extending duty time when there are lengthy delays”.*
	—Notification of extension of FDP”.
4.2 Limit number of sectors	*—The number of 4 sector flights per week has been limited”.*
4.3 Limiting number of early sign-on's	*—Limiting the number of legs for early sign-ons”.*
	—Not more than a certain amount of early morning flights in a row on certain occasions”.
4.4 Recognition of time zone changes	*“Assigned Duty Free Days. Recognition of time zone traversing”.*
Theme 5: Enough rest provided	
The participants found that their rest periods were adequate, in general, between duties and strings, and some said their airline‟s allowed them to rest during flight.	
—One day off in 7 and 2 days off in 14”.	
—12 hours between duty periods”.	

Sub-themes:

5.1 Rest between duties is adequate	*—Rest time between duties”.* *—Flights are seldom rostered to the absolute minimum time off between flights and thus generally speaking enough rest is attainable”.*
5.2 Controlled rest in-flight	*—My company allows short controlled napping on the flight deck during cruise”.* *—Controlled rest in the flight deck”.*

Theme 6: No fatigue mitigation

Some of the participants felt that there are no fatigue mitigating elements within the current regulations.

—Absolutely none in comparison to the latest ICAO FTL recommendations”.

—Not sure that the current regulations mitigate fatigue. It is antiquated and does not help the low cost model operation”.

Sub-themes:

6.1 Implications for short-haul	*—None whatsoever. They do not take the effects of short haul operations in consideration at all. The current regulations are archaic”.* *—Not much. If an airline where to fly its short haul pilots to the maximum of the CAA regulations it would be very dangerous indeed”.*
6.2 Inadequate for modern aviation standards	*—The fatigue limits are outdated and not scientifically established”.* *—They try to stop you from working too long in a high stress environment, it is unfortunately a bit outdated”.*

CHAPTER 5

5. DISCUSSION

This study aimed to determine the reported prevalence of aircrew fatigue and elucidate the perceived contributing factors to fatigue within the South African aviation industry from the perspective of cockpit and cabin crew and the crew operating in short and long-haul operations, predominantly from scheduled, but in some cases, non-scheduled aviation. Finally, the study also garnered the crews" perceptions around the current FTLs in the various parts of the South African aviation industry, but most predominantly amongst the scheduled aviation crew.

Summary of key findings

Respondents reported a high prevalence of fatigue in the part of the industry they worked in. The respondents also said the severity of fatigue when it comes to safety was a serious problem. In contrast, only a third of the participants reported fatigue as a very serious problem when doing their jobs. In terms of awareness of fatigue and its associated risks, respondents reported that this had predominantly increased across the industry and for them personally over the last five years, with reasons for this ranging from increased awareness raising and information sharing, the ability to report fatigue, while also stemming from increased workload (through more pairings) and a lack of response from management in dealing with fatigue. The most significant findings concerning the work-related factors, which the crew expressed concern about, were the length of duty, the number of sectors flown, early starts, and late finishes, consecutive duties, inadequate sleep while on duty, night flying effects, and successive night flights. For non-work-related factors, the participants reported that having young children to look after, financial stress, the impact of commuting to and from work, and the effects of a poor diet contribute to fatigue.

Regarding critical concerns related to the current FDP limits, key themes emerged that reflected concerns around unclear definitions of the civil aviation regulations, such as a local night, a sector, and the Window of Circadian Low (WOCL). Furthermore, the concerns regarding disruptive scheduling associated with early starts, late finishes, night flying, split duties, the crew being on standby or reserve duty, and the effects of extended duty periods emerged. The participants expressed concerns regarding high workloads (the number of sectors that are permitted to be flown during duty) and the inadequacy of permitted rest periods.

Lastly, the participants' perceived that the flying limits are being used as targets by the management. Additionally, there was a concern around the lack of scientific input and that the current FTLs are outdated and need to be amended.

In terms of the recommended changes to the current FTLs, the crew suggested more restrictive regulations and re-evaluating the FDP tables. The need for updating certain definitions within the CARs was highlighted, while the integration of FRMS in operations also emerged. Furthermore, the participants recommended having an additional crew on certain flights, part-specific regulations, reduced sectors, and for the operators to roster the crew by their chronotypes. The participants also recommended aligning the rules with the rest of the world and limiting disruptive rostering schedules and adjusting duty durations. Finally, the participants recommended increasing rest provision.

The key findings were that generally, the participants did not perceive that there were any mitigating elements but that those that did mention some were likely due to operator specific deviations from the legal limits.

The following section will discuss results related to the reported prevalence of fatigue, and explored possible reasons for emergent similarities and differences between cabin and cockpit crew and short and long-haul crew.

5.1 Perceived prevalence of fatigue

The current study found that just over 90% of the participants reported fatigue to be a relatively serious and a very serious problem, irrespective of the part of the industry in which they operated, which was similar to the Co *et al.* (1999) study upon which this survey was originally based. While challenging to compare to previous research, this finding supports previous research that has highlighted similar reported prevalence rates and concerns relating to crew fatigue (Jackson and Earl, 2006; European Cockpit Association, 2012; Reis *et al.,* 2013). Although these studies determined their prevalence rates through different survey questions and approaches, they support the findings in that crew perceived fatigue to be a concern across different contexts.

Linked to this, over three-quarters of the participants agreed that fatigue presents a safety concern. There were similar concerns in studies from the European countries of Norway, Denmark, Germany, Sweden, and France, where the participants in those studies reported fatigue-related safety concerns (ECA, 2012). More often than not, though, the participants in the ECA (2012) study admitted to having made fatigue-related errors or mistakes while on duty, which nearly resulted in accidents (ECA, 2012). The perceptions of the crew that it is a safety issue support the research team and broader working groups' activities in trying to understand and raise awareness around the challenges that fatigue can present and how updating the current FDPs may help with this. The appreciation of fatigue as a safety concern may also be the result of the increased awareness (across the industry and the individual respondents) that crew reported. More specifically, the impact of the fatigue workshops and courses, the ability to report, the integration of more science and risk-based fatigue management strategies may account for this perception, along with the actual experiences of the participants who also reported how increased workload and lack of responsiveness from operators around fatigue management. An encouraging finding was that there were no differences between the perceptions of cabin and cockpit crew and short and long-haul crew in the study with regard to fatigue as a safety concern. This consensus across these different groups is encouraging and shows a collective appreciation of the impact that fatigue may have on aviation safety in this context.

An interesting disconnect emerged between the participant's perceptions of the seriousness of crew fatigue in the industry, its impact when it happens, and how much it affected them during their duties. Just over 50% of the participants reported that fatigue was a <u>very serious issue</u> in the industry, while just fewer than 80% agreed that it was <u>very serious</u> when fatigue occurs. However, only 29% of the respondents indicated that fatigue was a <u>very serious problem</u> for them during their work. Linked to this, the majority of the respondents indicated that fatigue only interferes with their ability to do their jobs half of the time. Similarly, most of the participants reported becoming fatigued on about half of the trips or occasionally. While there could be many reasons for this, one possible reason for this may be that crew, following the increased awareness raising and workshops around fatigue, may have developed strategies to cope with and manage the demands of their work and the associated factors that contribute to fatigue. Similar results were reported by Efthymiou *et al.* (2021) who argued that improving awareness of fatigue, its effects, and providing insights into various countermeasures can help combat its long-term effects during operations. The importance of such training has been emphasized in previous research and is something that needs to continue as the demands of aviation change (Signal *et al.,* 2009; Davy, 2014; Efthymiou *et al.,* 2021)

In comparing responses to how often crew perceived experiencing fatigue while on duty, the cockpit crew reported experiencing fatigue more frequently than cabin crew did. While challenging to account for, this could be an artefact of the fact that more cockpit crew answered the survey and that the role of cockpit crew is often more stressful than that of the cabin crew, given the complexity associated with operating aircraft (Powell *et al.,* 2007; Powell *et al.,* 2008). However, more in depth research is necessary to fully elucidate this finding.

Similarly, the long-haul crew was more likely to report feeling fatigued while carrying out their duties than the short-haul crew. While also likely multifactorial, this may be explained by the fact that long-haul crew operations are associated with extended wakefulness and circadian disruption due to flying at night and across multiple time zones during extended operations (Roach *et al.,* 2010; Roach *et al.,* 2011; Chapman *et al.,* 2012). This combined with attempting to sleep in foreign environments at times of day that are not aligned with the domicile time, may result in poor recovery and sleep loss when compared to short-haul crew (Roach *et al.,* 2011; Fowler *et al.,* 2017). Additionally, the quality of sleep attained in-flight may not be sufficient for the long-haul crew due to the uncomfortable or noisy onboard rest facilities, which may not afford the crew enough quality sleep compared to sleeping at home (Roach *et al.,* 2010; Signal *et al.,* 2013). However, some of these factors are discussed in more detail below.

5.2 Aircrews' feelings during the take-off/landing and cruise phase

Generally, the participants perceived being more alert during the takeoff and landing phases of duties, compared to the cruise phase. This could be explained by the fact that these phases (takeoff and landing), for both types of crew, but particularly for cockpit crew, are the most stressful and present the highest workload and risk (Cullen *et al.,* 2017; Cahill *et al.,* 2021; Sallinen *et al.,* 2021). With respect to perceptions during the cruise phase, just over a third of the crew reported that the cruise phase made them feel moderately tired and let down, however, further research may be required to determine the reasons why some of the participants perceived this phase as tiring. However, when comparing the cockpit with the cabin crew, the cruise phase for the cockpit crew, in particular, was more fatiguing. A possible explanation for this is that during the cruise phase, the cockpit crew can engage the autopilot, reducing their workload, which, during extended duties, may lead to monotony and boredom given that their role becomes less active (Hancock and Verwey, 1997; Alcéu, 2015). Furthermore, during this time, the effects of disruptive duties (such as early starts, late finishes, extended duties, having flown multiple sectors and flying at night, discussed in more detail below) may manifest, as cockpit crew have less stimulation and their role changes to more of observation and monitoring. Conversely, the cruise phase is the most active phase for cabin crew, where they need to attend to the needs of passengers (Avers *et al.,* 2009; van den Burg *et al.,* 2020). This stimulation associated with physically moving around the cabin and interacting with passengers may mask feelings of fatigue, and might account for this finding (van den Burg *et al.,* 2020). However, further research involving a larger cohort of crew is necessary to substantiate and make a comparison.

There were significant differences when comparing the short-haul crew with the long-haul crew; the long-haul crew was more likely to feel fatigued during the cruise phase than the short-haul crew was. Due to shorter duty periods given the short distances in South Africa that short-haul crew can fly, there is more stimulation from completing multiple sectors for the short-haul as compared to the long-haul (Yuliawati *et al.,* 2015). Therefore, higher workload during the multiple sectors flown for the short-haul (Honn *et al.,* 2016). However, for the long-haul the cruise phase is longer and requires the crew to be awake for longer periods of time which can result in extended wakefulness (Roach *et al.,* 2011). Moreover, the long-haul crew may also cross a number of time-zones whilst in the cruise phase which can result in circadian misalignments that can lead to elevated levels of fatigue during the flight and disruptive sleep during the flight (Roach *et al.,* 2011).

Key to understanding these differences more holistically, is to understand what aspects of their work that crew perceive contributes to fatigue. These factors are explored in more detail below. While it is important to acknowledge the impact of all the work-related factors explored in the study, the focus of this section of the discussion will be on the most relevant and salient factors that crew rated as contributory to fatigue. Additionally, common concerns and recommendations that the crew raised regarding the current FDPs have been integrated into this section. This will hopefully highlight the common areas of concern across these two different sections of the survey and offer a coherent overview of where future interventions and research studies should. In addition, the unique work-related factors that affect cockpit, cabin, short-haul and long-haul crew is discussed.

5.3 Perceived work-related factors that contribute to fatigue

In this study, the most commonly cited work-related factor that crew felt influenced fatigue was the length of duty, which aligns with previous research (Co *et al.,* 1999; Powell *et al.,* 2007, Croft 2009, Caldwell *et al.,* 2009, and Åkerstedt *et al.,* 2021). Crew also highlighted this in the section regarding their concerns around the current FDPs, where the crew highlighted the need to address regulations regarding not only the length of each duty, but also the length of a duty period (consecutive workdays). Extended duty periods are associated with extended wakefulness and increased sleepiness, which does affect the crews' alertness levels and performance while on duty (Gander *et al.,* 1998; Co *et al.,* 1999; Caldwell *et al.,* 2009; Previc *et al.,* 2009), particularly if this coincides with other disruptive duties such as early starts, late finishes or night flying. In line with this, the participants recommended reducing the length of duty periods to allow the crew to get adequate rest. This was in line with the findings of Co *et al.* (1999), who reported in their study that length of duty periods should be reduced. Additionally, the participants also suggested that if the duty periods are increased, then the participants require more time off for recovery – this was suggested by some crew with respect to the implementation of a block roster (this involves a pattern where there are both working days as well as days off where the amounts of days are fixed which was suggested in the study by Novak *et al.* (2020)).

The number of sectors was another commonly cited factor that contributed to fatigue. The pilots' workload is particularly high during can take-offs and landings during each sector of flight. The association between a high number of sectors and the development of fatigue aligns with previous research (Co *et al.,* 1999, Powell *et al.,* 2007, Honn *et al.,* 2016, and Sallinen *et al.,* 2016) where, with an increasing number of sectors, self-rated sleepiness increased over the duty day. The operating context of South Africa likely also contributed to this perception, as short sectors (not more than 2 hours) are common and therefore require the pilots to fly between three to four sectors per day at times. This highlights the unique impact of the South African context and how it contributes to workload.

When comparing the participants who flew short-haul with those who flew long-haul, the short-haul participants were more likely to report feeling fatigued due to the number of sectors flown. Short-haul crew, by nature of their job, are required to fly more sectors per duty than the long-haul (Powell *et al.,* 2007; Powell *et al.,* 2008; Reis *et al.,* 2016), than long-haul, with the impact of flying more sectors often resulting in changes in alertness and performance ability, a finding that was reported following the laboratory-based study by Honn *et al.* (2016). One of the recommendations, which supports suggestions from the Co *et al.* (1999) study was to reduce the number of sectors per duty, which should entail fewer take-offs and landings to be carried out. While this would be operator and context-specific, it may be challenging to implement, given that nature of operations in South Africa. Furthermore, another recommendation was to reduce the number of sectors per duty when crew work disruptive duties, such as later sign-on's or early sign-on"s. While feasible, this would require an amendment to current FDP tables, which will hopefully be a debate that emerges from this and other research.

The crew had concerns regarding insufficient nighttime sleep as a contributory fatigue factor. This supports previous research within aviation and, more broadly, where many aspects of how working time is arranged can infringe on or limit the amount of sleep crew can obtain (NASA, 1999; Caldwell *et al.,* 2009; FAA, 2011; Hartzler, 2013; Reis *et al.,* 2016). Sallinen *et al.* (2017) and Dai *et al.* (2018) reported that adequate sleep is essential for maintaining alertness while on duty. The concerns raised by the crew may be linked to the impact of having to work disruptive duties, such as standby or on call duties, finishing duty late, starting duty early or night flying, many of which were also cited as working factors of concern, which are discussed below.

Early sign-on's, late finishes, working consecutive duties, and night flying were the next most commonly cited work factors that crew felt contributed to fatigue. These were also common aspects of the current FDPs that crew highlighted as areas that needed further attention. Early sign-on"s that are scheduled with late finishes in the same string of consecutive duties create irregularity in the roster. This can lead to inadequate sleep for the crew as they may be required to wake up early to get ready for and still commute to work in time for the early sign-on and this can lead to disruptive sleep, but also extended wakefulness. This supports the findings of Co *et al.* (1999), Bourgeois-Bougrine *et al.* (2003), and the ECA (2012) who have reported similar findings, regarding early starts and, as reported by Åkerstedt *et al.* (2021), extra early starts, results in shortened and poor quality sleep and increased reports of fatigue while on duty. In exploring the comparison of short-haul with long-haul, the short-haul participants were more likely to report early sign-on's as contributory to fatigue. This may reflect the contextual demands of short haul crew in South Africa, where often, domestic flights can commence from as early as 06h00, where as long haul flights may, but not always, be scheduled to occur later in the day or in the evening. Early starts often result in extended duty periods, which Vejvoda *et al.* (2014) reported are associated with increased likelihood of fatigue at the end of the duty. Other researchers reported short-haul crew self-reported fatigue was moderate to severe when the flight duty period (FDP) ended late at night (Jackson and Earl, 2006; Vejvoda *et al.,* 2014; van den Burg *et al.,* 2020). Therefore, the crew recommended reducing the number of early starts and the number of consecutive early starts given the impact this disruptive way of rostering duty has on sleep opportunities, and in turn, alertness while on duty, while also suggesting an increase in the number of rest days after consecutive early starts.

Late finishes presented an area of concern, both in the questions on work related factors and concerns regarding FDPs. Late finishes are often also associated with disruptive rostering practices in conjunction with early starts and can lead to extended wakefulness and inadequate nighttime sleep for the crew. This is consistent with Vejvoda *et al.* (2014), Arsintescu *et al.* (2021) and Sallinen *et al.* (2021), who reported that the final landing after a late finish FDP is associated with the crew being awake for extended hours and higher self-reported fatigue than responses observed for the crew who had early starts. Furthermore, late finishes (particularly those that end after midnight in the early morning) often require the crew to attempt to sleep during the day, which can be challenging due to the societal noise, light, and the circadian-modulated drive for wakefulness (Caldwell, 2005; Jackson and Earl, 2006; Powell *et al.,* 2007).

In comparing short-haul and long-haul crew, the short-haul participants were more likely to report the link between late finishes and the risk of fatigue. This could be due to the fact that long-haul crew are afforded the opportunity to sleep at night in-flight (Gregory *et al.,* 2021) or do not often experience late finishes (given that they fly over night), whereas the short-haul crew have late finishes that do not afford them adequate nighttime sleep once their duty has ended, as reported by (Roach *et al.,* 2012). Previous research has stressed that fatigue experienced by the short-haul crew was moderate to severe when the flight duty period (FDP) ended late at night (Jackson and Earl, 2006; Vejvoda *et al.,* 2014; van den Burg *et al.,* 2020). Therefore, the participants' recommendations for late finishes were to reduce the number of late finishes, but also to reduce the number of consecutive late finishes due to the impact they have on sleep and fatigue in subsequent duties.

Working consecutive duty days was the sixth most commonly cited contributing factor. Apart from the impact of working multiple consecutive days, it is likely that the effect of working consecutive days is also influenced by the nature of the duties – as discussed above, with many crew experiencing disruptive and extended duties with high workloads. This demonstrates the complex interaction between different work factors and how they contribute to fatigue. While difficult to account for, the effects of working too many consecutive days is likely affected by having to work disruptive duties (as discussed above) which affect the amount and quality of sleep obtained, while also being influenced by another concern outlined by crew – inadequate rest (discussed in the following sections). While not explored in this study, cumulative sleep loss can result in increased fatigue and reduced alertness levels whilst on duty that could impact the crews‟ performance particularly towards the end of a string of duties, as highlighted in some of the accident examples cited in the literature review (Goffeng *et al.,* 2019; Gillet and Tremblay, 2021). This was also highlighted by the participants as a concern about the FDPs, that crew should be afforded more days off to prevent cumulative sleep loss.

When comparing the participants who flew short-haul with those who flew long-haul, the short-haul were more likely to report feeling fatigued due to working too many workdays in a row. This would be more common in short-haul due to the length of the flights compared to long-haul flights. Long-haul flights mean daily and weekly flight limits are reached following one outbound flight and a return flight, while for short-haul in South Africa; the short sectors mean that crew can technically work more days to reach this limit. In South Africa, legally, pilots can work up to five or six days in a row before having a rest day (SACAA, no date). Therefore, if the crew (short-haul) do work several days in a row, with schedules that include early sign-ons and late finishes, with multiple sectors flown this could lead to increased levels of fatigue accumulating throughout the consecutive days of duty. Therefore, the crew recommended not being rostered for more than three consecutive early sign-ons per week. In addition, the crew recommended instilling a block roster system that may assist the crew in planning their working week for fatigue-inducing factors, recovery, and sleep, as argued by Novak *et al.* (2020).

Duty at night was also flagged as a concern with just over one-fifth of the participants reporting that it always contributes to fatigue. One of the concerns for the crew regarding night flying, according to the literature, is that it does result in crew fighting a natural inclination to sleep and is often associated with extended periods of wakefulness, which can affect alertness and increase fatigue (Freedman *et al.,* 1999; Panda *et al.,* 2002; Roenneberg *et al.,* 2003; Marqueze *et al.,* 2017). In addition, the participants were concerned about consecutive night flights as this may disrupt the crew's sleep-wake behaviour, much the same as the effects that night flights have on the crew. Furthermore, night duties require the crew to sleep during the day, which results in shorter, poorer quality sleep due to societal noise, light, and the circadian-modulated drive for wakefulness (Marqueze *et al.,* 2017). When comparing the cockpit crew with the cabin crew, the cockpit crew was more likely to report fatigue being the result of flying at night and flying consecutive night flights. This may be due to the fact that the cockpit crews" role becomes more observational at night and so their stimulation changes whereas the cabin crew still have to interact with passengers at night. However, more research is necessary to fully account for why this may be the case.

Similarly, when comparing short-haul with the long-haul crew, the long-haul crew were more likely to feel the effects of fatigue due to night flights. This may be due to the fact that long-haul crew spend a longer period of time operating at night as compared to the short-haul crew. The effects on the long-haul crew have been outlined in the above section. Therefore, the crew recommended increasing the number of rest days following a night flight or reducing the number of consecutive night flights.

Insufficient rest breaks between duties was another work-related factor of concern, however, the participants expanded upon this in the perceptions section where they raised concerns about insufficient rest not only between shifts, but also between duty days. The insufficient rest periods may be linked to the nature and demands of duty and the fact that the rest periods need to consider the requirements to commute and wind down, while still providing an opportunity for eight hours of consolidated sleep. Rest periods are important for the crew to reduce the effects of exertion and to allow for recovery (Techera *et al.,* 2016). In addition, rest periods according to the SACAA should be at least nine-consecutive hours between duties (SACAA, 2016). However, due to the participants‟ work schedules; they may not be afforded the nine-consecutive hours of rest, which may in turn limit the crew from obtaining not only adequate and quality sleep, but also time to fulfill certain biological and social needs (Rudari *et al.,* 2016; Karhula *et al.,* 2017). Moreover, the timing of the rest periods may also impact the crew if the rest periods fall between duties. This may inhibit rest for the crew if the rest period is during the day due to the circadian-modulated drive for wakefulness, light and societal noise (Rudari *et al.,* 2016; Efthymiou *et al.,* 2021). Therefore, the crew recommended reducing the daily FDPs by increasing the number of days off, and increasing the rest periods within the duty day.

Split duties, although not explored in detail were also raised as a concern. The effect of split duties is that they are associated with extended duties and wakefulness (Venus, 2021). When comparing the cockpit with the cabin crew, the cockpit crew reported split duties as contributing to fatigue compared to the cabin crew. Therefore, the recommendation is to improve the rest facilities so that they afford the crew with time to nap, or the crew should be provided a designated area (other than the common airport spaces) to rest.

In summary, there were a number of key work-related factors that were identified by participants in this study that are consistent with previous literature. Additionally, when comparisons were made between the different groups (cabin and cockpit crew and short and long haul) additional fatigue risks were elucidated. These are discussed below. While there were many different unique concerns raised between these groups, not all can be discussed here. In the section that follows some of the key factors that may be of relevance and are controllable or relate to established literature are discussed.

Additional fatigue risks for the cockpit crew

Cockpit crew were more likely to rate congested airspace, conflicting low-level air traffic, long idle time between flights, high cockpit temperature, environmental conditions in the cockpit or cabin crew, no autopilot function on aircraft, having to rest away from home, poor cockpit or cabin design or layout, bad weather, severe turbulence, and ambient light - very bright or low light conditions as factors associated with the development of fatigue.

Congested airspace and conflicting low-level traffic and poor design of cockpit, while not really mentioned in previous research, would add to the workload of pilots when trying to navigate the operation of the aircraft (Vaaben and Larsen, 2015). Linked to this and in support of previous research (Lee and Kim, 2018), bad weather and severe turbulence were two more factors that the cockpit crew attributed to fatigue (Bendak and Rashid, 2020). As with the abovementioned factors, bad weather can add to the crew workload due to the emergent stress and attentional resources necessary for the concentration required when operating in such conditions. In addition, the weather and turbulence can affect the crews' sleep when on long haul flights due to the noise and turbulence caused by the weather (Kulesa, 2003; Buck and Buck, 2013; Zaslona *et al.,* 2018). Lastly, low light levels in the cockpit, as discussed in the study by Roach *et al.* (2012) may result in reduced stimulation during the cruise phase of the flight and increased sleepiness and feelings of fatigue.

A high environmental temperature may lead to an increase in the cockpit temperature, which may make it difficult for the crew to concentrate due to the physiological processes involved in regulating body temperature (Gaoua, 2010; Schminder *et al.,* 2018). This may result in an increased heart rate, sweating and this may make concentration challenging for the crew when carrying out their duties in the cockpit (Gaoua, 2010; Schminder *et al.,* 2018). In addition, the temperature in the cockpit may be high which may be challenging for crew to carry out their duties in the cockpit (Zaslona *et al.,* 2018). Lastly, having to rest away from home emerged as another cockpit crew work-related factor contributing to fatigue – this finding aligns with previous research which has shown the detrimental effects of sleeping away from home and the impacts on the duration and quality of sleep (Tamaki *et al.,* 2005). While not addressed in any detail, these additional factors point to a complex network of factors that are sometimes unavoidable in aviation settings, but nevertheless important when considering their impact on crew alertness.

Additional fatigue risks for the short-haul crew

When focusing specifically on short haul crew, unplanned change in shift or schedule was the only additional fatigue risk. Uncertainty and irregularity in working time arrangements can affect the ability to plan rest, sleep and domestic responsibilities that may be challenging for the crew (Caldwell, 2012; Novak *et al.,* 2020). However, more research is needed to understand the impact of these factors in more detail.

5.4 Perceived non-work-related factors that contribute to fatigue

Having young children or looking after dependents was cited by just under one-third of the crew, with this being more prominent in cockpit crew and long-haul crew than the cabin and short-haul crew respectively. While there could be many reasons for this, minding children, particularly younger children, is associated with increased disruptions to sleep at night (Goffeng *et al.,* 2019; Richter *et al.,* 2019) which may in turn influence fitness for duty. Alternatively, the stress associated with being away from home while on duty (Demerouti *et al.,* 2019) in the case of long-haul crew may interfere with the ability to rest effectively, which can present a fatigue risk as well.

Over a quarter of the crew cited financial stress as contributing to fatigue. Financial stress, albeit challenging to ascertain the actual cause, can affect the stress of the crew, which can affect the crews' recovery (Choi, 2008; Suni and Dimitriu, 2020). As the participants answered the survey at the beginning of the pandemic, many operators may have started to experience the impact of the National lockdown on their operations, which threatened the job and financial security of crew who may have also participated in this study. The stress associated with financial challenges, irrespective of their origin, may affect crew sleep and recovery (Suni and Dimitriu, 2020) which might explain why crew associated this particular factor with fatigue.

Around one-fifth of the crew found they were constantly fatigued due to extended commuting to and from work. In this study, the median time to commute to and from work for cockpit crew was 60 minutes and 40 minutes for cabin crew. This commute duration could be explained in part by most of the participants living in large city centers like Johannesburg in Gauteng, where the main international airport is situated. The effects on the crew if they have early starts could be disruptive sleep due to the time the crew would have to get up and commute to work as reported by (Brown and Whitehurst, 2011) on the effects of commuting.

5.5 Other concerns and recommendations raised by crew

Apart from the abovementioned perceptions related to working time arrangements, the participants shared various perceptions and attitudes more generally in relation to their perceptions of the current FDPs. This revolved around themes such as the „flying limits being used as targets‟ by the operators, that there is a lack of scientific input with regard to the FDPs and the participants raised concerns that the current FDPs are inadequate and outdated. These perceptions, but in particular the one regarding the limits being used as targets by the operators may stem from the fact that crew feel like they are being exploited, which may point to the need for further research debate about why crew have this perception, given that it points more to how operators are rostering crew, rather than the actual limits being a problem. There is therefore a need for more research around this issue, given that it may be indicative of organisational culture that may favour economic returns over safety and wellbeing.

As per ICAO‟s recommendations when designing FDPs the latest science available and operational experience should be made use of or applied (ICAO, 2015). The participants recommended that the regulations need to be modernised with the rest of the world or aligned with other countries or regions FDP regulations such as EASA‟s regulations. The participants also recommended the inclusion of more science and the use of operational experience when designing FDP regulations.

RECOMMENDATIONS

In light of these findings, there are a number of practical and research recommendations outlined below. These recommendations, where possible are specific to operators, the regulator and the broader industry.

Practical considerations for the working group in relation to the FDP regulations

This study has revealed some crucial areas of concern that may need to be addressed by both operators and the Regulator, both in their rostering practices and the legal frameworks respectively

Although the reported prevalence of fatigue was high in this study, the participants recognized the risk it presents to safety which, indicates there is awareness within the industry. Therefore, fatigue management training and awareness raising, that is facilitated by operators and monitored by the Regulator should continue to ensure that any changes in the demands of operating, such as those associated with COVID-19 restrictions, are considered and integrated into the training.

In terms of areas of concern in the FDPs, the results of this study highlight the need for more focus to be given to the FDPs, but in particular, sections that focus on the allowable length of duty in relation to the time at which a duty starts; the amount of rest provided between duties and between consecutive duty strings; the number of allowable sectors during a duty period, late finishes and night duties. There needs to be more consideration around defining a local night, the Window of Circadian Low (WOCL), and the definition of a sector, given that they have implications for rest.

More consideration around the appropriateness of the current FDPs for other parts that have different operating contexts and demands (such as aerial work, aviation medical services or aid flights) is necessary to ensure that these parts are catered for.

Practical recommendations for operators

The results of this study, while broad, do highlight the importance of appropriate, evidenced-based and human centered rostering practices, which many of the participants argue and perceive, needs to be improved. Thus, operators should consider, carefully, how they roster crew, mainly by limiting the irregularity associated with duties, while limiting crew working consecutive disruptive duties. This could be achieved through limiting the number of early starts, late finishes or combinations of these so that the crew can balance the working time to ensure that they have opportunities to sleep at appropriate times. Furthermore, so that the rosters are more predictable for the crew to work with, thus affording the crew more time to recover and fulfill biological needs.

Another recommendation is specific duties that include standby or reserve duty. The crew recommends reducing the number of standby duties or putting in place facilities for the crew who are placed on standby so that if they are required to be on duty, then the crew are potentially more rested. However, this may need to be explored within different operators or at different airports.

The number of consecutive night flights highlighted as a concern for crew, particularly those who fly long-haul. Therefore, the recommendation for the operators is to reduce the number of consecutive night flights for the crew or increase the number of rest days following night flights due to the cumulative effects of fatigue associated with consecutive night flights.

Due to the disruptive nature of the duties that include early starts and late finishes, night flying and trans-meridian traversing, the crew are not afforded enough time to recover. Therefore, more careful consideration is needed around how to ensure that there is enough time dedicated to rest, which includes not only time to sleep, but also time to fulfil other social commitments, and commuting to and from work. Therefore, making it the law of extending the rest period by three hours to 12-hours instead of nine hours may compensate for the commuting, fulfilling biological and social needs, but also afford the crew a longer time for rest. Linked to this was a repeated suggestion for the installation of a block roster schedule that the crew can plan their off days so that the crew have more time to recover, spend time with their families, but also fulfil biological needs.

Common practice in South Africa is flying a number of sectors due to the short distances flown. While perhaps challenging, there were calls for the reduction in the number of sectors completed per duty, but in particular for those that involve disruptive duties.

There are a number of countries that have implemented FRMS due to the benefits that FRMS brings with regard to managing fatigue. Therefore, the South African aviation industry needs to build capacity to be able to implement these risk-based approaches to fatigue mitigation alongside the prescriptive approach.

Areas for future research

Future research needs to apply more objective measures to objectively quantify the effects of different duty periods on crew sleep-wake behaviour, alertness and performance ability. This could include the use of actigraphy and sleep diaries and objective performance measurements such as the psychomotor vigilance task in order to gain more objective data on the effects of certain duties (such as those that involve early sign-ons and late finishes, night flights and extended duties). This will provide important data to inform future decisions regarding appropriate rostering practices and changes to the current FDPs.

As this study identified the contributory fatigue factors related to disruptive rosters that entails long duties, consecutive early starts and late finishes, standby duty and night flying; but also inadequate sleep and rest before and during duty periods, future research should explore ways that the crew cope with these demands and the countermeasures they use.

More research is needed to understand how the context and demands of other operations influences fatigue risk. This would be important to ensure that this data is used to design context specific strategies to manage fatigue.

The cockpit crew also mainly answered the survey therefore more research is necessary to gather further data on the cabin crew who were not well represented in this study. Therefore, future research should focus on the cabin crews working time arrangements and factors that affect and contribute to cabin crew fatigue only.

LIMITATIONS

The current study did have limitations. Firstly, the National Lockdown shortened the study's data collection period; which resulted in the cessation of all aviation operations and the study two weeks after it began. This likely resulted in an under-represented and underpowered study sample. Thus, the results of this study are not necessarily representative of all scheduled operations crew in South Africa.

As this study was a survey, the results are based on subjective responses from the participants who may have had a vested interest in this topic. Therefore, there is a need to garner a more representative sample from across the aviation sector in South Africa.

Although the original intention was to ensure that the survey reached all different parts of the industry, the results of this study are not representative of the broader crew in non-scheduled aviation. Therefore, future research should focus on getting better representation from more crew from different parts of the aviation industry. This will be critical to ensure that any changes to FDPs consider the unique operating context of this crew (and the associated fatigue risks).

CHAPTER 6

6. CONCLUSION

This research aimed to quantify the prevalence of reported fatigue, the perceived contributing factors, and the perceptions around the current FTLs from the various parts of the South African aviation industry.

There was a high reported prevalence and it is recognized as a safety concern. It is encouraging that the awareness is increasing which means the programs are working and it is being recognized as something that requires management. This study found that fatigue, as perceived by participants is the results of a complex interaction of both work and non-work related factors, which need to be considered in training programs, workshops, and how the law is designed. More attention is needed on the rostering practice as one can design the best laws, but if rostering is poor, it does not matter.

It is, therefore, essential to understanding that the management of fatigue can be challenging. Still, it requires appropriately designed rostering practices and regulations that use context-specific data underpinned by operational insight and the latest science available. The data from this study can inform the proposed changes to the FTLs in South Africa, given the identification of the fatigue prevalence, their contributory factors, and the fact that there are no fatigue mitigating aspects of the current regulations. As a point of departure, the global COVID-19 pandemic has created several challenges in the aviation industry as a whole.

The effects of the COVID-19 pandemic on the aviation industry

The outbreak of the COVID-19 pandemic resulted in a decline in passenger numbers, flights and airport capacities within the global aviation industry (ICAO, 2022). This has resulted in several adaptations to be made within the aviation industry to cope and deal with the worldwide pandemic from adjustments to the number of flights and passenger numbers, travel bans to certain countries and reduced profit made by airlines, to name a few (Gallego and Font, 2020; Liu *et* *al.,* 2021). The end of the pandemic is unknown but with the increasing number of vaccinations worldwide there are encouraging signs for the industry to return to a new normal (Xuan *et al.,* 2021). However, the challenges related to fatigue that both crew and management faced before the pandemic now need to factor in the effects the pandemic may have on the crew and management alike, as well as the factors which affected the crew before the pandemic.

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APPENDICES

APPENDIX A: Adaptations from Co *et al.* (1999), Johns (1991) and Bourgeois-Bougrine *et al.* (2003)

DEMOGRAPHIC INFORMATION (Source: Dylan Blair and Jonathan Davy – NASA study – Co et al., 1999) **Relevance: this section is important to characterise the sample, which affords important insights into whether fatigue is experienced within specific age groups, gender groups or other personal information.** • Gender • Age (years) • Mass (Kgs) • Stature (m) • Flight category (part) • Function (Commander, first officer, other) • Flying experience (hours) • In what time zone is your domicile • How long does it usually take you to travel from your home to your assigned domicile (hours and minutes) • What is the typical mode of transportation from your home to your assigned domicile
SLEEPING AT HOME (Source: Dylan Blair and Jonathan Davy – NASA study – Co et al., 1999) **Relevance: although considered a secondary contributory factor, it is important to gain insights into practices outside and away from work. If these practices**

around sleep and recovery are not appropriate, this could be provide the necessary evidence for improved education programs for staff.

Based on an average night of sleep at home (at least 2 days after your return home following a trip), please give one best answer to each of the following questions. Use your local 24-hour clock.

- On average, how many nights of sleep do you get at home between trips? – nights
- On your days off duty, what time do you usually go to bed? – time, 24hr clock
- On your days off duty, how long after going to bed do you usually fall asleep?

Hours and minutes

- When sleeping at home, how many times on average do you wake up?

Times

- If you wake during the night, what most often awakens you? (Check ONLY one answer):

Bathroom /children /spouse /other ______/ can't sleep/noise

- If you wake during the night, on average, how long does it take you to go back to sleep? –

Hours and minutes

- When sleeping at home, what is the amount of total sleep you get on average? –

Hours and minutes

- On your days off duty, what time do you usually get out of bed?

24 hour clock

- How often do you take a nap at home?

never/rarely (1-10yr)/sometimes (1-3/month)/often (1-4/wk)/very often (5-7/wk)

- On average, how long are your naps? –

hours and minutes

- When sleeping at home, how often do you have problems getting to sleep?

never/rarely (1-10/yr)/sometimes (1-3/month)/often (1-4/wk)/ very often (5-7/wk)

- How often do you take medication to help you sleep?

never/rarely (1-10/yr)/sometimes (1-3/month)/often (1-4/wk)/ very often (5-7/wk)

- If yes, please specify the medication - _____________
- How often do you use alcohol to help you sleep? - never/rarely (1-10/yr)/sometimes (1-3/month)/often (1-4/wk)/ very often (5-7/wk)
- Overall, what kind of sleeper are you? – very poor/poor/good/very good
- Do you have a sleep problem? – yes/no
- If yes, what is your sleep problem? ______________
- If yes, has it been diagnosed by a physician? – yes/no
- Has it ever prevented you from flying? – yes/no

- REMEMBER: Give only one best answer (for each factor) based on an average night of sleep at home (at least 2 days after you return from a trip).
- Please rate the following factors and indicate how much they affect your sleep.
    - Quality of sleep surface – 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Heat - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Cold - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Thoughts running through your head - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Random noise events - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Constant background noise - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Background lighting - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Readiness for sleep - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Comfort of clothing - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Low humidity/dry air - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - High humidity - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Trips to bathroom - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Bed partner - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Privacy - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Ventilation - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Sheets - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Blankets - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Pillows - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5
    - Other (specify) - 1 (interferes)/ 2/ (no effect) 3/4/ (promotes) 5

- Please rate the following on the extent to which they interfere with your sleep at home.
    - Hunger – 1 (strongly interferes)/ 2 /3/ 4/ 5 (no effect)
    - Thirst - 1 (strongly interferes)/ 2 /3/ 4/ 5 (no effect)
    - Personal worries - 1 (strongly interferes)/ 2 /3/ 4/ 5 (no effect)
    - Respiratory factors (asthma, allergies, etc.) - 1 (strongly interferes)/ 2 /3/ 4/ 5 (no effect)
    - Other (specify) - 1 (strongly interferes)/ 2 /3/ 4/ 5 (no effect)
- From the list in #28, please list the top three factors that promote your sleep at home in rank order – 1. /2. /3.
- When on reserve status and not called out, what is the total amount of sleep you usually get at home? – hours and minutes
- Considering only when on reserve status, please list in rank order, the top three factors that interfere with or promote your sleep – INTERFERE 1. / 2. / 3.; PROMOTE 1. / 2. / 3.

BASELINE SLEEP CHARACTERISTICS (Source: Alison Bentley; literature??)

Relevance: although considered a secondary contributory factor, it is important to gain insights into practices outside and away from work. If these practices around sleep and recovery are not appropriate, this could be provide the necessary evidence for improved education programs for staff.

1. What time would you normally go to bed? ____________

2. What time would you normally fall asleep? ______________

3. What time is your preferred wake up time? _______________

4. Do you consider yourself to have trouble sleeping / insomnia?   Yes / no

INSOMNIA SEVERITY SCALE (Source: Alison Bentley; literature??)

1. Please rate the current (i.e. last 2 weeks) **SEVERITY** of your insomnia problem(s)

	None	Mild	Moderate	Severe	Very severe
Difficulty falling asleep	0	1	2	3	4
Difficulty staying asleep	0	1	2	3	4
Problem waking up too early	0	1	2	3	4

2. How **SATISFIED / DISSATISFIED** are you with your current sleep pattern?

Very satisfied				Very dissatisfied
0	1	2	3	4

3. To what extent do you consider your sleep problem to **INTERFERE** with your daily functioning (e.g. daytime fatigue, ability to function at work / daily chores, concentration, memory, mood etc)

Not at all interfering	A little	Somewhat	Muc h	Very much interfering
0	1	2	3	4

4. How **NOTICEABLE** to others do you think your sleeping problem is in terms of impairing the quality of your life?

Not at all noticeable	Barely	Somewhat	Muc h	Very much noticeable
0	1	2	3	4

5. How **WORRIED** / **DISTRESSED** are you about your current sleep problem?

Not at all	A little	Somewhat	Muc h	Very much
0	1	2	3	4

Yes / No

Yes / No

If yes

Does the sensation go away (even partly) when you move your legs?	**yes**	**no**
Is the sensation worse at night – compared to the day-time?	**yes**	**no**
Does the sensation occur only when your legs are resting e.g. lying down or sitting still?	**yes**	**no**

7. STOP-BANG

		YES	NO	Don"t know
Snoring	All positions			
Tiredness during the day	ESS score:			
Observed apneas / waking gasping or choking				
High blood Pressure	Medication:			
BMI >30	Height			
	Weight			
Age	_____ years			
Neck circumference	_____ cm			
Gender				

Epworth Sleepiness scale (Source: Alison Bentley: Johns (1991)

How likely are you to doze off or fall asleep in the following situations after you"ve had your usual night"s sleep: (circle one number for each)

	Would never doze	Slight chance	Moderate chance	High chance

a. Sitting and reading	0	1	2	3
b. Watching television	0	1	2	3
c. Sitting inactive in a public place	0	1	2	3
d. Passenger in a car for an hour without a break	0	1	2	3
e. Lying down to rest in the afternoon	0	1	2	3
f. Sitting and talking to someone	0	1	2	3
g. Sitting quietly after lunch with no alcohol	0	1	2	3
h. In a car, while stopped for a few minutes in the traffic	0	1	2	3

Characteristics of duty (Source: Jonathan Davy and Dylan Blair – NASA study – Co et al,. 1999)

Relevance: understanding which aspects of their duty are challenging can point to areas of concern or poor implementation and how regulations are applied

- How many duty days do you fly in a month? – **(typical) days/ (least) days/ (most) days**

- What is your number of **scheduled** flight hours per month? - **(typical) days/ (least) days/ (most) days**
- What is your number of **actual** flight hours per month? - **(typical) days/ (least) days/ (most) days**
- How many flight segments do you fly in a duty day? – **typical/ least/ most**
- How much time do you have on the ground between flights (time between blocking in and out)? – **(typical) hours/ (least) hours/ (most) hours**
- On how many duty days in a month does your actual flying time exceed 8 hours? – **typical/ least/ most**
- How often does your company readjust schedules to account for actual block times? – **never/rarely/occasionally/frequently**
- During a six-month period, how many times do you ferry a plane under Part 91 after already flying 8 hours under Part 121 and/or Part 135? – **times**
- During a typical year, how many times do you have a check ride or training flight under Part 91 after already flying 8 hours under Part 121 and/or Part 135? – **times**
- During the past year, how many times have you exceeded the 7-consecutive-day flight time limit? – **(Part 121-130 hr) times/ (Part 135-34 hr) times**
- What is the duration of your duty day? – **typical: hours and minutes/ shortest; hours and minutes/ longest: hours and minutes**
- What is the longest duty day you have had in your airline career? – **hours and minutes**
- How many times a month is your duty day extended to keep your duty day extended to keep your regulated flight time within limits? – **typical/best case/worst case**
- In a typical month of flying, how many times do you stay in the following accommodations during your layover rest periods? – **hotel/trailer/other: specify___**
- During the past month, how many times have you reported for duty during each of the following time periods? – **0000-0359hrs/0400-0759hrs/0800-1159hrs/1200-1559hrs/1600-1959hrs/2000-2359hrs**
- How many times are you scheduled for reduced rest in a month? - **(typical) times/ (least) times/ (most) times**
- How many times are you asked to take unscheduled reduced rest in a month? - **(typical) times/ (least) times/ (most) times**
- When asked to take unscheduled reduced rest, how many times in a typical month is your rest period reduced to the following number of hours? – **(8hrs) times/ (9hrs) times**
- In a month of flying, how many duty days include continuous duty overnights (CDOs)? – **typical/least/most**
- During a continuous duty overnight, how long is the scheduled ground time (“stand-up” portion)? – **typical: hours and minutes/best case: hours and minutes/worst case: hours and minutes**
- How much time is available for **sleep** during the “stand-up” portion of the CDO? - **typical: hours and minutes/best case: hours and minutes/worst case: hours and minutes**

- How often do you sleep during the “stand-up” portion of the CDO? - **typical: hours and minutes/best case: hours and minutes/worst case: hours and minutes**
- How often do you sleep during the “stand-up” portion of a CDO? – **never/rarely/occasionally/frequently**
- Which of the following accommodations does your company provide for CDOs (check as many as applicable)? – **hotel/trailer/other: specify_______**
- In a typical month of flying, how many times do you stay in the following accommodations during the “stand-up” portion of a CDO? – **hotel/trailer/other: specify_______**
- Please rate the accommodations. – **very poor/poor/fair/good/very good**
- What are the good qualities of the accommodation? - **lines for description**
- What are the bad qualities of the accommodation? - **lines for description**
- How much total sleep do you get during the “stand-up” portion of a CDO? – **typical: hours and minutes/ best case: hours and minutes/worst case: hours and minutes**
- During a typical month, how many times do you ferry a plane during the “stand-up portion of a CDO? – **times**
- Have you ever flown in the segment of a CDO without getting any sleep at the out-station? – **yes/no**
- How long is the scheduled **rest period** between consecutive CDOs? – **typical: hours and minutes/ best case: hours and minutes/ worst case: hours and minutes**
- How much is time is available for **sleep** between consecutive CDOs? - **typical: hours and minutes/ best case: hours and minutes/ worst case: hours and minutes**
- How much total sleep do you get between consecutive CDOs? - **typical: hours and minutes/ best case: hours and minutes/ worst case: hours and minutes**

FATIGUE (Source: Jonathan Davy: NASA study – Co et al., 1999)

Relevance: This section asks broad questions pertaining to fatigue and how it experienced and coped with.

- Describe the worst work day you‟ve had while flying regional‟s, including the specific factors that made it the worst.
- In your opinion, to what extent is fatigue a concern in regional flight operations?

Not at all **Minor** **Moderate** **Serious**

- Is crew fatigue a common occurrence in flight operations?

Yes **No**

- When crew fatigue occurs, how significant a safety issue is it?

Not at all **Minor** **Moderate** **Serious**

- In what ways does fatigue affect your flight performance?

____-

- When your flight performance is affected by fatigue, which phase of flight performance is most affected (choose only **ONE** answer)?

Taxi **takeoff** **enroute** **descent** **landing**

- List three strategies that you use for coping with fatigue in rank order.

PRETRIP: 1.

2.

3.

INFLIGHT 1.

2.

3.

- What three changes would you make to reduce fatigue in regional airline operations? List the most important first.

1.

2.

3.

- Have you ever “nodded off” during a flight?

Yes **No**

- Have you ever been on a flight where arrangements were made for one of the pilots to sleep during the leg?

Yes **No**

Adaptations from Bourgeois-Bougrine *et al.,* (2003) – 21st March 2019

FATIGUE (ADDITIONAL OPTIONS) (Source: Jonathan Davy and Bourgeois-Bourgine *et al.,* 2003).

Relevance: This section asks specific questions about fatigue and what factors (workload related) contribute to it in the context of aviation.

- **Which of your usual schedules makes you feel tired?**
- **During the climb and decent, which aspects make you tired?**

(1 – no impact, 2 – small impact, 3 – medium impact, 4 – high impact, 5 – very high impact)

- **Significant workload**
- **Executing actions in a limited amount of time**
- **Simultaneous actions**
- **Interruption during activities**
- **Problem with coordination between other cockpit crew members**
- **Density of verbal exchanges**
- **Communicating in foreign language**

- Lack of sleep
- In general, what is the impact of the following events on your level of fatigue?

(1 – no impact, 2 – small impact, 3 – medium impact, 4 – high impact, 5 – very high impact)

- Flight delay
- Difficult flight
- Dissension between crew members
- Necessity of performing n additional leg that was not planned
- Compliance with time constraints
- During the flight, what are the symptoms of fatigue for you and for the other crewmembers?
- When you get tired, to what extend are the following flying tasks affect by fatigue?
- What are your strategies to cope with fatigue:
- Before and after an exhausting roster
- During flight
- During layover

Adaptations from Co *et al.,* (1999) "Crew Factors in Flight Operations XI: A Survey of Fatigue Factors in Regional Airline Operations" – 21st March 2019

PART 1: PERSONAL INFORMATION

Relevance: This section is important to characterise the sample, which affords important insights into whether fatigue is experienced within specific age groups, gender groups or other personal information.

- **Age: ____________**
- **Sex:**
- **Racial Group:**

White

Coloured

African

Indian

Asian

Other (specify): __________

- **What is your job title? (Commander, first officer, cabin crew manager)**
- **What part of the aviation industry do you work in?**
- **How long have you worked in your present job?**
- **What is your flying experience (hours) or how long have you been involved in the industry (years)?**
- **Please indicate the characteristics of your flight duty?**

Long-haul

Short-haul

- **Based on your answer in question 8, do you experience time zone changes?**

YES **NO**

- **In what rime zone is your domicile?**
- **How long does it usually take you to travel from your home to your assigned domicile and back again?**

___________________ (hours and minutes)

- **What is your typical mode of transportation from your home to your assigned domicile?**

Self-drive surface transport

Self-fly air transport

Public transport (taxi; bus; train)

Walking

Other (specify): _____________

PART 2: CREW PERCEPTIONS AROUND FATIGUE

Relevance: This section asks questions pertaining to fatigue and how it is experienced

For the purposes of this section, fatigue is defined as „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" – International Civil Aviation Organisation (2016). In light of this, please answer the following questions.

In your opinion, how much of a problem is fatigue in your part of the industry?

A very serious problem

A relatively serious problem

A minor problem

Not a problem at all

When crew fatigue occurs, how significant a safety issue is it?

- **A very serious problem**
- **A relatively serious problem**
- **A minor problem**
- **Not a problem at all**

How much of a problem is fatigue to YOU PERSONALLY in your job?

- **A very serious problem**
- **A relatively serious problem**
- **A minor problem**
- **Not a problem at all**

How often do you become fatigued while flying?

- **On every trip**
- **On most trips**
- **On about half your trips**
- **Occasionally**
- **Very rarely**

Do you think that AWARENESS of crew fatigue has changed over the last 5 years IN THE INDUSTRY in general?

- **Has increased a lot**
- **Has increased**
- **No change**
- **Has decreased**
- **Has decreased a lot**

Please provide a reasons for your answer above. ___________________________

Do you think AWARENESS of crew fatigue has changed over the last 5 years, FOR YOU?

Has increased a lot

Has increased

No change

Has decreased

Has decreased a lot

Does fatigue interfere with your ability to carry out of your duties?

Always

Most of the time

Sometimes

Not at all

PART 3: CONTRIBUTORY FACTORS TO FATIGUE

Relevance: The following questions relate to what factors contribute to fatigue in the context of aviation.

- Which of the following contributes to your fatigue? Please use the Likert scale to indicate the extent that each factor contributes to your fatigue.

Work-related factors

- Number of sectors completed

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Long duty hours**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Flying during early afternoons**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Insufficient rest breaks between duty periods/shifts**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Congested air space**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Short turnarounds (between sectors)**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Flying with inexperienced pilots**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Monotony of the job**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

• **Unscheduled/organizational delays** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Having to rest away from home** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Poor cockpit design/layout** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Irregular/inadequate sleep during periods of duty** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Irregular/inadequate sleep before periods of duty** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Not enough night time sleep** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Flying at night** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**

- **Early sign on‟s(before 6am)**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Late sign offs (after 11pm)**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **On call work**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Unplanned changes in shift/schedule**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Split duties**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Bad weather**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- **Too much non-flying work (report writing/incident reporting etc)**

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- Extended commuting to get to and from work

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- Too many consecutive work days in a row

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- Disruption of sleep wake patterns due to time zone changes

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

Non-work related factors

- Marital problems

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- Having young children

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- Poor diet

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

- After effects of stay awake drugs

1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always

• **Use of alcohol** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Lack of exercise** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Sleep disorders** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**
• **Financial stress** **1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always**

APPENDIX B: Research seminar presentation – An overview of industry wide survey on fatigue in aviation in SA

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Overview of industry wide survey on fatigue in aviation in SA

Jonathan Davy (PhD), Swantje Zschernack (PhD),
Chloe Bennett, Cleo Bennett, Dylan Blair, Chumani Mona and Shaurissa Borchard

Department of Human Kinetics and Ergonomics; Rhodes University, Makhanda (Grahamstown)

Research Seminar
28th March 2019

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What is 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 adequately perform safety-related operational duties."

ICAO, 2016

International Civil Aviation Organisation (ICAO) (2016). Doc 9966, Manual for the Oversight of Fatigue Management Approaches

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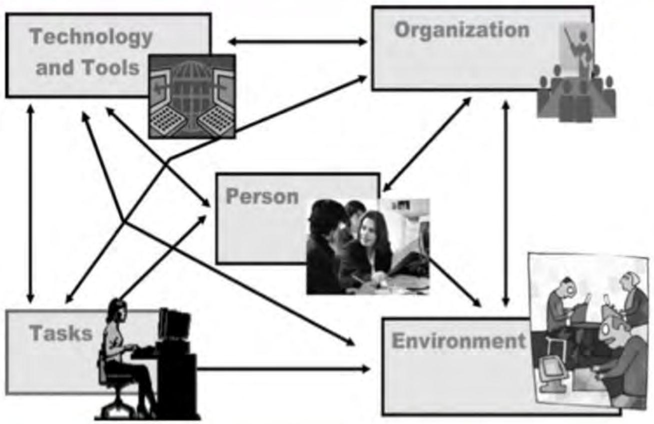
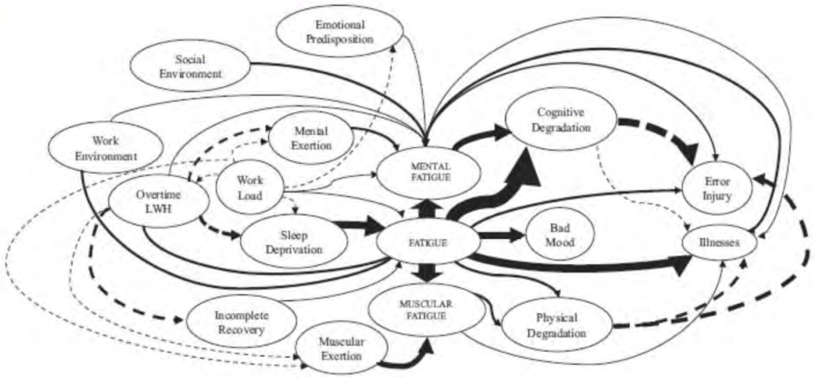
Systems approach to understanding fatigue

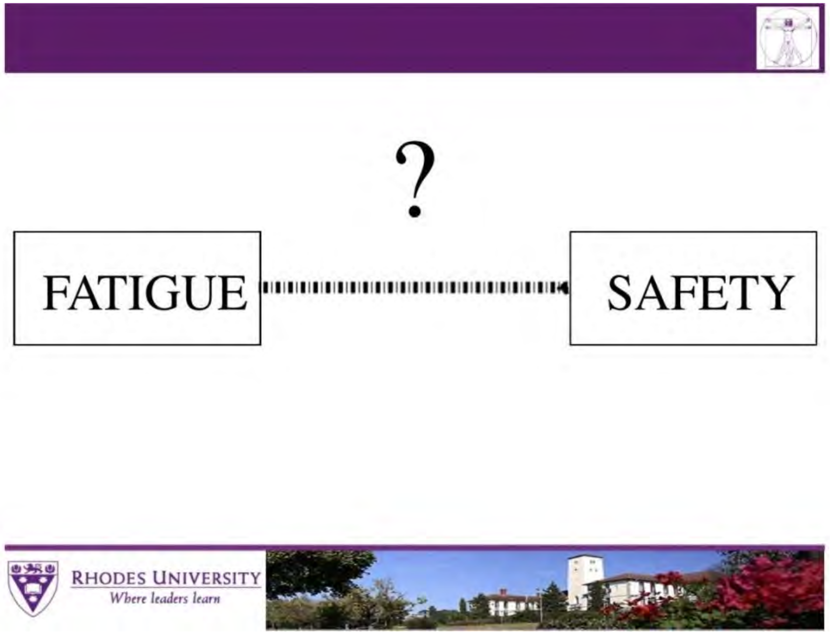


Carayon et al., 2005: Implementing a Systems Engineering Intervention for Improving Safety in Outpatient Surgeries

Fatigue is the product of complex interactions



Techera, U., Hallowell, M., Stambaugh, N., & Littlejohn, R. (2016). Causes and consequences of occupational fatigue: meta-analysis and systems model. Journal of Occupational and Environmental Medicine, 58(10), 961-973.


?
FATIGUE
SAFETY
RHODES UNIVERSITY
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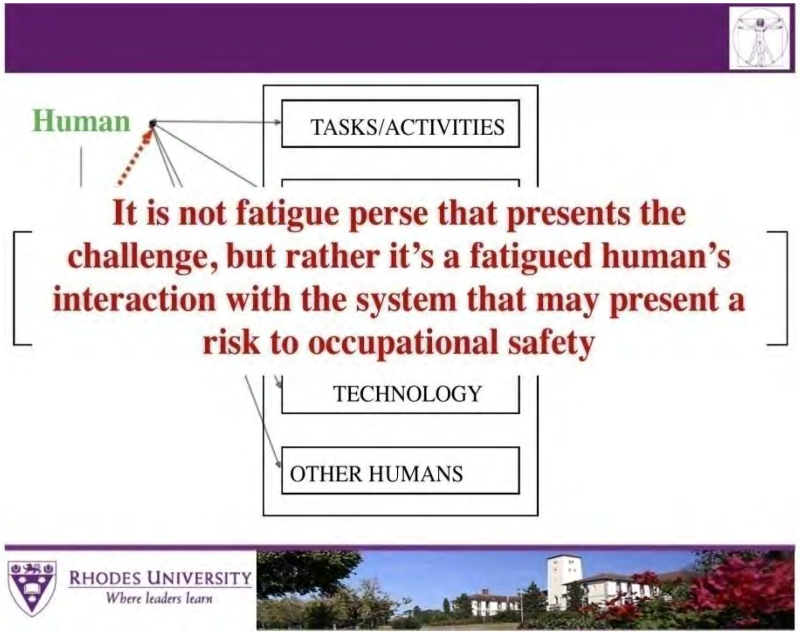
Human
TASKS/ACTIVITIES
It is not fatigue perse that presents the challenge, but rather it's a fatigued human's interaction with the system that may present a risk to occupational safety
TECHNOLOGY
OTHER HUMANS
RHODES UNIVERSITY
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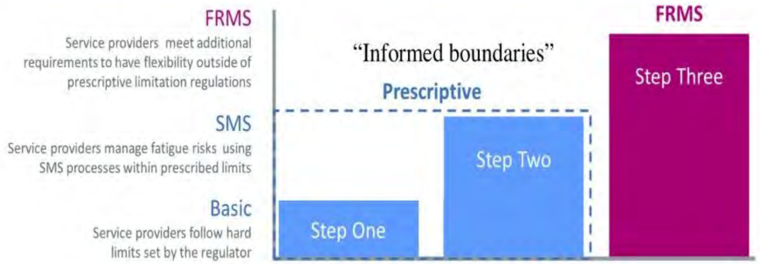
Current approaches to fatigue management



Scientific evidence + Operational experience

Shared responsibility between all stakeholders

https://www.icao.int/safety/fatiguemanagement/Pages/FM-Approaches.aspx

Current approaches to fatigue management

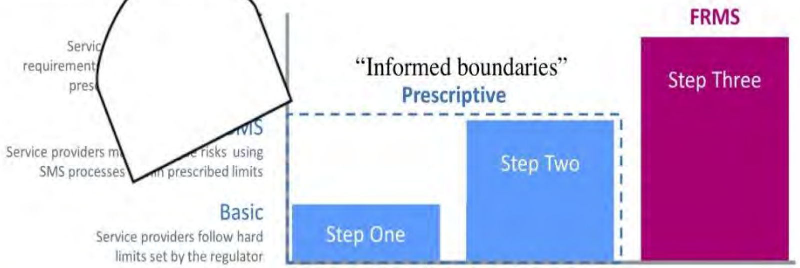
Safety policy and objectives

Safety risk management

Safety assurance

Safety assurance

FRMS = '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.' (https://www.skybrary.aero/index.php/Fatigue_Risk_Management_System_(FRMS))



https://www.icao.int/safety/fatiguemanagement/Pages/FM-Approaches.aspx

Amendments to Flight time limits

FEDERAL AVIATION ADMINISTRATION

EASA European Aviation Safety Agency APPROVED

HOME > OPERATIONS & TECHNOLOGY > AEROPOLITICS > REGULATION > CANADA AMENDS PILOT FLIGHT-TIME, DUTY R

Canada amends pilot flight-time, duty regulations

Bill Carey

Dec 12, 2016

EMAIL Share Tweet Recommend 0 COMMENTS 0

RELATED MEDIA

Study shows multiple takeoffs and landings contribute to pilot fatigue

Transport Canada on Dec. 12 announced amendments to Canadian Aviation Regulations that prescribe new flight- and duty-time limits for airline pilots that align with current scientific data and international standards. The amendments, published in the official Canada Gazette, Part II, provide fleet operators the option of implementing a Fatigue Risk Management System if they are constrained in meeting the new limits. Major carriers have two years to comply with the new requirements; smaller ...

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Background to our involvement in aviation

SOUTH AFRICAN CIVIL AVIATION AUTHORITY

AIRLINES ASSOCIATION OF SOUTHERN AFRICA AASA

ALPA-SA

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Background to the problem

Our mandate

Quantify the prevalence of fatigue across all sectors of aviation

Identify 'hot spots' where more in depth research could be performed

Overview of envisaged research plan

Fatigue in aviation in SA

Dylan (MSc)
Part 121
(Commercial
aviation)

Fatigue survey (1)

Quantification and analysis (2)

Pilots / Aircrew

Cabin crew

Chloe (PhD?)
All parts

Cleo (PhD?)
All parts/relevant
parts

Comparison of CARs across the globe

Chumani (Hons)
Rest periods, on call and stand by duties

Shaurissa (Hons)
Duty length, sectors in relation to flight times

Overview of envisaged research plan

Fatigue in aviation in SA

Dylan (MSc)
Part 121
(Commercial aviation)

Fatigue survey (1)

Quantification and analysis (2)

Pilots / Aircrew

Chloe (PhD)
All parts

Cabin crew

Cleo (PhD)
All parts/relevant parts

Comparison of CARs across the globe

Chumani (Hons)
Rest periods, on call and stand by duties

Shaurissa (Hons)
Duty length, sectors in relation to flight times

Approach to survey design

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Problem identification & areas of interest

According ALPA-SA and the CAA, reports of pilot fatigue have increased significantly over the last 3 years, with the union calling for alterations to the Flight and Duty time regulations captured in the CAR-SA as a first step to reducing the fatigue pf pilots. Following robust engagements around this issue, the CAA, AASA and ALPA-SA have agreed that the FTLs need to change, but that, prior to any change, research on whether fatigue is prevalent in the SA aviation context is necessary.

As such, this research project has the following objectives:

- To determine if all air crew, in all parts, perceive that fatigue is an issue
- To determine the prevalence of fatigue in all parts of the aviation industry in SA
- To determine, if relevant, what factors are significant contributors to fatigue in SA
- To determine whether and how fatigue is managed in the different parts of the industry
- To determine personal strategies of fatigue management
- To determine what the perceptions are within the industry about the current CAR pertaining to FTLs

Development of questions

PART 1: DEMOGRAPHIC INFORMATION

Relevance: This section is important to characterise the sample, which affords important insights into whether fatigue is experienced within specific age groups, gender groups or other personal information.

PART 2: SLEEPING AT HOME

Relevance: Although considered a secondary contributory factor, it is important to gain insights into practices outside and away from work. If these practices around sleep and recovery are not appropriate, this could provide the necessary evidence for improved education programs for staff.

PART 3: CHARACTERISTICS OF DUTY

Relevance: Understanding which aspects of their duty are challenging can point to areas of concern or poor implementation and how regulations are applied

PART 4: CREW PERCEPTIONS AROUND FATIGUE

Relevance: This section asks questions pertaining to fatigue and how it is experienced

Development of questions

PART 5: CONTRIBUTORY FACTORS TO FATIGUE

Relevance: The following questions relate to what factors contribute to fatigue in the context of aviation.

PART 6: FLIGHT TIME LIMITATIOS LEGISLATION

Relevance: Understanding which aspects of the current FDP legislations are challenging and need to be re-addressed.

PART 7: FATIGUE MANAGEMENT STRATEGIES IN YOUR ORGANIZATION

Relevance: Understanding which aspects of fatigue management strategies are used in the organization.

PART 8: PERSONAL STRATEGIES TO COMBAT FATIGUE

Relevance: Understanding personal strategies used by aircrew to mitigate fatigue

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Thank you

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APPENDIX C: Human Kinetics and Ergonomics Department academic staff and senior Postgraduate students" comments

Human Kinetics and Ergonomics Department Academic Staff and Senior Postgraduate Students"Comments – 21st March 2019 The text in **bold** are the comments/questions from the HKE staff and students	**Research Team responses**
With regards to Part 2: Personal Information: • Age: ________ • Sex:	
• Racial Group: **White** **Coloured** **African** **Indian** **Asian** **Other (specify): ________** • Mass: _________(kg)	

● Stature/height: ________(m) ● Please indicate with a tick your marital status? **Married/living with partner** **Separated/Divorced** **Widowed** **Single** ● Do you have children? YES NO ● If you answered yes to #7 please indicate how many and their ages? ● Please state the number of people living in your household? ● Do you smoke? YES NO ● If Yes to #10, how many times a day do you smoke? ● Do you consume alcohol? YES NO ● If yes to #12, how many units of alcohol do you consume per day? ● Do you consume alcohol after duty? YES NO	
The academic staff and senior postgraduate students" comments to the above	The survey was amended to factor in the staff and postgraduate students" comments, so that the focus of the survey was not on prevalence of fatigue

questions (numbered 1-14): **“Do you have the adequate rationale for asking all these demographics questions – I understand some – if this is now a prevalence study?”**	predominantly.
Q9 stated: Please state the number of people living in your household? • **And who as there could be kids, for example, impacting sleep.**	That question has now been removed from the survey entirely.
Q18 stated: What is your job title? (Commander, first officer, cabin crew manager). • **First maybe?**	This question was moved higher up the order of questions asked in Part 2.
Q19 stated: How long have you worked in your present job? • **First maybe?**	This question was moved higher up the order of questions asked in Part 2.
Q20 stated: What is your flying experience (hours) or how long have you been involved in the industry (years)______________________________ • **First maybe?**	This question was moved higher up the order of questions asked in Part 2.
Q21 stated: How long does it usually take you to travel from your home to your assigned domicile? _________________ (hours and minutes) • **And back home**	This has since been amended on the actual survey.
Maybe define each of these up front:	The wording to the multiple choice answers has changed in the survey:

• **What is the difference between major and substantial?** • **Maybe define each of these up front** • **What is the difference between major and substantial?** **A major problem** **A substantial problem** **A minor problem** **Not a problem at all**	A very serious problem A relatively serious problem A minor problem Not a problem at all
Still under PART 3: the question stated: when crew fatigue occurs, how significant a safety issue is it? • **When crew fatigue occurs, how significant in your opinion is it a safety issue?**	This question has been amended as per the feedback received.
The question stated: How much of a problem is fatigue to YOU PERSONALLY in your job? **A major problem** **A Substantial problem**	This was not added to the survey under PART 2, but was added to the Likert scale questions in PART 3.

A minor problem **Not a problem at all**	
The question stated: How often do you become fatigued while flying? **On every trip** **On most trips** **On about half your trips** **Occasionally** **Very rarely**	This was not added to the survey under PART 2, but was added to the Likert scale questions in PART 3.
The question stated: Between the two questions: Do you feel fatigue is related to: ● Work; ● Life outside work ● Lifestyle factors (diet, exercise, etc.) Tick as many as are relevant to you	This was not added to the survey under PART 2, but was added to the Likert scale questions in PART 3.

The question stated: Do you think that AWARENESS of crew fatigue has changed over the last 5 years IN THE INDUSTRY in general? **Has increased a lot** **Has increased** **No change** **Has decreased** **Has decreased a lot** ● **Provide a rationale for your answer**	Another question (Q6) was asked as a follow up to Question 5: Please provide reasons for your above answer______________________
The question stated: When you get tired, to what extent are the following flying tasks affected by fatigue? (Please tick the impact level of fatigue for each flying task using the Likert scale ranging from not at all to significantly) ● **When you get tired, whether due to work or a combination of factors, to what extent are the following flying tasks affected by fatigue? (Please tick the impact level of fatigue for each flying task using the Likert scale ranging from not at all to significantly)**	This question was ultimately removed from the survey.
● **The feedback relates to the whole of Part 3"s questions are answered on a Likert scale.** ● **The questions should be specific to your work environment – then maybe a section relevant to "life in general" i.e. money issues, personal problems, children, poor diet, lack of exercise, etc.** ● **"I see it is interspersed but poor diet when travelling (i.e. there is still bias that the work itself is the issue) for example may different to poor diet when at home. Plus, it needs more detail (outside work factors).**	The Likert scale was adjusted for the survey, with two separate sections: work-related factors and non-work related factors. This is now PART 4.

● The consensus was mainly that the drafts of the questionnaire were too long and needed to be shortened. At times terminologies needed to be adjusted, for example asking a question, “what is your sex?” Could be adjusted to „what is your gender?” At times the consensus was there were ambiguities as to how some questions were asked for example “how many duty days do you fly in a month? – typical days ___________ most days_____________ ● The criticism was, the difference between a typical day and most days, what do those two mean? ● Overall, the feedback was based on the questions needing to be refined; ● the questionnaire was too long; the language used was at times ambiguous – needed to be more neutral; ● there was more need to explore the things that link to fatigue – refrain from using the word „fatigue‟, try to work around the issue so that people are not pushed to think in a certain way; ● find the best practice for coping with fatigue (pilots); ● ask other departments such as the psychology, sociology departments on how to refine a questionnaire; ● change the category headings to areas of peoples‟ lives – work section; home section; lifestyle section, etc.	The feedback was of great significance as the research team managed to take the feedback and make the questionnaire shorter, more specific and tackled the pointers that were provided by the staff and postgraduate students.
● The consensus was mainly formatting errors which needed minor adjustments and acronyms – FDP – Flight Duty Period, which should have	Very constructive criticism which assisted with the overall amendments of the survey, and adjustments of the language used – refraining from using acronyms.

been written in full to begin with then abbreviated. ● Overall the consensus was questionnaire was thorough and the questions asked were clean	
● The overall consensus was that the questionnaire was too long, there were also a lot of formatting errors which needed to be adjusted. In addition, there were open ended questions which needed more space in order to type out a coherent answer. There were also areas where more options could have been provided, such as racial groups: white coloured, African, other (specify) – Asian could have been added. ● Generally, the questions were pertinent to the context, except some terminologies such as „trailer" which is American for a caravan, needed adjusting due to the context.	The feedback was informative and relevant, the adjustments were made necessary, especially the length of the survey, the formatting, and space required to type out answers.
● The feedback was mainly the formatting needed to be adjusted as there were many mistakes and spelling errors. At times the language used needed to be adjusted as well and some of the follow-up questions needed to be added, especially when closed questions were asked.	The feedback was helpful and the spelling mistakes were corrected, as were the errors, language, and the follow-up questions post-closed questions were added.

APPENDIX D: PART 2 to PART 5 full breakdown of the number of questions, the contents of each part, where the questions were adapted from and the rationale behind their admission to the survey

Adapted Question and PART	**Content**	**Adapted from**	**Rationale for question (why)**
PART 2: PERSONAL INFORMATION			
1	Age?	Co *et al.,* (1999); Bourgeois-Bougrine *et al.,* (2003)	
2	Sex? ● Female ● Male ● Non-binary ● Prefer not to say	Bourgeois-Bougrine *et al.,* (2003)	
3	Race Group?		
4	What is your job title? (Commander, first officer, cabin crew manager).	Co *et al.,* (1999); Bourgeois-Bougrine *et al.,* (2003)	To separate the participants into their respective job titles.
5	What part of the aviation industry do you work in?	Co *et al.,* (1999)	The survey was sent out to all parts of the industry, so it was important for the participants to stipulate which part of the industry they worked in, and to separate the different parts into the relevant categories.
6	How long have you worked in your present job?	Co *et al.,* (1999); Bourgeois-Bougrine *et al.,* (2003)	Experience in the field, so if fatigue had been experienced, they would have been knowledgeable about fatigue in the aviation industry and the coping mechanisms within their context.

7	What is your flying experience (hours) or how long have you been involved in the industry (years)?	Co *et al.,* (1999)	This was largely a demographic-based question.
8	In which province are you based?	AASA (2019)	Identifying potential contributors to fatigue due to multiple segments flown (from home base to other provinces and back to home base). In addition, long-haul flights for those who did not live in South Africa.
9	Please indicate the characteristics of your flight duty? • Long-haul • Short-haul • Aerial work • Other	Co *et al.,* (1999)	Potential for crossing time zones which would have led to circadian rhythm disruptions which could have contributed to fatigue. In addition, flying short-haul flights could have meant multiple take-offs and landings which could also have contributed to fatigue and multiple segments flown which could have added to the workload and the length of the duty period. Aerial work would have added to workload as the time in the air could have been strenuous given that a number of factors (turbulence, heat, rain etc) could possibly have been needed to have been dealt with.
10	If you indicated „Other" in the above question, kindly state what the characteristics of your flight duty are?	Co *et al.,* (1999)	Identifying whether there were other characteristics of flight duties which were not included in the options in the previous question, given that there were only three stipulations.
11	Based on the question above, do you experience time zone changes? • Yes • No	Co *et al.,* (1999)	Time zone changes would have affected circadian rhythms, leading to sleep related problems and therefore, flying through time zones could have been a factor which contributed to aircrew fatigue.
12	In what time zone is your domicile?	Co *et al.,* (1999)	Same as question 11 above.
13	How long does it usually take you to travel from your home to your assigned place of work and back again? (hours and minutes)	Co *et al.,* (1999); Bourgeois-Bougrine *et al.,* (2003); AASA (2019)	Commuting time would have led to a longer time being awake (depending on the distance travelled) and added workload from a cognitive perspective as the commute (in the event of self-driven or self-flying), to have had to have concentrated for that period of time to get to and from work. Furthermore, reduced sleep if the distance travelled was long, there would still be time needed for home-based

			activities prior to sleeping. These factors could have contributed to fatigue.
14	What is the typical mode of transportation from your home to your assigned place of work? • Self-drive surface transport • Self-fly air transport • Public transport (taxi; bus; train) • Walking • Flying as a passenger	Co *et al.,* (1999); ALPA-SA (2019); AASA (2019)	Aircrew had different modes of travel to get to and from work and cannot be generalised. The mode chosen could have similar effects to the above question, question 13.
15	What non-flying work duties do you have? (Refresher training, pre-flight paperwork, report writing)	South African Red Cross AMS (2019)	The non-flying duties were recurrent measures taken by aircrew, which added to their overall workload. Besides the other factors which contributed to their workload, having to do non-flying work duties could also have contributed to fatigue.
PART 3: CREW PERCEPTIONS AROUND FATIGUE			
1	In your opinion, how much of a problem is fatigue in your part of the industry? • A very serious problem • A relatively serious problem • A minor problem • Not a problem at all	Co *et al.,* (1999)	This question was posed in order to get a sense of which potential „hotspots" within the different Parts of the industry (given that the survey was sent to all parts) and to identify how the participants felt on the severity of fatigue.
2	When serious crew fatigue occurs, how significant a safety issue is it? • A very serious problem • A relatively serious problem • A minor problem	Co *et al.,* (1999); AASA (2019)	It was important to find out how the participants felt when crew fatigue occurred as the study was to a large extent based on fatigue in aviation. And fatigue could have led to safety breaches.

	• Not a problem at all		
3	How much or a problem is fatigue to YOU PERSONALLY in your job? • A very serious problem • A relatively serious problem • A minor problem • Not a problem at all		To get a sense from the participants personal feelings towards the issue of fatigue given that they work at the sharp end.
4	How often do you become fatigued while flying or performing your job? • On every trip • On most trips • On about half your trips • Occasionally • Very rarely		To get a sense if there was a serious problem that would needed to have been addressed to avoid safety breaches and fatigue mitigating factors that were outdated.
5	Do you think that AWARENESS of crew fatigue has changed over the last 5 years IN THE INDUSTRY in general? • Has increased a lot • Has increased • No change • Has decreased • Has decreased a lot		To get a sense if the fatigue mitigating factors were still considered as pertinent reminders or if they had of been lulled down.
6	Please provide reasons for your answer above.		
7	Do you think AWARENESS of crew fatigue has changed over the last 5 years, FOR YOU?		To get a sense from the participants" personal feelings on the issue.

	- Has increased a lot - Has increased - No change - Has decreased - Has decreased a lot		
8	During the take-off/landing phases, how do you typically feel? - Fully alert, wide awake - Very lively, responsive, but not at peak - Okay, somewhat fresh - A little tired, less than fresh - Moderately tired, let down - Extremely tired, very difficult to concentrate - Completely exhausted, unable to function effectively	An experienced specialist with work experience in aviation.	As the two mentioned phases (take-off/landing) were deemed as very taxing tasks which would have added to the workload of the pilots. The two phases could have been contributors to fatigue within their flight duty period. Additionally, a similar question was asked in another fatigue in aviation survey.
9	During the cruise phase, how do you typically feel? - Fully alert, wide awake - Very lively, responsive, but not at peak - Okay, somewhat fresh - A little tired, less than fresh - Moderately tired, let down - Extremely tired, very difficult to concentrate - Completely exhausted, unable to function effectively	An experienced specialist with work experience in aviation.	Depending on the length of the flight, the cruise phase could have been extended which could have led to boredom as that phase of the flight (if the weather was clear) would not have been taxing on the pilots in particular. Therefore, there would have been a reduced likelihood of fatigue onset in comparison to the previous question (question 8).
10	Does fatigue interfere with your ability to carry out your duties?	Co *et al.*, (1999)	Safety breaches could ensue, which made that question pertinent to the study and to have gotten a

	• On every trip • On most trips • On about half your trips • Occasionally • Very rarely		sense of the impact fatigue had on the participants.
PART 4: CONTRIBUTORY FACTORS TO FATIGUE			
Work-related factors			
1	Number of sectors • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This was pertinent for short-haul aircrew as a higher number of sectors would have meant more take-off and landing tasks, increased workload as a result. Therefore, those, among other factors could have contributed to fatigue as a work-related factor and other aviation surveys have asked the said question.
2	Long duty hours • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Aircrew would have had periods on duty which exceeded the usual working day schedule. The question was pertinent as long duty hours could have contributed to fatigue in the sense that the aircrew would have been awake for a long period of time, besides flying and other cognitive aspects of which they would have had to have considered which could have contributed to fatigue.
3	Flying during early afternoons	Co *et al.,* (1999)	As there would have been a „dip" in their circadian rhythm, their cognitive abilities such as concentration

	• 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable		(workload) would have been reduced. Additionally, their duty period could have possibly been longer and that could have contributed to fatigue.
4	Insufficient rest breaks between duty periods/shifts • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Lack of time for recovery to occur, which could have contributed to fatigue ensuing. A recurring event within the industry.
5	Congested air space • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This would have made the flight longer in the sense that the pilots would not have been able to land their aircraft which would have added to their workload and the importance of this question was that such an event could have happened to the participants during their careers, potentially more than once.
6	Short turnarounds (between sectors) • 1=Not at all • 2=Rarely • 3=Sometimes	Co *et al.,* (1999)	Lack of recovery time and rest to have been fully alert for the next flight could have led to safety breaches.

	• 4=Often • 5=Always • 6=Not applicable		
7	Flying with inexperienced crew • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Tasks may not have been completed as fast as they should have been which could have frustrated customers and given the airline a bad review. Frustration may have ensued which could have been avoided had the crew been experienced and so this could have led to more cognitive inhibition as there may been more tasks added due to the inexperienced crew.
8	Monotony of the job • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This would reduce the alertness levels of the aircrew which could have breached safety protocols. The importance of this question was that being bored could have happened on many occasions to aircrew and therefore, a drop in alertness could also have made aircrew tired which could have contributed to fatigue onset.
9	Unscheduled/organisational delays • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This could have resulted in boredom onset, as well as tiredness if the delays were for extended periods of time. This could have happened at any time during their days on duty.

10	Having to rest away from home • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Quality of sleep could have been inhibited – uncomfortable bed, loud hotel etc which could have inhibited the aircrew"s abilities to carry out their job.
11	Poor cockpit or cabin design/layout • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This could have led to discomfort which could have resulted in frustration. Having to carry out the other pertinent activities of flying as well as being in discomfort could have contributed to fatigue.
12	Irregular/inadequate sleep during periods of duty • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Sleep is important to function and carry out day-to-day activities and if the aircrew were not getting the adequate sleep they required then they would not have been able to carry out their daily duties. Inadequate sleep could contribute to fatigue.
13	Irregular/inadequate sleep before periods of duty • 1=Not at all • 2=Rarely	Co *et al.,* (1999)	Same as question 12.

	• 3=Sometimes • 4=Often • 5=Always • 6=Not applicable		
14	Not enough night time sleep • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This would have affected their circadian rhythm, as they may have had to try and sleep during the morning when the sun was up. This question was important as it also exposed the fact that the duty periods of the aircrew ended late at night.
15	Flying at night • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	A period when humans should have been shutting down to sleep or should have already been asleep. Night flying would affect aircrew"s circadian rhythms as well which could have contributed to fatigue as their sleep would have been disrupted, and they would have been awake for extended periods of time. However, a common theme for aircrew was night flying, especially for long-haul flights.
16	Early sign on"s (before 6am) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always	Co *et al.,* (1999)	This would have reduced sleep time, due to the time that would have been needed to carry out the morning"s duties prior to commuting to work. The length of the day would also have been increased due to the time being awake. Increased length of time awake and having a full day"s work could have contributed to fatigue.

	• 6=Not applicable		
17	Late sign offs (after 11pm) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Same as the above question. The only difference would have been reduced night time sleep as they would have ended their duty late into the night.
18	On call work • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	A common occurrence for aircrew which could mean they were not fully resting at their domicile which could have interfered with their sleep being disrupted as they knew they may have needed to be called into work. The lack of adequate rest due to being on call could also have contributed to fatigue.
19	Unplanned changes in shift/schedule • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This could have resulted in less recovery time available especially if the aircrew had had two consecutive days on duty and were to rest the third day but then told they had to fly on that rest day, would be taxing on them and could be contributing to fatigue.
20	Split duties	Co *et al.,* (1999)	This would have affected circadian rhythms because the shift may have been at a time where biologically the crew member should have been asleep. Thus

	• 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable		they would have had to have flown during irregular hours which would have meant they were not fully alert or fully able to carry out the required tasks at hand. Split duties were a common occurrence in the aviation industry.
21	Bad weather • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	The weather would be considered as an unpredictable phenomenon and so bad weather could have occurred at any flight period which would have led to an increase in cognitive workload and performance. Both of which could have been taxing on the aircrew, among other factors, could have contributed to fatigue.
22	Too much non-flying work (report writing/incident writing etc) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Pertinent activities for aircrew to carry out, however, could have led to increased workload for the aircrew, especially post-flight and if the duty period was long. Besides other factors and duties which they would have had to have carried out, could have been major factors which contributed to fatigue.
23	Too many consecutive work days in a row • 1=Not at all • 2=Rarely • 3=Sometimes	Co *et al.,* (1999)	This would have led to a reduction in recovery and could contribute to fatigue either in between the said consecutive work days or post-work days. A pertinent question in the field of aviation studies.

	• 4=Often • 5=Always • 6=Not applicable		
24	Disruption of sleep wake patterns due to time zone changes • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	This would have affected sleep, recovery, the onset of jet lag. All of which may have contributed to fatigue. And were common in the aviation industry.
25	Dealing with passengers • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Taxing on the cabin crew"s workload, however, a day-to day activity whilst on duty. This could contribute to cabin crew fatigue.
26	Environmental conditions in the cockpit or cabin (noise, vibrations, low air pressure, low lighting, low humidity etc) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Increased workload, performance could be distracting and could contribute to safety breaches as well as fatigue.

27	Equipment problems (service trolleys onboard) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Co *et al.,* (1999)	Increased workload for cabin crew, besides their other activities that they had to carry out, could contribute to fatigue.
28	No autopilot function on aircraft • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	South African Red Cross AMS (2019)	Increased workload and performance as the pilots would have had to have flown the aircraft the entire duration of the flight. Among other factors and compulsory duties, the autopilot would have reduced their workload. A more common theme in smaller aircraft.
29	Extra work to supplement income • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	South African Red Cross AMS (2019)	This could have contributed to sleep deprivation and reduced recovery if the extra work were conducted on rest days.
30	Successive night flights • 1=Not at all • 2=Rarely	AASA (2019)	Disruption of circadian rhythms which would affect sleep and recovery. These both could have contributed to fatigue.

	• 3=Sometimes • 4=Often • 5=Always • 6=Not applicable		
31	Insufficient time for pre and post flight duties • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	AASA (2019)	Incorrect information could be relayed, or information that should have been relayed could be forgotten which could have meant safety breaches were made.
32	Long idle time between flights • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	AASA (2019)	Increased workload, monotony could ensue due to the time sat idle. This could have contributed to fatigue if it was a recurring theme.
33	Quality of on-board rest facility • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always	AASA (2019)	This could affect the sleep of the aircrew on a long flight, for when they did shift change, if the sleep quality of the resting crew member was not sufficient they may not have been fully alert which could have led to safety breaches and eventually fatigue could have ensued due to disrupted sleep.

	• 6=Not applicable		
34	Spraying difficult fields • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Targeting the crop-sprayers, the workload and performance required to spray the crops would both be increased as the task at hand was taxing.
35	Difficult bombing terrain • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Same as question 34.
36	Presence of power lines • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Increased workload and performance for the crop-sprayers to have avoided flying into the power lines. Both factors could have contributed to fatigue.
37	Difficult landing strips	Aerial Farming Services (2019)	Increased workload and performance to have landed small aircraft on difficult landing strips which was a

	• 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable		common task for crop sprayers.
38	Difficulties identifying fields • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Workload and performance increased, as the ability to have identified the fields to spray and to be having been accurate.
39	Hot and humid ambient conditions • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Workload and performance increased, as the ability to have identified the fields to spray and to have been accurate.
40	Hot and high ambient conditions • 1=Not at all • 2=Rarely • 3=Sometimes	Aerial Farming Services (2019)	Same as question 39.

	• 4=Often • 5=Always • 6=Not applicable		
41	High cockpit temperature • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Same as question 40.
42	Severe turbulence • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Same as question 40.
43	Ambient light – very bright/low light conditions • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Same as question 40.

44	Long ferries (15lm+) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Increased workload for the pilots and a potentially common occurrence for crop spraying pilots.
45	Fields with long runs (2km+) • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Increased workload and performance as the length of the fields would all have needed to have been sprayed accurately.
46	Hold ups when loading/refuelling • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Could have led to monotony, and time wasted to get crops sprayed.
47	Pressure to get work done • 1=Not at all • 2=Rarely	Aerial Farming Services (2019)	Increased workload to get the tasks at hand completed. Pressure from the employers could be taxing on the pilots to do their work.

	• 3=Sometimes • 4=Often • 5=Always • 6=Not applicable		
48	Chemical/fuel fumes in cockpit • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	This could have been a common occurrence for crop-sprayers which could have affected their abilities to do their work.
49	Conflicting low level air traffic • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always • 6=Not applicable	Aerial Farming Services (2019)	Same as question 48.
50	Periods of inactivity while on duty • 1=Not at all • 2=Rarely • 3=Sometimes • 4=Often • 5=Always	Aerial Farming Services (2019)	This could have led to monotony ensuing and a potentially common occurrence for crop-sprayers.

	• 6=Not applicable		
51	Other (specify)?		
Non-work related factors			
1	Relationship problems 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.*, (1999)	The participants may have a significant other and they may have been having problems which could have affected their sleep, concentration at work. These factors could have contributed to fatigue.
2	Having young children/looking after additional dependents 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.*, (1999)	As some aircrew end their duty late. They would want to sleep in the following day (if they had an off-day), however having young children or looking after dependents could have inhibited the sleep duration. This is because children wake-up early for school, at times when the aircrew would want to still be asleep, thus disrupting their sleep. Having had disrupted sleep after long duty hours, could have contributed to fatigue and led to a lack or reduced recovery.
3	Poor diet 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.*, (1999)	Having a poor diet could have led to health problems which could have affected their abilities to do their job. It would also have been generalising, that all the participants had a balanced diet.
4	After effects of stay awake drugs 1=Not at all	Co *et al.*, (1999)	The stay awake drugs may have interfered with the aircrew"s sleep pattern, circadian rhythms and cognitive abilities which could all have contributed to

	2=Rarely 3=Sometimes 4=Often 5=Always		fatigue.
5	Use of alcohol 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.,* (1999)	Alcohol affects sleep, which could affect the aircrew"s ability to carry out their duties. In addition, if their sleep was affected then that could have contributed to fatigue.
6	Lack of exercise 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.,* (1999)	This would also have led to health related problems which could have affected the abilities of the individuals at hand during flight. It would also be generalising the population of participants, that they all exercised.
7	Sleep disorders (diagnosed or suspected) 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.,* (1999)	A sleep disorder could affect the quality and amount of sleep. Poor sleep may have contributed to fatigue onset. Sleep disorders could have affected a random amount of potential participants so by ignoring those who may have had would not have been fair and their potential reasons for fatigue ensuing may have been the sleep disorder.
8	Financial stress 1=Not at all 2=Rarely	Co *et al.,* (1999)	This could have affected the cognitive side, which could have affected recovery. Those who were in financial trouble may have found that that was what was contributing to them fatiguing as they may have had a constant worrisome feeling.

	3=Sometimes 4=Often 5=Always		
9	Additional health problems 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.,* (1999)	As there a large number of health problems, it was important to add the question as health problems could have contributed to fatigue for those who had them.
10	Excessive exercise 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.,* (1999)	Excessive exercise would make the individuals tired all the time and they would potentially have struggled to carry out their day-to-day operations which could also have contributed to fatigue.
11	Use of sleeping tablets 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	AASA (2019)	Individuals with irregular sleeping patterns would have used sleeping tablets to help them sleep and this may have disrupted their circadian rhythm which could have affected their performance during their flights. As there may have been individuals who used sleeping tablets, it was important to include them.
12	Use of over the counter medications 1=Not at all 2=Rarely	AASA (2019)	The medication may have affected sleep of the individuals who purchased and used over the counter medications. A lack of sleep (among other factors) could then have contributed to fatigue.

	3=Sometimes 4=Often 5=Always		
13	Extended commuting to get to and from work 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	Co *et al.,* (1999)	Commuting for long periods of time would have meant, staying awake for longer periods of time. Which would lead to reduced sleep time due to the time taken to wake-up, carry out the morning duties before getting to work on time. Conversely, leaving work late and travel time increased would have meant less time available to sleep given that there would still have been time needed to carry out home duties. Overall, fatigue could eventually ensue, if this was a recurrent pattern of events.
14	Use of herbal remedies to assist with sleep and fatigue 1=Not at all 2=Rarely 3=Sometimes 4=Often 5=Always	AASA (2019)	Some individuals may have used herbal remedies to mitigate fatigue and to assist them with sleep instead of using sleeping tablets so it was important to include the question.
15	Other (specify)?		
PART 5: SA FLIGHT TIME LIMITATIONS LEGISLATION			
1	With respect to the current South African Flight and Duty Period regulations, what aspects of the current regulations present a concern for you?	ALPA-SA (2019); AASA (2019); SACAA (2019)	The study was contributing to the changing of the current Flight and Duty Period regulations in South Africa and therefore, finding out from those who operate at the sharp end (aircrew) was pertinent to the study.
2	If you have concerns, what recommendations do you have to address these concerns?	ALPA-SA (2019); AASA (2019); SACAA (2019)	The participants" suggestions, feelings, opinions could prove important pieces of information which needed to be brought to the SACAA"s attention, in order for changes to be made.

3	What are the current, effective fatigue mitigating aspects of the current regulations?	An experienced specialist with work experience in aviation.	The current fatigue mitigating factors may not be adhered to. Or, as they were effective to begin with, they do not need to be adjusted which would have saved a lot of time. Therefore, that question would entice the participants to provide information to the researchers on which aspects were effective and if they were being adhered to or not.

APPENDIX E: Feedback from the aviation industry and fatigue in aviation academic

ALPA-SA Comments – 6th May 2019	Research Team responses
A major issue wrt Fatigue that is perhaps not closely monitored, could be the issue of Domicile [Q 10 - 12], especially in modern times where many of them work in city A, even Province and Country, but works from B. Thus jump-seating / positioning before and after flights. Worst case scenarios including living in Perth and working from Johannesburg. Thus I would suggest Q12 to include Flying as passenger as mode of transport	Part 1, Q12 of initial draft and Q14 of current survey: What is the typical mode of transportation from your home to your assigned domicile? ● Self-drive surface transport ● *Self-fly air transport ● Public transport (taxi; bus; train) ● Walking ● Other: *the „self-air transport" as a mode of transport was added to the survey
In addition, I believe a major role player in prevention is organisational culture, thus how do crews perceive their organisation / authorities culture wrt Fatigue Risk Management. Do they have a FRM program in place and it adhered to? [In this I believe the recent study by ALPA-SA pointed out a lot of „deficiencies' as well, where crews take sick leave to recover from fatigue, etc].	These comments were agreed upon by the research team but were not added as questions to the survey.
South African Red Cross Air Medical Services (AMS) Comments – 16th May 2019	
Part 1: Q4 Add to the question 'what non-flying work duties do you have?' Reason being pilots who occupy positions with multiple responsibilities will be more prone to fatigue and stress.	That question was added as a new question to the current questionnaire as Q5: what non-flying duties do you have? (Refresher training, pre-flight paperwork, report writing).
Part 2: Consider adding a question such as 'When flying what are the symptoms of stress that you have experienced?' Could be a multiple choice with options such as distraction, situational awareness lapses, irritability etc.	The question was rephrased: "What symptoms of stress have you experienced during flying?" The question was a multiple choice question: ● Distractions

	● Situational awareness lapses ● Irritability However, this question was ultimately removed.
Part 3: A lack of currency/recency will increase stress levels thus expediting the effects of fatigue, consider adding something to this effect under section 21.	As Part 3 of the questionnaire is a Likert scale, the question posed by AMS was added as number 28 on the „work-related factors" section of Part 3: "Lack of recency/currency". However, this question was removed when the survey was released.
Also consider asking if the pilot flies an aircraft that does not have an autopilot for the same reason above	As Part 3 of the questionnaire is a Likert scale, the question posed by AMS was added as number 28 on the „work-related factors" section of Part 4: No autopilot function on aircraft".
A general point, does the pilot have to do extra work to supplement income.	As Part 3 of the questionnaire is a Likert scale, the question posed by AMS was added as number 29 on the „work-related factors" section of Part 4: "Extra work to supplement income".
Airlines Association of Southern Africa (AASA) and Anonymous Airlines Comments – 19th July 2019	
AASA comments: ● My first take on this survey is that it considers fatigue purely from a pilot / crew perspective. Whilst some questions are objective and establish facts, others are based on perceptions very much from the pilot perspective. ● I questioned my airlines whether there should not be a section which considers the Management perspective? In addition, should there not be a section where statistics can be provided by airlines (if airlines wish to share this) on fatigue reports, issues and trends and identifying other issues that may be impacting the perceptions? ● Through past discussions, the majority of the problems seem to have been the early morning departures and long haul issues. Should we also not ask	● This is true and was this was intentional. ● This was taken into consideration, however, a questionnaire for the management side would be separate from the current questionnaire. The time it would take the airlines to provide the statistics on reported fatigue (should they choose to do so) may take too long to then get the questionnaire in circulation. ● Valid point, taken into consideration.

the question to all as to what aspects of the current FDP are presenting a concern? ● Some airlines have addressed my questions and I provide a comment after the airline management feedback.	● Thank you and much appreciated.
Airline number one"scomments: ● As he understands the questionnaire, the idea is to try and gauge the experience of fatigue at the coal face. It is aimed at everyone who doesn"t work office hours, like ops personnel and crew managers, as well as flight crew. Until we come up with an easy to use, objective measure for fatigue, we are probably stuck with subjective perceptions. ● Worldwide experience of these types of questionnaires show that very few crew members bother to complete them, even where fatigue is a genuine issue. ● I think the other airlines will probably concur that very few fatigue reports are filed, and those would mostly be by the same individuals. It is probably open to debate whether those individuals are more prone to fatigue or just more prone to bothering to report it. ● Management perspective certainly has a place, but maybe in a different questionnaire. ● I think Part 3 "CONTRIBUTORY FACTORS TO FATIGUE" adequately covers the question about which part of the current regulations present a concern, because it has a question about almost every part of the regulations, including number of sectors, early starts and long duty days.	● As it stands this is the option we have to measure fatigue. Given the time constraint, it would be difficult to attempt to apply objective measures of fatigue. ● Although this maybe an anecdotal comment from the airline, the current FDP regulations in South Africa need to be adjusted, given that other parts of the world have (in the recent past) made adjustments to theirs. ● We have to just hope that all pilots do fill out their fatigue reports, or if they do not then as the survey is anonymously filled out, there is a greater chance of honesty from the respondents when filling out questions that relate to fatigue as they perceive it. ● We all agree with that comment. ● Thank you, we appreciate the compliment.
Airline number two"s comments: ● Over the years there have no doubt been numerous fatigue surveys conducted to assess flight crew perceptions of fatigue in aviation. There are a variety of questions that could be included in any survey, but in my opinion, the proposed survey will serve the intended purpose of capturing	● Thank you, we appreciate the compliment. ● Questions 11 and 12 were amended however, due to additional questions on the survey, the questions numbers have changed but they have been

the perceived levels of fatigue in the aviation industry in South Africa. ● The only proposed amendment is the use of "domicile" in Part 1. Domicile is usually used in the context of "home address", whereas in part 1, it is used as place of work. Questions 11 and 12 should thus be amended to read "from home to place of work". ● Although he agrees that Airline Management should be given the opportunity to state their case, he does not feel that this questionnaire should include a section for Management to provide statistics. He suggests that a separate survey should be designed for this purpose.	amended as per the airline"s suggestions. ● Q11 is now Q13: How long does it usually take you to travel from *your home to your assigned place of work* and back again? (hours and minutes) ● Q12 is now Q14: What is the typical mode of transportation from *your home to your assigned place of work?* ● We concurred with this suggestion. The text in *italics* are the amendments to the suggested questions.
Airline number three"scomments: ● In general, the question cover perceptions plus whether the CAA flight and duty is assisting with the management of fatigue to an acceptable level. The questions may show deficiencies that the EASA regulations may cover and we would have to wait for analysis once completed. ● It appears to be a first round survey to give some direction to the group to assist with the workshops the CAA is proposing. We are comfortable with the questions being asked and would suggest questions to be added under Part 3: ● Work Related Factors: ● Successive night duties ● Sufficient time provided for pre and post flight duties. ● Long sit between flights ● Quality of on board rest facility.	

● Non Work Related Factors: ● Use of sleeping pills ● Use of herbal remedies to assist with sleep and fatigue. ● Use of over the counter medications.	● Thank you and indeed we will have to wait and see. ● Both the work-related factors and the non-work related factors suggested were added to the questionnaire in their respective categories. Both of which were added towards the bottom of the respective Likert scales. However, Part 3 is now Part 4.

Airline number four's comments:
● His expressed view is that FDP regulations should be compiled based on scientific grounds only. Including any data obtained from pilots and cabin crew will totally skew a system.
● With respect to the questionnaire he has a couple of remarks:
  ● Question 11: He is not sure what the intention is of adding this. Individuals choose where they stay and the operator has no control over that. The operator cannot be penalized because somebody chooses to stay 2 hours from the place of work, or an individual stays in another town and commutes to work.
  ● Question 12: Similar to above, the mode of transport has no relevance on what FDP should be allowed.
  ● Question 13: History has shown that even if crew fly 10 days a month only, that they will still insist that they are fatigued. The definition of fatigue must be established as crew identify "I am tired because I am not an early person" as being fatigued.
	● This is the only method we feel will give accurate results given the context and time constraints.
	● Q11: we agree with this statement; it is now Q13 due to additions made to the survey. However, we have left the question there because, the operator may not be penalised for the choice made by the pilots as to where they choose to stay but the fact remains that travelling to and from work contributes to fatigue. It is not to say that the airline should be punished but an acknowledgment that fatigue has many contributing factors and one of them is travel as it increases their cognitive workload, if they are indeed, driving to the airport for a period of time.
	  ● This question is now Q14 and the research team believes the mode of transport still is a contributing factor to fatigue as the pilot driving himself/herself to work is more taxing as compared to them being driven or flown to their place of work.
	  ● The anonymous survey will hopefully bring out honest responses.

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Airline number five‟s comments:

- Somewhere around question 7 or 8: Please add “Which province are you based?”
- Question 14: He feels this question is not qualified…we are all under some degree of fatigue most of the day, hence the SP scales or similar. He thinks this question needs to be phrased as “when serious crew fatigue occurs, how significant……?”
- Question 20: Immediately follow this with a Q21. What level of fatigue is acceptable in your opinion…..None, A little, Some, Fatigued, Exhausted?
- Question 21/22: Should extended commuting time not be under Non-Work related factor. After all it is the individual‟s choice where he resides?

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- This question has been added to the questionnaire, it is now Q9 under Part 1.
- This is Q2 under Part 2: it now reads, “When serious crew fatigue occurs, how significant a safety issue is it?
    - A very serious problem
    - A relatively serious problem
    - A minor problem
    - Not a problem at all
- This question is Q9 under Part 2, it reads, “What level of fatigue is acceptable in your opinion?
    - None
    - A little
    - Some
    - Fatigued
    - Exhausted
- We agreed upon this and it has been added to the „non-work related‟ section under Part 3.

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My final comments on some airline management responses and the way forward:

- Regarding including a question for management perceptions (my item 2b), two airlines are of the view that a separate questionnaire should be

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compiled. My response to this is that I probably don"t see a separate questionnaire going out for management"s perspective, so I would suggest that this does get considered in some way. If not in the questionnaire, then some other feedback could be invited. • In respect of my comment under 2c) related to the items which are of concern with the current FDP, some airlines believe that this is taken care of. I would suggest that you review the relevant questions to ensure that it does cover that aspect. • In respect of the additional comments and questions proposed, please consider these requests. I am sure that you may have received other comments and questions from the SACAA and the ALPA-SA team. It would be interesting to see the next draft.	• We agree that some form of feedback to the management is feasible, although a separate questionnaire may be more informative, that will have to be figured it at a later date. • We have done so, thank you. • Thank you, we have done so.
Aerial Farming Services Comments – 25th November 2019	
In response to your request for comment on the Fatigue in Aviation Survey I offer the following: Q 10. Add aerial work. A large disparity exists between mainstream aircraft and pilot deployment and aerial work in particular crop spraying, firebombing operations, game capture etc. The difference basically being single cockpit non-complex aircraft, flown VFR by day head-up and hands-on at low level vs. complex aircraft carrying passengers 24/7 in all-weather on auto-pilot for extended periods. The nature/cause of fatigue will vary due to these disparate environments.	Thank you for your suggestion. We have inserted this question.
Q 24. A "not applicable" box should be added OR a note should be added indicating that "not ticking any box in response to a question will indicate that the question is not applicable to the responders operational envelope". Ticking "not at all" may be	Thank you for your suggestion. We have inserted this question.

misconstrued in the analysis.	
Q 26. As for Q 24 above “not at all” can mean there is no effect on fatigue for example after the use of alcohol. There should be a box which indicates that the responder does not use alcohol OR make a note that no tick for the question indicates “not applicable”.	Thank you for your suggestion. We have inserted this question.
Additional questions in Part 3 for aerial work category - <u>crop spraying and firebombing</u>: ● Spraying difficult fields ● Difficult bombing terrain ● Presence of powerlines ● Awkward landing strips ● Problems identifying fields ● Hot and humid ambient conditions ● Hot and high ambient conditions ● High cockpit temperature ● Severe turbulence ● Ambient light very bright or low light conditions ● Long ferries (15km+) ● Fields with long runs (2km+) ● Holdups when loading/refueling ● Pressure to get work done ● Chemical/fuel fumes in cockpit ● Conflicting low level traffic	Thank you for your suggestions. We have inserted these questions.

• Periods of inactivity while on duty	
Fatigue in Aviation Academic"s Comments – 23rd January 2020 The questionnaire looks very comprehensive and it covers most of the things that we included in our questionnaire in the EU FTL project. I also like much the inclusion of other than work-related fatigue factors. That will give a chance to get a comprehensive picture of the fatigue factors. Below a list of comments / suggestions regarding the questionnaire:	
C1 - if you like to examine the association of individual factors and fatigue then you could ask about habitual sleep need, sleep-disordered breathing, insomnia symptoms, use of sleep medicine, diurnal type, height & weight (-> BMI), self-estimated health status, (but maybe this not the purpose of the questionnaire?)	C1 – We thought that it is not the primary focus but this would be useful information - the concern from the CAA was the length of the questionnaire and hit rate if we made it any longer and so we decided to not add the proposed questions to the survey.
C2 - in Q22, you could use the Samn-Perelli scale so that 1-3 would be "not at all" (1. Fully alert, wide awake, 2. Very lively, but not at a peak, 3. Okay, somewhat fresh,) and 4-7 as they are phrased on the scale (4. A little tired, less than fresh, 5. Moderately tired, let down, 6. Extremely tired, very difficult to concentrate, 7. Completely exhausted, unable to function effectively.), This would provide a nice opportunity to interpret the results in relation to what is known about the Samn-Perelli scale based on field studies in aviation.	C2 – We agreed with this comment and added it to the survey.
C3 - if you liked to be more precise you could ask Q22 separately for the cruise phase and takeoff / landing (my experience is that fatigue is usually considered more acceptable for the cruise phase than for takeoff / landing)	C3 – We also agreed with this comment and added it to the survey.
C4 - you could also ask about on-duty measures that the aircrew use to counteract	C4 – We thought it was a relevant comment and would be nice to have but we

fatigue and how effective they find these measures (e.g., caffeine consumption, in-flight rest, cockpit rest, talking, eating… see for example Anund et al 2008, Scand. J Work Environ. Health) (or is this outside your scope?)	thought it may be out of the scope of the project.
C5 - you could ask how easy it is for the aircrew to report on fatigue and if reporting is an efficient way to make a difference (or is this outside your scope?)	C5 – We thought of just maybe adding a question on whether they can report fatigue and method in which they do this. Although we thought this may get the employers a little concerned and decided to not add the question.
C6 - the scale of Q18 could be used in Q23 and Q24, too (quantifies better the frequency)	C6 – We agreed with this comment and added it to the survey.
C7 - you could have a question about the effective (fatigue mitigating) aspects of the current regulations?	C7 – We agreed with this comment and added it at the end of the survey (under PART 5).

APPENDIX F: Complete and final version of the survey

Fatigue in Aviation Survey

This survey is comprised of four sections. The first section asks for information pertaining to your personal characteristics, which part of the aviation industry you are involved in and your experience. Section two explores your perceptions on the issue of fatigue and its prevalence and impact in your working environment, while section 3 explores the impact of work and non-work related factors on fatigue. Section 4 offers the opportunity to comment on the current Flight and Duty limitations in South Africa.

***Required**

PART 1: PERSONAL INFORMATION

1.

Age? *

2.

Sex? *

Tick all that apply.

Female

Male

Non-binary

Prefer not to say

3.

Race group? *

4.

What is your job title? (Commander, first officer, cabin crew manager). *

5.

What non-flying work duties do you have? (Refresher training, pre-flight paperwork, report writing)

6.

What part of the aviation industry do you work in? *

7.

How long have you worked in your present job? *

8.

What is your flying experience (hours) or how long have you been involved in the industry (years)? *

9.

In which province are you based? *

10.
Please indicate the characteristics of your flight duty? *

Tick all that apply.

Long-haul

Short-haul

Aerial work

Other

11.
Based on your answer to the question above, do you experience time zone changes? *

Tick all that apply.

Yes

No

12.
In what time zone is your domicile? *

13.

How long does it usually take you to travel from your home to your assigned place of work and back again? (hours and minutes) *

14.

What is the typical mode of transportation from your home to your assigned place of work? *

Tick all that apply.

Self-drive surface transport

Self-fly air transport

Public transport (taxi; bus; train)

Walking

Flying as a passenger

Part 2:CREW PERCEPTIONS AROUND FATIGUE

For the purposes of this section, fatigue is defined as „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"– International Civil Aviation Organisation (2016). In light of this, please answer the following questions.

15.
In your opinion, how much of a problem is fatigue in your part of the industry? *

Mark only one oval.

A very serious problem

A relatively serious problem

A minor problem

Not a problem at all

16.
When serious crew fatigue occurs, how significant a safety issue is it? *

Mark only one oval.

A very serious problem

A relatively serious problem

A minor problem

Not a problem at all

17.

How much of a problem is fatigue to YOU PERSONALLY in your job? *

Mark only one oval.

A very serious problem

A relatively serious problem

A minor problem

Not a problem at all

18.

How often do you become fatigued while flying or performing your job? *

Mark only one oval.

On every trip

On most trips

On about half your trips

Occasionally

Very rarely

19.

Do you think that AWARENESS of crew fatigue has changed over the last 5 years IN THE INDUSTRY in general? *

Mark only one oval.

Has increased a lot

Has increased

No change

Has decreased

Has decreased a lot

20.

Please provide reasons for your answer above. *

21.

Do you think AWARENESS of crew fatigue has changed over the last 5 years, FOR YOU? *

Mark only one oval.

Has increased a lot

Has increased

No change

Has decreased

Has decreased a lot

22.

During take-off/landing, how do you feel?

Mark only one oval.

Fully alert, wide awake

Very lively, responsive, but not at peak

Okay, somewhat fresh

A little tired, less than fresh

Moderately tired, let down

Extremely tired, very difficult to concentrate

Completely exhausted, unable to function effectively

23.

During the cruise phase, how do you feel?

Mark only one oval.

Fully alert, wide awake

Very lively, responsive, but not at peak

Okay, somewhat fresh

A little tired, less than fresh

Moderately tired, let down

Extremely tired, very difficult to concentrate

Completely exhausted, unable to function effectively

24.

Does fatigue interfere with your ability to carry out your duties? *

Mark only one oval.

On every trip

On most trips

On about half your trips

Ocassionally

Very rarely

PART 3: CONTRIBUTORY FACTORS TO FATIGUE

Which of the following contributes to your fatigue?

Please use the Likert scale to indicate the extent that each factor contributes to your fatigue.

25.

Work-related factors *

Mark only one oval per row.

1=Not at all

2=Rarely

3=Sometimes

4=Often

5=Always

6=Not applicable

Number of sectors
Long duty hours
Flying during early afternoons
Insufficient rest breaks between duty periods/shifts
Congested air space
Short turnarounds (between sectors)
Flying with inexperienced crew
Monotony of the job
Unscheduled/organizational delays
Having to rest away from home
Poor cockpit or cabin design/layout

Irregular/inadequate sleep during periods of duty

Irregular/inadequate sleep before periods of duty

Not enough night time sleep

Flying at night

Early sign on's (before 6am)

Late sign offs (after 11pm)

On call work

Unplanned changes in shift/schedule

Split duties

Bad weather

Too much non-flying work (report writing/incident reporting etc)

Too many consecutive work days in a row

Disruption of sleep wake patterns due to time zone changes

Dealing with passengers

Environmental conditions in the cockpit or cabin (noise, vibrations, low air pressure, low lighting, low humidity etc.)

Equipment problems (service trolleys onboard).

No autopilot function on aircraft
Extra work to supplement income
Successive night flights
Insufficient time for pre and post flight duties
Long idle time between flights
Quality of on-board rest facility
Spraying difficult fields
Difficult bombing terrain
Presence of power lines
Difficult landing strips
Difficulties identifying fields
Hot and humid ambient conditions
Hot and high ambient conditions
High cockpit temperature
Severe turbulence
Ambient light - very bright/low light conditions

Long ferries (15km+)

Field with long runs (2km+)

Hold ups when loading/refueling

Pressure to get work done

Chemical/fuel fumes in cockpit

Conflicting low level of traffic

Periods of inactivity while on duty

Number of sectors

Long duty hours

Flying during early afternoons

Insufficient rest breaks between duty periods/shifts

Congested air space

Short turnarounds (between sectors)

Flying with inexperienced crew

Monotony of the job

Unscheduled/organizational delays

Having to rest away from home

Poor cockpit or cabin design/layout

Irregular/inadequate sleep during periods of duty

Irregular/inadequate sleep before periods of duty

Not enough night time sleep

Flying at night

Early sign on"s(before 6am)

Late sign offs (after 11pm)

On call work

Unplanned changes in shift/schedule

Split duties

Bad weather

Too much non-flying work (report writing/incident reporting etc)

Too many consecutive work days in a row

Disruption of sleep wake patterns due to time zone changes

Dealing with passengers

Environmental conditions in the cockpit or cabin (noise, vibrations, low air pressure, low lighting, low humidity etc.)

Equipment problems (service trolleys onboard).

No autopilot function on aircraft

Extra work to supplement income

Successive night flights

Insufficient time for pre and post flight duties

Long idle time between flights

Quality of on-board rest facility

Spraying difficult fields

Difficult bombing terrain

Presence of power lines

Difficult landing strips

Difficulties identifying fields

Hot and humid ambient conditions

Hot and high ambient conditions

High cockpit temperature

Severe turbulence
Ambient light - very bright/low light conditions
Long ferries (15km+)
Field with long runs (2km+)
Hold ups when loading/refueling
Pressure to get work done
Chemical/fuel fumes in cockpit
Conflicting low level of traffic
Periods of inactivity while on duty

26.

Other (specify)?

27.

Non-work related factors *

Mark only one oval per row.

1=Not at all

2=Rarely

3=Sometimes

4=Often

5=Always

Relationship problems

Having young children or/ looking after additional dependents

Poor diet

After effects of stay awake drugs

Use of alcohol

Lack of exercise

Sleep disorders (diagnosed or suspected)

Financial stress

Additional health problems

Excessive exercise

Use of sleeping tablets

Use of over the counter medications

Extended commuting to get to and from work

Use of herbal remedies to assist with sleep and fatigue

Relationship problems

Having young children or/ looking after additional dependents

Poor diet

After effects of stay awake drugs

Use of alcohol

Lack of exercise

Sleep disorders (diagnosed or suspected)

Financial stress

Additional health problems

Excessive exercise

Use of sleeping tablets

Use of over the counter medications

Extended commuting to get to and from work

Use of herbal remedies to assist with sleep and fatigue

28.

Other (specify)?

SA FLIGHT TIME LIMITATIONS LEGISLATION

29.

With respect to the current South African Flight and Duty Period regulations, what aspects of the current regulations present a concern for you? *

30.

If you have concerns, what recommendations do you have to address these concerns?

31.

Are there any effective fatigue mitigating aspects of the current regulations?

APPENDIX G: Gate keeper"s letter

SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Physical Address: Ikhaya Lokundiza, Treur Close, Waterfall Park, Bekker Street, Midrand
Postal Address: Private Bag X 73, Halfway House, 1685
Telephone Number: +27 11 545 1000
Fax Number: +27 11 545 1465
E-mail Address: mail@caa.co.za
Website Address: www.caa.co.za
Southern Region Office: PO Box 174, Cape Town International Airport
Tel. Number: +27 21 934 4744
Fax Number: +27 21 934 1326

The Chair of the Rhodes Ethical Standards committee
Rhodes University
Grahamstown

GATEKEEPER PERMISSION TO APPROACH THE SOUTH AFRICAN AVIATION INDUSTRY

The South African Civil Aviation Authority (SACAA) is the aviation regulator in South Africa and carry's out activities as mandated by the Minister of Transport, as part of the Department of Transport.

We have approached Rhodes University's Department of Human Kinetics and Ergonomics to assist with the amendment of national regulations pertaining to Flight and Duty Periods (FDP), across all sectors of the aviation industry. This project is expected to span 3- 5 years.

As the national regulator, we hereby give permission for the study entitled 'The quantification of fatigue prevalence and its contributing factors in the South African Aviation Industry' under the principal investigation of Dr Jonathan Davy and Dr Swantje Zschernack to go ahead in all parts of the industry.

As the project leader, feel free to contact me should you require anything else in this regard.

Best Regards,

Captain Amina Moola
Specialist Flight Operations Inspector
Exemptions and Regulation Development
Tel: 011 545 1340 | **Fax:** 011 545 0000 | **Cell:** 083 461 6335 | **Email:** moolaa@caa.co.za |
www.caa.co.za

APPENDIX H: Ethical clearance letter

RHODES UNIVERSITY
Where leaders learn

Faculty of Pharmacy
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e: dean.pharmacy@ru.ac.za

www.ru.ac.za

Grahamstown 27th February 2020

From:
Associate Professor Roman Tandlich, PhD
Chairperson of the Rhodes University Ethical Standards Committee
Rhodes University
P.O. Box 94
Grahamstown 6140
South Africa
e-mail: r.tandlich@ru.ac.za

To:
Dr. Swantje Zschermack, Dr. Jonathan Davy and Dylan Blair

Re: Extension and amendment of the Ethics application HKE-2018-02.

Dear Dr. Swantje Zschermack, Dr. Jonathan Davy and Dylan Blair,

Thank you for your application for extension & amendment of the Human Kinetics and Ergonomics Application number HKE-2018-02 with the following details for extension and amendment:

Progress report of the project
The original project sought to analyse the workload of pilots using questionnaires and psychophysiological measures. Because of unforeseen obstacles in obtaining gatekeeper permission, industry access could not be granted, the project was changed to expert interviews. The expert interviews were conducted and written up as MSc thesis as well as presented at the 4th African Symposium on Human Factors and Aviation Safety & 14th Conference of the Ergonomics Society of South Africa in 2019.

Reason for the amendment/extension:
Results from the expert interviews as well as continuous engagement with the different stakeholders in the aviation industry it became clear that the topic needs to be studied more systemically and encompassing. In consultation with the Civil Aviation Authorities, airline operators and pilot/cabin crew associations a survey was developed (attached). In this phase of the extension, it is planned that this survey is conducted by pilots and cabin crew members throughout the aviation industry. Gatekeeper approval will be obtained from the South African Civil Aviation Authority.

Duration of the extension:
Until the end of 2020

5) Investigators involved in the new phase of the project
Dr Jonathan Davy (principal investigator, supervisor)
Dr Swantje Zschernack (co-supervisor)
Mr Dylan Blair (MSc student, student number: 15b5135)

The Rhodes University Ethical Stndards Committee considered the details of your request and I am happy to inform you that in my capacity as the Chairperson of the Rhodes University Ethical Standards Committee I hereby grant an extension of the ethical clearance for your study until 31st December 2020.

Please ensure that the Rhodes University Ethical Standards Committee is notified should any substantive changes(s) be made, for whatever reason, during the research process.

Yours sincerely,

Roman Tandlich

Roman Tandlich, PhD

APPENDIX I: Letter to participant

Dear pilot/flight attendant,

We would like to invite you to participate in the National Fatigue in aviation survey which is being conducted by researchers and students in the Department of Human Kinetics and Ergonomics at Rhodes University.

Background of the study

Over the last five years, there has been debate within the aviation industry about whether the current Flight and Duty Periods (FDPs) regulations are in line with the latest scientific and operational knowledge relating to fatigue management. Various stakeholders have agreed that these regulations may need to be updated, but that in order for this to happen there is a need to carry out research within the entire South African aviation industry. This will serve as an important first step to identifying potential fatigue „hotspots" within the different Parts of the aviation industry, which can assist in the identification of factors that need to be considered in the amendment of the current FDP regulations, while allowing the researchers to identify where more in depth research should be conducted. In partnership with the Airline Pilots Association of South Africa (ALPS-SA), the Airlines Association of Southern Africa (AASA) and the South African Civil Aviation Authority (SACAA), researchers from the Department of Human Kinetics and Ergonomics at Rhodes University have developed an online survey that aims to investigate the reported prevalence of aircrew fatigue and the reported factors that contribute to aircrew fatigue across the different parts of the aviation industry in South Africa.

Who should participate?

Crew in Parts 93 (Corporate pilots), 121 (Commercial pilots and cabin crew); 127 (Helicopter pilots); 128 (Air school instructors); 135 (Small aircraft), 137 (Agricultural aviation, including aerial work, crop spraying and firebombing) and 138 (Air Ambulances) and other aviators involved in non-scheduled aviation.

Structure of the survey

The survey is online and administered through Google forms, a secure online platform that only the research team have access to. The survey consists of five sections:

- Consent to partake in the study – 1 question.
- General personal and professional information (which part of the aviation industry you work for, experience – 14 questions.
- Crew perceptions on the issue of fatigue, its prevalence and impact it may have in the working environment – 10 questions.
- Impact of work and non-work related factors and their contribution to fatigue – 67 questions (65 tick box questions and 2 open-ended questions).
- Comments on the current Flight and Duty limitations in South Africa – 3 open-ended questions.

Once the survey has been completed, please click the "Submit" button to lodge your answers. The survey will take between 15-20 minutes to complete.

Ethical Considerations

The completion is completely voluntary, and you should only complete the survey once. Upon submission of the survey, your response will only be sent to the researchers at the Human Kinetics and Ergonomics Department at Rhodes University for data analysis. Participation is anonymous, no questions about your identity or who you work for is asked about. The data will be analysed by the researchers and disseminated back to the industry with the help of the various bodies mentioned above and other relevant stakeholders.

The survey has ethical approval from the Rhodes University Ethical Standards Committee under the reference number HKE-2018-02 (Miriam Mattison; m.mattison@ru.ac.za; +29 (0) 82 319 4626). Any other queries can be directed to Mr Siyanda Manqele, the Ethics Coordinator at Rhodes University, who can be contacted via email (s.manqele@ru.ac.za) or telephonically (+27 (0) 46603 7727).

If you have further questions, comments, please contact:

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APPENDIX J: Summaries of statistical measures undertaken

Statistical method	Purpose	Question
Mann-Whitney U test	Difference between cockpit vs. cabin crew	How long does it usually take you to travel from your home to your assigned place of work and back again? (hours and minutes)
	Difference between cockpit vs. cabin crew	In your opinion, how much of a problem is fatigue in your part of the industry?
	Difference between cockpit vs. cabin crew	In your opinion, how much of a problem is fatigue in your part of the industry?
	Difference between cockpit vs. cabin crew	When serious crew fatigue occurs, how significant a safety issue is it?
	Difference between cockpit vs. cabin crew	How much of a problem is fatigue to YOU PERSONALLY in your job?
	Difference between short haul and long-haul	Please indicate the characteristics of your flight duty?
	Difference between cockpit vs. cabin crew	Does fatigue interfere with your ability to carry out your duties?
	Difference between cockpit vs. cabin crew	How often do you become fatigued while flying or performing your job?
	Difference between cockpit vs. cabin crew during the different phases	During the cruise phase and take-off/landing, how do you feel?
	Difference between cockpit vs. cabin crew	All work-related factors
	Difference between cockpit vs. cabin crew	All non-work related factors
	Difference between short-haul vs. long-haul	Does fatigue interfere with your ability to carry out your duties?
	Difference between short-haul vs. long-haul	How often do you become fatigued while flying or performing your job?
	Difference between short-haul vs. long-haul	All work-related factors
	Difference between short-haul vs. long-haul	All non-work related factors

APPENDIX K: Do you think that awareness of crew fatigue has changed over the last 5 years in the industry in general?

<table>
<tr><td colspan="2" align="center">Theme 1: Attend fatigue workshops</td></tr>
<tr><td colspan="2">"we nowadays attend fatigue workshops".

"We have had a workshop on fatigue management".</td></tr>
<tr><td>Sub-theme:

1.1 Company courses provided

"The company has a course on this".

"We get to have more knowledge on fatigue each time to attend training, which happens every year".

–Awareness amongst crew due to training”.

–Our Airline provides fatigue training on a yearly basis”.

–There have been an effort from companies to try and address this through certain forums, but only legislation can bring about real change”.

–Safair provides training”.

–Our company gives us training on Fatigue Risk Management which gives us knowledge about how serious fatigue can be and how to prevent it in the aviation industry as it can lead to human errors and failure in safety operations/duty. It has changed a lot because fatigue plays a big role in aviation and you need to be on high alert at all time. There is no space for fatigue as it is a serious matter”.</td><td></td></tr>
<tr><td>Sub-theme:

1.2 Communication on fatigue

"communication on fatigue has increased".

"We are more aware of it via communication from the company and also crew resource management".</td><td></td></tr>
</table>

"more accessibility to information and focused training on the subject". *"We have also been given Fatigue Awareness briefings at work which helped with awareness".* *"fatigue committee".* *"Flight crew are more aware of the risk".* *"Company policy has encouraged reporting of fatigue and adherence to flight and duty limits. IATA has also raised much more awareness of fatigue".* *"There is more talk and awareness around it as flying duties have increased".* *"We are more aware of being fatigued and brief the threats of being fatigued before a flight".* *"It's either because there's more general awareness or because it's been discussed at my airline".* *"More awareness and better control".* *"Part of discussions almost on every trip".* *"It seems that more emphasis is placed in recent years on getting crew more knowledgeable about fatigue prevention methods".* *"Definitely more information available regarding fatigue and different ways to measure possible fatigue".* *"It is material discussed a lot in the safety correspondence circulated by our safety officer".* *"Pressure from authorities to implement fatigue risk strategies, Safety awareness campaigns relating to fatigue from the company".* *"More training and information on fatigue is given and roster pattern also take fatigue into account".* *"I've only been in the industry for 4 years but my airline has definitely listened to what we have said regarding fatigue and some of our flight pairings and have changed it".* *"By getting the necessary information".* *"more focus on fatigue in airline ops".* *"Involved in crew FDP management".* *"Previous accidents have drawn attention to the dangers of fatigue",* *"More accessibility to information and focused training on the subject".* *"Safety Awareness".*	

Theme 2: FTL adherence (positive response)
"Strict adherence to FDP has been observed and flights cancelled due to possible exceedance".
Theme 3: The ability to complete fatigue reports (positive response)
"You can now file a fatigue report and take the day off where previously you had to call in sick". *"Some degree of focus and documentation (Fatigue Reporting)".* *"fatigue report systems".* *“can fill in fatigue reports”.* *“also if you write a report they look at it very carefully and make decisions which is best suited for us”.* *“We fill in fatigue report”.* *“Fatigue reports available for crew at work”.* *“Crews are asked to report fatigue and not ignore it”.* *“people are just aware and are reporting on flight safety reports”.*
Theme 4: Increased scientific input and fatigue management (positive response)
“Have fatigue risk management program”. *"Through FRM training".* *“Our company has introduced a fatigue management course for crew to attend compulsory”.* *“Fatigue risk management courses are provided as part of initial induction training at reputable airlines”.* *“Fatigue Risk Management systems are becoming a) mandatory”.* *“FRMS implemented”.*

<table>
<tr><td colspan="2">There has been lots of talk around FRMS, and it has also been implemented at our company recently”.

Airlines have incorporated fatigue risk management portals and offered support”.

An FRMS has been implemented in my company”.

We have FRMS”.</td></tr>
<tr><td>Sub-theme:

4.1 Scientific input

combined with more published material regarding fatigue studies, that is being pushed by crew in individual airlines has resulted in a general increase in knowledge regarding actual fatigue".

"Many studies on fatigue and fatigue management".

More studies have been done”.

More studies done”.

Better studies and evidence to support crew fatigue issues”.

Articles written, surveys conducted”.

HUPER and sleep expert inputs”.

they perform a fatigue study to improve”.</td><td></td></tr>
<tr><td colspan="2">Theme 5: Increased pressure from unions (positive response)</td></tr>
<tr><td colspan="2">"Awareness has increased due to pressure from unions".</td></tr>
<tr><td colspan="2">Theme 6: Effects of current rostering practices (negative response)</td></tr>
</table>

<table>
<tr><td>Sub-theme:

6.1 Increased flight pairings

"it has increased a lot due to an increase in pairings (flights)".

"My schedule on some days or consecutive days indicates this. Late sign offs with an off day and then a night stop or early sign after an off day".

"I've been in the industry 8 years between 2 different airlines, the one I currently am in has longer hours and longer pairings".</td><td></td></tr>
<tr><td colspan="2">Theme 7: Experiences of cumulative fatigue onset (negative response)</td></tr>
<tr><td colspan="2">"Most of my colleagues have now also reached the cumulative fatigue stage resulting in a much greater awareness of the problem due to its shared nature versus 5 years ago. Several incidents at work have highlighted the threat posed by the fatigue level reached, thereby contributing to increasing awareness of the issue".</td></tr>
<tr><td colspan="2">Theme 8: No change (negative response)</td></tr>
<tr><td colspan="2">"No change in laws managing fatigue".

"There is no change".

The systems that the airlines bring in is not changing the situation”.

There is no change in CAA on working hours, according to my knowledge”.

Haven't heard of anything”.

no improvement in type of roster”.

We still have the same rules dictating our flight and duty limitations”.

No change in rostering patterns”.

Nil”.

There is no change”.</td></tr>
</table>

Nil”. *The rules are still the same since 15 years ago!”* *Laws regarding FDP are archaic”.* *no new studies have taken place for many years”.* *Flight and duty limitations have remained unchanged”.* *Nil”.* *No change”.*	
Sub-theme: **8.1** Aircrew not reporting *"The issue of fatigue has come into more awareness overall, but probably not to the extent that it should - because crew and pilots don't report it".*	
Sub-theme: **8.2** Ignored by management *"it looks like it is ignored from management level".* *"Nothing changes operationally when management is informed about crew being fatigue. It is normally a laughing matter of just brushed off".* *"Fatigue is disregarded due to operational and monetary reasons".* *but never get feedback”.* *The company I work for as well as the SACAA has no interest in adopting best practice FTL limits and regulations”.* *from Civil aviation SA No”.* *If you complain about fatigue and note it, nothing gets done about it. They say it will only get fixed in a years‘*	

time". *~~"~~We recently got a fatigue report, but it doesn't get anyway, because the company every so often decides they want to start over and want fresh data. So the shifts we have been complaining about is kept on because all previous data was chucked out".*	
Sub-theme: **8.3** Misconception of fatigue equal to being tired "There is a misconception that fatigue is equal to being tired. Crew and the industry do not understand the difference".	

APPENDIX L: Work-related factors

Number of sectors
—long duty days or many sectors following a night stop” *—Ridiculous amount of sectors (flights) performed due to no existing limitations on sectors, recently operated 18 sectors (19 if a positioning sector preceding 3 operating sectors is included) of which the last 3 days totalled 12 sectors???”* *—Sector combinations. By the second flight most flight attendants are exhausted”.*
Early sign-ons (before 6am)
—6 days in a row when you start at 5am and day 6 ends at 11pm” *—Scheduling of early morning duties for consecutive days then a brief (2days) off period and then consecutive late night duties makes it impossible to establish a reasonable sleep routine and get quality sleep”.* *—Too many early morning sign on‘s”*
Late sign-offs (after 11pm)
“Early morning sign on(05h15) followed by late night sign off(22h00+)”. *Scheduling of early morning duties for consecutive days, then a brief (2days) off period and then consecutive late night duties makes it impossible to establish a reasonable sleep routine and get quality sleep”.*
Irregular rostering
—Being rostered for e.g. 4 early reporting times, before 630am. Then on the 3rd or 4th day to start at 1400 and then fly till 2330. To be off for 2 day to start again at 500am. There is never enough time to recover from the changes in circadian rhythms”.

“*Constant circadian disruption during 5 or 6 days‘ work due to no proper structure between early and late duties”.*
Insufficient rest breaks between duty periods/shifts
―I be off for 2 days to start again at 500am. There is never enough time to recover from the changes in circadian rhythms”.   *―When finishing late at night at least 2 nights recovery is required”.*   *―I wake up at 3am for 6 days in a row adds to fatigue”.*

APPENDIX M: Statistical comparison between the cockpit and cabin crew, and the short-haul and long-haul for the work-related factors

Statistical method	Purpose	Question	Statistical result and *p* value
		Work-related factors for cockpit crew	
		Congested airspace	(U (*N* = 158, *N* = 27,) = 1288.00, z = 3.46, $p < .01$)
		Having to rest away from home	(U (*N* = 158, *N* = 27,) = 1128.50, z = 3.97, $p < .01$)
		Poor cockpit or cabin design or layout	(U (*N* = 158, *N* = 27,) = 1614.50, z = 4.73, $p = .03$)
		Irregular or inadequate sleep before periods of duty	(U (*N* = 158, *N* = 27,) = 1278.50, z = 3.38, $p < .01$)
		Irregular or inadequate sleep during periods of duty	(U (*N* = 158, *N* = 27,) = 1546.00, z = 2.35, $p = .01$)
		Not enough night time sleep	(U (*N* = 158, *N* = 27,) = 1593.50, z = 2.17, $p = .02$)
		Flying at night	(U (*N* = 158, *N* = 27,) = 1518.50, z = 2.45, $p = .01$)
		Split duties	(U (*N* = 158, *N* = 27,) = 1564.00, z = 2.24, $p = .02$)
	Difference between cockpit vs. cabin crew	Bad weather	(U (*N* = 158, *N* = 27,) = 947.00, z = 4.73, $p < .01$)
		Disruption of sleep wake patterns due to time zone changes	(U (*N* = 158, *N* = 27,) = 1354.50, z = 3.09, $p < .01$)

Mann-Whitney U test		Environmental conditions in the cockpit or cabin crew	(U (N = 158, N = 27,) = 1504.50, z = 2.50, p =.01)
		No autopilot function on aircraft	(U (N = 158, N = 27,) = 1593.00, z = 2.20, p = .02)
		Successive night flights	(U (N = 158, N = 27,) = 1174.50, z = 3.80, p < .01)
		Long idle time between flights	(U (N = 158, N = 27,) = 1499.50, z = 2.50, p = .01)
		High cockpit temperature	(U (N = 158, N = 27,) = 1461.50, z = 4.15, p < .01)
		Severe turbulence	(U (N = 158, N = 27,) = 1484.50, z = 2.57, p = .009)
		Flying at night	(U (N = 158, N = 27,) = 1383.50, z = 2.99, p = .002)
		Ambient light - very bright or low light conditions	(U (N = 158, N = 27,) = 1421.00, z = 2.85, p = .004)
		Conflicting low level air traffic	(U (N = 158, N = 27,) = 1614.00, z = 2.12, p = .03)
		Work-related factors for short-haul crew	
		Number of sectors	(U (N = 139, N = 32,) = 1182.50, z = 4.30, p < .01)
		Early afternoon flights	(U (N = 139, N = 32,) = 1668.00, z = 2.29, p = .02)
		Insufficient rest breaks between duty periods or shifts	

			(U (N = 139, N = 32,) = 1646.00, z = 2.36, p = .01)
		Short turnarounds (between sectors)	(U (N = 139, N = 32,) = 1208.50, z = 4.12, p < .01)
		Early sign-on"s (before 6am)	(U (N = 139, N = 32,) = 1630.50, z = 2.42, p = .01)
	Difference between short-haul vs. long-haul	Late finishes (after 11pm)	(U (N = 139, N = 32,) = 1737.50, z = 1.97, p = .04)
		Irregular/inadequate sleep before periods of duty	(U (N = 139, N = 32,) = 1636.00, z = 2.40, p = .01)
		Unplanned change in shift or schedule	(U (N = 139, N = 32,) = 1663.00, z = 2.28, p = .02)
		Too many consecutive work days in a row	(U (N = 139, N = 32,) = 1475.50, z = 3.05, p = .002)
		Insufficient time for pre and post flight duties	(U (N = 139, N = 32,) = 1724.50, z = 2.05, p = .03)
		Long idle time between flights	(U (N = 139, N = 32,) = 1345.00, z = 3.54, p < .01)
		High cockpit temperature	(U (N = 139, N = 32,) = 1604.00, z = 2.50, p = .01)
		Pressure to get work done	(U (N = 139, N = 32,) = 1670.00, z = 2.23, p = .02)
		Periods of inactivity while on duty	(U (N = 139, N = 32,) = 1516.50, z = 2.85, p = .004)

		Work-related factors for long-haul crew	
		Irregular/inadequate sleep during periods of duty	(U (N = 139, N = 32,) = 1656.00, z = -2.29, p = .02)
		Disruption of sleep wake patterns due to time zone changes	(U (N = 139, N = 32,) = 561.50, z = -6.75, p < .01)
		Flying at night	(U (N = 139, N = 32,) = 1024.50, z = -4.87, p < .01)
		Quality of onboard rest facility	(U (N = 139, N = 32,) = 1730.00, z = 2.02, p = .04)

APPENDIX N: Non-work-related factors

Theme 1: Disrupted sleep	
"disrupted sleep". ***"Manage healthy sleep patterns of at least 8 hours per night is very difficult to manage when roster periods is ever changing".*** ***"Unable to go back to sleep (wife works from home, domestic workers and pets)".*** ***"Not getting adequate sleep is a huge factor".*** ***"Get enough time in bed but struggle to get quality sleep".***	
Theme 2: Stress	
"Still experiencing massive amounts of stress". ***"having to deal with my ex-wife in respect of matters relating to my son as well as providing financial needs".*** ***"Experiencing stress due to feeling/being unable to stop smoking under the circumstances".*** ***"Experiencing stress as well due to feeling emotionally drained most of the time having to try to deal with everything on top of trying to do my work".*** **"Stress due to poor Top Management, a lack in leadership and vision".**	
Theme 3: Relationship problems and work-family conflict	
"relationship stress". ***"I have to jumpseat to another city and back at least once a month in order to visit my son due to his mother divorcing me because she couldn't stand my roster anymore".***	
Sub-theme: **3.1 Poor family time**	

"Not seeing your children for 3 days, arriving home late at night after they went to bed, waking up early because of guilt feeling to see them before they leave for school". *"Wife is also a shift worker. Can be extremely challenging to stay on the same page especially when nightstopping or when minimum rest with early sign on's".*	
Theme 4: **Commuting**	
"143km to airport and 143km back home after the flight".	
Theme 5: **Disrupted social life**	
"Often, my social life is severely affected".	
Theme 6: **Political interferences**	
"State interference and capture issues, indiscriminent application of BEE and subsequent unsure job security most of the time!"	
Theme 7: **Family safety**	
"Living in a country where my safety and that of my family is constantly at threat from savage criminals whether I am at home or not".	

APPENDIX O: With respect to the current South African Flight and Duty Period regulations, what aspects of the current regulations present a concern for you?

<table>
<tr><th colspan="2">Theme 1: Definitions</th></tr>
<tr><td colspan="2"> "no clear definition of a local night by SA CAA".
"Flight and duty limits base their time restrictions on; sign on time and number of sectors. A sector is defined as the time between when an aeroplane first commences to move…until it finally comes to rest after landing. This time does not take into account the pre-flight time. I.E. The time when the crew are preparing/setting up the aircraft before the start of the 'sector'. This time on the ground is a critical time. The aircraft is being pre-flighted (pre checks being completed) and the crew are managing, ATC, cargo and passenger loading, refuelling, etc. The definition of sector, needs to change to include this time".
~~R~~eserve duty periods and credit for being on standby. Rest periods and definitions of early sign on vs. late sign off. The "2 HR Rule"
Late sign off, 2 consecutive off days and early sign on=Unconscionable!!”
~~S~~hould include limits for low cost carrier type operations”.
~~T~~oo broad”.
~~A~~ system that is designed to help us does not work as planned. Companies that stick within the FDP limits still have fatigue as an issue”.
~~ac~~tual reporting times vs. company ops manual stipulated times”.
~~n~~o clear definition of a local night by SA CAA”.
~~U~~ndefined wocl for south Africa”.
“Local Night definition”. </td></tr>
<tr><td> Sub-theme:
1.1 Local night definition
"Local night definition". </td><td></td></tr>
<tr><td> Sub-theme:
1.2 Sector definitions </td><td></td></tr>
</table>

<table>
<tr><td>"Flight and duty limits base their time restrictions on; sign on time and number of sectors. A sector is defined as the time between when an aeroplane first commences to move…until it finally comes to rest after landing. This time does not take into account the pre-flight time. I.E. The time when the crew are preparing/setting up the aircraft before the start of the 'sector'. This time on the ground is a critical time. The aircraft is being pre-flighted (pre checks being completed) and the crew are managing, ATC, cargo and passenger loading, refuelling, etc. The definition of sector, needs to change to include this time".</td><td></td></tr>
<tr><td>Sub-theme:

1.3 WOCL definition

"undefined wocl definition in South Africa".</td><td></td></tr>
<tr><td colspan="2">Theme 2: Applicability</td></tr>
<tr><td colspan="2">"The law is not specific to regional airline operators".

"I think FDP for Part 135 is well thought out. My concern is that proposed regulations for Part 137 aim to put a pilot on duty for 42 to 49 days without one day of rest".

“Should include limits for low cost carrier type operations”.

“That carriers can make their own flight and duty policies”.

“Duty is to long for our operational environment and operators do not adhere to local night rule”.

“Beginning duty at +- 24h00 and flying until 06h00 without any onboard rest 2 man crew”.

“Insufficient flexibility”.

“No FDP regulations for line engineers”.

“Different interpretation of the regulations”.

“Short haul should have total different FDP calculations”.

“That there is only one, putting all the different aviation fields under basically an airline based scheme does not work. All FDP schemes should be operation specific”.

“inflexibility to adapt or vary depending on different types of operation (some ops are made worse by having to stick to current F&D regulations)”.

“In aerial fire fighting our flight and duty periods do not require the amount of time off etc as stipulated in the regulations”.</td></tr>
</table>

Theme 3: Disruptive rostering

"Allowing early then late duty with insufficient time between each for a sleep routine to be established - 3 early morning followed by 2 late night duties in a 5-day period".

"Routine of sign on/flight times. Can be awake at 3am for a 5am sign on today and have an afternoon sign on the next day flying until midnight. Can mean 4 days irregular/minimum sleep for 2 days of duty".

“Signing on late before an off day and signing on early after the off day does not lend time to rest well”.

“Working 6 days in a row with a late sign off and then only two days off and working again another 6 days in a row with the first day being a early sign on”.

“Doesn‘t deal adequately with repeated long duty days with consecutive early sign on and/or late sign off‘s. Results in accumulated fatigue”.

“Flight and Duty period especially early sign on‘s or Late sign offs with early sign on‘s with long days”.

“Long duty periods for early sign ons and late sign offs. Adequate rest between duties”.

“The regulations for early and late sign on; sectors; and time zone changes do not take cognisance of workload in relation to circadian rhythms or time zones sufficiently well to mitigate fatigue. Companies are loathe to agree to better limits in this regard, despite the science available”.

“Max weekly and monthly hour limits. Late sign offs followed by early sign on. Roster/schedule instability. Time away from home”.

“Often have a series of early sign on then on, then the last day of the working week are forced to the opposite end of the clock before time off. Robbing one of actual rest time and placing one in a dangerous position at the end of a busy week”.

“Late sign offs and being allowed to do early sign one with minimum rest”.

“Too long flight and duty periods for early sign on‘s and late sign off‘s”.

“The ability to be rostered for consecutive days of early sign on's and then a late sign on on the last day or two of duty, which really does not allow your body to have any constant circadian rhythm”.

Sub-theme:

3.1 Early sign-on

"Too many early sign on's in a row".

“It allows for a week of early sign ons (before 6am) It should not allow more than 3 early sign ons in a row”.

“The early sign ons after landing/arrivals and early sign ons after minimum rest including off days”.

“Early flights with to many legs”.

“Too many early sign on in a row”.

Too long flight and duty periods for early sign on‘s and late sign off‘s”. *It allows for a week of early sign ons (before 6am) It should not allow more than 3 early sign ons in a row”.* *The number of early morning sign on's allowed. The amount of max FDP with permission to still extend duty with 1 hour after situations like "several return to bay's and RTO'S".*	
Sub-theme: **3.2 Late duties** *Signing off after midnight and signing on, on the same day as long as it's after 12pm to accommodate 12 hours‘ rest, without regard that those 12 hours, you still need to drive home and still have to see to your family”.* *Number of sectors that can be flown with late sign on times. The length of the duty sectors”.* *It allows for late sign ons in the afternoon, followed by long duties, often when a person has been awake since early in the morning”.* *Too many early sign on in a row. Or too many late night finishes in a row”.* *Consecutive late night flights on short haul”.*	
Sub-theme: **3.3 Night flights** “Consecutive night flights”. “long duties during night flying”. “Night flying”.	
Sub-theme: **3.4 Specific flights**	

“We have a flight that departs Lagos late at night and arrived in Jhb early (5am) the next morning. This flight is rostered as 2 crew flight. It is seldom possible to sleep before this flight, and it is not possible to sleep during the flight. So effectively, one is awake all night without any preceding sleep. I find this flight extremely tiring/fatiguing. All other flights that operate through the night have 3 crew members”. *“No relief crew on certain flights (Lagos to Johannesburg)”.*	
Sub-theme: **3.5 Split duties** *“Split duties”.* *“Split duties. Length of FDP with Capt. discretion”.*	
Sub-theme: **3.6 Time zone changes** *“Time zone changes”.* *“They don‘t take enough account of sleep deprivation due to time zone shifts”.*	
Theme 4: High workload	
“FDP limits for 4 sectors: an average working day could easily be 4 sectors and exceed 10 hours‘ duty consistently such is the case for me. This cannot be sustained without developing chronic fatigue”. *“It is basically the number of sectors in relation to the high service standards that we need to maintain”.* *“the amount of sectors one is allowed to operate after a minimum rest turnaround”.* *“Early flights with to many legs”.* *“Numerous 4 sector days in a row”.* *“Number of sectors that can be flown with late sign on times”.*	

The length of the duty sectors”.

It‘s based on long sectors not low cost models”.

The regulations for early and late sign on; sectors; and time zone changes do not take cogniscance of workload in relation to circadian rythms or time zones sufficiently well to mitigate fatigue. Companies are loathe to agree to better limits in this regard, despite the science available”.

Duty hours for many sectors”.

Long duty periods flying multiple sectors with short turn around (low cost model), with insufficient rest periods in between duties. 6 day On / 2 days Off is not ideal!!”

120 hours per month is dangerous! Too many sectors flying too many hours with minimum rest is dangerous”.

Long duty time with repetitive short sectors, not enough rest time, local night enforcement, no time off for training”.

Inadequate rest/recuperation verses high intensity stress/workload operational environment”.

Lack in Rest Periods, especially wrt low cost carriers being allowed to fly many sectors with limited rest periods. Crew taking leave to rest!”.

FDP limits for 4 sectors: an average working day could easily be 4 sectors and exceed 10 hours duty consistently such is the case for me. This cannot be sustained without developing chronic fatigue”.

Too many sectors”.

Amount of sectors we do for a day”.

Theme 5: Duty length concerns

“Length of allowable duty is too long, the last sector on a long day is always subject to fatigue at some level. Too little provision is made for the cumulative effects of successive late night duty is made, duties starting in the afternoon/evening and continuing into the night need to be shortened”.

“long hours (upto 12hrs a day)with minimum rest”.

“Prolonged working hour. Eg standby”.

“Also, the 16 hour standby rule that I fond to be absolutely ridiculous”.

“It allows discretionary extension of FD”.

“Minimum rest time when sleeping away from home and then still a long day ahead the next day after minimum rest”.

“To extend hours”.

“Extending flight duty for cabin crew and flight deck should be the same”.

“Likewise, recovery periods are shortened to the barest minimum in cases. Since fatigue is such a nebulous concept to companies, and just costs them money, naturally, companies treat commercial pressures as overriding, and this kind of thing comes about. Likewise, long duty days can form part of the schedule that companies are fully aware will often result in extensions just for the crew to get home - nothing is done about this as there is no requirement for companies not to plan unrealistic schedules based on wishful thinking, that doesn't account for the realities of airline scheduling and turnarounds in difficult or busy conditions (ie. everything is planned on best-case scenarios)”.

“minimum rest periods, longer duty periods, application of sacaa limits to long range operations are not correct”.

“Combined standby and duty time of 21 hours is inhumane as airlines allow crew to operate extensive duty hours when being called out from standby due to this regulation - crew do not rest during the standby period at the office due having to be present for every crew sign on and also due to poor resting facilities”.

“Long standby days (0500 until 21:00) and then called out near the end of duty to go and fly”.

“Doesn‘t deal adequately with repeated long duty days with consecutive early sign on and/or late sign off‘s. Results in accumulated fatigue”.

“The maximum allowable hours an operator can have an employee fly”.

“The length of the duty sectors”.

“Flight and Duty period especially early sign on‘s or Late sign offs with early sign on‘s with long days”.

“Long duty periods for early sign ons and late sign offs. Adequate rest between duties”.

“It allows for late sign ons in the afternoon, followed by long duties, often when a person has been awake since early in the morning”.

“Duty periods for flights and rest periods between pairings”.

“Currently, the duty periods are far too long. We can legally work for 11hrs45minutes while flying four sectors with a sign on before 6am. This is unsafe, considering you can also legally extend this up to 3hrs if required which is often the case”.

“Airlines use the regulations in order to maximise profit and working crew to the maximum duty times- hiring further crew costs money !”

“They are very fatiguing! Particularly the max duty time with multiple sectors and the minimum off time after long-haul flights. The current CAA limits are not based on any industry research”.

“The long duty times allowed”.

“Amount of hours you can work a day depending on your sign on time”.

“Max FDP when signing on at 0500”.

“Duty hours for many sectors”.

“No provision made for repetitive long duty periods, no provision for accumulated fatigue”.

“Long duty periods flying multiple sectors with short turn around (low cost model), with insufficient rest periods in between duties. 6 day On / 2 days Off is not ideal!!”

“Duty is to long for our operational environment and operators do not adhere to local night rule”.

“rest periods between consecutive long duty periods”.

“Fight and duty times and rest periods”.

“Long duty, minimum rest”.

“long duty time with repetitive short sectors, not enough rest time, local night enforcement, no time off for training”.

“Min rest before a flight. Max duty time for 4 sectors”.

“long duties during night flying”.

“Split duty . Length of FDP with Capt discretion”.

“too many hours allowed to be flown in law”.

“SACAA FDP's are way to high”.

“Too long flight and duty periods for early sign on‘s and late sign off‘s”.

“Maximum flights times (CATS 121.02.13 point 2) are too high and cumulative fatigue sets in quickly when flying to those limits”.

“Exemptions to extend the already stretched a FDP program”.

“FDP limits for 4 sectors: an average working day could easily be 4 sectors and exceed 10 hours duty consistently such is the case for me. This cannot be sustained without developing chronic fatigue”.

“Office standby and flight duty total hours for cabin crew”.

“Duty hours should one get called out from AIRPORT standby to do 4sectors”.

“The amount of time Cabin Crew can do standby and then go on to do flying duty”.

“After a 9-11 hour shifts still having captain's descression”.

“The number of early morning sign on's allowed. The amount of max FDP with permission to still extend duty with 1 hour after situations like "several return to bay's and RTO'S" .

“the current duty period legislation”.

Sub-theme:	

5.1 Duty period limits *~~6~~ day On / 2 days Off is not ideal!!”* *~~T~~he 1 in 7 and 2 in 14 days off posses a problem to roster personnel”.* *~~T~~he one day in seven and two in fourteen. As I am based away from my home I cannot get home for one day or two”.* *~~E~~specially with consecutive duty periods”.* *~~R~~est periods on night stops and consecutive working days”.* *~~B~~eing allowed to fly 120 hrs a month in a high sector short haul airline operation is crazy. It starts becoming very fatiguing when you go over 80 hrs. Regulations are way to simplistic. Doesn't take all factors into account. Doesn't differentiate between short haul and long haul”.* *~~W~~orking 6 days in a row with a late sign off and then only two days off and working again another 6 days in a row with the first day being a early sign on”.* *~~H~~ours per month”.* *~~c~~onsecutive flying hrs per day and minimum rest days”.* *~~1~~00 hr monthly limit is very high”.* *~~M~~ax weekly and monthly hour limits. Late sign offs followed by early sign on. Roster/schedule instability. Time away from home”.* *~~1~~20 hours per month is dangerous! Too many sectors flying too many hours with minimum rest is dangerous”.* *~~T~~he maximum duty hours that one can operate through the night and the maximum monthly hours”.* *~~1~~20 hours a month, above 85 hours I start feeling the effects. Minimum rest regarding travel time and home preparations”.* *~~t~~oo many hours allowed to be flown in law”.* *~~1~~20hrs per month as well as 1000hrs per year. Should be reduced. Minimum rest should be extended by 1 hour”.* *~~F~~lying too many consecutive days”.* *~~3~~0 day/monthly hour limitations being high”.*	
Sub-theme:	

5.2 Standby/reserve

"Also, the 16-hour standby rule that I found to be absolutely ridiculous”.

“Standby”.

“Combined standby and duty time of 21 hours is inhumane as airlines allow crew to operate extensive duty hours when being called out from standby due to this regulation - crew do not rest during the standby period at the office due having to be present for every crew sign on and also due to poor resting facilities”.

“Long standby days (0500 until 21:00) and then called out near the end of duty to go and fly”.

“Duty hours should one get called out from AIRPORT standby to do 4sectors”.

“The amount of time Cabin Crew can do standby and then go on to do flying duty”.

Theme 6: Inadequate rest

“minimum rest periods, longer duty periods, application of sacaa limits to long range operations are not correct”.

“long hours (upto 12hrs a day)with minimum rest”.

“The required rest”.

“We are allowed to sign on and off on the same day. ie. We sign of at 2am and need to be at work at 14h00 the same day”.

“Minimum rest time when sleeping away from home and then still a long day ahead the next day after minimum rest”.

“The early sign ons after landing/arrivals and early sign ons after minimum rest including off days”.

“and the amount of sectors one is allowed to operate after a minimum rest turnaround”.

“Rest periods between flights”.

“Rest periods on night stops and consecutive working days”.

“The minimum rest period between duties is not sufficient should you do long shifts back to back”.

“Airlines asking crew to assist on off days due to shortage of crew”.

“Signing off after midnight and signing on on the same day as long as it's after 12pm to accommodate 12 hours rest, without regard that those 12 hours, you still need to drive home and still have to see to your family”.

“Duty periods for flights and rest periods between pairings”.

“consecutive flying hrs per day and minimum rest days”.

“Rest period between duty and duty limitations”.

”They are very fatiguing! Particularly the max duty time with multiple sectors and the minimum off time after long-haul flights. The current CAA limits are not based on any industry research”.

“Rest period between duty and duty limitations”.

“Rest between duties”.

“Not enough protection for time off”.

“Minimum rest between long duty days can be too short sometimes, especially when regularly doing through the night flying”.

“Rest periods before or after a duty period are inadequate”.

“rest time”.

“Insufficient rest between duties. Little to no protection from working a wide time range”.

“Often have a series of early sign on then on, then the last day of the working week are forced to the opposite end of the clock before time off. Robbing one of actual rest time and placing one in a dangerous position at the end of a busy week”.

“Lack of sleep routine”.

“Long duty periods flying multiple sectors with short turn around (low cost model), with insufficient rest periods in between duties. 6 day On / 2 days Off is not ideal!!”

“120 hours per month is dangerous! Too many sectors flying too many hours with minimum rest is dangerous”.

“Lack of rest between duties”.

“insufficient rest period after long range night flight”.

“rest period is too short”.

“Layover times between legs very tiring”.

“rest periods between consecutive long duty periods”.

“Late sign offs and being allowed to do early sign one with minimum rest”.

“Flight and duty times and rest periods”.

“Long duty, minimum rest”.

“Ten hour rest period. Make it twelve hours and it would be much better”.

“long duty time with repetitive short sectors, not enough rest time, local night enforcement, no time off for training”.

“travel time between hotel and airport, resting time between flights”.

“Minimum rest regarding travel time and home preparations”.

“consecutive and min days off pm”.

“Min rest before a flight. Max duty time for 4 sectors”. “insufficient rest days to switch to day flying, i.e. reset circadian rhythms”. “Inadequate rest/recuperation verses high intensity stress/workload operational environment”. “Lack in Rest Periods, especially wrt low cost carriers being allowed to fly many sectors with limited rest periods. Crew taking leave to rest!” “Minimum rest is not realistic: When adding commuting time and the frequency of minimum rest occurence it leads to acute fatigue often”. “One-night layovers after a long haul flight”. “Compulsory rest period between flights Is too short”. “MIN REST PERIODS IS VERY SHORT. EVEN AN EXTRA HOUR WILL MAKE A HUGE DIFFERENCE. THE LIMITS NEED TO BE INCREASED”. “Minimum rest at home base requirements could use some revising”. “Cabin Crew wise that we only need 8 hours sleeps between duty and can fly longer periods than the flight deck”. “Short layovers after long periods of duty”.
Theme 7: Perceptions towards FDPs
“Our limits are being treated as targets in times of high workload. Likewise, recovery periods are shortened to the barest minimum in cases. Since fatigue is such a nebulous concept to companies, and just costs them money, naturally, companies treat commercial pressures as overriding, and this kind of thing comes about. Likewise, long duty days can form part of the schedule that companies are fully aware will often result in extensions just for the crew to get home - nothing is done about this as there is no requirement for companies not to plan unrealistic schedules based on wishful thinking, that doesn't account for the realities of airline scheduling and turnarounds in difficult or busy conditions (i.e. everything is planned on best-case scenarios)”. “Old antiquated system, no consideration for FRMS”. “The duty and flight times are not updated for the current flying conditions”. “Current FDP limits are a thumb suck, no science behind the numbers, originally a limit, now a target. When originally constructed, pilots flew no where near the limits imposed by them. They are dated and dangerous”. “long hours (upto 12hrs a day)with minimum rest”. Prolonged working hour. Eg standby”. “The 1 in 7 and 2”. “It is outdated”. “No concerns”. “Limits as targets”. “Nil”. “All of it. It is archaic and lightyears behind the latest available scientific data and recommendations and presents a significant safety risk”.

"That overall at a base, some crew are flown to death and others not".

"lack of updated legislation based on international best practise".

"The duty times are ok but we might lose them or revert to worse regulations".

"Out dated legislation that is open to exploitation of flight crew".

"THE WAY THESE REGULATIONS GET INTERPRETED BY THE VARIOUS MANAGEMENT STRUCTURES".

"FDP duty periods are outdated".

"None".

"The cumulative effect of limits being used as targets".

"Old antiquated system, no consideration for FRMS".

"The current legislation is overly complex in my opinion. Makes it very difficult to adhere to every requirement".

"None".

"The overall problem is that FDP is a limit but operators use it as a target".

"The entire FDP section is inadequate and outdated".

"Out dated, does not take new schedule of airline into consideration".

"The current legislation only looks at total flight,duty and rest time but not at the circadian effect and sleep patterns".

"Airlines use the flight and duty limits as a target and not a limit".

"Split duties".

"The law is not specific to regional airline operators".

"Nil".

"Lack of rest between duties. No".

"Nil".

"None".

"N/A Emirates".

"The fdp tables are old and instead of being used as maximums they are now seen as targets".

"The refs could be revised due to the modern efficient aircraft flown".

"None".

"NONE".

“None”.

“Its out dated for the amount and type of flying done in airlines”.

“The limits are extremely dangerous. And I have personally seen the effect of crew fatigue where crews have fallen asleep during approach to land. The limits are used as targets by the operators to squeeze the maximum out of crew. I have also seen where crew have complained about the schedule and the response normally is. But it's legal. I think the FDP scheme should really be updated with more modern research. I have had instances where I return from a "legal" duty and I can barely drive my car home safely. How was I able to land a aircraft just 30 minutes ago with a 150 passengers on board with their live depending on my performance. Should anything abnormal have occurred during the last part of that flight. I highly doubt that I would have been able to deal with it successfully”.

“They seem to be a target, not a limit”.

“No FDP regulations for line engineers”.

“Different interpretation of the regulations”.

“Short haul should have total different FDP calculations”.

“outdated and for the most part not backed up by science”.

“Flight and Duty gets rostered to the maximum allowed, to make us look productive”.

“None”.

“None”.

“inadequate recognition of natural sleep pattern needs”.

“The company sees the max FDP as a target to be reached while trying to optimize its crew usage. It allows for a week of early sign ons (before 6am) It should not allow more than 3 early sign ons in a row”.

“Operators use the limit as a target for planning duty periods”.

“Nil”.

“None so far”.

“N/A”.

“The company uses the law as the target or the goal, not the limit”.

Sub-theme:

7.1 Limits as targets

~~“O~~ur limits are being treated as targets in times of high workload”.

~~“o~~riginally a limit, now a target”.

~~“L~~imits as targets”.

~~“T~~hat overall at a base, some crew are flown to death and others not”.

THE WAY THESE REGULATIONS GET INTERPRETED BY THE VARIOUS MANAGEMENT STRUCTURES". *The cumulative effect of limits being used as targets".* *The overall problem is that FDP is a limit but operators use it as a target".* *Airlines use the flight and duty limits as a target and not a limit".* *The fdp tables are old and instead of being used as maximums they are now seen as targets".* *The limits are extremely dangerous. And I have personally seen the effect of crew fatigue where crews have fallen asleep during approach to land. The limits are used as targets by the operators to squeeze the maximum out of crew. I have also seen where crew have complained about the schedule and the response normally is".* *They seem to be a target, not a limit'.* *The company sees the max FDP as a target to be reached while trying to optimize its crew usage".* *Operators use the limit as a target for planning duty periods".* *The company uses the law as the target or the goal, not the limit'.*	
Sub-theme: **7.2 No concerns** *The duty times are ok but we might lose them or revert to worse regulations".* *No concerns".* *Nil".* *None".* *None".* *Nil"* *Nil".* *None".* *N/A Emirates".* *None".*	

NONE”. *None”.* *None”.* *None”.* *Nil”.* *None so far”.* *N/A”.*	
Sub-theme: **7.3 No science** *lack of updated legislation based on international best practise”.* *Current FDP limits are a thumb suck, no science behind the numbers”.* *All of it. It is archaic and lightyears behind the latest available scientific data and recommendations and presents a significant safety risk”.* *lack of updated legislation based on international best practise”.* *The current legislation is overly complex in my opinion. Makes it very difficult to adhere to every requirement”.* *The current legislation only looks at total flight,duty and rest time but not at the circadian effect and sleep patterns”.* *But it's legal. I think the FDP scheme should really be updated with more modern research. I have had instances where I return from a "legal" duty and I can barely drive my car home safely. How was I able to land a aircraft just 30 minutes ago with a 150 passengers on board with their live depending on my performance. Should anything abnormal have occurred during the last part of that flight. I highly doubt that I would have been able to deal with it successfully”.* *outdated and for the most part not backed up by science* *inadequate recognition of natural sleep pattern needs”.*	
Sub-theme:	

7.4 Outdated FDPs

The entire FDP section is inadequate and outdated".

The duty and flight times are not updated for the current flying conditions".

When originally constructed, pilots flew no where near the limits imposed by them. They are dated and dangerous".

It is outdated".

All of it. It is archaic and lightyears behind the latest available scientific data and recommendations and presents a significant safety risk".

Out dated legislation that is open to exploitation of flight crew".

FDP duty periods are outdated".

Old antiquated system, no consideration for FRMS".

The entire FDP section is inadequate and outdated".

Out dated, does not take new schedule of airline into consideration".

The fdp tables are old and instead of being used as maximums they are now seen as targets".

The regs could be revised due to the modern efficient aircraft flown".

Its out dated for the amount and type of flying done in airlines".

outdated and for the most part not backed up by science".

APPENDIX P: If you have any concerns, what recommendations do you have to address these concerns?

<table>
<tr><th colspan="2">Theme 1: Attitudes and perceptions</th></tr>
<tr><td colspan="2">The regulations need to get aligned with pace and demand of modern life. We are not androids”.

Changed ASAP before disaster, not after it”.

management must understand that we shorten our lifespan and compromise our own health with the long flights and continuous night shift. it has irreparable damage to our bodies”.

Roster effectively and not pushing the limits days in a row”.

Address other factors that causes fatigue such as noise”.

My concern is listed above, hopefully this survey will enable a change in regulations to force compliance by companies”.

Re think flight and duty to make it safer”.

Normal working hours”.

Revisit”.

Have to relook at the FDP”.

Fatigue management is not respected by crews and companies alike”.

Allow for increased pilot input”.

poor pilot selection. not selecting the best available but race based selections”.

Recommend the regulator and lawmaker's realise that the law as is provide employers with the opportunity to over optimize flight crew for the benefit of the company and for the long term detriment of the employee. It is far too easy to roster a sustained fatiguing pattern with minimum rest and 4 sector duty time at current limits. Law should be adjusted / unions should be stronger / regulator should oversee airline roster patterns for misuse”.

Nothing. SACAA very reluctant to take fatigue seriously”.

PLEASE DON'T ALLOW COMPANIES TO TAKE AWAY THE FDP REGULATIONS. AND IT'S NOT WRITTEN VERY WELL, ITS HARD TO DECIPHER WHEN THE SCHEDULE CHANGES AND THE FDP BECOMES COMPLICATED.”

Contact the appropriate authority.</td></tr>
<tr><td>Sub-theme:

1.1 Health effects

management must understand that we shorten our lifespan and compromise our own health with the long</td><td></td></tr>
</table>

flights and continuous night shift. it has irreparable damage to our bodies”. *“The regulations need to get aligned with pace and demand of modern life. We are not androids”.*	
Sub-theme: **1.2 More restrictive regulations** *“Stricter FDP for high frequency short haul operations”.* *“Enforce stricter Flight and Duty regulations on the operators”.* *“More stringent”.* *“More restrictive duty rules for low cost airline”.* *“FDP regulations on the operator need to be more stringent to ensure crew welfare”.* *“CAA should change the FDP scheme to be more restrictive in order to prevent companies run by money hungry CEO's from abusing crew and forcing them to work fatiguing schedules”.* *“Not to roster to the maximum according to F&D regulations, or make the regulations more restrictive, if that is what rostering continue to do”.* *“Recommend the regulator and lawmaker's realise that the law as is provide employers with the opportunity to over optimize flight crew for the benefit of the company and for the long term detriment of the employee. It is far too easy to roster a sustained fatiguing pattern with minimum rest and 4 sector duty time at current limits. Law should be adjusted / unions should be stronger / regulator should oversee airline roster patterns for misuse”.*	
Sub-theme: **1.3 Re-evaluated FDP table** *“Re-evaluate the FDP table”.* *“re-evaluate legislation”.* *“Better pairings, change in FDP scheme”.*	

Adjustment of the FDPs and reduction of layovers between flights”. Re think flight and duty to make it safer”. Have to relook at the FDP”. That duties don‘t get rostered on minimum rest and that a roster operates at a max of 90 hours but not continuously with more effective duty allocation”. the current duty period system not effective for our industry”.	
Theme 2: Specific interventions	
Have companies look at having early morning crew and late crew. Designing a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period(off) - 4 days‘ late flights. Rest period. That the body can to a degree have recovering time and time to adjust”. Scientific FRMS system incorporated into roster generation system with binding limits. Currently we have a knee jerk system, if enough pilots complain about a pairing, the pairing is changed" More application of current scientific knowledge regarding sleep/fatigue schedules built into the SACAA FDP limits, that requires more rigorous reporting and compliance from airline companies. If we were to work to the allowable SACAA FDP limits year in and year out, we would be vegetative zombies within six months to a year (but more importantly, accidents would result) - the allowable limits are too high in general, and don't account for realistic recovery to a well-rested state; IF higher workloads are going to be allowed, strict FRMS systems MUST be mandated, and followed up on by regulatory authorities”. enforce FRMS for each operator”. Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons”. Reduced sectors especially for early morning late night. Finish early preceding days off and start later after days off”. As stated above. Change the definition of ‘sector‘ to include the time on the ground preparing. Sector should be defined as, ‘The time from sign on for a flight to sign off”.	
Sub-theme: **2.1 Alter definitions** Reduce monthly/annual hours by 15%”. The CAA need to change the limits on flying to fall in line with the rest of the world. 900hrs per year and maximum of 100hrs (not 120) per month”. Lower monthly limit for consecutive months of flying”.	
Sub-theme:	

2.2 FRMS integration *Scientific FRMS system incorporated into roster generation system with binding limits. Currently we have a knee jerk system, if enough pilots complain about a pairing, the pairing is changed”.* *More application of current scientific knowledge regarding sleep/fatigue schedules built into the SACAA FDP limits, that requires more rigorous reporting and compliance from airline companies. If we were to work to the allowable SACAA FDP limits year in and year out, we would be vegetative zombies within six months to a year (but more importantly, accidents would result) - the allowable limits are too high in general, and don't account for realistic recovery to a well-rested state; IF higher workloads are going to be allowed, strict FRMS systems MUST be mandated, and followed up on by regulatory authorities”.* *enforce FRMS for each operator”.* *In general - Refer to the recent well documented FRMS, still not approved. All the answers are there, but it seems top management [Regulator & Operator?] not in agreement”.*	
Sub-theme: **2.3 More crew** *I feel a 3rd crew member would reduce the fatigue and increase the safety of this flight”.* *Add more crew”.*	
Sub-theme: **2.4 Part specific regulations** *Part 137 operations may well operate safely for longer periods than Part 135 (without rest days) but not for uninterrupted stints of 6 to 7 weeks. I would suggest one rest day every 14 days for Part 137 operations with a compulsory 12-day break after a 6-week tour. There should be a limitation that if the Part 137 flying hours are within 80% of the stipulated Part 135 hours, then Part 135 limitations regarding rest should be adhered to (1 day every 7 days and 2 days within every 14-day period etc.)”.*	

Each part should be 'governed' on own merit". *complete Part 137".*	
Sub-theme: **2.5 Reduce sectors** *Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons".* *Reduced sectors especially for early morning late night. Finish early preceding days off and start later after days off".*	
Sub-theme: **2.6 Roster by chronotype** *There should be measures in rostering to identify morning larks and night owls and roster them accordingly - frequently they are rostered the wrong way around which is completely avoidable".* *Have companies look at having early morning crew and late crew".* *If one requires to do just PM shifts, can they be granted their request".* *Crew that prefers to do early morning flights, should be allowed to do so, crew that prefers later sign on's, should be allowed to do so".* *Choosing your crew for the day as an in Charge should be considered. This will minimize fatigue on board".*	
Theme 2: Adjust duty durations	
They have to re look and reduce the duty times that pilots and cabin crew can work. Currently the aviation industry is running all on the limit". *Flight duty limits that take into account the short haul fatigue issues. Encouraging operators not to push flight and duty to the maximum routinely".* *also look at consecutive duty hours".*	

“Reduce the max allowable”.

“Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons”.

“Reduce monthly/annual hours by 15%. Regulation in respect of layovers in excess of two hours need to be addressed. Regulation in respect of the limits on sign-on's before 07:00 Local time. (Max two, the rest or later sign-on)”.

“Shorter duty days and longer rest periods between duties”.

“The CAA need to change the limits on flying to fall in line with the rest of the world. 900hrs per year and maximum of 100hrs (not 120) per month”.

“Lower monthly limit for consecutive months of flying”.

“Shorter duty days. If more than 3 sectors... shorted sectors to be considered”.

“Cumulative duties should restrict duty period”.

“For a 0500 sign on a max period of 10 hrs duty”.

“They need to be lowered”.

“long duty periods should be followed with consecutively shorter periods until an off day”.

“Put in limits that are reasonable. Why should a pilot work consecutive 12-hour duty days just because it is legal?”

“Shorter duty, longer rest”.

“Max duty for 4 sectors reduced”.

“Shorten duty time on increasing sectors”.

“The early morning and then change to late afternoon sign on or vice versa should reduce the allowed FDP. This makes it very difficult to get a sort of normal sleeping pattern which greatly increases fatigue. Flying 4 Sectors a day for more than 4 days in a row should be prohibited. I know there are some operations where they only do short hobs and these would then have special dispensation. Night cargo operations needs to have a special table. The current limits are extremely dangerous. I have seen how crew literally fall asleep while taxing out to go on a flight. Even if they are able to keep their eyes open for take-off. What real level of alertness do they have? And should there be an emergency would then be able to deal with it effectively? I highly doubt this. The reason we don't see more accidents is because aircraft are built with lots of redundancy's in place. But this is still not an excuse to let crew operate this highly complex equipment while being fatigued”.

“Not to roster to the maximum according to F&D regulations, or make the regulations more restrictive, if that is what rostering continue to do”.

“Reduce the maximum flight times by at least 20%”.

“That these be reduced by about 10 hours”.

“Always operating on the red line is not good. The limit and its extensions should be for exceptions, thus every day operating limits should be slightly reduced from the limit. The limit shouldn't be the norm”.

Sub-theme: **2.1 Alter monthly FDPs**	

Reduce monthly/annual hours by 15%”. *Lower monthly limit for consecutive months of flying”.* *The CAA need to change the limits on flying to fall in line with the rest of the world. 900hrs per year and maximum of 100hrs (not 120) per month”.*	
Sub-theme: **2.2 Increase duty times** *"Work for longer periods with longer time off periods”.* *Five weeks on every day and two weeks off”.*	
Sub-theme: **2.3 Limit discretionary extensions** *The discretionary extension of FD is often forced on Captains by rostering - no standbys available and other excuses. This should be discouraged”.* *Never have to extend hours”.* *If flight deck is can only extend to a certain time, it should be the same cabin crew, crew are physically working and under pressure at all times. Dealing with pax, OTP and service”.*	
Sub-theme: **2.4 Reduce daily FDPs** *Shorter duty days and longer rest periods between duties”.* *Shorter duty days. If more than 3 sectors... shorted sectors to be considered”.* *Lower monthly limit for consecutive months of flying”.*	

<table>
<tr><td>–Cumulative duties should restrict duty period‘.

–For a 0500 sign on a max period of 10 hrs duty”.

–Put in limits that are reasonable. Why should a pilot work consecutive 12-hour duty days just because it is legal?”

–Shorter duty, longer rest”.

–Reduce the maximum flight times by at least 20%”.

–That these be reduced by about 10 hours”.</td><td></td></tr>
<tr><td>Sub-theme:

2.5 Taper duty lengths

–long duty periods should be followed with consecutively shorter periods until an off day”.

–Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons”.

–Reduced sectors especially for early morning late night. Finish early preceding days off and start later after days off”.

–For a 0500 sign on a max period of 10 hrs duty”.</td><td></td></tr>
<tr><td colspan="2" align="center">Theme 3: Modernise regulations</td></tr>
<tr><td colspan="2">–Re-evaluate fdp limitations to reduce fatigue and increase safety. Adopt FAA and EASA fdp limits”.

–At least implement without delay the latest ICAO FTL recommendations if not more restrictive regulations in the interest of safety”.

–Do and implement research”.

–Presume there should be an algorithm built into the rostering system that evens out flights across the entire base, and which would highlight any anomalies”.

–Base regulations on up to date scientific data that is available regarding fatigue”.

–Use the latest medically researched and supported data to compile/adjust the regulations”.

–AS AN IATA AIRLINE THERE SHOULD BE A UNIVERSAL OUTLINE WHICH MUST BE ADOPTED, THIS MUST HAVE VARIANCES ACCORDING TO YOUR GEOGRAPHICAL LOCATION. BASIC STATE MAXIMUMS</td></tr>
</table>

<table>
<tr><td colspan="2">WHICH SOME AIRLINES ADAPT ARE BRUTAL ESPECIALLY IN HTOSE AIRLINES WHERE LABOUR INTERACTION IS NOT ENCOURAGED”.

SACAA should adopt ALPA flight and duty recommendations”.

There are many scientific studies that have been done around the world on this. Many international airlines have researched this and their Flight and Duty limits are far more restrictive than the SACAA's, for good reason”.

Re address the entire FDP scheme using real-world, accurate and new data from studies of sleep and the effects of fatigue”.

Follow the revised world standards as developed by recent studies”.

Intelligent oversight from SACAA”.

Review FDP to scientific data & amend”.

They should at the very minimum, be aligned with EASA FDP's”.

more studies required and adopting international best practices”.

Study to determine this for our cultural behaviour”.

further study needed”.

To do surveys and studies like this one to change the regulations and FDP schemes to operation specifics”.</td></tr>
<tr><td>Sub-theme:

3.1 Align with other regulations and guidance

AS AN IATA AIRLINE THERE SHOULD BE A UNIVERSAL OUTLINE WHICH MUST BE ADOPTED, THIS MUST HAVE VARIANCES ACCORDING TO YOUR GEOGRAPHICAL LOCATION. BASIC STATE MAXIMUMS WHICH SOME AIRLINES ADAPT ARE BRUTAL ESPECIALLY IN HTOSE AIRLINES WHERE LABOUR INTERACTION IS NOT ENCOURAGED”.

At least implement without delay the latest ICAO FTL recommendations if not more restrictive regulations in the interest of safety”.

SACAA should adopt ALPA flight and duty recommendations”.

Re-evaluate fdp limitations to reduce fatigue and increase safety. Adopt FAA and EASA fdp limits”.

Follow the revised world standards as developed by recent studies”.

get up to date with first word”.

They should at the very minimum, be aligned with EASA FDP's”.</td><td></td></tr>
</table>

<table>
<tr>
<td>Sub-theme:

3.2 Inclusion of more science and operational experience

“Re address the entire FDP scheme using real-world, accurate and new data from studies of sleep and the effects of fatigue”.

“Do and implement research”.

“Base regulations on up to date scientific data that is available regarding fatigue”.

“Use the latest medically researched and supported data to compile/adjust the regulations”.

“There are many scientific studies that have been done around the world on this. Many international airlines have researched this and their Flight and Duty limits are far more restrictive than the SACAA's, for good reason”.

“Review FDP to scientific data & amend”.

“more studies required and adopting international best practices”.

“Study to determine this for our cultural behaviour”.

“further study needed”.

“To do surveys and studies like this one to change the regulations and FDP schemes to operation specifics”.</td>
<td></td>
</tr>
<tr>
<td colspan="2" align="center">Theme 4: Limit disruptive rosters</td>
</tr>
<tr>
<td colspan="2">“Split duty needs to be looked at. Or duty with long gaps and no rest facilities provided (we often sit with the public for up to 6hrs in an airport lounge between legs). Circadian rhythm disruptions (some late sign offs, then early sign ons and then back to late)”.

“Designing a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period(off) - 4 days‘ late flights. Rest period. That the body can to a degree have recovering time and time to adjust”.

“Rosters should not allow duties to fly early mornings and late nights in one roster period. Say in a roster block of 5 - 7 days. Do not allow 3 or 4 early, before 7 am reporting times, with duty in excess of 12 hours and then the last few days 12 - 13 hour duties ending late at night”.

“I recommend re looking into rest periods, consecutive early morning sign on, minimum rest hours and signing on and off on the same day”.

“To please extend rest time away from home, to balance the amount of early morning and late night flights. To look into long pairings when sleeping away from home”.

“Shortening the allowable duty for very early morning and late night duty. Allowing less night-time sectors to be flown during a duty. It would be better to have 5 early in a row followed by a few days off then 5 late so as a sleep routine can be”.</td>
</tr>
</table>

Some night flying is difficult to manage”.

Fatigue is more incumbent than hours only. Should include duty sign on, night flying etc.”.

Regulation in respect of layovers in excess of two hours need to be addressed. Regulation in respect of the limits on sign-on's before 07:00 Local time. (Max two, the rest or later sign-on)”.

Reduced sectors especially for early morning late night. Finish early preceding days off and start later after days off”.

Limit the early mornings to 3 in a row and if you finish late then to do the same”.

Min off days should not precede by late night sign off followed by early sign on. Or to many late nights and early mornings in one string”.

Limit recurrent late night flights”.

Reduce the time between split duties”.

Certain parameters if you have an early sign on that you can‘t work late into the night the following night. Body clock is used to the early flights or early trend, so even though you sign on late in the afternoon your body woke up naturally at an early hour”.

The early morning and then change to late afternoon sign on or vice versa should reduce the allowed FDP. This makes it very difficult to get a sort of normal sleeping pattern which greatly increases fatigue. Flying 4 Sectors a day for more than 4 days in a row should be prohibited. I know there are some operations where they only do short hobs and these would then have special dispensation. Night cargo operations needs to have a special table. The current limits are extremely dangerous. I have seen how crew literally fall asleep while taxing out to go on a flight. Even if they are able to keep their eyes open for take-off. What real level of alertness do they have? And should there be an emergency would then be able to deal with it effectively? I highly doubt this. The reason we don't see more accidents is because aircraft are built with lots of redundancy's in place. But this is still not an excuse to let crew operate this highly complex equipment while being fatigued”.

Should you start a pairing early, stay in that time frame for consecutive days. It is extremely tiring to do early and late flights in one 3-day pairing for example. Brake early sign ons to late sign ons with consecutive off days”.

Day time operation”.

Don‘t allow more than 3 sign ons before 6am in a row”.

More thought should be given to repeated East/West pairings”.

Sector combinations, amount of sleep before an early morning duty, long hours”.

Running a roster of 5days on (all early sign on) then 4 days of, then 5days on (all late sign on) then 4days off. The 5/4 roster will at least allow some form of circadian rhythm”.

Sub-theme:

4.1 Alter standby provisions

A home standby needs to be split a duty of only 8 hours”.

Combined standby and duty time should be reduced to a reasonable amount". *Reduce the time between split duties".* *Office standby should be treated differently to home standby/reserve".*	
Sub-theme: **4.2 Instil a block roster schedule** *Block roster of 5 on and 4 off to give sufficient time at home for rest".* *Work a roster of 5 days on and 4 days off. 5 early's, 4 days off and then 5 late's and 4 days off. Ryanair has this in place and apparently it works well. I think it's the way to reduce fatigue with a short haul multi sector operation".* *Designing a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period(off) - 4 days' late flights. Rest period. That the body can to a degree have recovering time and time to adjust".* *Block rosters. 5/4".* *Working a block type roster with sufficient rest would be ideal. When on duty working efficiently".* *Running a roster of 5days on (all early sign on) then 4 days of, then 5days on (all late sign on) then 4days off. The 5/4 roster will at least allow some form of circadian rhythm".*	
Sub-theme: **4.3 Limit quick returns (double sign-on/sign-off on the same day)** *NO sign off early in the morning just to sign on later the afternoon again(I don't mean split duty)".* *and signing on and off on the same day".*	

Signing off and signing on within the same day should not be allowed”.	
***S*ub-theme:** **4.4 Extend rest away from home** *To please extend rest time away from home, to balance the amount of early morning and late night flights. To look into long pairings when sleeping away from home”.* *Rosters should not allow duties to fly early mornings and late nights in one roster period. Say in a roster block of 5 - 7 days. Do not allow 3 or 4 early, before 7 am reporting times, with duty in excess of 12 hours and then the last few days 12 - 13 hour duties ending late at night”.* *Shortening the allowable duty for very early morning and late night duty. Allowing less night-time sectors to be flown during a duty. It would be better to have 5 early in a row followed by a few days off then 5 late so as a sleep routine can be”.* *The legislation needs to be simplified. Rostering programs need to follow the FDP rules, so the simpler the rules the better the rostering programs can adhere to them”.* *Designing a block roster to aid in getting some form of normality or a shift type of work order in place. 4 days early - rest period(off) - 4 days‘ late flights. Rest period. That the body can to a degree have recovering time and time to adjust”.* *Limit the early mornings to 3 in a row and if you finish late then to do the same”.* *Min off days should not precede by late night sign off followed by early sign on. Or to many late nights and early mornings in one string‘.* *Body clock is used to the early flights or early trend, so even though you sign on late in the afternoon your body woke up naturally at an early hour”.* *Should you start a pairing early, stay in that time frame for consecutive days. It is extremely tiring to do early and late flights in one 3-day pairing for example. Brake early sign ons to late sign ons with consecutive off days”.* *Don‘t allow more than 3 sign ons before 6am in a row”.* *Running a roster of 5days on (all early sign on) then 4 days of, then 5days on (all late sign on) then 4days off. The 5/4 roster will at least allow some form of circadian rhythm”.*	

<table>
<tr><td>Sub-theme:

4.5 Split shifts

Split duty needs to be looked at. Or duty with long gaps and no rest facilities provided (we often sit with the public for up to 6hrs in an airport lounge between legs)”.

Reduce the time between split duties”.</td><td></td></tr>
<tr><td colspan="2" align="center">Theme 5: Adjust duty durations</td></tr>
<tr><td colspan="2">They have to re look and reduce the duty times that pilots and cabin crew can work. Currently the aviation industry is running all on the limit”.

Flight duty limits that take into account the short haul fatigue issues. Encouraging operators not to push flight and duty to the maximum routinely”.

also look at consecutive duty hours”.

Reduce the max allowable”.

Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons”.

Reduce monthly/annual hours by 15%. Regulation in respect of layovers in excess of two hours need to be addressed. Regulation in respect of the limits on sign-on's before 07:00 Local time. (Max two, the rest or later sign-on)”.

Shorter duty days and longer rest periods between duties”.

The CAA need to change the limits on flying to fall in line with the rest of the world. 900hrs per year and maximum of 100hrs (not 120) per month”.

Lower monthly limit for consecutive months of flying”.

Shorter duty days. If more than 3 sectors... shorted sectors to be considered”.

Cumulative duties should restrict duty period”.

For a 0500 sign on a max period of 10 hrs duty”.

They need to be lowered”.

long duty periods should be followed with consecutively shorter periods until an off day”.

Put in limits that are reasonable. Why should a pilot work consecutive 12-hour duty days just because it is legal?”</td></tr>
</table>

<table>
<tr><td colspan="2">
Shorter duty, longer rest”.

Max duty for 4 sectors reduced”.

Shorten duty time on increasing sectors”.

The early morning and then change to late afternoon sign on or vice versa should reduce the allowed FDP. This makes it very difficult to get a sort of normal sleeping pattern which greatly increases fatigue. Flying 4 Sectors a day for more than 4 days in a row should be prohibited. I know there are some operations where they only do short hobs and these would then have special dispensation. Night cargo operations needs to have a special table. The current limits are extremely dangerous. I have seen how crew literally fall asleep while taxing out to go on a flight. Even if they are able to keep their eyes open for take-off. What real level of alertness do they have? And should there be an emergency would then be able to deal with it effectively? I highly doubt this. The reason we don't see more accidents is because aircraft are built with lots of redundancy's in place. But this is still not an excuse to let crew operate this highly complex equipment while being fatigued”.

Not to roster to the maximum according to F&D regulations, or make the regulations more restrictive, if that is what rostering continue to do”.

Reduce the maximum flight times by at least 20%”.

That these be reduced by about 10 hours”.

Always operating on the red line is not good. The limit and its extensions should be for exceptions, thus every day operating limits should be slightly reduced from the limit. The limit shouldn‘t be the norm”.
</td></tr>
<tr><td>
Sub-theme:

5.1 Alter monthly FDPs

Reduce monthly/annual hours by 15%”.

Lower monthly limit for consecutive months of flying”.

The CAA need to change the limits on flying to fall in line with the rest of the world. 900hrs per year and maximum of 100hrs (not 120) per month”.
</td><td></td></tr>
<tr><td>
Sub-theme:

5.2 Increase duty times

"Work for longer periods with longer time off periods”.

Five weeks on every day and two weeks off”.
</td><td></td></tr>
</table>

Sub-theme: **5.3 Limit discretionary extensions** *–The discretionary extension of FD is often forced on Captains by rostering - no standbys available and other excuses. This should be discouraged”.* *–Never have to extend hours”.* *–If flight deck is can only extend to a certain time, it should be the same cabin crew, crew are physically working and under pressure at all times. Dealing with pax, OTP and service”.*	
Sub-theme: **5.4 Reduce daily FDPs** *–Shorter duty days and longer rest periods between duties”.* *–Shorter duty days. If more than 3 sectors... shorted sectors to be considered”.* *–Lower monthly limit for consecutive months of flying”.* *–Cumulative duties should restrict duty period‘.* *–For a 0500 sign on a max period of 10 hrs duty”.* *–Put in limits that are reasonable. Why should a pilot work consecutive 12-hour duty days just because it is legal?”* *–Shorter duty, longer rest”.* *–Reduce the maximum flight times by at least 20%”.* *–That these be reduced by about 10 hours”.*	
Sub-theme: **5.5 Taper duty lengths**	

long duty periods should be followed with consecutively shorter periods until an off day”. *Shorten some of the duty periods, more restrictions on the number of sectors that can be flown with later sign ons”.* *Reduced sectors especially for early morning late night. Finish early preceding days off and start later after days off”.* *For a 0500 sign on a max period of 10 hrs duty”.*	

Theme 6: No recommendations

Not too many concerns”.

No concerns”.

Nil”.

Na”.

None”.

Nil”.

n/a”.

NA”.

None”.

NONE”.

None”.

n/a”.

None”.

N/A”.

None. "Rules is rules". (although this study, one hopes, could change that)”.

Not sure”.

No answer”.

–N/A”.

–N/A”.

–Na”.

–N/A”.

Theme 7: Increase rest provision

–Block rosters. 5/4”.

—12 hour rest period”.

–long hrs must be followed by longer rest”.

–longer time off periods”.

–Usually the last duty before off time end late, after 2100 and the first duty of the new period start again at 455. The 2 days off is not enough. because the night before the start of your next duty you have to try and get to bed at 2000 latest to be up at 3 again. This practice is extremely fatiguing over 2 or 3 cycles”.

–I can recommend that subsequent to a 6-day flying period, three days off needs to be given to an individual. There should be no 1 day off”.

–Five weeks on every day and two weeks off”.

–I recommend re looking into rest periods, consecutive early morning sign on, minimum rest hours”.

–To please extend rest time away from home, to balance the amount of early morning and late night flights. To look into long pairings when sleeping away from home”.

–Rostering of crew needs to improve drastically. Better planning with enough rest in between long flying days and off days. Service procedures also need to be re looked at”.

–Definitely look at increasing the minimum rest period”.

–Block roster of 5 on and 4 off to give sufficient time at home for rest. Rest periods of no less than 12 hours on night stops to allow for travel time between the hotel and airport”.

–Increase the rest period/period between sign on/off times. The average person requires 8 hours of rest, with the current regulation and travel times to work, the rest period is not sufficient”.

–Off day regulation should be made stricter - airlines should not be allow to phone crew on off days”.

–Signing off and signing on within the same day should not be allowed”.

–Work a roster of 5 days on and 4 days off. 5 early's, 4 days off and then 5 late's and 4 days off. Ryanair has this in place and apparently it works well. I think it's the way to reduce fatigue with a short haul multi sector operation”.

–Long cumulative fatigue is not taken into account. Bi-annual leave should be mandatory for long haul pilots. Annual limits should be lower”.

–longer rest periods between duties”.

More consecutive days off / am or pm standby days”.

More time off between flights”.

Lengthen the minimum rest periods”.

3days consecutive off is needed for proper rest”.

As above, insufficient consecutive rest. The negligence of companies to sleep patterns. We are termed as shift workers. However true shift workers have set shifts, wherein with our case, the shift work shifts over too large a time scale making it extremely disruptive and leave almost no time to create a sort of routine. This plays havoc with family and rest time. Very little can be planned in advance adding to the disruption of the precious little rest time we have”.

Min off days should not precede by late night sign off followed by early sign on. Or to many late nights and early mornings in one string”.

three consecutive off duty days needs to be mandatory to allow proper recovery”.

Working a block type roster with sufficient rest would be ideal. When on duty working efficiently”.

Mandate preparation days before ratings”.

all long range night flight should have 2 local nights off before next flight”.

Extend the rest period by 1 hour. align with ICAO/EASA/FAA”.

reduce these layover periods”.

Adjust minimum rest to be longer”.

longer rest”.

Change the FDP tables to give the crew more rest. Also allow longer minimum rest periods between duties”.

Make law the appropriate rest and duty requirements”.

look at increasing min off days”.

Change min rest to 11 hours”.

Allow body to recover fully - longer time off with time zone changes”.

3 days to reset from night (shift) today flying”.

Flight pairings and rest periods should always be analysed according to their impact on natural sleep patterns”.

Two or more night layovers”.

Compulsory rest from sign-off to next sign-on may not less than 12 hours”.

“Greater “night time” hours or more hours should be included in minimum rest requirements”. *“Longer layovers with longer recovery times”.*	
Sub-theme: **7.1 Minimum number of days off** *“I can recommend that subsequent to a 6-day flying period, three days off needs to be given to an individual. There should be no 1 day off”.* *“3days consecutive off is needed for proper rest”.* *“Usually the last duty before off time end late, after 2100 and the first duty of the new period start again at 455. The 2 days off is not enough. because the night before the start of your next duty you have to try and get to bed at 2000 latest to be up at 3 again”.* *“Block roster of 5 on and 4 off to give sufficient time at home for rest”.* *“Work a roster of 5 days on and 4 days off. 5 early's, 4 days off and then 5 late's and 4 days off. Ryanair has this in place and apparently it works well. I think it's the way to reduce fatigue with a short haul multi sector operation”.* *“More consecutive days off / am or pm standby days”.* *“three consecutive off duty days needs to be mandatory to allow proper recovery”.* *“all long range night flight should have 2 local nights off before next flight”.* *“look at increasing min off days”.* *“Change min rest to 11 hours”.* *“Allow body to recover fully - longer time off with time zone changes”.* *“3 days to reset from night (shift) today flying”.* *“Longer layovers with longer recovery times”.*	
Sub-theme: **7.2 Minimum rest between duties**	

More time off between flights”. *Usually the last duty before off time end late, after 2100 and the first duty of the new period start again at 455. The 2 days off is not enough. because the night before the start of your next duty you have to try and get to bed at 2000 latest to be up at 3 again”.* *I can recommend that subsequent to a 6-day flying period, three days off needs to be given to an individual. There should be no 1 day off. A home standby needs to be split a duty of only 8 hours”.* *Five weeks on every day and two weeks off”.* *Rest periods of no less than 12 hours on night stops to allow for travel time between the hotel and airport”.* *Increase the rest period/period between sign on/off times. The average person requires 8 hours of rest, with the current regulation and travel times to work, the rest period is not sufficient”.* *longer rest periods between duties”.* *More time off between flights”.* *Lengthen the minimum rest periods”.* *all long range night flight should have 2 local nights off before next flight”.* *Extend the rest period by 1 hour. align with ICAO/EASA/FAA”.* *12hour rest period”.* *Change min rest to 11 hours”.* *Compulsory rest from sign-off to next sign-on may not less than 12 hours”.*	

APPENDIX Q: What are the current, effective mitigating aspects of the current regulations?

<table>
<tr><th colspan="2">Theme 1: Just culture</th></tr>
<tr><td colspan="2">The CAHRS system is flawed and needs revising. The installation of a true Just Culture” will go a long way to addressing this problem. The blanket imposition of a R10 000 fine on anyone reporting a transgression does not engender a reporting culture”.

FRMS - but keep in mind that most flight crew will not be willing to speak up about fatigue as it could compromise their position. Some airline cultures are just not conducive for reporting and unfortunately many pilots try to be 'strong' and not speak up because they don't think it will make a difference”.</td></tr>
<tr><th colspan="2">Theme 2: Negotiation</th></tr>
<tr><td colspan="2">ALTHOUGH NASA HAS DONE GREAT STUDIES ON THE FATIGUE MANAGEMENT, THE ONLY WAY WE HAVE GOT SOME RESPITE IS BY NEGOTIATING CONCESSIONS WITH MANAGEMENT BY LABOURS INVOLVEMENT.IE AT SAA WE GET 3DAYS OF AFTER ANY 4DAY PAIRING, AND WE ALSO HAVE EAST WEST PROTECTION. THIS AGREEMENT HOWEVER HANGS IN THE BALANCE AS MANAGEMENT TRY TO GET MORE PRODUCTIVITY OUT OF ITS CREWS IN ORDER TO EMPLOY LESS PILOTS TO MAX PROFIT”.

Approved fdp schedule as per operator. FMS starting to be developed. Minimal”.

Company limits are more restrictive than the CAA limits”.</td></tr>
<tr><th colspan="2">Theme 3: Fatigue reporting and training</th></tr>
<tr><td>Sub-theme:

3.1 Fatigue management training

Airlines have incorporated fatigue risk management awareness but there is still a stigma” attached to declaring oneself as in a fatigued state”.

The current regulations only require the company to draw up a fatigue risk management schedule”.

CRM courses where fatigue is discussed”.</td><td></td></tr>
<tr><td>Sub-theme:

3.2 Mandatory fatigue reporting</td><td></td></tr>
</table>

fatigue reports”. *There are systems in place for reporting. On consultation with colleagues, we evidently report often, but nothing tangible changes, all that has now happened is a drop in actually reporting because it bears little to no results”.* *fatigue reporting”.* *Supposed to be reports”.* *Being able to sign off as unfit to fly, however people don't do this for fear of their jobs and they fly anyway”.* *self-assessment”.* *The whole idea is that crew should not report for duty if they feel fatigued. But this is unfortunately not happening in the real world. The fear of losing your job keeps crew from doing this. Pilots do not self-report fatigue”.* *Fatigue reports”.*	
Theme 4: Rostering practices	
Sub-theme: **4.1 Flight deck extension** *Maximum time allowed on duty has saved us from being forced into extending duty time when there are lengthy delays”.* *Notification of extension of FDP”.* *Flight deck extension time is less than cabin crew”.*	
Sub-theme: **4.2 Limit number of sectors** *The number of 4 sector flights per week has been limited”.*	

Sub-theme: **4.3 Limiting number of early sign-on's** *–Limiting the number of legs for early sign-ons”.* *–Not more than a certain amount of early morning flights in a row on certain occasions”.*	
Sub-theme: **4.4 Recognition of time zone changes** *–Assigned Duty Free Days. Recognition of time zone traversing”.*	
Theme 5: Enough rest	
–One day off in 7 and 2 days off in 14”. *–12 hours between duty periods”.* *–Minimum rest periods avoid less than 9 hrs rest between consecutive duty”.* *—12hour rest periods”.* *–12 hours‘ rest after 22:00 sign off”.* *–Sufficient rest after duty”.* *–2 Consecutive off days in 14”.* *–Suitable place to rest during a split duty”.* *–More time off”.* *–eight hours‘ local night”.* *–Minimum rest periods between signing off and sign on are good. More sectors should reduce weekly flight times permissible”.* *–Enough Rest”.*	

<table>
<tr><td colspan="2">“Compulsory off days”.

“Time off”.

“REST PERIODS”.

“Rest time between duties”.

“None are very good but the rest periods are good and will be even better if the maximum flight times are reduced”.

“Defined off days”.

“Time off between flights helps”.

“The number of days of in a 14-day cycle”.

“allowing time off after long stints”.</td></tr>
<tr><td>Sub-theme:

5.1 Rest between duties is adequate

“Rest time between duties”.

“flights are seldom rostered to the absolute minimum time off between flights and thus generally speaking enough rest is attainable”.

“Well....I like it that a local night principle still applies and that we have 12 hours at Base before commencing further duty”.

“Sufficient rest time between flight days when sleeping at home”.

“Minimum rest periods avoid less than 9 hrs rest between consecutive duty”.

“12 hour rest periods”.

“12 hours between duty periods”.

“12 hours‘ rest after 22:00 sign off”.</td><td></td></tr>
</table>

~~S~~ufficient rest after duty". *~~e~~ight hours' local night".* *~~M~~inimum rest periods between signing off and sign on are good".* *~~L~~ocal night adherence".* *~~T~~ime between shifts".* *~~N~~one are very good but the rest periods are good and will be even better if the maximum flight times are reduced".* *~~T~~ime off between flights helps".* *~~L~~ocal nights(can be increased though) and only be allowed to operate a certain number of hours(can be decreased)".* *~~T~~he number of days of in a 14-day cycle".* *~~a~~llowing time off after long stints".* *~~2~~ Consecutive off days in 14".* *~~o~~ne day off in 7 and 2 off in 14".* *~~D~~efined off days".* *~~O~~ne day off in 7 and 2 days off in 14".*	
Sub-theme: **5.2 Controlled rest in flight** *~~M~~y company allows short controlled napping on the flight deck during cruise".* *~~c~~ontrolled rest in the flight deck".* *~~C~~ompany limits are more restrictive than the CAA limits".* *~~T~~he ability to ~~c~~at-nap" on the flight deck".*	

Controlled sleep on the flight deck and flight and duty regulations”. *On duty naps”.* *Napping on the flight deck”.* *additional crew, controlled rest on flight deck”.*	
Theme 6: No fatigue mitigation	
Absolutely none in comparison to the latest ICAO FTL recommendations”. *Not sure that the current regulations mitigate fatigue. It is antiquated and does not help the low cost model operation”.* *N/A”* *Effective vs. instituted. We are bound by a roster, the creation of that roster currently does not incorporate adequate fatigue mitigating tools”.* *Non”.* *Nil comment”.* *Not much really. It is not scientifically backed”.* *None”.* *Nothing”.* *None”.* *Nil”.* *None whatsoever. They do not take the effects of short haul operations in consideration at all. The current regulations are archaic”.* *Flight and duty. Outdated though. Airlines fly crew now to limit”.* *Absolutely none in comparison to the latest ICAO FTL recommendations”.* *There are none”.* *None I know of”.* *Not much. If an airline where to fly its short haul pilots to the maximum of the CAA regulations it would be very dangerous indeed”.* *CAR 121.02.13.8b”.* *SACAA needs to revise all current regulations asap”.*	

They are quite comprehensive but insufficient. Would have to review the SACAA regulations. Most pilots I know complain of fatigue".

Haven't seen any".

General Regulations on duty and rest, but needs to be more detailed".

Min 12 hours' rest and cumulative hours and duty hours are being pushed".

NIL, only company window dressing".

I believe the current FDP tables and rest requirements work well, but they are complicated to understand and even harder to follow".

None".

None".

None, absolutely none".

Honestly not much".

It is just the law. The bare minimum".

None".

1000 hrs per year is fine, but not 100 hrs for 10 months in a row".

Honestly not much".

None".

None".

None".

No longer effective, Needs revision".

None".

None".

None".

The fatigue limits are outdated and not scientifically established".

Old and out dated".

Nil".

None".

nil safety traded for financial reasons".

None”.

Not effective at all. Just a legality”.

None”.

They try to stop you from working too long in a high stress environment, it is unfortunately a bit outdated”.

None”.

none that I know of, just FDP rules. not sufficient in my opinion”.

Although legislated few are implemented and taken seriously by the operator. The provide a lip service to FRMS as a box ticking exercise”.

There are none. As long as the SACAA FDP's are in force, unnecessary high fatigue levels will remain”.

None that I can think of right now”.

None”.

None”.

Non”.

None”.

IT AT LEAST PROVIDES A CONCISE GUIDELINE TO OPERATORS WHICH IS A START”.

Very limited fatigue mitigating aspects in the current regulations –.

Just the general inability for companies to force their pilots to push beyond reasonable rest requirements”.

Very little”.

Sub-theme:

6.1 Implications for short-haul

None whatsoever. They do not take the effects of short haul operations in consideration at all. The current regulations are archaic”.

Not much. If an airline where to fly its short haul pilots to the maximum of the CAA regulations it would be very dangerous indeed”.

Not sure that the current regulations mitigate fatigue. It is antiquated and does not help the low cost model

operation”.	
Sub-theme: **6.2 Inadequate for modern aviation standards** *“The fatigue limits are outdated and not scientifically established”.* *“They try to stop you from working too long in a high stress environment, it is unfortunately a bit outdated”.* *“Not much really. It is not scientifically backed”.* *“None whatsoever. They do not take the effects of short haul operations in consideration at all. The current regulations are archaic”.* *“Flight and duty. Outdated though. Airlines fly crew now to limit”.* *“They are quite comprehensive but insufficient. Would have to review the SACAA regulations. Most pilots I know complain of fatigue”.* *“NIL, only company window dressing”.* *“I believe the current FDP tables and rest requirements work well, but they are complicated to understand and even harder to follow”.* *“The fatigue limits are outdated and not scientifically established”.* *“Old and out dated”.* *“none that I know of, just FDP rules. not sufficient in my opinion”.*	